Ministère
de l'Économie,
de l'Innovation
et de l'Énergie
Québec

Bureau du sous-ministre et Secrétariat général

PAR COURRIEL

[redacted]

La présente donne suite à votre demande d'accès à l'information reçue le 13 mai 2024 pour laquelle vous souhaitez obtenir :

> « *les échanges, sous toutes formes, et les rapports, analyses, études ou tout autre document produit ou commandé, entre le ministère et la Société de gestion des déchets nucléaires ces cinq dernières années.* »

Conformément à l'article 47 de la Loi sur l'accès aux documents des organismes publics et sur la protection des renseignements personnels (chapitre A-2.1) (« la Loi sur l'accès »), nous vous informons que le ministère de l'Économie, de l'Innovation et de l'Énergie détient des documents quant à votre requête. Vous trouverez ceux pouvant vous être transmis en cliquant sur le lien suivant : Documents_SGDN.pdf.

Toutefois, d'autres documents ne sont pas accessibles. Ainsi, nous ne divulguerons pas de documents qui contiennent, en substance, des informations ayant des incidences sur l'économie et sur les décisions administratives ainsi que des documents au stade d'ébauche, notes préparatoires ou autres documents de même nature. Nous invoquons à l'appui de notre décision les articles 9, 14, 22 à 24, 34 et 37 de la Loi sur l'accès.

Si vous désirez contester cette décision, il vous est possible de le faire auprès de la Commission de l'accès à l'information. Vous trouverez ci-joint une note explicative concernant l'exercice de ce recours.

Je vous prie de recevoir, [redacted], l'expression de mes sentiments distingués.

Pierre Bouchard
Responsable de l'accès aux documents

710, place D'Youville, 6e étage
Québec (Québec) G1R 4Y4
Téléphone : 418 691-5656
Télécopieur : 418 646-6497

AVIS DE RECOURS

Suite à une décision rendue en vertu de la *Loi sur l'accès aux documents des organismes publics et sur la protection des renseignements personnels.*

RÉVISION

a) Pouvoir

L'article 135 de la loi prévoit qu'une personne, dont la demande écrite a été refusée en tout ou en partie par le responsable de l'accès aux documents ou de la protection des renseignements personnels, peut demander à la Commission d'accès à l'information de réviser cette décision.

La demande de révision doit être faite par écrit; elle peut exposer brièvement les raisons pour lesquelles la décision devrait être révisée (art. 137).

L'adresse de la Commission d'accès à l'information est la suivante :

Québec
525, boulevard René-Lévesque Est, bureau 2.36
Québec (Québec)
G1R 5S9
Téléphone : 418 528-7741
Télécopieur : 418 529-3102

Montréal
500, boulevard René-Lévesque Ouest, bur. 18.200
Montréal (Québec)
H2Z 1W7
Téléphone : 514 873-4016
Télécopieur : 514 844-6170

b) Motifs

Les motifs relatifs à la révision peuvent porter sur la décision, sur le délai de traitement de la demande, sur le mode d'accès à un document ou à un renseignement, sur les frais exigibles ou sur l'application de l'article 9 (notes personnelles inscrites sur un document, esquisses, ébauches, brouillons, notes préparatoires ou autres documents de même nature qui ne sont pas considérés comme des documents d'un organisme public).

c) Délais

Les demandes de révision doivent être adressées à la Commission d'accès à l'information dans les 30 jours suivant la date de la décision ou de l'expiration du délai accordé au responsable pour répondre à une demande (art. 135).

La loi prévoit spécifiquement que la Commission d'accès à l'information peut, pour motif raisonnable, relever le requérant du défaut de respecter le délai de 30 jours (art. 135).

APPEL DEVANT LA COUR DU QUÉBEC

a) Pouvoir

L'article 147 de la loi stipule qu'une personne directement intéressée peut porter la décision de la Commission d'accès à l'information en appel devant trois juges de la Cour provinciale, sur toute question de droit ou de compétence. Cet appel ne peut toutefois être porté qu'avec la permission d'un juge de la Cour provinciale. Ce juge accorde la permission s'il est d'avis qu'il s'agit d'une question qui devrait être examinée en appel.

b) Délais et frais

L'article 149 prévoit que la requête pour permission d'appeler doit être déposée au greffe de la Cour provinciale, à Montréal ou à Québec, dans les 30 jours de la décision, après avis aux parties et à la Commission d'accès à l'information. Les frais de cette demande sont à la discrétion du juge.

c) Procédure

L'appel est formé, selon l'article 150 de la loi, par dépôt auprès de la Commission d'accès à l'information d'un avis à cet effet signifié aux parties dans les 10 jours qui suivent la date de la décision qui l'autorise. Le dépôt de cet avis tient lieu de signification à la Commission d'accès à l'information.

Liste des articles invoqués de la Loi sur l'accès aux documents des organismes publics et sur la protection des renseignements personnels

9. Toute personne qui en fait la demande a droit d'accès aux documents d'un organisme public. Ce droit ne s'étend pas aux notes personnelles inscrites sur un document, ni aux esquisses, ébauches, brouillons, notes préparatoires ou autres documents de même nature.

1982, c. 30, a. 9.

14. Un organisme public ne peut refuser l'accès à un document pour le seul motif que ce document comporte certains renseignements qu'il doit ou peut refuser de communiquer en vertu de la présente loi.

Si une demande porte sur un document comportant de tels renseignements, l'organisme public peut en refuser l'accès si ces renseignements en forment la substance. Dans les autres cas, l'organisme public doit donner accès au document demandé après en avoir extrait uniquement les renseignements auxquels l'accès n'est pas autorisé.

1982, c. 30, a. 14.

22. Un organisme public peut refuser de communiquer un secret industriel qui lui appartient.
Il peut également refuser de communiquer un autre renseignement industriel ou un renseignement financier, commercial, scientifique ou technique lui appartenant et dont la divulgation risquerait vraisemblablement d'entraver une négociation en vue de la conclusion d'un contrat, de causer une perte à l'organisme ou de procurer un avantage appréciable à une autre personne.

Un organisme public constitué à des fins industrielles, commerciales ou de gestion financière peut aussi refuser de communiquer un tel renseignement lorsque sa divulgation risquerait vraisemblablement de nuire de façon substantielle à sa compétitivité ou de révéler un projet d'emprunt, de placement, de gestion de dette ou de gestion de fonds ou une stratégie d'emprunt, de placement, de gestion de dette ou de gestion de fonds.

1982, c. 30, a. 22; 2006, c. 22, a. 11.

23. Un organisme public ne peut communiquer le secret industriel d'un tiers ou un renseignement industriel, financier, commercial, scientifique, technique ou syndical de nature confidentielle fourni par un tiers et habituellement traité par un tiers de façon confidentielle, sans son consentement.

1982, c. 30, a. 23.

24. Un organisme public ne peut communiquer un renseignement fourni par un tiers lorsque sa divulgation risquerait vraisemblablement d'entraver une négociation en vue de la conclusion d'un contrat, de causer une perte à ce tiers, de procurer un avantage appréciable à une autre personne ou de nuire de façon substantielle à la compétitivité de ce tiers, sans son consentement.

1982, c. 30, a. 24.

34. Un document du bureau d'un membre de l'Assemblée nationale ou un document produit pour le compte de ce membre par les services de l'Assemblée n'est pas accessible à moins que le membre ne le juge opportun.

Il en est de même d'un document du cabinet du président de l'Assemblée, d'un membre de celle-ci visé dans le premier alinéa de l'article 124.1 de la Loi sur l'Assemblée nationale (chapitre A-

23.1) ou d'un ministre visé dans l'article 11.5 de la Loi sur l'exécutif (chapitre E-18), ainsi que d'un document du cabinet ou du bureau d'un membre d'un organisme municipal ou scolaire.

1982, c. 30, a. 34; 1982, c. 62, a. 143; 1983, c. 55, a. 132; 1984, c. 47, a. 1.

37. Un organisme public peut refuser de communiquer un avis ou une recommandation faits depuis moins de dix ans, par un de ses membres, un membre de son personnel, un membre d'un autre organisme public ou un membre du personnel de cet autre organisme, dans l'exercice de leurs fonctions.

Il peut également refuser de communiquer un avis ou une recommandation qui lui ont été faits, à sa demande, depuis moins de dix ans, par un consultant ou par un conseiller sur une matière de sa compétence.

1982, c. 30, a. 37.

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

MISE EN OEUVRE DE LA GESTION ADAPTATIVE PROGRESSIVE 2022 À 2026

Mars 2022

Déclaration de reconnaissance du territoire

La Société de gestion des déchets nucléaires (SGDN) reconnaît que, depuis notre création, nous avons travaillé au sein de plusieurs territoires autochtones. Nous sommes reconnaissants envers les nombreuses collectivités autochtones et municipales qui ont travaillé avec nous au cours des 20 dernières années.

Nous reconnaissons également qu'actuellement, nous travaillons dans le nord-ouest de l'Ontario, au sein du territoire traditionnel de la Nation ojibwée de Wabigoon Lake, avec Wabigoon et le canton d'Ignace.

Dans le sud de l'Ontario, nous travaillons au sein du territoire traditionnel de la Nation ojibwée de Saugeen (NOS), avec ses deux collectivités – les Chippewas de la Première Nation non cédée de Nawash et les Chippewas de la Première Nation de Saugeen – ainsi qu'avec la municipalité de South Bruce.

Nous reconnaissons en outre que, tant dans le nord-ouest que dans le sud, nous avons le privilège de travailler avec d'autres Premières Nations et organisations autochtones, avec des collectivités métisses et la Métis Nation of Ontario, de même qu'avec plusieurs collectivités municipales qui ont toutes manifesté leur intérêt à en apprendre davantage sur notre travail.

Dans le cadre de notre engagement envers la réconciliation, nous reconnaissons les injustices historiques et actuelles subies par beaucoup trop de collectivités autochtones et nous nous engageons à faire tout ce que nous pouvons pour favoriser le bien-être des collectivités avec lesquelles nous travaillons.

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Bienvenue au document *Mise en oeuvre de la Gestion adaptative progressive 2022 à 2026*.

Il s'agit du plan stratégique quinquennal qui guidera la SGDN dans notre mise en oeuvre du plan canadien de gestion à long terme sûre du combustible nucléaire irradié.

Vision, mission et valeurs

Vision

Notre vision est d'assurer la gestion à long terme des déchets nucléaires du Canada d'une façon qui protège la population et respecte l'environnement, maintenant et pour l'avenir.

Mission

L'objectif de la SGDN est d'élaborer et de mettre en oeuvre, de concert avec le public canadien, une méthode de gestion à long terme du combustible nucléaire irradié canadien, qui soit socialement acceptable, techniquement sûre, écologiquement responsable et économiquement viable.

Valeurs

SÛRETÉ

Nous accordons la plus haute des priorités à tous les aspects de la protection du public et de nos employés – que ce soit sur le plan de la sûreté de l'environnement, classique, nucléaire et radiologique – dans tout ce que nous faisons.

INTÉGRITÉ

Nous agissons de manière franche, honnête et respectueuse.

EXCELLENCE

Nous nous appuyons sur les connaissances, la compréhension et la pensée innovante de la plus haute qualité et cherchons continuellement à nous améliorer dans tout ce que nous faisons, dans une poursuite constante de l'excellence.

COLLABORATION

Nous favorisons une participation inclusive et nous tenons compte de l'avis de tous, dans un esprit de confiance mutuelle, de dialogue constructif et de véritable partenariat.

RESPONSABILITÉ

Nous assumons la responsabilité de nos actions, y compris en ce qui a trait à la gestion avisée, prudente et efficiente des ressources.

TRANSPARENCE

Nous communiquons de manière ouverte et responsable les informations qui permettent de saisir notre approche, nos processus et nos décisions.

Engagement envers la transparence

La SGDN est résolue à agir avec transparence.

En fait, la transparence constitue l'une de nos valeurs fondamentales. Ce plan de mise en oeuvre annuel est l'un des moyens que nous prenons pour respecter cet engagement. Ces plans sont des documents « vivants ». Ils évoluent et se développent dans le temps. Chaque année, nous révisons nos plans en tenant compte de la progression de nos travaux, de ce que nous ont dit les collectivités et le public, des avancées scientifiques et technologiques, de l'éclairage fourni par le savoir autochtone, de l'évolution des valeurs sociétales et des changements apportés aux politiques publiques.

Malgré la pandémie de COVID-19 qui a sévi jusqu'en 2021, la SGDN n'a cessé de travailler en vue de faire avancer le plan canadien de gestion à long terme sûre du combustible nucléaire irradié, tout en veillant à protéger à la fois nos employés et le public. La pandémie a continué de nous forcer à nous adapter à des circonstances changeantes. Le plan canadien est justement conçu pour favoriser une telle adaptation; ce principe est inscrit dans la fibre même de notre organisation et nous avons trouvé des façons innovantes en 2021 de maintenir notre cadence de travail.

À certains moments de l'année, nous avons oscillé entre la collaboration en personne et la collaboration virtuelle, en tenant compte des directives de la santé publique les plus récentes. Lorsque cela s'est avéré nécessaire, notre travail de collaboration s'est fait virtuellement, afin de protéger la santé et la sécurité des collectivités avec lesquelles nous travaillons et de notre personnel. Nous avons mené plusieurs activités en ligne, allant d'ateliers environnementaux et de séances de concertation sur le transport dans les régions hôtes potentielles à des réunions d'échange de connaissances avec nos homologues étrangers. Les leçons que nous avons apprises pourront servir à guider notre plan de mise en oeuvre dans le futur, si nous sommes de nouveau confrontés à des défis similaires.

Allant de l'avant, nous continuerons d'élargir la gamme des possibilités que nous offrons aux personnes intéressées par le plan canadien de participer à notre processus. Compte tenu de ce que nous avons appris pendant la pandémie, nous sommes maintenant mieux outillés que jamais pour discuter à distance avec les auditoires concernés.

Pendant la pandémie, nous avons aussi innové dans d'autres domaines que notre travail virtuel. Par exemple, au début de la pandémie, nous avons déterminé, en collaboration avec nos principaux partenaires et fournisseurs, comment reprendre la fabrication et l'inspection des prototypes physiques des conteneurs et des équipements que nous mettons au point, en utilisant des processus virtuels et à distance. Pendant que la pandémie évoluait, nous avons réussi à mettre en place des mesures de santé et de sécurité appropriées afin de pouvoir reprendre la collaboration en personne là où elle était nécessaire.

La flexibilité soutient nos progrès. Malgré les défis posés par la pandémie, nous avons maintenu notre cadence – au printemps de 2021, nos travaux de forage ont repris dans la région de Wabigoon-Ignace et ont commencé dans la région de la NOS-South Bruce. Avant la fin de l'année, nous avions terminé nos forages dans la région de Wabigoon-Ignace. Les tests et l'analyse des carottes rocheuses extraites dans les deux régions sont maintenant bien avancés.

Nous demeurons en bonne voie de pouvoir choisir un site à la date prévue, soit en 2023, une année charnière pour le plan canadien. Les défis posés par la pandémie ont été relevés et les échéances à long terme pour la construction et le début de l'exploitation du dépôt sont demeurées inchangées.

À la fin de 2020, le ministre des Ressources naturelles du Canada nous a demandé de diriger un processus de concertation distinct avec les Canadiens et les peuples autochtones en vue de l'élaboration d'une Stratégie intégrée pour les déchets radioactifs. Ces travaux sont principalement axés sur les déchets de faible et moyenne activité, pour lesquels il n'existe à l'heure actuelle aucun plan à long terme. En 2021, nous avons écouté des collectivités de tout le Canada, des peuples autochtones, des universitaires, d'un large éventail de groupes d'intérêts et des experts techniques. Leurs contributions éclaireront les recommandations pratiques que nous ferons au gouvernement canadien concernant une stratégie exhaustive de gestion des déchets radioactifs.

Tout au long de ce rapport, vous pourrez prendre connaissance du travail accompli par la SGDN avec les collectivités pour faire en sorte que le plan canadien respecte le caractère unique du futur site de dépôt. Le projet n'ira de l'avant que dans une région avec des hôtes informés et consentants, où la municipalité, les collectivités des Premières Nations et métisses et les autres municipalités de la région travaillent ensemble à sa mise en oeuvre.

Votre point de vue est essentiel à la mise en oeuvre du plan canadien. Chaque année, nous demandons aux Canadiens et aux peuples autochtones de contribuer par des commentaires au plan de mise en oeuvre qui éclairera et guidera nos travaux. Notre formulaire de commentaires sur le plan de mise en oeuvre est disponible en ligne.

Nous vous invitons à suivre le lien www.nwmo.ca/implementationplan pour nous faire part de vos réflexions d'ici le 10 juin 2022.

Vous pouvez également nous envoyer un courriel à l'adresse learnmore@nwmo.ca ou nous envoyer une lettre par la poste. Dans toute réponse écrite, veuillez indiquer votre nom, votre adresse postale et vos coordonnées.

Veuillez adresser votre réponse à :

Lisa Frizzell
Vice-présidente des communications, SGDN
Re. : Plan de mise en oeuvre 2022 à 2026
22, avenue St. Clair Est, 4e étage
Toronto (ON) M4T 2S3
Canada

Présentation de la SGDN

Depuis près de 60 ans, le Canada utilise l'énergie nucléaire comme source d'énergie fiable et à faible teneur en carbone pour alimenter nos foyers et nos entreprises. Aujourd'hui, alors que la demande mondiale d'énergie augmente et que la nécessité de lutter contre les changements climatiques s'intensifie, l'énergie nucléaire occupe une place de plus en plus importante dans la conversation.

La Société de gestion des déchets nucléaires (SGDN) joue un rôle capital en aval du cycle du combustible. Nous avons été chargés de mettre en oeuvre un plan canadien de gestion à long terme sûre du combustible nucléaire irradié dans un dépôt géologique en profondeur, et ce, d'une manière qui protégera les gens et l'environnement pour les générations à venir.

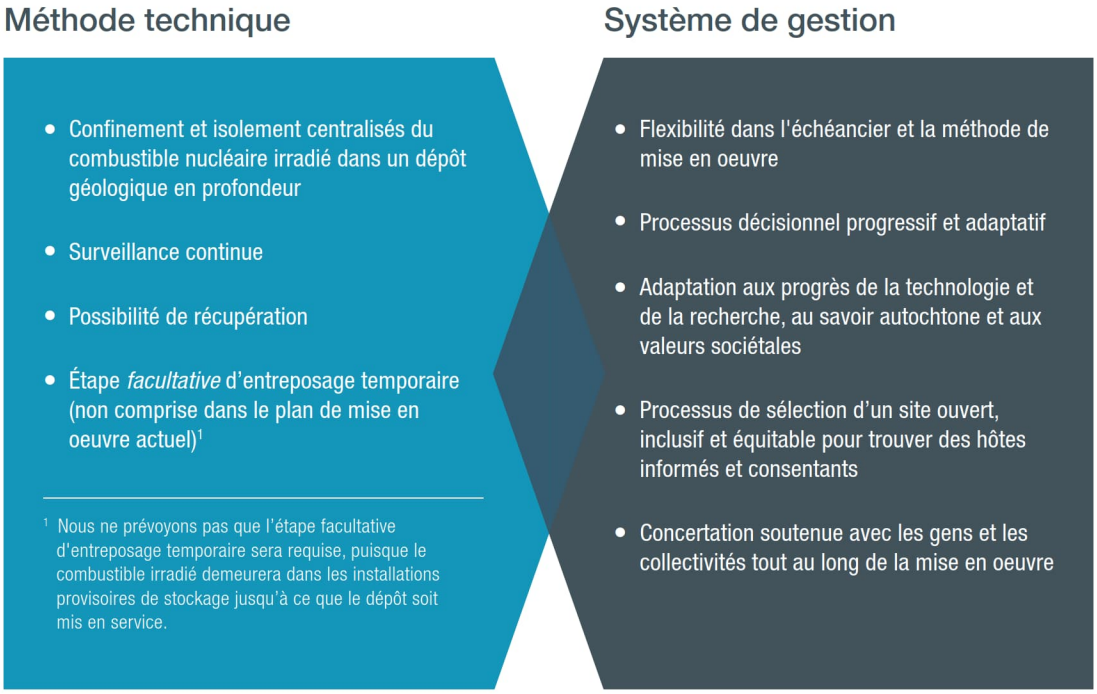
En 2002, le gouvernement canadien a ordonné l'établissement de la SGDN en vertu de la *Loi sur les déchets de combustible nucléaire*. Nous sommes une organisation indépendante, sans but lucratif, qui est financée par les propriétaires de déchets au Canada : Ontario Power Generation, Énergie Nouveau-Brunswick, Hydro-Québec et Énergie atomique du Canada limitée.

À l'heure actuelle au Canada, le combustible nucléaire irradié est entreposé dans des installations autorisées situées en surface. Bien que cette approche soit sûre, elle est de nature temporaire et il est largement reconnu qu'elle ne convient pas pour le long terme. Les Canadiens et les peuples autochtones nous ont clairement dit qu'ils reconnaissaient l'importance d'agir dès maintenant pour trouver une solution à long terme et de ne pas laisser cette tâche aux générations futures.

Le plan canadien de gestion du combustible nucléaire irradié, appelé la Gestion adaptative progressive (GAP), est le fruit d'un dialogue tenu pendant trois ans avec les Canadiens et les peuples autochtones, notamment des spécialistes et le public. Il est fondé sur les valeurs et les objectifs qu'ils avaient ensemble identifiés comme étant importants. En 2007, le gouvernement du Canada a choisi la GAP comme plan national pour la gestion à long terme sûre du combustible nucléaire irradié canadien.

Une étape importante se profile maintenant à l'horizon, puisque nous prévoyons choisir le site du dépôt en 2023. Pour faire un bon choix, nous devrons nous appuyer sur tout le travail que nous avons accompli pour près de 20 ans. Devant un projet d'une telle complexité et d'une telle portée générationnelle, il est essentiel que nous restions concentrés sur nos prochains objectifs, sans perdre de vue nos objectifs à plus long terme.

Le plan canadien : La Gestion adaptative progressive



La GAP est une méthode technique (ce que nous envisageons de construire) et un système de gestion (comment nous travaillerons avec les gens pour y parvenir). La méthode technique consiste à construire un dépôt géologique en profondeur au sein d'une formation rocheuse appropriée pour confiner et isoler en toute sûreté le combustible nucléaire irradié. Le système de gestion a comme élément central un processus de décision progressif et adaptatif, qui est soutenu par la concertation publique et un apprentissage continu.

Un système de transport sûr et sécuritaire sera également mis au point pour transporter le combustible nucléaire irradié depuis les installations où il est actuellement entreposé, à titre provisoire, jusqu'au site du dépôt.

Le projet comprend également la planification d'un Centre d'expertise, qui sera établi sur le site choisi ou à proximité de celui-ci. Il soutiendra initialement la mise à l'épreuve et l'évaluation pluriannuelles du site, principalement en ce qui concerne les questions de sûreté et le bien-être de la collectivité. Le centre deviendra par la suite un carrefour canadien et international d'échange de connaissances.

Calendrier de planification

Malgré la persistance de la pandémie de COVID-19, les travaux de la SGDN ont progressé en 2021, et le calendrier des activités d'évaluation des sites, retardées en 2020 en raison des arrêts de travail, a été respecté. Nous demeurons en bonne voie de pouvoir choisir un site à la date prévue, soit en 2023. Les calendriers liés à la construction du dépôt et au commencement de l'exploitation demeurent également inchangés.

Élaboration du plan canadien	2002	La SGDN est créée.
	2005	La SGDN réalise pendant trois ans une étude avec des personnes intéressées, dont des spécialistes, des peuples autochtones et des membres du public canadien.
	2007	Le gouvernement du Canada choisit la Gestion adaptative progressive (GAP) et confie à la SGDN le mandat d'en entreprendre la mise en oeuvre.
Élaboration du processus de sélection d'un site	2008 à 2009	Des travaux sont menés avec des citoyens pour concevoir un processus de sélection d'un site centralisé optimal pour le dépôt géologique en profondeur et le Centre d'expertise.
Choix d'un site à l'aide du processus de sélection d'un site	2010	Le processus de sélection d'un site est lancé. Il comprend un programme visant à fournir de l'information, à répondre aux questions et à sensibiliser le public.
	2010 à 2015	Vingt-deux collectivités manifestent initialement un intérêt pour le projet. En collaboration avec les collectivités intéressées, la SGDN mène des évaluations de présélection, puis des études de bureau d'évaluation préliminaire et des activités de concertation communautaire. Les régions les moins susceptibles de répondre aux exigences du projet ne sont plus considérées pour le projet.
	2015 à 2023	La SGDN élargit le processus d'évaluation pour ajouter des études sur le terrain. Les régions les moins prometteuses sont retranchées à mesure que le processus d'élimination progresse.
	2023	Un site optimal unique est choisi.
Vers la construction	2024	La caractérisation détaillée du site débute. La description du projet est présentée, ce qui lance l'évaluation d'impact fédérale. La demande de permis pour la préparation du site est présentée à la Commission canadienne de sûreté nucléaire (CCSN). Une mise à jour du cadre de planification du transport est publiée (mis à jour tous les trois ans).
	2026	Les études pour l'évaluation d'impact sont présentées dans le cadre du processus réglementaire.
	2027	La grande ouverture du Centre d'expertise a lieu.
	2028	L'évaluation d'impact est approuvée (estimation). Le permis pour la préparation du site est accordé (estimation).
	2029	La demande de permis de construire est présentée à la CCSN.
	2032	Le permis de construire est accordé (estimation).
	2033	La construction commence.
Début de l'exploitation	2040 à 2045	L'exploitation du dépôt géologique en profondeur débute. Le transport du combustible nucléaire irradié vers le dépôt commence.

Sélection d'un site

La SGDN dirige depuis plusieurs années un processus axé sur les collectivités, qui vise à trouver un site sûr où établir un dépôt géologique en profondeur pour confiner et isoler le combustible nucléaire irradié canadien.

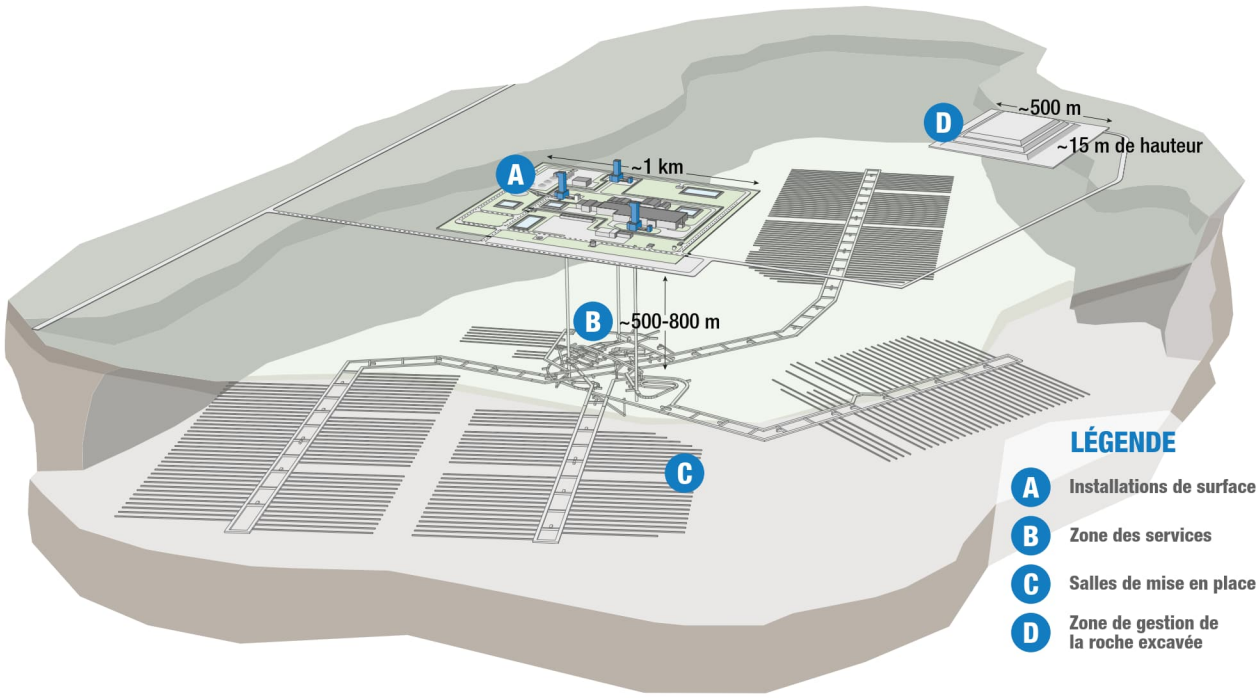
Nous avons lancé ce processus en 2010 et, au cours des deux années suivantes, 22 municipalités et collectivités autochtones ont exprimé de leur propre initiative l'intérêt à en apprendre davantage sur le projet et d'explorer leur aptitude à l'accueillir. Au fil du temps, nous avons progressivement réduit notre champ d'action à deux sites potentiels par le biais d'un programme exhaustif de concertation sociale et d'évaluations techniques visant à évaluer la sûreté du dépôt et du transport, de même que la possibilité de créer des partenariats solidaires et résilients.

En ce moment, nos activités liées à la sélection d'un site se concentrent sur deux régions restantes, les deux situées en Ontario – la région de Wabigoon-Ignace, dans le nord-ouest, et la région de la NOS-South Bruce, dans le sud. Tout au long de l'année 2021, nous avons réalisé des évaluations techniques plus détaillées sur les deux sites. Nos discussions constructives avec les collectivités sur l'établissement de partenariats ont avancé et nous avons exploré comment la mise en oeuvre du projet pourrait favoriser le bien-être des collectivités concernées. Nous demeurons en bonne voie de pouvoir choisir un site unique optimal d'ici 2023.

Pendant que le processus de sélection d'un site avance, nous maintiendrons notre engagement fondamental à ce que le projet n'aille de l'avant que dans une région avec des hôtes informés et consentants, où la municipalité, les collectivités des Premières Nations et métisses et les autres de la région travaillent ensemble à sa mise en oeuvre.

Pour en savoir plus sur le processus de sélection d'un site, visitez la page www.nwmo.ca/sitingprocess.

Principaux éléments du dépôt



Cette illustration montre le plan conceptuel des installations de surface ainsi qu'une superficie approximative de 1500 acres (600 hectares) de la zone souterraine des services et des salles de mise en place pour un dépôt géologique en profondeur construit sur le site proposé dans une formation de roche cristalline. La conception continuera d'évoluer au fur et à mesure de l'avancement du projet.

Le dépôt géologique en profondeur est basé sur un système à barrières multiples conçu pour confiner et isoler de manière sûre et à très long terme le combustible nucléaire irradié. Construit à plus de 500 mètres sous terre, le dépôt consistera en un réseau de salles de mise en place où sera stocké le combustible nucléaire irradié. Cette approche est conforme aux meilleures pratiques internationales.

À la surface, le dépôt comprendra des installations où le combustible irradié sera reçu, inspecté, puis remballé dans des conteneurs de conception spéciale qui seront enchâssés dans une boîte tampon en argile de bentonite. Le combustible sera ensuite envoyé au puits principal afin d'être stocké sous terre.

Le dépôt comprendra une zone de services centralisée, qui assurera la ventilation souterraine par la voie de trois puits situés dans une zone sécurisée unique. L'aménagement comprendra aussi de multiples tunnels d'accès, qui permettront d'aménager les salles de mise en place aux endroits où la roche est la plus stable. Les boîtes tampons renfermant les conteneurs de combustible irradié seront disposées dans des salles de mise en place horizontales et tous les espaces vides seront remblayés avec des pastilles de bentonite.

Pour préparer le processus de décision réglementaire et la construction, la SGDN a commencé à réaliser des dessins conceptuels de l'aménagement du dépôt sur la base des informations tirées des évaluations géoscientifiques et des premiers forages réalisés dans les régions hôtes potentielles. Ce processus est de nature itérative – la SGDN continuera d'affiner la conception du dépôt à mesure que nous recueillerons des renseignements propres à chacun des sites. Le site proposé dans la région de Wabigoon-Ignace se situerait dans une formation de roche cristalline et dans la région de la NOS-South Bruce, il serait dans une formation de roche sédimentaire.

Pour une description plus exhaustive du projet, voir *Description d'un dépôt géologique en profondeur et d'un Centre d'expertise pour le combustible nucléaire irradié canadien* à l'adresse www.nwmo.ca/backgrounders.

Centre d'expertise

Un Centre d'expertise sera établi à l'emplacement du dépôt ou à proximité une fois que le site hôte aura été choisi. L'emplacement exact sera déterminé en collaboration avec les collectivités hôtes.

Il deviendra un carrefour canadien et international d'échange de connaissances et offrira des possibilités pour les gens de se renseigner sur le projet par le biais de galeries d'exposition publiques et de présentations interactives. Le centre pourra également servir de carrefour de sensibilisation au savoir, à la culture, à l'histoire et aux traditions autochtones.

La conception et l'utilisation du centre seront définies en collaboration avec les résidents de la région choisie, y compris des collectivités des Premières Nations et métisses. La SGDN travaillera avec les collectivités locales afin de préciser une vision pour le Centre d'expertise qui correspondra aux exigences et aux aspirations des collectivités.

Le centre sera initialement utilisé pour soutenir un programme pluriannuel d'essais et d'évaluation du site axé sur la sûreté technique et le bien-être de la collectivité. Il sera le siège de recherches techniques et sociales ainsi que de programmes de démonstration technologique auxquels contribueront des scientifiques et d'autres experts de la SGDN et du monde entier appartenant à un large éventail de disciplines.

Le Centre d'expertise comprendra une installation d'essais techniques où seront mis au point les matériaux et l'équipement qui seront utilisés dans le dépôt. Cette installation soutiendra aussi les activités de construction et d'exploitation du dépôt.



Un artiste représente de ce à quoi pourrait ressembler le Centre d'expertise, en guise d'exemple. La conception définitive sera élaborée en collaboration avec les résidents de la région.

Réconciliation et savoir autochtone

La SGDN demeure fidèle à notre engagement de comprendre le savoir autochtone, de l'honorer et de l'intégrer dans tous nos travaux. Cet engagement se traduit de nombreuses façons, notamment par la supervision assurée par notre équipe des relations avec les Autochtones, par les avis fournis par le Conseil des aînés et des jeunes de la SGDN, par la représentation autochtone au sein de notre organisation – y compris de notre équipe de direction et de notre Conseil d'administration – par les politiques concrètes qui guident nos travaux et par les échanges réguliers que nous avons avec les collectivités des Premières Nations et métisses. Cet engagement n'est pas seulement essentiel pour établir de bonnes relations. Il constitue aussi une démonstration importante du travail utile et bon que nous faisons dans toutes les sphères de nos activités.

Au cours des cinq prochaines années, la SGDN continuera de mettre en oeuvre notre *Politique sur la réconciliation* (2019) (www.nwmo.ca/reconciliationpolicy), de mesurer nos progrès et d'incorporer le savoir autochtone dans tout ce que nous faisons. Ces efforts témoignent de notre engagement à répondre à l'appel à l'action 92 de la Commission de vérité et réconciliation, qui incitait le secteur des entreprises à établir des relations respectueuses avec les peuples autochtones et à éduquer son équipe de gestion et son personnel relativement à l'histoire des peuples autochtones.

Réconciliation

À la SGDN, nous reconnaissons l'importance d'établir de bonnes relations avec les peuples autochtones qui résident dans les territoires où nous travaillons.

Afin d'asseoir de solides bases pour travailler avec les peuples autochtones, la SGDN a publié en 2019 notre *Politique sur la réconciliation*, qui définit la manière dont nous contribuerons à la réconciliation dans toutes nos activités. Les efforts de réconciliation permettent à la SGDN d'établir des relations constructives avec toutes les collectivités participant au processus de sélection d'un site, relations fondées sur l'amour, la confiance, l'honnêteté, l'humilité, le courage, le respect et la sagesse. Conformément à notre politique, la SGDN continuera d'avoir des échanges concrets avec les collectivités et les organisations des Premières Nations, métisses et municipales pendant que nous travaillerons ensemble à la mise en oeuvre du plan canadien.

La SGDN continuera aussi de reconnaître la vérité sur les injustices passées et les défis que nous devons relever aujourd'hui, ainsi que de chercher des façons de créer ensemble un avenir meilleur. La politique exige que la SGDN établisse avec les collectivités des Premières Nations et métisses des rapports qui seront basés sur le respect de leurs langues, de leurs coutumes, de leur culture et de leurs institutions. De plus, nous travaillerons avec les collectivités pour soutenir les occasions de favoriser la réconciliation dans leur région.

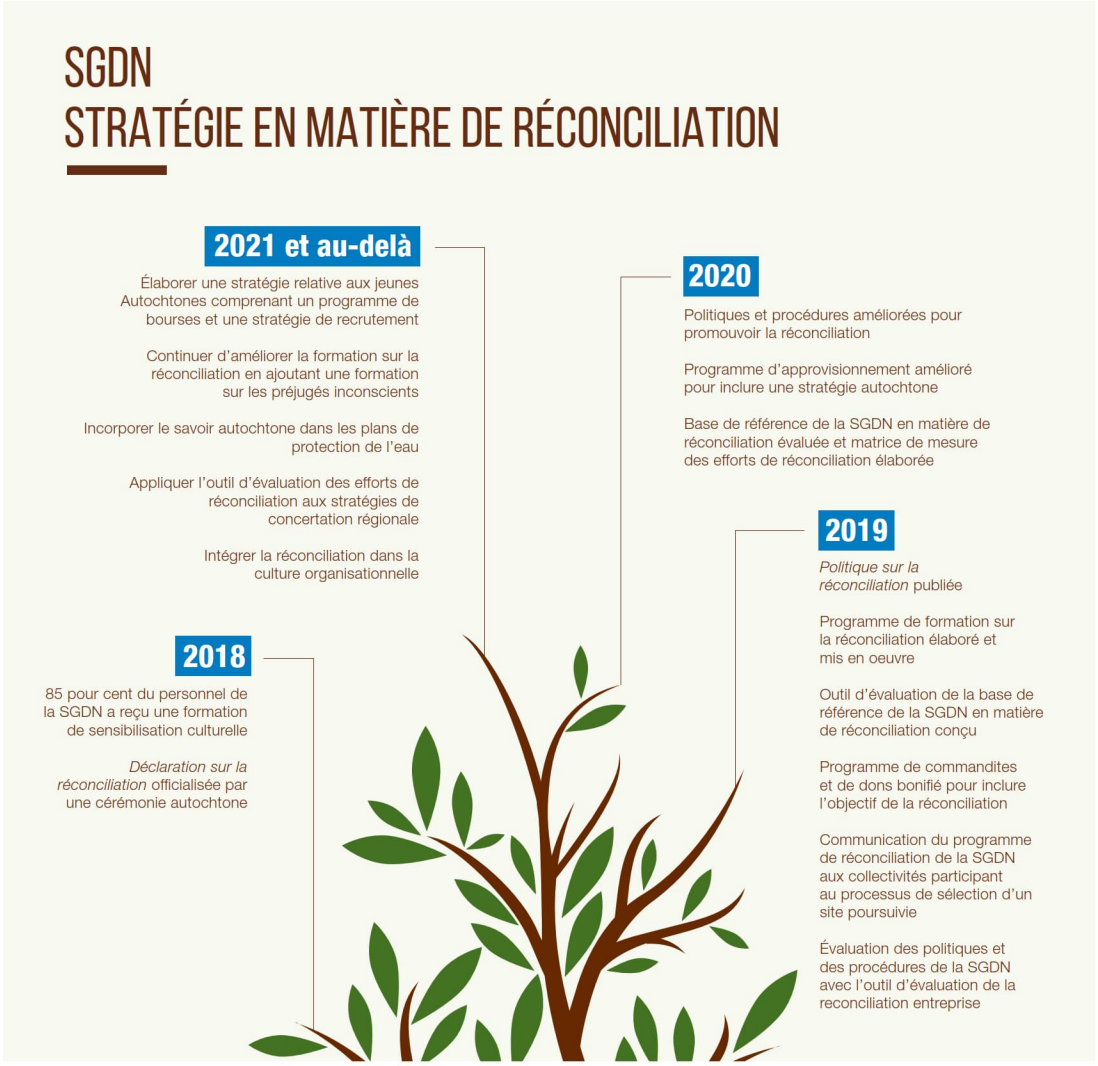
L'année dernière, l'équipe chargée des relations avec les Autochtones a travaillé avec Reciprocal Consulting – une entreprise autochtone spécialisée dans l'évaluation et la surveillance des affaires liées aux Autochtones – pour produire notre rapport annuel sur la réconciliation et un tableau de bord des relations avec les Autochtones, qui seront évalués par rapport au référentiel pour s'assurer que nous respectons les engagements décrits dans notre *Politique sur la réconciliation* (2019). Le référentiel sur la réconciliation est utilisé pour évaluer notre contribution à la réconciliation, identifier nos lacunes et déterminer ce que nous pourrions faire pour progresser en tant qu'organisation. Mesurer nos progrès aide à instaurer la réconciliation comme valeur fondamentale, ce qui se manifeste par la façon dont nous agissons en tant qu'organisation. Tout au long de l'avancement du projet, nous veillerons à ce que tous nos travaux favorisent la réconciliation.

Nous continuons d'utiliser notre outil d'évaluation des efforts de réconciliation pour examiner nos documents importants. Nous avons effectué 13 évaluations en matière de réconciliation des politiques de la SGDN, et nous avons appliqué l'outil aux stratégies de concertation régionales et à la Stratégie intégrée pour les déchets radioactifs. Nous avons également utilisé l'outil d'évaluation à l'extérieur de notre organisation, notamment avec certaines de nos universités partenaires, afin d'appliquer cette optique dans le cadre de l'expansion de leurs programmes de recherche liés à notre travail.

Dans le cadre du processus d'apprentissage de notre équipe, nous avons identifié des domaines d'amélioration pour l'outil d'évaluation et nous l'avons révisé pour le rendre plus convivial et plus clair, de même que pour faire en sorte qu'il soit plus accessible et favorise un dialogue plus approfondi. Cela améliorera son efficacité lorsque nous l'appliquerons à l'avenir.

La formation de sensibilisation culturelle est l'un des moyens par lesquels la SGDN soutient l'apprentissage de notre équipe. En date de décembre 2021, 95 pour cent des membres du personnel de la SGDN avaient suivi une formation de sensibilisation culturelle et la formation ReconciliACTION (ou la première partie de notre formation sur la réconciliation), et 80 pour cent avaient suivi la deuxième partie de notre formation sur la réconciliation. La troisième partie de notre formation sur la réconciliation a été déployée à l'automne 2021 et notre programme de formation sur les relations avec les Autochtones continue d'évoluer.

Les mesures que nous prendrons pour appliquer la *Politique sur la réconciliation* (2019) témoigneront de notre contribution à cet important mouvement en faveur du changement.



Savoir autochtone

La SGDN est résolue à intégrer le savoir autochtone dans tout ce que nous faisons. Nous avons appuyé notre travail sur les importants enseignements des gardiens du savoir autochtone. Ces enseignements portent notamment sur le rôle et la signification des choses spirituelles et des cérémonies, la compréhension des lois naturelles, le respect de notre mère la Terre et la création d'un espace pour donner voix aux Autochtones.

Par exemple, lors du choix d'un emplacement pour un forage, le savoir autochtone, notamment celui acquis par le biais des cérémonies, a contribué au processus décisionnel, parallèlement aux études géoscientifiques et aux études environnementales. De plus, sur les deux sites potentiels, des experts autochtones locaux travaillent avec nous pour veiller à ce que les protocoles autochtones guident nos activités sur le terrain. Cela permet de créer un espace sûr où les spécialistes de la science occidentale et les gardiens du savoir autochtone peuvent tirer des enseignements sur le territoire, ce que nous continuerons de favoriser au fil de l'avancement du projet.

En 2021, nous avons à nouveau organisé deux ateliers qui ont fourni des occasions d'explorer les recoupements qui existent entre le savoir autochtone et la science occidentale. Les participants à ces ateliers comprenaient des gardiens du savoir autochtone, des aînés autochtones, des scientifiques, des professionnels de l'industrie et des employés de la SGDN.

Les discussions de l'atelier ont porté sur la relation sacrée que les gardiens du savoir autochtone ont avec l'eau, le rôle d'intendance qu'ils ont à son égard et les points communs qui relient cette perspective à celle de la science occidentale. Nous avons exploré les raisons pour lesquelles la gestion de l'eau est importante, de même que les rôles que jouent la durabilité, les changements climatiques et l'intendance environnementale dans les initiatives de gestion de l'eau, tant à partir de la vision autochtone du monde que de la vision non autochtone. Nous avons appris que la gouvernance de l'eau doit inclure la protection de l'eau et que nous devons réparer les torts qui ont été causés à l'eau.

Nous avons également appris que l'eau a une histoire à raconter et nous avons la responsabilité d'écouter cette histoire et d'en tirer des enseignements. L'eau a des forces vitales, ce qui implique que nous avons certains devoirs et responsabilités à son égard pour garantir son respect, sa protection et son entretien. Tous les participants ont été encouragés à commencer à établir une relation personnelle avec l'eau.

Nous avons de plus intégré les perspectives autochtones dans nos présentations sur l'eau, un sujet d'une importance capitale pour les gens. Plusieurs collectivités participant à notre processus de sélection d'un site nous ont demandé de leur fournir davantage de renseignements sur les façons dont nos travaux protégeront l'eau. Depuis 2017, nous avons préparé trois présentations qui examinent la relation avec l'eau, l'argile et le cuivre, tous des éléments essentiels du système à barrières multiples de notre dépôt géologique en profondeur, et nous continuons de nous en servir dans nos activités de concertation.

Élaborées avec la participation de collectivités autochtones, ces présentations incorporent les enseignements autochtones sur l'eau, l'argile et le cuivre, et la façon dont elles sont données s'inspire de la tradition orale. La SGDN a donné cinq de ces présentations en 2021. Nous continuerons de rechercher des occasions de présenter ces enseignements essentiels dans le futur.

On pense souvent à tort que le savoir autochtone ne s'applique qu'à la connaissance de la terre, alors qu'en fait, il couvre également la gestion des ressources, les sciences, la gouvernance, la résolution des conflits et bien d'autres choses encore. Par exemple, notre service des ressources humaines a pris des dispositions pour intégrer le savoir autochtone dans ses activités, en se coordonnant avec l'équipe des relations avec les Autochtones pour offrir des cercles du partage et ainsi continuer de soutenir la santé mentale pendant la pandémie de COVID-19.

Au cours des cinq prochaines années, nous continuerons de chercher des occasions d'intégrer le savoir autochtone dans tout ce que nous faisons et de créer un espace permettant de tirer des enseignements des cérémonies et d'appliquer les connaissances ainsi acquises au processus décisionnel de la SGDN.

Coût et financement

Le public canadien s'attend à ce que les fonds nécessaires à la gestion à long terme du combustible nucléaire irradié soient disponibles au moment voulu. Les mesures prises satisfont à cette exigence.

Le plan canadien de gestion à long terme du combustible nucléaire irradié est financé par les propriétaires de déchets au Canada : Ontario Power Generation (OPG), Énergie Nouveau-Brunswick (ÉNB), Hydro-Québec (HQ) et Énergie atomique du Canada limitée (ÉACL). En vertu de la *Loi sur les déchets de combustible nucléaire* (*LDCN*), chacune de ces quatre sociétés était tenue d'établir son propre fonds en fiducie et d'y verser une contribution annuelle pour faire en sorte que l'argent requis pour financer le projet soit disponible au moment voulu.

La contribution de chacune de ces sociétés à son fonds en fiducie est basée sur le nombre de grappes de combustible nucléaire irradié qu'elle a produites et qu'elle continuera de produire. Les sommes versées couvrent les coûts fixes que la SGDN devra payer, selon les estimations, pour construire, exploiter, surveiller et déclasser un dépôt géologique en profondeur, ainsi que les coûts variables liés à la gestion de chacune des grappes de combustible. Ce processus est conçu pour assurer le financement à long terme du plan canadien.

Pour de plus amples informations sur les sommes versées aux fonds en fiducie, veuillez vous reporter au *Rapport annuel de 2021 de la SGDN* (www.nwmo.ca/annualreport2021). En sus de ces contributions aux fonds en fiducie, les propriétaires de déchets sont également tenus de financer le budget de fonctionnement annuel de la SGDN.

Contributions totales aux fonds en fiducie : Année 2022

Propriétaire	Solde des fonds en fiducie (millions $) Décembre 2021	Contributions aux fonds en fiducie (grappes engagées et futures) (millions $)* 2022
OPG	5025	52
ÉNB	205	4
HQ	182	0
ÉACL	59	1
Total	5471	57

* Les versements annuels aux fonds en fiducie doivent se faire au plus tard 30 jours après la présentation du rapport annuel. La date de versement du 30 avril est supposée aux fins d'illustration.

La SGDN a comme responsabilité de déterminer, selon toute vraisemblance, quels coûts devront être assumés pendant la durée du projet et de prévoir des fonds pour couvrir les dépenses associées aux imprévus. Nous appliquons un système pour estimer les exigences de financement et pour communiquer avec les propriétaires de déchets de façon à ce qu'ils versent les sommes requises aux fonds en fiducie.

De nombreux facteurs influenceront le coût à long terme du plan canadien : le volume de combustible nucléaire irradié à gérer, l'emplacement de l'installation, l'infrastructure environnante, le type et les caractéristiques de la formation rocheuse hôte, la conception du dépôt ainsi que le temps qui sera consacré à la surveillance du site après que le combustible aura été stocké. Le Canada a jusqu'à maintenant produit environ 3,1 millions de grappes de combustible nucléaire irradié et d'autres grappes seront produites chaque année par les réacteurs nucléaires qui continueront de générer de l'électricité.

La SGDN a effectué en 2021 une mise à jour complète de l'estimation du coût du projet. Les estimations de la sorte servent de base à la planification financière et à l'établissement des sommes qui devront être versées dans les fonds en fiducie dans les années à venir. Pour les besoins de la planification, notre estimation du coût est basée sur une quantité prévue d'approximativement 5,5 millions de grappes de combustible. D'après ce volume, le coût du cycle de vie du projet – du début du processus de sélection d'un site, en 2010, jusqu'à l'achèvement du projet après environ 175 ans – s'élèverait approximativement à 26 milliards $ (en dollars de 2020). Ce chiffre couvre les nombreuses décennies du cycle de vie du projet, lequel se poursuivra bien au-delà du début du siècle prochain.

Prise en compte du contexte externe et adaptation aux changements

La SGDN s'est engagée à surveiller les développements locaux, nationaux et internationaux qui pourraient changer le contexte dans lequel nous évoluons ou avoir une incidence directe sur le projet. Nous continuons de surveiller les avancées qui se font dans le secteur de l'énergie, les innovations qui touchent la gestion des déchets nucléaires, les changements apportés aux politiques énergétiques et environnementales, les développements potentiels liés à la construction de nouveaux réacteurs, l'évolution des attentes, des valeurs et des idées de la société ainsi que les nouveaux développements liés aux autres initiatives canadiennes de gestion des déchets nucléaires.

Au Canada, des travaux sont en cours dans le secteur nucléaire pour faire progresser la technologie des petits réacteurs modulaires (PRM). La SGDN serait responsable de la gestion à long terme de tout déchet de combustible nucléaire qu'ils produiraient. Nous travaillons avec les concepteurs de PRM pour identifier les types de déchets de combustible qui pourraient en résulter. Une fois que nous aurons suffisamment d'informations à ce sujet, nous déterminerons comment optimiser et traiter les déchets de combustible en vue de leur gestion à long terme, quel impact ils pourraient avoir sur la conception du dépôt et comment adapter nos formules de financement pour inclure les nouveaux producteurs.

Nous mettons à jour chaque année un dossier de suivi des progrès réalisés dans le retraitement du combustible nucléaire irradié et dans les technologies de remplacement qui pourraient être utilisées pour la gestion du combustible nucléaire irradié (www.nwmo.ca/adaption). Nous assurons aussi un suivi des quantités de combustible nucléaire irradié qui pourraient être produites pour en tenir compte dans la conception du dépôt et nous publions ces données (www.nwmo.ca/howmuchfuel).

Un des principes fondamentaux de la Gestion adaptative progressive est l'engagement à adapter les plans en fonction des commentaires reçus dans le cadre des activités de concertation. À titre d'exemple, nous avons élaboré un cadre de planification du transport d'après ce que les collectivités et les personnes intéressées par le plan canadien nous ont dit. À partir de 2020, nous l'avons diffusé publiquement en vue d'une concertation plus large. En 2021, nous avons affiné le cadre en fonction des commentaires fournis par les Canadiens et les peuples autochtones.

Autre exemple encore, nous avons adapté nos plans réglementaires en réponse aux changements apportés à la *Loi sur l'évaluation d'impact* en 2019. De plus amples informations sur le plan réglementaire sont fournies à la section *Processus de décision réglementaire* du présent rapport.

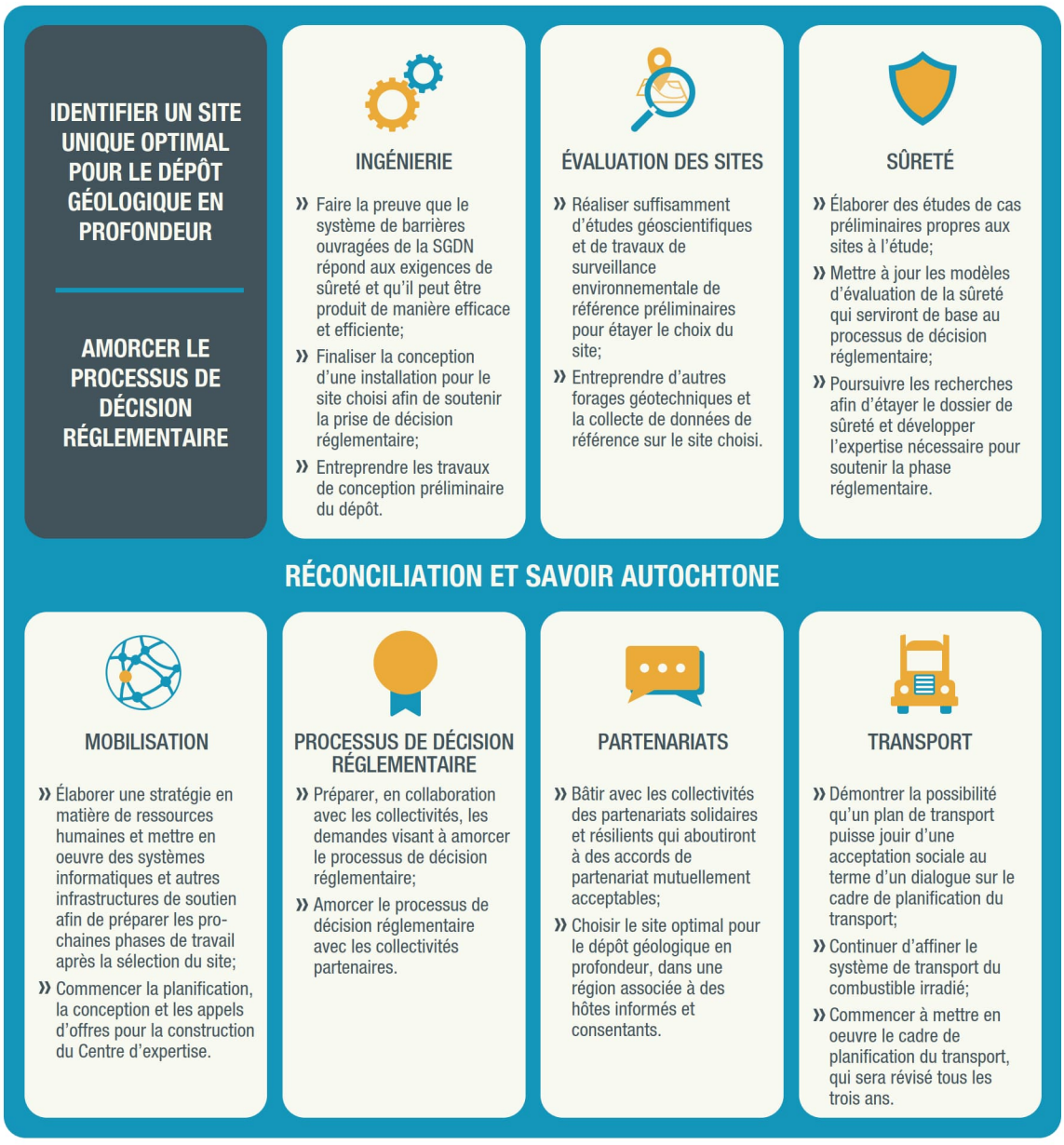
Priorités de planification

À la SGDN, nous articulons nos plans de travail autour de sept priorités – l'ingénierie, l'évaluation des sites, la sûreté, la mobilisation, le processus de décision réglementaire, les partenariats et le transport.

Notre engagement envers la réconciliation et l'intégration du savoir autochtone dans notre travail guide nos efforts dans tous nos domaines prioritaires.

Au cours des cinq prochaines années, nous passerons de la phase de la sélection d'un site à celle du processus de décision réglementaire. Ces priorités de planification reflètent les nombreuses activités qui devront être menées au cours de cette période de transition.

Dans cette section, nous décrivons nos plans en fonction de ces sept catégories de travaux.



INGÉNIERIE

La SGDN :

- Fera la preuve que notre système de barrières ouvragées répond aux exigences de sûreté et qu'il peut être produit de manière efficace et efficiente;
- Finalisera la conception d'une installation pour le site choisi afin de soutenir la prise de décision réglementaire;
- Entreprendra les travaux de conception préliminaire du dépôt.

Le dépôt géologique en profondeur est une approche reconnue à l'échelle internationale et qui fait consensus au sein de la communauté scientifique pour ce qui est de la gestion à long terme sûre du combustible nucléaire irradié. De multiples barrières ouvragées seront mises en place dans une formation rocheuse stable pour confiner et isoler à grande profondeur sous terre le combustible nucléaire irradié.

Au cours des cinq prochaines années, nous affinerons les modèles conceptuels propres aux sites envisagés en incorporant les données recueillies par le biais des forages exploratoires et des études environnementales préliminaires de référence. Ce travail soutiendra le processus décisionnel lié au choix du site et, à la fin, la conception préliminaire progressera en fonction de l'emplacement choisi. Ces informations serviront aussi de base à la préparation des demandes et des évaluations réglementaires.

Nous continuerons d'optimiser nos processus et nos techniques pour renforcer la confiance dans la robustesse du système de barrières ouvragées et de chacun de ses éléments. Nous intégrerons aussi dans nos modèles les informations les plus récentes tirées de nos activités en cours de recherche-développement par le biais d'examens interdisciplinaires menés par notre comité d'examen de la recherche technique.

De plus, de 2022 à 2026, la SGDN :

- Achèvera la conception, la fabrication et la mise à l'essai des prototypes de conteneurs pour le dépôt et des systèmes tampons et de mise en place;
- Exploitera une installation de mise à l'épreuve et de démonstration des prototypes pour l'évaluation des barrières ouvragées;
- Réalisera les essais à pleine échelle de mise en place du système de barrières ouvragées à notre installation d'essai et de démonstration;
- Continuera de tenir à jour les informations sur l'estimation des coûts du projet;
- Soutiendra la préparation de la description du projet et des évaluations requises pour le processus réglementaire;
- Fera réaliser par des pairs indépendants des examens des caractéristiques et aspects particuliers de la conception des barrières ouvragées et sollicitera des examens du programme de mise à l'essai du système de barrières ouvragées.



ÉVALUATION DES SITES

La SGDN :

- Réalisera suffisamment d'études géoscientifiques et de travaux de surveillance environnementale de référence préliminaires pour étayer le choix du site;
- Entreprendra d'autres forages géotechniques et la collecte de données de référence sur le site choisi.

De 2022 à 2026, la SGDN choisira un site optimal unique et passera ensuite à l'étape du processus d'autorisation et de décision réglementaire.

Au cours des cinq prochaines années, les activités d'évaluation des sites passeront de l'évaluation préliminaire des deux sites potentiels restants à la caractérisation détaillée du site choisi.

Pour faire en sorte que nous intégrions le savoir autochtone de manière appropriée, nous sollicitons l'avis des gardiens du savoir local concernant la planification et la réalisation de nos études. Des experts autochtones locaux veillent à ce que les protocoles autochtones guident toutes les activités sur le terrain. Ces activités comprennent des études de vérification culturelle des secteurs potentiellement touchés, des cérémonies tenues avant la réalisation des travaux et des formations de sensibilisation culturelle données au personnel et aux sous-traitants qui travaillent sur le terrain.

Pendant que l'évaluation des sites se poursuivra de 2022 à 2026, nous travaillerons avec les municipalités intéressées et les collectivités des Premières Nations, métisses et autres de la région afin de les aider à réfléchir aux effets environnementaux, sociaux, culturels et économiques que le dépôt géologique en profondeur pourrait avoir. Faire participer les résidents de l'ensemble des régions hôtes potentielles garantira qu'un large éventail de retombées et d'incidences potentielles sera pris en considération alors que nous progresserons au-delà du choix d'un site.

Pendant que la SGDN travaille à la sélection d'un site qui accueillera le dépôt géologique en profondeur, nous continuons d'échanger avec les citoyens de diverses façons, en partie pour soutenir les collectivités qui explorent le projet et qui se demandent si elles sont prêtes à l'accueillir. Le plan canadien est constamment adapté pour refléter les priorités de nos collectivités hôtes potentielles.

En 2021, nous avons poursuivi nos activités géoscientifiques sur le terrain dans les deux régions hôtes potentielles, y compris le forage et l'essai de trous de sonde et l'installation de réseaux de surveillance des eaux souterraines peu profondes. Les évaluations de sites et travaux environnementaux, sociaux et techniques se poursuivront dans les deux régions au cours des prochaines années, comme nous l'avons décrit tout au long de ce rapport.

De plus, de 2022 à 2026, la SGDN :

- Soutiendra la mise en oeuvre du projet en menant un dialogue sur des sujets précis comme la protection des gens et de l'environnement, les retombées du projet et l'intendance du territoire;
- Poursuivra nos études sur le terrain, y compris nos forages géotechniques, et utilisera les facteurs relevés par les gardiens du savoir autochtone pour éclairer les évaluations géoscientifiques, techniques, environnementales et de sûreté;
- Soutiendra le processus de sélection d'un site propice à l'établissement du dépôt géologique en profondeur dans un endroit sûr en menant des études géoscientifiques à proximité des collectivités intéressées;
- Soutiendra le processus de décision réglementaire et entreprendra les études de caractérisation détaillée pour confirmer que le site choisi est techniquement propice à l'établissement du dépôt géologique en profondeur.



SÛRETÉ

La SGDN :

- Élaborera des études de cas préliminaires propres aux sites à l'étude;
- Mettra à jour les modèles d'évaluation de la sûreté qui serviront de base au processus de décision réglementaire;
- Poursuivra les recherches afin d'étayer le dossier de sûreté et développera l'expertise nécessaire pour soutenir la phase réglementaire.

La SGDN est résolue à protéger les gens et l'environnement pour les générations à venir. Nous accordons la priorité à tous les aspects de la sécurité du public et des employés dans tout ce que nous faisons, y compris la sécurité environnementale, classique, nucléaire et radiologique.

Le dépôt géologique en profondeur sera construit dans une formation rocheuse propice au confinement et isolement sûrs et à long terme du combustible nucléaire irradié. Dans le cadre du futur processus d'autorisation, il faudra démontrer que la performance du dépôt sur ce site satisfait aux exigences réglementaires de la Commission canadienne de sûreté nucléaire ou les surpasse.

La SGDN a amorcé l'élaboration des études liées aux dossiers de sûreté des deux sites toujours envisagés dans le processus de sélection d'un site. Nous utilisons pour ces sites nos méthodes d'évaluation de la sûreté pré-fermeture et post-fermeture. Ce travail comprend l'examen des caractéristiques du système de dépôt en fonction des conditions propres à chacun des sites ainsi que la confirmation que les personnes et l'environnement seront protégés à long terme dans une série de scénarios.

La sûreté est un sujet de discussion important pour les collectivités, qui continuent de trouver et de poser des questions sur des sujets tels que : le système à barrières multiples, les évaluations de la sûreté et la gestion de l'eau pendant la construction et l'exploitation du dépôt. Pendant que nous continuons d'améliorer notre connaissance des sites, nous partageons notre compréhension de la sûreté avec les collectivités par le biais de présentations et de nos plateformes numériques, de même qu'en mettant à leur disposition des spécialistes de la SGDN.

De plus, de 2022 à 2026, la SGDN :

- Continuera de participer à des projets communs de recherche avec des organisations internationales et des sociétés homologues d'autres pays tels que la Suède, la Suisse, la Finlande, la France, la Corée, le Japon et le Royaume-Uni. Cela permet à la SGDN de tirer parti de l'expérience d'autres pays, tout en se tenant au courant de l'état des connaissances géoscientifiques et des dossiers de sûreté développés pour diverses formations rocheuses hôtes;
- Liera des partenariats de recherche avec des universités pour garantir si le travail technique de la SGDN est scientifiquement rigoureux et pour assurer le développement de jeunes ingénieurs et scientifiques qui auront des connaissances dans la gestion des déchets. La SGDN continuera notamment de tenir notre Symposium annuel sur les géosciences et notre Atelier sur la science des barrières ouvragées, où se réunissent des chercheurs universitaires et de l'industrie.
- Fera de la sensibilisation sur le rôle important que joue le savoir autochtone dans nos projets, en partie en proposant des formations et en parrainant des ateliers sur le savoir autochtone et la science occidentale pour nos partenaires de recherche;
- Continuera d'inculquer à nos employés une solide culture de la sûreté et de la sécurité pendant que nous nous préparons à la phase des autorisations réglementaires du projet, notamment en créant et en maintenant un milieu où les employés assument proactivement la responsabilité de leur sécurité et de celle de leurs collègues, et ce, dans toutes leurs activités.



MOBILISATION

La SGDN :

- Élaborera une stratégie en matière de ressources humaines et mettra en oeuvre des systèmes informatiques et autres infrastructures de soutien afin de préparer les prochaines phases de travail après la sélection du site;
- Commencera la planification, la conception et les appels d'offres pour la construction du Centre d'expertise.

La planification se poursuit en vue de déterminer comment le plan canadien sera mis en oeuvre après la sélection d'un site en 2023. Une fois le site optimal choisi, les activités s'accéléreront à l'échelle locale et régionale.

Ce projet national d'infrastructure de grande envergure générera des retombées économiques importantes. Le nombre d'emplois créés dans la région hôte dépendra en partie de l'emplacement du dépôt. Les retombées comprendront les emplois directs générés sur le site du dépôt et dans les environs, les emplois indirects créés par les fournisseurs et les sous-traitants qui participeront au projet, et les emplois induits par les dépenses faites par les personnes employées dans la région.

La SGDN cherchera à mettre en place un effectif équitable, diversifié et inclusif, à maximiser les possibilités d'emplois à l'échelle locale – la municipalité et la région environnante, y compris les collectivités des Premières Nations et métisses – et à renforcer les capacités des collectivités en investissant dans des initiatives de formation et d'éducation.

Le choix du site marquera aussi pour la SGDN le début d'une transformation organisationnelle en plusieurs phases. Comme nous nous concentrerons sur une seule région hôte, nous devrons accroître nos ressources dans cette région, faire en sorte que nous ayons en place la technologie requise pour soutenir le plan canadien et acquérir les droits sur les terrains où seront établis les installations de la SGDN et le Centre d'expertise. Nous déménagerons aussi nos opérations à l'emplacement choisi pour le dépôt.

À l'interne, nous nous préparerons à cette intensification de nos activités en mettant progressivement en place les ressources humaines, organisationnelles et informationnelles nécessaires pour entreprendre les travaux de caractérisation détaillée, pour présenter les demandes réglementaires et pour construire et exploiter le dépôt géologique en profondeur.

De plus, de 2022 à 2026, la SGDN :

- Élaborera des plans de travail et identifiera les ressources requises pour réaliser les travaux de caractérisation détaillée, les évaluations environnementales, les modèles conceptuels ainsi que la préparation du dossier de sûreté pour la région d'établissement choisie à l'appui au processus de réglementation;
- Continuera de renforcer nos effectifs dans les régions hôtes potentielles et d'offrir aux entrepreneurs locaux des possibilités de contrats liés à la mise en oeuvre du projet;
- Renforcera la culture de sûreté et d'apprentissage de l'organisation, une culture qui encourage et soutient l'apprentissage continu des employés;
- Investira dans le développement des compétences et des capacités des jeunes et autres membres des municipalités et des collectivités des Premières Nations et métisses participant au processus de sélection d'un site afin de les aider à bien se positionner pour décrocher les emplois générés par le plan canadien;
- Continuera d'utiliser les outils et technologies de l'information pour automatiser les processus, soutenir les initiatives stratégiques et numériser les informations, le contenu et les dossiers. Nous utiliserons aussi l'intelligence artificielle, l'intelligence d'affaires et l'analyse des données pour améliorer notre efficience opérationnelle et nos prises de décisions cruciales;
- Continuera de renforcer la culture de l'entreprise en appliquant des comportements, des normes et des outils organisationnels appropriés, y compris des plateformes technologiques. Cette culture englobera la recherche de l'excellence dans la gestion des projets, la création de partenariats solides, la promotion de la diversité et de l'inclusion, l'engagement envers la réconciliation et l'intégration du savoir et des pratiques autochtones dans tout notre travail.

PROCESSUS DE DÉCISION RÉGLEMENTAIRE

La SGDN :

- Préparera, en collaboration avec les collectivités, les demandes visant à amorcer le processus de décision réglementaire;
- Amorcera le processus de décision réglementaire avec les collectivités partenaires.

L'objectif prioritaire de la SGDN dans notre mise en oeuvre du plan canadien est de protéger les gens et l'environnement pour les générations à venir. Nous devrons démontrer que le projet respectera ou surpassera les rigoureuses exigences réglementaires établies en matière de protection de la santé, de la sûreté et de la sécurité de la population et de l'environnement, et que le Canada saura remplir ses engagements internationaux.

Nos investigations des sites et les études techniques associées seront menées en conformité avec les exigences municipales, provinciales et fédérales pertinentes. Nous nous tenons au courant de tous les changements réglementaires qui pourraient toucher le projet.

Par exemple, la SGDN a déjà commencé, et continuera de le faire au cours des cinq prochaines années, de réaliser des études en vertu de la *Loi sur l'évaluation d'impact* adoptée en 2019. Nous avons adapté nos plans à cette modification législative. Nous prévoyons lancer officiellement le processus de décision réglementaire en 2024.

Nous continuerons d'interagir avec la Commission canadienne de sûreté nucléaire (CCSN) conformément aux dispositions d'un accord spécial conclu avec elle pour la période menant à la présentation d'une demande de permis.

De plus, de 2022 à 2026, la SGDN :

- Mettra au point des méthodologies d'évaluation de l'impact du projet, en collaboration avec les collectivités municipales et autochtones des régions hôtes potentielles, en prévision du lancement officiel du processus de décision réglementaire;
- Trouvera des possibilités d'améliorer notre compréhension des conditions locales et régionales actuelles, en collaboration avec les collectivités et d'autres. Cela comprend la collaboration avec les collectivités autochtones pour intégrer le savoir autochtone local à cette compréhension afin d'étayer les évaluations environnementales, sociales, sanitaires et économiques;
- Établira des programmes de surveillance environnementale dans les régions hôtes potentielles, en collaboration étroite avec les membres des collectivités et les gardiens du savoir autochtone;
- Travaillera avec les collectivités hôtes potentielles en vue de définir leur rôle dans le processus de décision réglementaire et ensuite faciliter leur participation;
- Travaillera avec la CCSN et les autres autorités réglementaires pour pleinement comprendre les exigences de la *Loi sur l'évaluation d'impact* et comment cette loi s'applique à la mise en oeuvre du projet;
- Préparera la documentation requise pour lancer le processus fédéral d'évaluation d'impact et le processus de décision réglementaire;
- Déposera la description du projet requise pour amorcer le processus d'évaluation d'impact;
- Entreprendra le processus d'évaluation d'impact et préparera les rapports nécessaires pour l'obtention des permis requis après avoir reçu de l'Agence d'évaluation d'impact du Canada les Lignes directrices relatives à l'évaluation d'impact et le Plan d'autorisation pour le site proposé.

Le plan de prise de décision réglementaire

Une fois qu'un site aura été choisi en 2023, la SGDN se concentrera sur le processus de décision réglementaire qui permettra de passer à la construction du dépôt géologique en profondeur si les approbations sont accordées. Ces décisions réglementaires feront l'objet d'un examen indépendant par les organismes de réglementation fédéraux et provinciaux et par un comité d'examen désigné. Le processus sera ouvert et transparent et permettra la participation des membres du public qui voudront y participer.

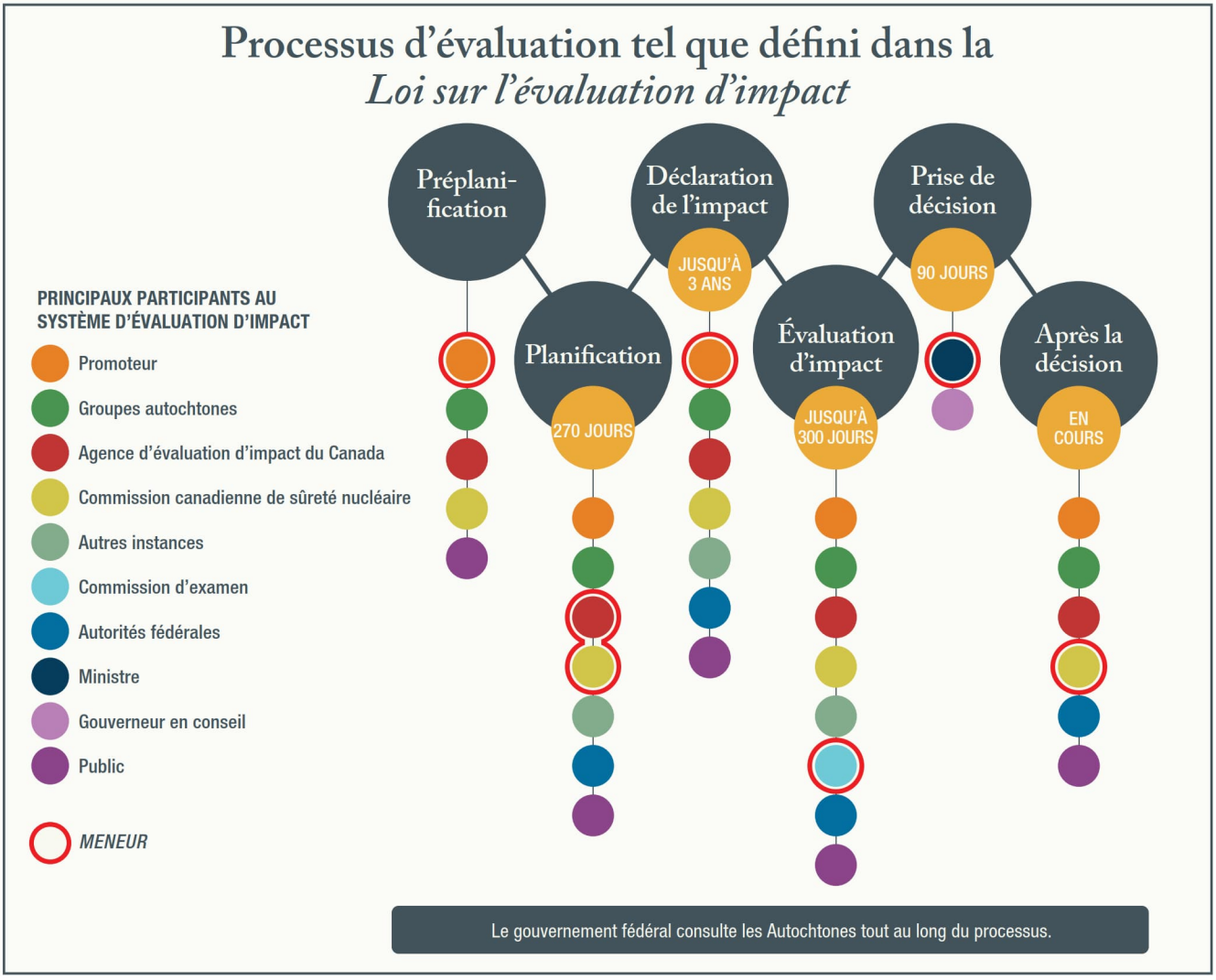
Deux processus de décision réglementaire intégrés seront mis en oeuvre :

- Une évaluation d'impact conforme à la *Loi sur l'évaluation d'impact*;
- La délivrance d'un permis en vertu de la *Loi sur la sûreté et la réglementation nucléaires*.

Ensemble, ces processus aideront le gouvernement à évaluer divers aspects du projet pour déterminer s'il doit aller de l'avant, notamment la sûreté, la durabilité, les effets négatifs, la sécurité nationale et les répercussions sur les peuples autochtones.

La SGDN et les collectivités hôtes du projet entreprendront un vaste programme de travail s'étendant sur plusieurs années. Globalement, notre objectif est de passer à la préparation du site sélectionné d'ici 2028.

Pour de plus amples informations sur le processus de décision réglementaire, suivez ce lien : www.nwmo.ca/regulatory.





PARTENARIATS

La SGDN :

- Bâtira avec les collectivités des partenariats solidaires et résilients qui aboutiront à des accords de partenariat mutuellement acceptables;
- Choisira le site optimal pour le dépôt géologique en profondeur, dans une région associée à des hôtes informés et consentants.

La SGDN travaillera avec les collectivités des régions hôtes potentielles à établir les partenariats durables et résilients nécessaires à la mise en oeuvre du projet. De 2022 à 2023, nous continuerons d'explorer la possibilité de créer un partenariat avec les collectivités municipales et autochtones de chaque région hôte potentielle.

En collaboration avec les collectivités, nous suivons une feuille de route et un cheminement qui nous mèneront vers un partenariat. Cette feuille de route décrit la séquence des principaux sujets que nous devons explorer au regard de l'établissement d'un partenariat. Les collectivités s'appuieront sur les valeurs et les principes qu'elles ont identifiés pour guider nos discussions et s'assurer que le projet est mis en oeuvre d'une manière qui améliorera le bien-être de leurs résidents.

Pendant qu'elles approfondissent leur exploration de la notion de partenariat, les municipalités participant au processus continuent de manifester l'intention d'améliorer leurs relations avec les collectivités autochtones voisines. La SGDN soutient leur apprentissage par des formations de sensibilisation culturelle et de promotion de la réconciliation, et fournit un soutien, au besoin, pour favoriser l'établissement de voies de communication officielles.

Conformément à l'engagement de la SGDN à favoriser le bien-être des collectivités, nous avons alloué des fonds à chaque collectivité hôte pour faire avancer des projets menés à leur initiative. Ces fonds ont été engagés pour s'assurer que chacune de nos collectivités hôtes est dans une position favorable pour participer et travailler activement avec la SGDN.

Après la sélection du site en 2023, nous passerons de l'exploration de la possibilité de créer un partenariat et de la réalisation de cet objectif avec les collectivités hôtes et régionales, à la mise en oeuvre et à la gouvernance globale des accords de partenariat. La concertation et l'élaboration d'un cadre qui se poursuivront pour tout ce qui concerne les partenariats porteront sur les valeurs communes et le soutien au bien-être à long terme de la collectivité. La participation des jeunes demeura également une priorité, compte tenu de la nature intergénérationnelle du projet et de la nécessité d'une transmission intergénérationnelle des connaissances pour soutenir sa mise en oeuvre.

En fin de compte, un seul site pourra être choisi pour le dépôt géologique en profondeur. La SGDN demeure résolue à s'assurer que les collectivités ont bénéficié de leur participation à mesure qu'elles quittent le processus de sélection d'un site. Nous tirons une grande fierté des commentaires reçus jusqu'à maintenant des dirigeants locaux, selon lesquels leurs collectivités ont tiré des avantages de leur participation au processus.

De plus, de 2022 à 2026, la SGDN:

- Continuera de lier contact avec les municipalités, les collectivités des Premières Nations et métisses des régions hôtes potentielles et les collectivités voisines pour les sensibiliser au projet et pour bâtir et entretenir des relations avec elles – en tenant compte de leurs lois, de leurs pratiques et de leur utilisation des terres;
- Réalisera des études socioéconomiques pour évaluer plus avant les répercussions et les retombées potentielles du projet;
- Travaillera avec les collectivités hôtes potentielles en vue de les sensibiliser au projet et d'identifier les partenaires requis pour créer des partenariats solidaires et résilients;
- Fera en sorte que les collectivités participant au processus de sélection d'un site aient les ressources et les renseignements nécessaires pour participer pleinement aux activités de sélection d'un site, réfléchir à leur intérêt et prendre une décision éclairée;
- Élaborera des accords mutuellement acceptables pour l'établissement du dépôt géologique en profondeur dans chaque région hôte potentielle et, une fois le site choisi, entreprendra la mise en oeuvre des accords dans la région hôte, qui passera au stade du processus de décision réglementaire;
- Veillera, par le biais de partenariats, à ce que les collectivités disposent de ressources suffisantes pour participer activement au processus réglementaire.



TRANSPORT

La SGDN :

- Démontrera la possibilité qu'un plan de transport puisse jouir d'une acceptation sociale au terme d'un dialogue sur le cadre de planification du transport;
- Continuera d'affiner le système de transport du combustible irradié;
- Commencera à mettre en oeuvre le cadre de planification du transport, qui sera révisé tous les trois ans.

La SGDN élabore actuellement des plans sûrs, sécuritaires et socialement acceptables qui encadreront le transport du combustible nucléaire irradié depuis les sites actuels d'entreposage provisoire jusqu'au dépôt géologique en profondeur.

Sur le plan technique, le combustible nucléaire irradié peut être transporté de manière sûre et sécuritaire au moyen de colis de transport robustes. Selon les exigences du processus de sélection d'un site, une route acceptable de transport doit être susceptible de pouvoir être aménagée. La SGDN continue de mener des évaluations techniques pour aider à définir les routes de transport potentielles.

La planification et l'évaluation des dispositions de transport tiendront pleinement compte des exigences réglementaires encadrant le transport sûr du combustible nucléaire irradié entre plusieurs provinces. Les activités de planification de la concertation technique et sociale concernant le site hôte se poursuivront après la sélection du site en 2023. Nous prévoyons commencer à transporter le combustible irradié vers le site du dépôt géologique en profondeur au cours des années 2040, lorsque le dépôt sera en service.

En plus des exigences techniques, les considérations sociales sont importantes pour notre processus de planification. Nous sommes conscients que le transport du combustible nucléaire irradié est un sujet important pour les Canadiens et les peuples autochtones, et nous suivons une approche collaborative, où les décisions sont prises en commun.

Cette approche axée sur la collaboration a donné lieu à un projet de cadre de planification du transport qui servira de base à l'élaboration d'un plan de transport socialement acceptable. Les consultations sur ce cadre et les mises à jour qui seront apportées à la description du concept de système de transport du combustible irradié permettront de nous assurer qu'un plan de transport socialement acceptable pourra être élaboré et soutiendront la sélection d'un site en 2023.

Conformément au cadre de planification du transport, la SGDN continuera de le mettre en oeuvre tout en sollicitant les commentaires du public pour nous assurer que notre planification continue de refléter les attentes des Canadiens et des peuples autochtones. La SGDN reconnaît que la planification du transport intéresse un large éventail de personnes et de groupes et nous nous employons à comprendre leurs intérêts afin que nous puissions continuer de répondre à leurs questions et à leurs préoccupations.

Il est important que les peuples autochtones participent à la planification du transport. Abordant tout notre travail sous l'angle de la réconciliation, nous reconnaissons que les injustices perpétrées dans le passé et encore aujourd'hui dans notre pays nous imposent de travailler à bâtir des relations positives et respectueuses fondées sur la confiance, les droits et l'équité.

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De plus, de 2022 à 2026, la SGDN :

- Poursuivra la planification du transport en tenant compte des valeurs, des principes et des objectifs des citoyens;
- Entreprendra des études sur la logistique du transport ainsi que des évaluations des risques posés par le transport;
- Cherchera à obtenir auprès de la Commission canadienne de sûreté nucléaire des certificats d'approbation de la conception des colis de transport routier et ferroviaire, selon le cas;
- Établira à des fins de planification les principales exigences relatives à la gestion des urgences et à la sécurité du transport;
- Continuera d'élargir nos activités de dialogue pour inclure les municipalités et les collectivités autochtones situées le long des routes potentielles de transport, ainsi que les personnes et les groupes intéressés;
- Tiendra au courant de nos progrès les collectivités hôtes d'installations nucléaires au Canada, y compris en ce qui a trait à la planification du transport du combustible nucléaire irradié depuis ces collectivités jusqu'au dépôt géologique en profondeur.

Élaboration d'une Stratégie intégrée canadienne pour les déchets radioactifs

En 2020, le ministre des Ressources naturelles a demandé à la SGDN de diriger l'élaboration d'une Stratégie intégrée pour les déchets radioactifs afin qu'une solution de gestion à long terme soit trouvée pour tous les déchets radioactifs canadiens (plandechetsradioactifs.ca).

Nous avons été sollicités pour diriger l'élaboration de la stratégie en partie en raison de nos quelque 20 années d'expertise dans la concertation avec les Canadiens et les peuples autochtones sur les plans de gestion à long terme sûre du combustible nucléaire irradié. Ces travaux sont axés sur les déchets de faible et moyenne activité pour lesquels aucun plan à long terme n'a été mis en place.

La SGDN suit un processus de concertation ouvert et transparent pour faire en sorte que la stratégie reflète les valeurs et les intérêts du public. En 2021, nous avons fait de grands pas. Nous avons écouté des collectivités de tout le Canada, des peuples autochtones et des experts techniques afin de pouvoir fournir des recommandations pratiques au gouvernement du Canada sur une stratégie plus exhaustive de gestion des déchets radioactifs.

Nous avons accueilli notre premier Sommet canadien sur les déchets radioactifs, organisé 12 événements de concertation avec des collectivités et dirigé une série d'ateliers techniques et de tables rondes avec les parties intéressées. Nous avons aussi échangé avec les peuples autochtones au moyen d'activités qui leur étaient consacrées. Les points de vue que nous avons entendus sont d'une grande utilité pour formuler des recommandations éclairées et pratiques à l'intention du gouvernement canadien sur une Stratégie intégrée pour les déchets radioactifs.

Comme le processus de concertation de la Stratégie intégrée pour les déchets radioactifs entre maintenant dans la phase de la déclaration des résultats, ces événements et séances seront résumés dans une série de rapports « Ce que nous avons entendu », qui seront publiés au cours du premier semestre de 2022. Ces rapports seront accessibles au public et contribueront à l'élaboration de la stratégie.

Nous avons également produit un rapport sur les options techniques possibles, un résumé accessible de ce rapport ainsi que divers outils d'apprentissage pour faire en sorte que les informations sur les options de gestion à long terme des déchets radioactifs du Canada soient disponibles pour ceux et celles qui souhaitent en savoir plus sur le sujet et faire part de leurs points de vue.

Nous avons sollicité l'avis des Canadiens et des peuples autochtones pour élaborer une stratégie pour les déchets radioactifs de faible et moyenne activité. Nous avons dû pour cela trouver de nouvelles façons de collaborer avec les personnes et les organisations intéressées tout en respectant les directives de la santé publique liées à la pandémie de COVID-19. Les personnes intéressées auront l'occasion de donner leur avis sur les recommandations à l'adresse plandechetsradioactifs.ca avant que ces recommandations soient présentées au gouvernement.

Tous les déchets radioactifs canadiens sont actuellement gérés de manière sûre dans des installations provisoires. Une stratégie intégrée garantira que ces matières continueront à long terme d'être gérées conformément aux meilleures pratiques internationales. S'appuyant sur plusieurs travaux réalisés antérieurement, cette stratégie représente une prochaine étape dans la détermination et la correction des lacunes qui existent dans la planification de la gestion des déchets radioactifs et jette un regard plus loin dans le futur.

Les recommandations de la SGDN ne seront pas finalisées tant que le gouvernement du Canada n'aura pas terminé la modernisation de sa politique en matière de déchets radioactifs. La Stratégie intégrée pour les déchets radioactifs s'appuiera sur cet examen de la politique et sera finalisée dès qu'une orientation sera connue.

Assurer la gouvernance et la reddition de comptes

La SGDN maintient une structure de gouvernance responsable afin que le public canadien puisse avoir confiance dans la conduite de nos affaires. La gouvernance de la SGDN comprend les organisations membres, le Conseil d'administration et le Conseil consultatif. La SGDN doit se conformer aux exigences de la *Loi sur les déchets de combustible nucléaire* (*LDCN*) et est assujettie à la surveillance du ministre des Ressources naturelles.

Membres

Ontario Power Generation, la Société d'énergie du Nouveau-Brunswick et Hydro-Québec sont les membres fondateurs de la SGDN. La convention d'affiliation et les règlements généraux définissent les rôles et les responsabilités des membres au regard des objectifs de la *LDCN* et du mandat de mise en oeuvre de la SGDN. La SGDN fait rapport régulièrement à nos sociétés membres.

Conseil d'administration

Le Conseil d'administration est chargé de la surveillance et d'exercer un leadership en ce qui a trait à l'élaboration des orientations stratégiques de la Société. Les membres du Conseil d'administration sont nommés par les sociétés membres. Le Conseil d'administration est actuellement formé de neuf personnes représentant un large éventail de compétences reliées à l'industrie nucléaire et à d'autres domaines, y compris à la culture autochtone et à la gestion financière.

Conseil consultatif

En vertu de la *LDCN*, le Conseil d'administration doit s'adjoindre un Conseil consultatif chargé d'examiner et de commenter les travaux de la SGDN. Le Conseil consultatif se réunit régulièrement avec la haute direction de la SGDN, examinant de près les plans et les activités de la Société et fournissant en continu des conseils et des avis.

L'expertise des membres du Conseil consultatif couvre une vaste gamme de domaines, dont le génie, la concertation avec les collectivités, les affaires publiques, l'environnement, le droit, le développement durable, les relations avec les Autochtones, le savoir autochtone et la recherche axée sur les collectivités. Les membres du Conseil consultatif possèdent de bonnes connaissances dans un éventail de sujets, dont les questions liées à la gestion des déchets nucléaires, et sont expérimentés dans le travail avec les citoyens et les collectivités sur des questions de politiques publiques très variées.

Conseil des aînés et des jeunes

Le Conseil des aînés et des jeunes est un organe consultatif indépendant composé d'aînés et de jeunes des Premières Nations et des peuples métis. Il se réunit régulièrement au cours de l'année pour conseiller la SGDN sur la façon d'appliquer le savoir autochtone à la mise en oeuvre du projet de la Gestion adaptative progressive. De plus, le Conseil offre des recommandations à la SGDN sur les mesures qui pourraient contribuer au développement et au maintien de bonnes relations avec les collectivités et organisations des Premières Nations et métisses.

Système intégré de gestion

La SGDN utilise un système intégré de gestion des activités qui soutiennent la gestion à long terme des déchets nucléaires. La SGDN veille à ce que notre système de gestion soit conforme aux normes canadiennes et internationales en matière de qualité, d'environnement, de santé et de sécurité.

Le système de gestion de la SGDN est également conforme à la norme CSA N286-12, *Exigences relatives aux systèmes de gestion des installations nucléaires*, qui couvre les installations de déchets nucléaires et s'appuie sur les normes internationales.

Le système intégré de gestion de la SGDN a pour but de garantir que l'organisation s'appuie sur des bases solides pour mener à bien notre mission et mettre en pratique nos valeurs. L'accent mis sur la protection des personnes et de l'environnement pour les générations à venir est entièrement conforme au principe de gestion de la norme CSA N286-12, selon lequel la sûreté doit constituer le fondement premier de nos décisions et de nos actions.

Examens indépendants

Conformément aux recommandations du Conseil consultatif, la SGDN continuera de solliciter l'avis et les commentaires d'experts externes sur notre programme technique. Comme le programme continue d'évoluer d'une phase de recherche vers une phase de conception, de fabrication et de démonstration, les examens portent de plus en plus sur des aspects et des éléments précis de la conception. Ces examens permettent de nous assurer du bien-fondé scientifique de notre approche, contribuent à la conception et à la qualité de l'ensemble du programme et aident à accroître la confiance du public dans les plans de mise en oeuvre et le processus décisionnel de la SGDN.

Présentation de rapports

La SGDN se conforme à des normes très élevées pour ce qui est de la présentation de rapports qui démontrent la sûreté, l'intégrité, l'excellence, la collaboration, la responsabilité et la transparence que nous exerçons dans la mise en oeuvre du projet. Nous faisons régulièrement état de nos progrès, particulièrement en réponse aux commentaires des Canadiens et à l'évolution de l'environnement.

Nous sommes tenus, en vertu de la *LDCN*, de publier des rapports annuels et triennaux. Chacun de ces rapports doit être présenté en même temps au ministre des Ressources naturelles et au public. Le ministre dépose chaque rapport au Parlement et publie une déclaration à son égard.

Transparence

La SGDN est résolue à faire preuve d'ouverture et de transparence dans nos processus, nos communications et notre processus décisionnel afin que les Canadiens et les peuples autochtones comprennent clairement l'approche que nous mettons en oeuvre. Pour démontrer cet engagement, nous appliquons une *Politique sur la transparence* (2020). Transmettre l'information et encourager l'échange des points de vue sont essentiels à notre mandat et nous veillons à ce que nos pratiques soient conformes à l'esprit de la *Politique sur la réconciliation* (2019) de la SGDN et de tous les textes législatifs portant sur la liberté de l'information, l'accès à l'information et la protection de la vie privée.

Glossaire

Combustible nucléaire irradié : combustible retiré d'un réacteur à fission nucléaire commercial ou de recherche. Le combustible nucléaire irradié est classé déchet radioactif de haute activité.

Consentement : élément fondamental du processus de sélection d'un site. Depuis le tout début de nos activités, la SGDN a établi un certain nombre de principes relatifs au consentement. Ceux-ci comprennent : l'engagement à n'établir le projet que dans une région comprenant des hôtes informés et consentants, offrir le temps et les ressources nécessaires pour que les collectivités puissent prendre une décision sur le projet en toute connaissance de cause et faire la démonstration convaincante du consentement de la collectivité.

Au-delà de la démonstration fournie par les collectivités, la SGDN doit également s'assurer que les autres exigences et engagements énoncés dans le processus de sélection d'un site pourront être remplis avant que le projet ne soit mis en oeuvre dans la région en question.

Dépôt géologique en profondeur : installation pour le stockage à grande profondeur sous terre du combustible nucléaire irradié, où des barrières tant naturelles qu'ouvragées le confinent et l'isolent des personnes et de l'environnement pour des générations à venir. Sa conception peut permettre le retrait du combustible nucléaire irradié.

Gestion à long terme du combustible nucléaire irradié : le confinement et l'isolement des substances radioactives. La radioactivité diminue substantiellement avec le temps, principalement en raison de la désintégration des radionucléides à vie courte. La radioactivité du combustible nucléaire irradié diminue jusqu'à environ un pour cent de sa valeur initiale au bout d'un an, à environ 0,1 pour cent au bout de 10 ans et à environ 0,01 pour cent au bout de 100 ans. Après environ un million d'années, la radioactivité du combustible nucléaire irradié est sensiblement équivalente à celle de l'uranium naturel.

Grappe de combustible : utilisée dans les réacteurs nucléaires CANDU, elle est fabriquée en agglomérant de l'oxyde d'uranium pour en faire des pastilles. Les pastilles sont insérées dans des tubes en Zircaloy (un alliage du métal zirconium résistant à la corrosion), lesquels sont soudés les uns aux autres pour former une grappe de combustible. Chaque grappe contient environ 1000 pastilles d'oxyde d'uranium.

Installation facultative de stockage souterrain à faible profondeur : consisterait en la construction d'une installation de stockage au sein d'une caverne rocheuse à faible profondeur sur le site choisi pour le dépôt géologique en profondeur. Cette option n'est pas présentée dans le plan de mise en oeuvre parce que le combustible irradié restera dans les installations d'entreposage provisoire jusqu'à ce que le dépôt soit en service.

Petits réacteurs modulaires (PRM) : ces réacteurs constituent une solution de rechange aux réacteurs nucléaires de grande puissance. Les PRM peuvent être achetés et construits selon une approche modulaire. La SGDN sera responsable de la gestion à long terme du combustible nucléaire irradié créé par toute technologie nouvelle ou émergente qui pourrait être mise en oeuvre au Canada, comme les PRM.

Récupérabilité : la possibilité de retirer le combustible nucléaire irradié de l'endroit où il a été placé. La récupérabilité est un élément important de la Gestion adaptative progressive et a été incorporée au plan à la demande des Canadiens. Elle fait partie d'une approche de gestion des risques qui permettra la prise de mesures correctives si le dépôt ne fonctionne pas comme prévu ou si, un jour, de nouvelles technologies permettant d'améliorer considérablement la sûreté de la gestion à long terme du combustible nucléaire irradié étaient mises au point. Même si le combustible nucléaire irradié sera récupérable dans le cadre du projet, le processus de récupération posera un défi de plus en plus grand à mesure que les conteneurs de combustible nucléaire irradié seront scellés dans les salles de mise en place et que, plusieurs années plus tard, les tunnels et puits d'accès seront remblayés et scellés.

Sûreté : la protection des individus, de la société et de l'environnement contre les effets dommageables ou dangereux du combustible nucléaire irradié, maintenant et dans l'avenir.

Note sur la terminologie utilisée : dans ce document, nous employons les termes « Autochtones », « autochtones », « Premières Nations », « Métis » et « métis ». Notre intention est d'honorer et de respecter les peuples, les nations et les collectivités, ainsi que les conceptions ancestrales et contemporaines qu'ils peuvent avoir.

Ce qu'on nous a dit

En mars 2021, la SGDN a publié *Mise en oeuvre de la Gestion adaptative progressive 2021 à 2025* – notre plan quinquennal précédent – et a invité le public à l'examiner et à le commenter.

Nous avons également publié un sondage numérique pour accompagner le rapport, afin de solliciter les commentaires en ligne des Canadiens et des peuples autochtones. C'était la première fois que nous utilisions un sondage numérique pour ce rapport et nous avons reçu 761 réponses. Cette nouvelle approche est l'un des nombreux exemples de la façon dont la SGDN recourt aux technologies numériques pour offrir plus d'options de concertation au sujet du plan canadien. Nous recevons aussi des idées intéressantes pendant que nous continuons de rendre les documents comme celui-ci plus accessibles.

Nous avons reçu des commentaires d'organisations et de particuliers de tout le pays, de personnes qui vivent dans les régions hôtes potentielles et de personnes qui vivent à l'étranger.

Le sondage fournit un instantané de la pensée des répondants. Il nous donne un aperçu de la confiance qu'ils ont dans notre capacité à mettre en oeuvre le plan canadien et ses résultats ont également révélé certains domaines d'amélioration relevés par les répondants. Ce type de contribution publique éclaire et guide notre travail et les commentaires reçus nous ont aidés à réviser le présent plan.

Plusieurs thèmes ont été dégagés des réponses. Voici un résumé des propos que nous avons entendus.

Confiance dans le plan canadien

La majorité des répondants à notre sondage numérique ont dit avoir confiance dans la capacité de la SGDN à mettre en oeuvre le plan canadien de gestion à long terme sûre du combustible nucléaire irradié.

Le sondage demandait aux répondants s'ils avaient confiance dans la capacité de la SGDN à mettre en oeuvre le plan, ainsi que dans chacune de nos priorités de planification – l'ingénierie, l'évaluation des sites, la sûreté, la mobilisation, les partenariats, le transport et l'autorisation. Dans l'ensemble, et pour chaque priorité, 55 pour cent des répondants ont dit avoir « confiance » ou « une grande confiance » dans la capacité de la SGDN à mettre en oeuvre le plan et à protéger les gens et l'environnement pour les générations à venir.

Bien entendu, l'envers de cette majorité montre que plusieurs Canadiens et peuples autochtones ont des interrogations sur notre travail et sur le plan canadien. Le sondage a révélé des variations régionales dans les niveaux de confiance. Il indique que dans le sud-ouest de l'Ontario, 72 pour cent des répondants avaient confiance dans le plan canadien, alors que dans le nord-ouest, ce chiffre n'était de 50 pour cent.

Ce clivage régional a incité la SGDN à nous pencher sur la façon dont nous communiquons nos informations aux résidents de chaque région. Nous avons poursuivi notre travail dans le sud-ouest et, au cours de l'été 2021, nous avons déployé davantage d'efforts de communication et de possibilités de concertation pour renseigner les gens dans le nord-ouest. Nous avons notamment réaménagé notre bureau d'Ignace et augmenté le nombre de visites de notre Centre mobile *En savoir plus*, une exposition itinérante conçue pour parcourir le pays et faire connaître le plan canadien.

Transport

Le transport du combustible nucléaire irradié est un autre domaine au sujet duquel les répondants au sondage ont soulevé des questions et des considérations propres à leur région.

Les réponses au sondage provenant du nord-ouest et des collectivités où du combustible irradié est actuellement entreposé ont exprimé le souhait d'en savoir plus sur les plans visant à transporter de manière sûre le combustible nucléaire irradié. Les répondants nous ont dit qu'ils avaient encore des questions concernant la sûreté du transport du combustible irradié et les effets de l'augmentation de la circulation routière ou ferroviaire. Toutefois, 76 pour cent des répondants nous ont fait savoir qu'ils comprenaient qu'il s'agissait d'un domaine prioritaire pour la SGDN.

La SGDN a également travaillé avec les Canadiens et les peuples autochtones sur notre cadre de planification du transport, qui a été publié en 2021. Les résultats du sondage ont montré que nous pourrions faire plus d'efforts pour informer le public au Canada au sujet du bilan mondial en matière de transport sûr des matières radioactives. Cela permettrait de jeter une base solide pour l'élaboration d'un plan de transport socialement acceptable.

Sûreté à long terme

La majorité des commentaires sur nos priorités de planification en matière de sûreté et d'ingénierie étaient favorables, et les Canadiens et les peuples autochtones ont indiqué qu'ils voulaient en savoir plus sur la sûreté à très long terme.

Il existe un consensus scientifique international, fondé sur des décennies d'études scientifiques, selon lequel un dépôt géologique en profondeur constitue la meilleure solution pour la gestion à long terme sûre du combustible nucléaire irradié. La SGDN vérifie et évalue constamment notre conception et nos hypothèses, et notre travail vise à nous assurer que le dépôt pourra confiner de manière sûre et à très long terme le combustible nucléaire irradié – soit aussi longtemps qu'il le faudra pour que le combustible nucléaire irradié retrouve le niveau de radioactivité du minerai d'uranium à l'état naturel.

Tout au long de 2021, et au cours des années à venir, nous avons vérifié et nous continuerons de vérifier ces hypothèses. Au cours de la période de cinq ans visée par ce plan, nous constituerons un dossier de sûreté qui rassurera les Canadiens et les peuples autochtones sur les aspects qui les préoccupent. Nous nous engagerons également dans un processus de décision réglementaire rigoureux, en vertu duquel nous serons tenus de démontrer la sûreté de la conception du dépôt. Pour plus de détails, veuillez lire la section *Priorités de planification* du présent plan.

La protection des personnes et de l'environnement pour les générations à venir est à la base de tout ce que nous faisons et de toutes les décisions que nous prenons dans le cadre de la mise en oeuvre du plan canadien.

L'eau

De nombreux répondants au sondage ont souligné que la protection de l'eau était un domaine d'une importance capitale.

Nous partageons cette valeur à la SGDN. L'eau est une force vitale qui nous nourrit, circule entre nous et façonne la terre. La protection de l'eau, des gens et de l'environnement est une priorité que nous partageons avec les Canadiens et les peuples autochtones.

L'objectif du plan canadien – la raison pour laquelle nous investissons du temps, des efforts et de l'argent pour le mettre en oeuvre – est de protéger les gens et l'environnement, y compris l'eau.

En écoutant les gardiens du savoir autochtone, les aînés autochtones, les scientifiques, les responsables de la conservation, les professionnels de l'industrie, les jeunes et d'autres personnes, en travaillant avec eux, et en intégrant ce que nous apprenons dans nos travaux, nous évaluons continuellement l'impact potentiel du projet sur la qualité de l'eau, les réseaux d'approvisionnement en eau et les milieux environnants, ce qui nous permettra de continuer de protéger tous les types d'eau.

Nous étudiions déjà l'eau sur les sites potentiels de dépôt et à proximité. Dans le dépôt proposé, le combustible nucléaire irradié sera isolé à grande distance de l'eau à l'aide d'une série de barrières ouvragées et naturelles que nous appelons le système à barrières multiples. Ce système est conçu pour maintenir le combustible nucléaire irradié à l'intérieur du dépôt et l'eau à l'extérieur, afin que les deux n'entrent pas en contact l'un avec l'autre.

Plusieurs études, dont des études de forage, nous ont appris qu'à la profondeur du dépôt géologique en profondeur proposé, il y a très peu d'eau. La roche à cette profondeur est essentiellement déconnectée de l'eau à la surface depuis des millions, voire des milliards d'années. La roche agit également comme une barrière naturelle et fait partie du système à barrières multiples qui confinera le combustible nucléaire irradié dans le dépôt et l'isolera de la quantité très limitée d'eau présente dans la roche et dans le milieu environnant.

Les réponses que nous avons reçues ont souligné l'importance de ce travail, et nous travaillons continuellement pour faire en sorte de protéger l'eau. Nous avons également fourni davantage d'informations sur notre site Web, dont une page consacrée à la protection de l'eau (www.nwmo.ca/water), et répondu aux questions des membres de la collectivité dans la section *Vous nous avez demandé* en ligne (www.nwmo.ca/waterFAQ).

Réconciliation

La SGDN s'est fermement engagée à promouvoir la réconciliation. Le savoir autochtone est intégré à tout ce que nous faisons. Il s'agit là d'engagements majeurs et de valeurs importantes pour notre organisation. Les répondants nous ont dit en majorité qu'ils partageaient ces priorités et qu'ils voulaient que nous continuions à en faire plus pour démontrer les résultats de notre travail dans ces domaines.

Au cours de la dernière année, nous avons réalisé une vérification de la mise en oeuvre de notre *Politique sur la réconciliation* (2019). Cet examen nous a permis de cerner les domaines où nous réussissons bien et ceux que nous pourrions améliorer. Il s'agit d'un outil important qui permet de nous assurer que nous ne nous contentons pas d'affirmer que nous nous sommes engagés envers la réconciliation. Il nous oblige à rendre compte des mesures que nous prenons pour respecter ces engagements.

Nous avons également intensifié nos efforts de communication concernant la manière dont nous intégrons le savoir autochtone. Vous constaterez que le savoir autochtone est clairement intégré au contenu de ce rapport, et surtout de notre Rapport annuel, qui a été publié en même temps que ce document. C'est une façon de nous assurer que les gens comprennent que le savoir autochtone est aussi essentiel à notre travail que la compréhension de la composition de la roche ou du cuivre.

Enfin, nous avons reçu une minorité de commentaires qui n'étaient aucunement en accord avec nos valeurs. La SGDN ne tolère pas les propos haineux et nous avons fait en sorte que nos plateformes de concertation – en personne et en ligne – soient des espaces sûrs. Lorsque cela s'est avéré nécessaire, la SGDN a supprimé les commentaires offensants, communiqué aux utilisateurs nos lignes directrices relatives aux communautés en ligne et dénoncé publiquement des remarques faites sur la page Facebook de la SGDN. Nous soutenons les collectivités qui souhaitent en savoir plus sur la façon dont elles peuvent contribuer à la réconciliation et nous faisons régulièrement des dons à des organisations qui appuient cette cause.

C'est ce que nous devons faire. C'est également pragmatique : les peuples autochtones ont le droit constitutionnel de donner leur avis sur les grands projets d'infrastructure, y compris sur un dépôt géologique en profondeur.

Consentement et partenariat

Nous avons entendu des gens qui pensaient que nous ne traitions peut-être pas les deux régions hôtes potentielles sur un pied d'égalité.

Un des principes qui sous-tendent le présent plan est que nous devons travailler avec tous ceux et celles qui sont intéressés. En collaboration avec les collectivités des deux régions hôtes potentielles restantes, nous sommes résolus à définir ce à quoi le partenariat devrait ressembler et à élaborer des critères pour déterminer si une collectivité consent au projet, comme nous l'avons décrit à la section *Sélection d'un site* de ce plan.

À plusieurs égards, une différente approche doit être adoptée pour chacune des deux régions. Chaque collectivité a ses propres besoins, priorités et aspirations. En raison des éléments géologiques qui les distinguent, les travaux d'évaluation technique différeront.

Un certain nombre de répondants nous ont dit qu'ils souhaitaient que la SGDN précise clairement comment elle définit le concept du « consentement ».

Cependant, nous pensons que ce n'est pas à nous de déterminer ce que signifie le consentement pour une collectivité. Il revient plutôt aux collectivités de nous dire ce que cela suppose pour elles et comment nous pourrons ensuite l'évaluer. C'est pourquoi nous aidons nos régions hôtes potentielles à élaborer leur propre définition du consentement et à réfléchir à ce à quoi pourrait ressembler un partenariat.

En 2021, le canton d'Ignace et la municipalité de South Bruce sont arrivés séparément au terme de leur processus visant à déterminer comment ils exprimeront leur consentement à accueillir un dépôt géologique en profondeur de combustible nucléaire irradié. Il s'agit d'une étape importante dans le processus de sélection d'un site.

À Ignace, le consentement sera déterminé par une résolution du conseil municipal éclairée par les commentaires du public. À South Bruce, le conseil municipal a approuvé un processus de détermination du consentement de la collectivité selon lequel une élection partielle se tiendra après la négociation d'un projet d'accord d'hébergement.

Nous avons toujours dit que le plan canadien n'avancera que dans une région comptant des hôtes informés et consentants et où la municipalité, les collectivités des Premières Nations et métisses et les autres de la région travaillent ensemble à sa mise en oeuvre. Un dialogue ouvert et transparent avec le public ainsi que l'écoute des différents points de vue ont toujours été des éléments fondamentaux de l'approche de la SGDN et continueront de faire partie intégrante de chaque étape future du projet.

Questions des collectivités environnantes des sites potentiels

Les réponses au sondage nous ont révélé que les personnes qui vivent à proximité des régions hôtes potentielles – mais pas directement dans celles-ci – veulent en savoir plus sur le plan canadien. Elles nous ont posé des questions sur les effets du transport, la protection de l'eau, l'impact de l'augmentation du niveau d'emploi dans la région et la sûreté à long terme du dépôt.

C'est pourquoi la SGDN s'est engagée à être présente dans les collectivités situées autour des régions hôtes potentielles, afin de s'assurer que les gens disposent des informations dont ils ont besoin sur le plan canadien. En 2021, notre Centre mobile *En savoir plus* a visité 32 collectivités et nous avons rencontré des représentants de 49 conseils municipaux. Notre personnel chargé de la concertation a également participé à plus de 50 activités dans les collectivités, offrant aux résidents locaux de nombreuses occasions de se renseigner et d'interagir avec la SGDN.

Dans le sud de l'Ontario, nous continuons d'entendre des questions sur les incidences que le projet pourrait avoir sur la valeur des propriétés. La SGDN s'est engagée à élaborer, en consultation avec la municipalité de South Bruce, un programme qui permettra aux résidents situés près du dépôt géologique en profondeur d'avoir l'assurance que la valeur de leur propriété sera protégée si la région de la NOS-South Bruce est choisie comme site d'accueil du projet.

La SGDN veille à ce que les Canadiens et les peuples autochtones disposent des informations dont ils ont besoin pour comprendre le plan canadien. Le présent rapport est l'un des documents produits à cette fin. Nous vous encourageons à répondre au sondage de cette année et à nous faire part de votre opinion sur nos priorités et les prochaines étapes qui mèneront à la construction d'un dépôt géologique en profondeur pour la gestion à long terme sûre du combustible nucléaire irradié.

Faites-nous part de vos réflexions

Vos commentaires sont essentiels à la mise en oeuvre du plan canadien de gestion à long terme sûre du combustible nucléaire irradié.

Chaque année, nous demandons aux Canadiens et aux peuples autochtones de contribuer par des commentaires au plan de mise en oeuvre qui éclairera et orientera nos travaux. Nous tenons ensuite compte de ces commentaires lors de notre planification et nous décrivons chaque année dans le plan de mise en oeuvre ce que le public nous a dit l'année précédente.

Notre formulaire de commentaires sur le plan de mise en oeuvre est disponible en ligne. Nous vous invitons à suivre le lien www.nwmo.ca/implementationplan et à nous faire part de vos réflexions **d'ici le 10 juin 2022**.

Vous pouvez également nous envoyer un courriel à l'adresse learnmore@nwmo.ca ou nous envoyer une lettre par la poste. Dans toute réponse écrite, veuillez indiquer votre nom, votre adresse postale et vos coordonnées.

Veuillez adresser votre réponse à :

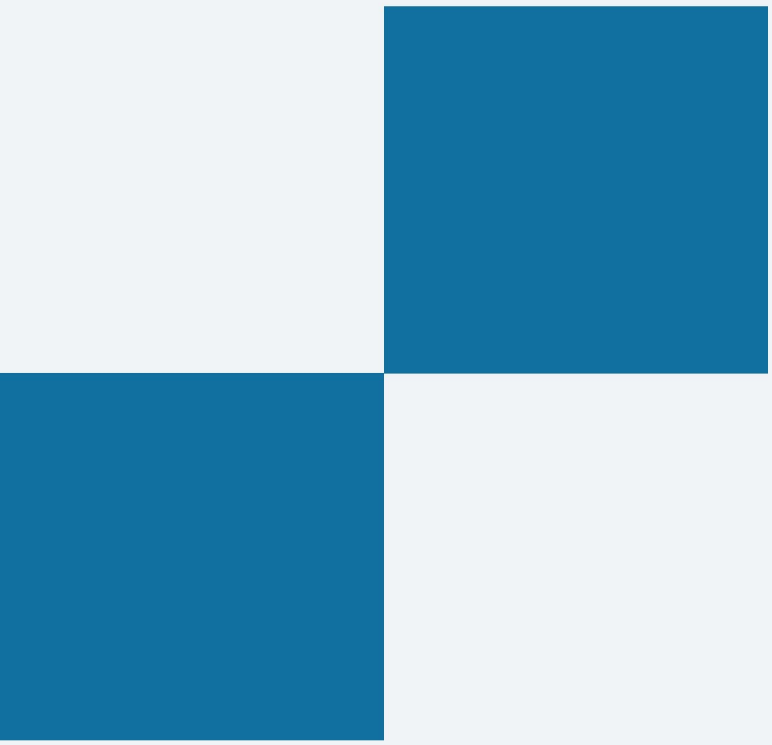
Lisa Frizzell
Vice-présidente des communications, SGDN
Re. : Plan de mise en oeuvre 2022 à 2026
22, avenue St. Clair Est, 4e étage
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Pour plus de renseignements, veuillez contacter:

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NUCLEAR WASTE MANAGEMENT ORGANIZATION

SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Mise en oeuvre de la Gestion adaptative progressive 2023-27

Mars 2023

Consultez la version numérique de ce plan de mise en oeuvre, qui propose un contenu plus interactif et multimédia.

nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Déclaration de reconnaissance du territoire

La Société de gestion des déchets nucléaires (SGDN) reconnaît que, depuis notre création, nous avons travaillé au sein de plusieurs territoires autochtones. Nous sommes reconnaissants envers les collectivités autochtones et municipales qui ont travaillé avec nous au cours des 20 dernières années.

Nous reconnaissons également qu'actuellement, nous travaillons dans le nord-ouest de l'Ontario, au sein du territoire traditionnel de la Nation ojibwée de Wabigoon Lake, avec la collectivité de la Nation ojibwée de Wabigoon Lake et le canton d'Ignace.

Dans le sud de l'Ontario, nous travaillons au sein du territoire traditionnel de la Nation ojibwée de Saugeen (NOS), avec ses deux collectivités – les Chippewas de la Première Nation non cédée de Nawash et les Chippewas de la Première Nation de Saugeen – ainsi qu'avec la municipalité de South Bruce.

Nous reconnaissons en outre que, tant dans le nord-ouest que dans le sud, nous avons le privilège de travailler avec d'autres Premières Nations et organisations autochtones, avec des collectivités métisses et la Nation métisse de l'Ontario, de même qu'avec plusieurs collectivités municipales qui ont toutes manifesté leur intérêt à en apprendre davantage sur notre travail.

Dans le cadre de notre engagement envers la réconciliation, nous reconnaissons les injustices historiques et actuelles subies par beaucoup trop de collectivités autochtones. Nous nous engageons à faire tout ce que nous pouvons pour favoriser le bien-être des collectivités avec lesquelles nous travaillons.

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Bienvenue

Voici le document *Mise en oeuvre de la Gestion adaptative progressive 2023-27*.

Il s’agit du plan stratégique quinquennal de la SGDN pour orienter notre mise en oeuvre du plan canadien de gestion à long terme sûre du combustible nucléaire irradié.

Vision, mission et valeurs

Vision

Notre vision est d'assurer la gestion à long terme des déchets nucléaires du Canada d'une façon qui protège les gens et respecte l'environnement, maintenant et pour l'avenir.

Mission

L'objectif de la SGDN est d'élaborer et de mettre en oeuvre, de concert avec le public canadien, une méthode de gestion à long terme du combustible nucléaire irradié canadien, qui soit socialement acceptable, techniquement sûre, écologiquement responsable et économiquement viable.

Valeurs



Engagement envers la transparence

L'engagement de faire preuve de transparence fait partie intégrante de notre culture à la SGDN. Il s'inscrit dans tout ce que nous faisons.

Ce plan de mise en oeuvre annuel est l'un des moyens que nous prenons pour respecter cet engagement. Ce plan est un document vivant qui évolue et se développe au fil du temps. Chaque année, nous révisons notre plan en tenant compte de la progression de nos travaux, de ce que nous ont dit les collectivités et le public, des avancées scientifiques et technologiques, de l'éclairage fourni par le savoir autochtone, de l'évolution des valeurs sociétales et des changements apportés aux politiques publiques.

Nous sommes résilients et vigilants. Nous anticipons les hauts et les bas qui peuvent accompagner la mise en oeuvre du plan canadien de gestion à long terme sûre du combustible nucléaire irradié, dont l'objectif est de protéger les gens et l'environnement. Le plan canadien a été conçu pour s'adapter aux éventualités. Et en 2022, c'est ce que nous avons fait.

Cette année encore, nous nous sommes inspirés de nos employés et des collectivités avec lesquelles nous travaillons. Notre travail collaboratif s'est effectué virtuellement et en personne. Nous avons mené de nombreuses activités en ligne, depuis les ateliers environnementaux et les séances de concertation sur le transport organisés dans les régions hôtes potentielles, jusqu'aux réunions d'échange de connaissances tenues avec nos homologues étrangers. Les leçons que nous avons tirées nous aideront à orienter notre plan de mise en oeuvre si nous devons un jour être confrontés à des défis semblables.

En 2022, les mesures de confinement provinciales associées à la pandémie de COVID-19 ont continué d'avoir des répercussions sur nos contacts en personne avec les collectivités avec lesquelles nous collaborons. Mais nous savions dès le départ qu'il nous faudrait être prêts à nous adapter aux circonstances, même si nous avons constamment le long terme à l'oeil. Lorsque nous avons comparé l'avancement de notre programme aux objectifs fixés dans la version de l'année dernière du plan annuel de mise en oeuvre, il nous est apparu clairement que nous devions ajuster le moment prévu de la sélection d'un site optimal pour le dépôt géologique en profondeur. Comme nous l'avons annoncé en août 2022, nous prévoyons maintenant que nous serons en mesure de choisir le site optimal d'ici l'automne 2024. Ce nouvel échéancier ne devrait pas avoir d'incidence sur le calendrier à long terme fixé pour la construction ou pour le début de l'exploitation au début des années 2040.

Les efforts déployés dans les collectivités des régions hôtes potentielles pour garantir que le plan canadien respecte le caractère unique du futur site du dépôt se poursuivent. Comme nous l'avons toujours affirmé, le projet ne sera mis en oeuvre que dans une région où les hôtes sont informés et consentants, où la municipalité, les collectivités des Premières Nations et métisses et les autres de la région travaillent ensemble à sa mise en oeuvre.

En 2022, nous avons publié, de concert avec les collectivités des régions hôtes potentielles, les constats d'une série d'études sur les collectivités. Ces constats portent sur un large éventail de sujets, dont la croissance de l'emploi et de la main-d'oeuvre, les possibilités d'affaires pour les entreprises, l'amélioration des infrastructures ainsi que la construction d'un Centre d'expertise, lequel attirera des universitaires de calibre international de partout dans le monde.

Nous avons également publié des rapports *Confiance dans la sûreté* pour chaque site potentiel, dont les constats s'appuient sur plusieurs années de recherche et de travail sur le terrain. Ces rapports résument les raisons pour lesquelles nous sommes convaincus qu'un dépôt géologique en profondeur pourra être construit et exploité en toute sûreté dans l'une ou l'autre des régions hôtes potentielles.

La SGDN a réalisé avec succès une démonstration à pleine échelle du système de barrières ouvragées qui servira à confiner et à isoler de manière sûre le combustible nucléaire irradié canadien dans le dépôt géologique en profondeur. Nous avons également publié une version révisée de notre cadre de planification du transport et notre *Plan de transport préliminaire*, qui ont pour but de faire avancer les discussions et de fournir plus d'informations sur la façon dont nous planifions de transporter en toute sûreté le combustible nucléaire irradié.

Nos progrès sont palpables à la SGDN et se poursuivront sans aucun doute au cours de la prochaine phase de mise en oeuvre du plan canadien.

Votre point de vue est essentiel à la mise en oeuvre du plan canadien. Chaque année, nous demandons aux Canadiens et aux peuples autochtones de fournir des commentaires sur le plan de mise en oeuvre afin de contribuer à éclairer et à orienter nos travaux. Nous vous invitons à nous transmettre vos réflexions d'ici le 9 juin 2023.

Autres moyens de donner votre avis (vous pouvez toujours indiquer que vous souhaitez que votre réponse reste anonyme) :

- Envoyez-nous un courriel à l'adresse learnmore@nwmo.ca
- Envoyez-nous une lettre (comportant votre nom et votre adresse postale) à :

  Lisa Frizzell
  Vice-présidente des communications, SGDN
  Sujet : Plan de mise en oeuvre 2023-27
  22, avenue St. Clair Est, 4e étage
  Toronto (ON) M4T 2S3
  Canada

Répondez au sondage sur le plan de mise en oeuvre

Présentation de la SGDN

Depuis près de 60 ans, le Canada utilise l'énergie nucléaire comme source d'énergie fiable et à faibles émissions de carbone pour alimenter nos foyers et nos entreprises. Aujourd'hui, alors que la demande mondiale d'énergie augmente et que la nécessité de lutter contre les changements climatiques devient chaque jour plus urgente, l'énergie nucléaire occupe une place de plus en plus grande dans la conversation publique. La Société de gestion des déchets nucléaires (SGDN) joue un rôle capital en fermant le cycle du combustible.

Nous avons été chargés de mettre en oeuvre le plan canadien de gestion à long terme sûre du combustible nucléaire irradié dans un dépôt géologique en profondeur, d'une manière à protéger les gens et l'environnement pour les générations à venir.

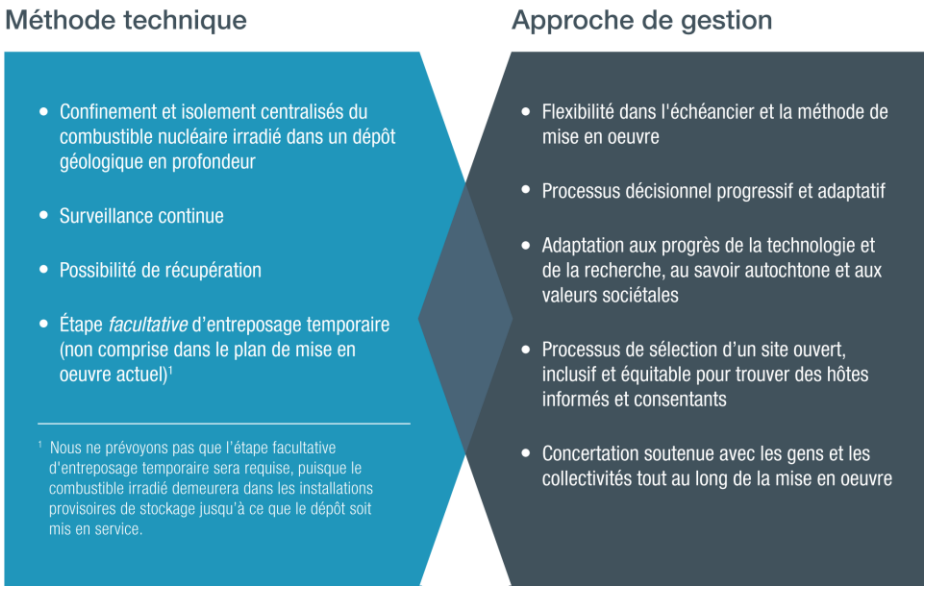
En 2002, le gouvernement du Canada a ordonné, en vertu de la *Loi sur les déchets de combustible nucléaire*, la création de la SGDN. La SGDN est une organisation sans but lucratif indépendante. Conformément au principe du « pollueur-payeur », nous sommes financés par les propriétaires de déchets au Canada : Ontario Power Generation, Énergie Nouveau-Brunswick, Hydro-Québec et Énergie atomique du Canada limitée.

À l'heure actuelle, le combustible nucléaire irradié au Canada est entreposé dans des installations de surface autorisées. Bien que cette approche soit sûre, elle n'est que provisoire et il est largement reconnu qu'elle ne constitue pas une approche à long terme adéquate. Les Canadiens et les peuples autochtones nous ont clairement dit qu'il était important que nous agissions dès maintenant pour trouver une approche à long terme afin de ne pas léguer le fardeau de la gestion du combustible nucléaire irradié aux générations futures.

Le plan canadien de gestion du combustible nucléaire irradié, qui suit une approche appelée Gestion adaptative progressive (GAP), est l'aboutissement d'un dialogue tenu pendant trois ans avec les Canadiens et les peuples autochtones, y compris des spécialistes et le public. Il est fondé sur les valeurs et les objectifs que ceux-ci avaient considérés comme importants. En 2007, le gouvernement du Canada a choisi la GAP comme plan national de gestion à long terme sûre du combustible nucléaire irradié canadien.

Un jalon important se profile maintenant à l'horizon, puisque nous prévoyons que nous serons en mesure de choisir le site du dépôt en 2024. Pour choisir le site, nous devrons nous appuyer sur tout le travail que nous avons accompli au cours des 20 dernières années. Devant un projet d'une telle complexité et d'une telle portée générationnelle, il est essentiel que nous restions concentrés sur nos prochains objectifs, sans toutefois perdre de vue nos objectifs à plus long terme.

Le plan canadien : la Gestion adaptative progressive (GAP)



La GAP est à la fois une méthode technique (ce que nous envisageons de construire) et une approche de gestion (comment nous travaillerons avec les gens pour y parvenir). La méthode technique consiste à construire un dépôt géologique en profondeur dans une formation rocheuse appropriée pour confiner et isoler en toute sûreté le combustible nucléaire irradié. L'approche de gestion a comme élément central un processus de décision progressif et adaptatif qui est soutenu par la concertation du public et l'apprentissage continu.

Un système de transport sûr et sécuritaire sera mis au point pour acheminer le combustible nucléaire irradié des installations où il est provisoirement entreposé jusqu'au site du dépôt.

Le projet prévoit également l'établissement d'un Centre d'expertise sur le site choisi, ou à proximité de celui-ci. Ce centre soutiendra initialement la mise à l'épreuve et l'évaluation pluriannuelles du site, principalement en ce qui a trait à la sûreté et au bien-être de la collectivité. Il deviendra par la suite un carrefour canadien et international d'échange de connaissances.

Calendrier de planification

Malgré les inconnues persistantes engendrées par la pandémie, nous avons fait de grands pas en 2022. La SGDN a progressé dans nos travaux et nous nous sommes adaptés. Comme pour toutes les organisations et entreprises, plusieurs mesures de confinement provinciales associées à la pandémie ont eu des répercussions sur notre travail. Les mesures de confinement ont fortement diminué les interactions en personne, qui sont si essentielles à notre processus de concertation, en particulier nos interactions avec les collectivités qui explorent actuellement la possibilité d'accueillir le projet. Lors de la révision de notre plan quinquennal de mise en oeuvre, nous avons pris la décision, compte tenu des incidences de la pandémie, d'ajuster le moment de la sélection d'un site. Bien que nous ayons décidé de reporter d'un an la date de la sélection d'un site, nous sommes toujours en bonne voie de pouvoir respecter le calendrier établi de construction et d'exploitation.

Élaboration du plan canadien	2002	La SGDN est créée.
	2005	Conformément à la *Loi sur les déchets de combustible nucléaire*, la SGDN réalise une étude de trois ans et produit le rapport *Choisir une voie pour l'avenir*, qui présente les options pour la gestion à long terme sûre du combustible nucléaire irradié canadien. Cette étude a été réalisée avec des personnes intéressées, les meilleurs scientifiques et autres experts, les peuples autochtones et le public canadien.
	2007	Le gouvernement du Canada choisit la Gestion adaptative progressive (GAP) et charge la SGDN d'entreprendre sa mise en oeuvre.
Élaboration du processus de sélection d'un site	2008-09	Des travaux sont menés avec des citoyens pour concevoir un processus de sélection d'un site centralisé optimal pour le dépôt géologique en profondeur et le Centre d'expertise.
Choix d'un site à l'aide du processus de sélection d'un site	2010	Le processus de sélection d'un site est lancé.
	2010-15	Vingt-deux collectivités manifestent initialement un intérêt pour le projet.
		En collaboration avec les collectivités intéressées, la SGDN procède à des évaluations de présélection, puis à des études préliminaires de bureau et à des activités de concertation avec les collectivités.
		Les régions moins susceptibles de pouvoir répondre aux exigences du projet ne sont plus considérées.
	2015-24	La SGDN élargit la portée de notre évaluation en amorçant des études sur le terrain. Les régions les moins prometteuses ne sont plus considérées au fur et à mesure de l'avancement du processus de retranchement.
	2022	Le gouvernement du Canada réaffirme qu'un dépôt géologique en profondeur est la meilleure solution pour le combustible nucléaire irradié canadien.
	2024	Un site unique optimal est choisi.
Vers la construction	2025	Des travaux supplémentaires de caractérisation du site sélectionné sont effectués.
		La SGDN entreprend le processus fédéral d'évaluation d'impact et le processus de décision réglementaire de la Commission canadienne de sûreté nucléaire (CCSN).
		Une version révisée du cadre de planification du transport est publiée (mis à jour tous les trois ans).
	2028	Les études d'évaluation d'impact sont transmises dans le cadre du processus de décision réglementaire.
		L'ouverture officielle du Centre d'expertise a lieu.
	2030	L'évaluation d'impact est approuvée (estimation).
		Le permis de préparation du site est accordé (estimation).
		La demande de permis de construire est présentée à la CCSN.
	2032	Le permis de construire est accordé (estimation).
	2033	La construction débute.
Début de l'exploitation	2040-45	L'exploitation du dépôt géologique en profondeur commence.
		Le transport du combustible nucléaire irradié vers le dépôt commence.
Surveillance prolongée	Après l'exploitation	Des décennies de surveillance sont lancées.

Sélection d’un site

La SGDN a entrepris un processus pluriannuel axé sur les collectivités qui vise à trouver un site sûr où établir un dépôt géologique en profondeur pour confiner et isoler le combustible nucléaire irradié canadien.



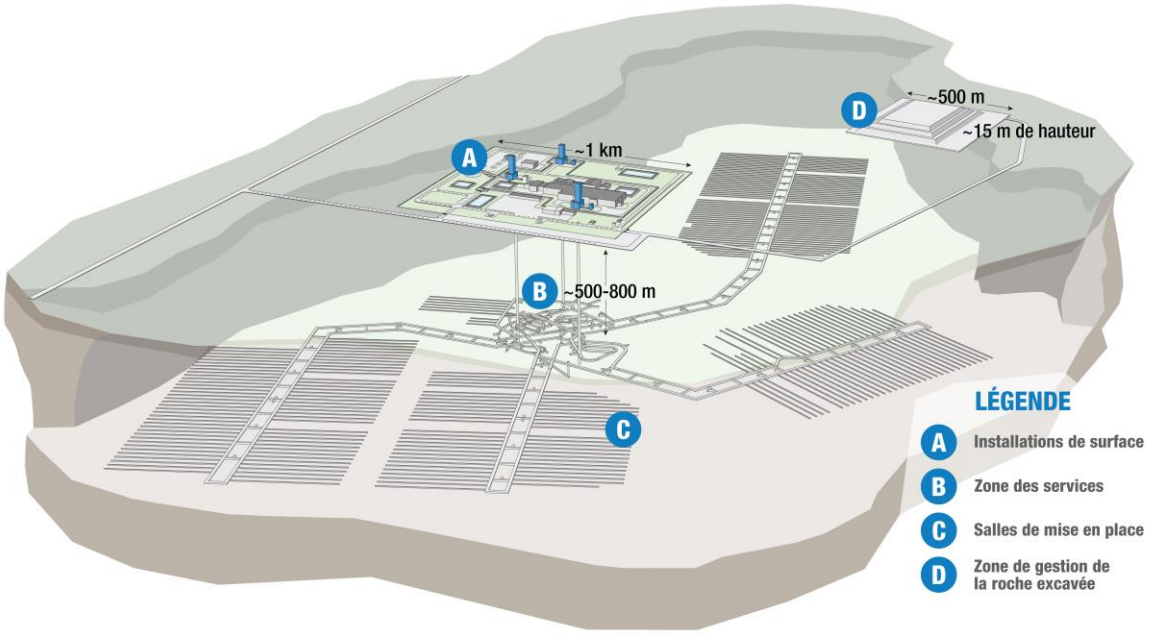
Nous avons lancé le processus de sélection d’un site en 2010. Au cours des deux années suivantes, 22 municipalités et collectivités autochtones ont exprimé l’intérêt à en apprendre davantage sur le projet et d’explorer leur aptitude à l’accueillir. Par le biais d’un programme exhaustif de concertation sociale et d’évaluations techniques visant à évaluer la sûreté de ces sites et du transport du combustible nucléaire irradié jusqu’à eux ainsi que la possibilité de créer des partenariats solidaires et résilients, nous avons progressivement réduit notre champ d’étude à deux sites potentiels.
Les deux se trouvent en Ontario : un dans la région de la Nation ojibwée de Wabigoon Lake (NOWL)-Ignace, dans le nord-ouest de l’Ontario, et l’autre dans la région de la Nation ojibwée de Saugeen (NOS)-South Bruce, dans le sud de l’Ontario.

En 2022, nous avons réalisé des évaluations techniques plus détaillées de ces deux sites potentiels et nous avons engagé avec les collectivités des discussions approfondies sur la possibilité de créer des partenariats et sur les investissements qui pourraient être faits pour améliorer le bien-être de la collectivité.

Au fur et à mesure que le processus de sélection d'un site avance, nous maintenons un principe fondamental que le projet ne sera mis en oeuvre que dans une région où les hôtes sont informés et consentants, où la municipalité, les collectivités des Premières Nations et métisses et les autres de la région travaillent ensemble à sa mise en oeuvre.

Apprenez-en davantage sur le processus de sélection d'un site.

Principaux éléments du dépôt



Cette illustration montre le plan conceptuel des installations de surface ainsi que de l'aire d'approximativement 1500 acres (600 hectares) qui englobera la zone des services et les salles de mise en place souterrains d'un dépôt géologique en profondeur construit sur le site proposé de roche cristalline.

Ce plan conceptuel continuera à évoluer au fur et à mesure de l'avancement du projet et s'adaptera aux changements technologiques ainsi qu'aux décisions qui seront prises dans le futur en matière de production d'énergie nucléaire, lesquelles pourraient venir modifier le volume ou le type de combustible à gérer.

Par exemple, un secteur actif de recherche au Canada explore actuellement de nouvelles technologies, telles que les petits réacteurs modulaires (PRM), le retraitement du combustible et d'autres types de réacteurs avancés. Ces nouvelles technologies nucléaires pourraient donner lieu à différents types de combustible irradié. Cependant, le consensus international veut que les dépôts géologiques en profondeur constituent également la meilleure pratique de gestion à long terme du combustible nucléaire irradié provenant des PRM et des déchets de haute activité issus des procédés de retraitement.

La taille envisagée du dépôt est suffisante pour accueillir l'inventaire actuel de combustible irradié de même que les inventaires découlant des projets prévus de prolongation de la durée de vie et de réfection des réacteurs actuellement en service. Les deux sites potentiels offrent également la possibilité d'agrandir le dépôt souterrain pour accueillir des quantités supplémentaires. Pour en savoir plus sur la manière dont la SGDN tiendra compte de la possibilité de devoir gérer le combustible irradié produit par les PRM, veuillez consulter la section *Prise en compte du contexte externe et adaptation aux changements*.

Le dépôt géologique en profondeur comprend un système à barrières multiples conçu pour confiner et isoler de manière sûre et à très long terme le combustible nucléaire irradié. Construit à plus de 500 mètres sous terre, le dépôt consistera en un réseau de salles de mise en place où sera stocké le combustible nucléaire irradié. Cette approche est conforme aux meilleures pratiques internationales.

À la surface, le dépôt comprendra des installations où le combustible irradié sera reçu, inspecté, puis remballé dans des conteneurs de conception spéciale enchâssés dans une boîte tampon en argile de bentonite, avant d'être envoyé au puits principal afin d'être mis en place sous terre. La conception des installations de surface du dépôt, notamment l'Usine d'emballage du combustible irradié, est en cours.

L'accès au dépôt souterrain se fera par trois puits, qui seront situés dans une zone unique des services centralisée et sécurisée. Cette zone des services comprendra également une installation de démonstration souterraine où seront effectués les premiers essais de l'équipement de mise en place des futures barrières ouvragées. L'aménagement comprend aussi de multiples tunnels d'accès qui permettront d'aménager les salles de mise en place aux endroits où la roche est la plus propice. Les boîtes tampons renfermant les conteneurs de combustible irradié seront disposées dans des salles de mise en place horizontales et tous les espaces vides seront remblayés avec de la bentonite granulaire sous forme de pastilles ou d'éclats.

En 2022, nous avons réalisé avec succès une démonstration à pleine échelle des barrières ouvragées qui permettront de confiner et d'isoler en toute sûreté le combustible nucléaire irradié canadien dans un dépôt géologique en profondeur. Cette importante réussite sur le plan de la sûreté et de l'ingénierie est l'aboutissement de plus de huit ans de préparation, au cours desquels l'équipe de spécialistes techniques et de partenaires d'ingénierie de la SGDN a notamment conçu et fabriqué les équipements et composants prototypes spécialisés nécessaires.

La SGDN a commencé à réaliser des dessins conceptuels de l'aménagement du dépôt sur la base des informations tirées des évaluations géoscientifiques et des premiers forages réalisés dans les régions hôtes potentielles. Nous procéderons aussi à l'évaluation du système de transport propre à chaque site et réaliserons la conception préliminaire du Système de transport du combustible irradié. Nous continuerons ensuite de préciser la conception du dépôt en tenant compte des informations que nous tirerons des études de caractérisation supplémentaires qui seront effectuées sur le site choisi, l'objectif étant de déposer vers 2030 une version révisée de la conception du dépôt en vue de l'obtention du permis de construire. Le site proposé dans la région de la NOWL-Ignace reposerait sur une formation de roche cristalline, alors que le site proposé dans la région de la NOS-South Bruce reposerait sur une formation de roche sédimentaire.

Apprenez-en davantage sur le projet.

Centre d’expertise

Un Centre d’expertise sera établi à l’emplacement du dépôt ou à proximité de celui-ci une fois que le site hôte aura été choisi. L’emplacement exact sera déterminé en collaboration avec les collectivités hôtes.

Ce centre deviendra un carrefour canadien et international d’échange de connaissances et un lieu où les résidents de la région pourront se renseigner sur le projet en visitant des galeries d’exposition publiques et des modules interactifs. Le centre pourra également servir de carrefour de transmission du savoir, de la culture, de l’histoire et des traditions des peuples autochtones.

La conception et l’utilisation du centre seront définies en collaboration avec les résidents de la région choisie, y compris avec les collectivités des Premières Nations et métisses. En 2022, la SGDN a commencé à travailler avec les collectivités locales dans le but de préciser le concept du centre en tenant compte de leurs exigences et de leurs aspirations. Ce processus de conception et les discussions autour des préférences des collectivités relatives à l’installation se poursuivront dans les deux régions hôtes potentielles au cours des prochaines années afin de soutenir un dialogue continu et les possibilités uniques que pourrait offrir le centre.

Pour les besoins de la SGDN, le centre sera initialement utilisé pour soutenir les travaux de caractérisation du site sur les plans de la sûreté technique, un programme continu d’éducation et de discussion ainsi que le bien-être de la collectivité. Il sera le siège de recherches techniques et sociales ainsi que de programmes de démonstration technologique, auxquels contribueront des scientifiques et d’autres experts de la SGDN et du monde entier appartenant à un large éventail de disciplines. Le Centre d’expertise comprendra une installation d’essais techniques où se poursuivra la mise au point des matériaux et de l’équipement qui seront utilisés dans le dépôt. Cette installation soutiendra aussi par la suite les activités de construction et d’exploitation du dépôt.

Une fois les exigences de la collectivité et de la SGDN précisées, le projet pourra débuter.



Cet exemple montre de quoi pourrait ressembler un Centre d'expertise dans la région de la Nation ojibwée de Wabigoon Lake-Ignace.



Cet exemple montre de quoi pourrait ressembler un Centre d'expertise dans la région de la Nation ojibwée de Saugeen-South Bruce.

Réconciliation et savoir autochtone

À la SGDN, nous sommes résolus à comprendre, à respecter et à aligner nos travaux sur le savoir autochtone. Cet engagement se traduit de nombreuses façons, notamment par la supervision assurée par notre équipe des relations avec les Autochtones, par les avis fournis par le Conseil des détenteurs du savoir autochtone de la SGDN, par la représentation autochtone au sein de notre organisation – y compris de notre équipe de direction et de notre Conseil d'administration – par les politiques concrètes qui guident nos travaux et par les échanges réguliers que nous avons avec les collectivités des Premières Nations et métisses. Partout où nous menons nos activités, cet engagement constitue un gage fondamental de réussite et de relations constructives.

Au cours des cinq prochaines années et par la suite, nous continuerons de mettre en oeuvre notre *Politique sur la réconciliation* (2019), de mesurer nos progrès et d'aligner nos travaux sur le savoir autochtone. Mesurés annuellement et déclarés publiquement, ces efforts témoignent de notre engagement de donner suite à l'appel à l'action 92 de la Commission de vérité et réconciliation, qui incite le secteur des entreprises à établir des relations respectueuses avec les peuples autochtones et à sensibiliser leur personnel à l'histoire des peuples autochtones.

En 2022, la SGDN a publié notre premier *Rapport sur la réconciliation* (2021), qui fournit une évaluation des résultats de la *Politique sur la réconciliation* de la SGDN depuis son officialisation en 2019. Les éléments évalués comprennent la formation obligatoire du personnel sur la réconciliation ou les occasions continues d'apprentissage, les occasions informelles de formation, les systèmes de soutien du personnel et les plans de travail axés sur les collectivités.

Réconciliation

La démarche de réconciliation est importante. Grâce à elle, nous pourrons tous et toutes au Canada tirer des leçons des injustices qui ont été commises dans le passé et qui continues d'être commises, y remédier et créer ensemble un avenir meilleur. La démarche de réconciliation de la SGDN est un engagement ferme. Nous veillons à ce que la réconciliation soit prise en compte dans tous nos travaux et à chaque étape de notre processus.

Notre *Politique sur la réconciliation* a été publiée en 2019 et s'inscrivait dans un ensemble de mesures visant à établir une base solide pour travailler avec les peuples autochtones. Conformément à notre politique, nous travaillons en étroite collaboration avec les collectivités et les organisations des Premières Nations, métisses et municipales à la mise en oeuvre du plan canadien.

À la SGDN, nous reconnaissons la véracité des injustices historiques et les défis que nous devons relever aujourd'hui, et cherchons continuellement des façons de créer ensemble un avenir meilleur. Notre politique exige que nous établissions avec les collectivités des Premières Nations et métisses des rapports basés sur le respect de leurs langues, de leurs coutumes, de leurs cultures et de leurs institutions.

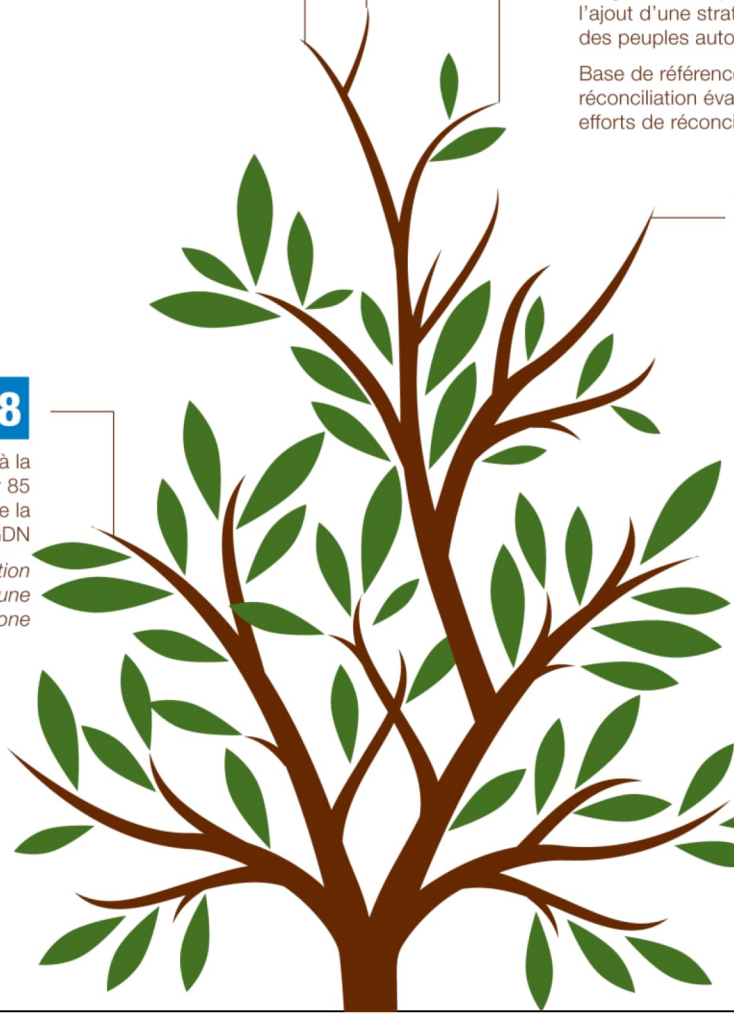
L'équipe des relations avec les autochtones de la SGDN travaille à la publication de notre rapport annuel sur la réconciliation en collaboration avec Reciprocal Consulting, un cabinet autochtone spécialisé dans l'évaluation et le suivi des affaires liées aux Autochtones. Ce rapport compare les progrès réalisés par la SGDN en matière de réconciliation avec la base de référence établie, ce qui nous permet de nous assurer que nous respectons bien les engagements décrits dans notre *Politique sur la réconciliation* (2019). Cette base de référence en matière de réconciliation est utilisée pour évaluer nos efforts de réconciliation ainsi que pour relever nos lacunes et déterminer ce que nous pourrions faire pour progresser sur ce plan en tant qu'organisation. Mesurer nos progrès aide à faire de la réconciliation une valeur fondamentale chez nous, ce qui se manifeste par la façon dont notre organisation agit.

Nous continuons d'examiner nos documents importants à l'aide de notre outil d'évaluation des efforts de réconciliation. Nous avons effectué 18 évaluations des politiques de la SGDN relatives à la réconciliation et nous avons appliqué notre outil d'évaluation à nos stratégies de concertation régionale et à l'ébauche de la Stratégie intégrée pour les déchets radioactifs. Nous avons également appliqué l'outil d'évaluation hors des limites de notre organisation, l'utilisant avec certaines de nos universités partenaires afin de promouvoir cette optique dans le cadre de l'expansion de leurs programmes de recherche liés à nos activités.

La formation de sensibilisation culturelle est l'un des moyens par lesquels la SGDN soutient notre apprentissage. À ce jour, plus de 80 pour cent du personnel de la SGDN a suivi les deux premiers modules de formation sur la réconciliation, qui fournissent un espace propice aux cercles d'apprentissage et à un dialogue dirigé par des Autochtones. La troisième partie de notre programme de formation sur la réconciliation a été mise en oeuvre à l'automne 2021. Notre apprentissage continu sur la réconciliation ne cessant d'évoluer, l'accent fut mis dans cette partie de la formation sur la compréhension historique et contemporaine des traités. En 2022, nous avons lancé un nouveau module de formation axé sur la sensibilisation aux Métis.

Par notre application de la *Politique sur la réconciliation* (2019), nous démontrons notre contribution à cet important mouvement de changement.

SGDN
STRATÉGIE EN MATIÈRE DE RÉCONCILIATION



2022

Programme de formation sur la réconciliation amélioré par l'ajout de modules sur les traités et les peuples métis

Premier rapport annuel sur les efforts de réconciliation publié

Outil d'évaluation des efforts de réconciliation appliqué à la gouvernance dans le cadre de notre transformation du système de gestion intégrée

Programme de formation sur la réconciliation élargi aux collectivités et aux partenaires externes

2021

Amélioration du programme de formation sur la réconciliation poursuivie par l'ajout d'une formation sur les préjugés inconscients

Savoir autochtone intégré à nos plans de protection de l'eau

Outil d'évaluation des efforts de réconciliation appliqué aux stratégies de concertation régionale

Principe de la réconciliation intégré à la culture de l'organisation

2020

Politiques et procédures améliorées pour favoriser la réconciliation

Programme d'approvisionnement amélioré par l'ajout d'une stratégie d'approvisionnement auprès des peuples autochtones

Base de référence de la SGDN en matière de réconciliation évaluée et matrice de mesure des efforts de réconciliation élaborée

2019

Politique sur la réconciliation publiée

Programme de formation sur la réconciliation élaboré et mis en oeuvre

Outil d'évaluation des efforts de la SGDN en matière de réconciliation conçu

Programme de commandites et de dons bonifié par l'ajout de l'objectif de la réconciliation

Communication poursuivie du programme de réconciliation de la SGDN aux collectivités participant au processus de sélection d'un site

Évaluation entreprise des politiques et procédures de la SGDN avec l'outil d'évaluation des efforts de réconciliation

2018

Formation de sensibilisation à la culture autochtone reçue par 85 pour cent du personnel de la SGDN

Déclaration sur la réconciliation officialisée au cours d'une cérémonie autochtone

Savoir autochtone

L'engagement de la SGDN d'aligner nos travaux sur le savoir autochtone et les enseignements importants des détenteurs du savoir autochtone guide tout ce que nous faisons. Ces enseignements portent notamment sur le rôle et la signification des choses spirituelles et des cérémonies, la compréhension des lois naturelles, le respect de notre mère la Terre et la création d'un espace qui donne voix aux Autochtones.

Des ateliers internes de discussion permettent d'explorer la relation sacrée que les détenteurs du savoir autochtone entretiennent avec l'eau, le rôle d'intendance qu'ils ont à son égard et les points communs qui relient cette perspective à celle de la science occidentale. Les participants à ces ateliers incluent des détenteurs du savoir autochtone, des aînés autochtones, des scientifiques, des professionnels de l'industrie et des employés de la SGDN. Ensemble, nous explorons le thème de l'eau, qui constitue une force vitale qui nous nourrit, circule entre nous et en nous, et façonne la terre.

> « L'eau est un être unificateur et transformateur autour de qui nous nous rassemblons. L'eau est une formidable enseignante. Elle a une voix et des choses à nous dire. »
>
> **– Diane Longboat, aînée autochtone**

Il est de notre devoir et de notre responsabilité d'écouter l'eau pour apprendre à la respecter, à la protéger et à en prendre soin en toutes circonstances. C'est pourquoi protéger l'eau, les gens et l'environnement est si important pour nous. C'est un élément central de nos activités et une valeur que nous partageons avec les Canadiens et les peuples autochtones, car nous avons tous un lien personnel avec l'eau.

Il est essentiel pour nous de comprendre l'eau, ses qualités, sa mémoire et les endroits où elle coule pour que nous puissions prendre de bonnes décisions lorsque nous évaluons la géologie et d'autres caractéristiques environnementales des collectivités hôtes potentielles dans le cadre de nos études environnementales et géologiques.

En collaborant avec les détenteurs du savoir autochtone, les aînés, les scientifiques, les professionnels de l'industrie, les responsables de la conservation, les jeunes et d'autres personnes encore, nous continuons à en apprendre davantage sur l'eau et nous pouvons ainsi échanger nos connaissances entre nous et avec d'autres personnes et groupes dans le monde.

Plusieurs collectivités qui participent à notre processus de sélection d'un site nous ont demandé de leur fournir davantage de renseignements sur les façons dont nos travaux permettent de protéger l'eau. Depuis 2017, nous avons eu avec les collectivités de nombreux échanges basés sur notre série de présentations, nommée *Le parcours de l'eau*. Nous nous alignons sur le savoir autochtone dans ces présentations sur l'eau, un sujet d'une importance capitale pour tous. Cette série, élaborée en collaboration avec le Conseil des détenteurs du savoir autochtone, le Cercle des femmes de la Nation ojibwée de Wabigoon Lake et plusieurs groupes communautaires autochtones, nous aide à raconter l'histoire de l'eau et à expliquer comment elle interagit avec les matériaux que nous envisageons d'utiliser dans le système à barrières multiples. La SGDN continuera dans le futur de rechercher des occasions de présenter ces enseignements essentiels.

Au cours des cinq prochaines années, nous demeurerons fidèles à notre engagement, en continuant d'aligner tout ce que nous faisons sur le savoir autochtone, en créant un espace propice à l'apprentissage par les cérémonies et en appliquant les enseignements pertinents au processus décisionnel de la SGDN.

Coût et financement

Les Canadiens et les peuples autochtones s'attendent à ce que les fonds nécessaires à la gestion à long terme du combustible nucléaire irradié soient disponibles au moment voulu. Les mesures que nous avons prises satisfont à cette exigence.

Conformément au principe du « pollueur payeur », le plan canadien de gestion du combustible nucléaire irradié est financé par les propriétaires de déchets au Canada : Ontario Power Generation (OPG), Énergie Nouveau-Brunswick (ÉNB), Hydro-Québec (HQ) et Énergie atomique du Canada limitée (ÉACL). En vertu de la *Loi sur les déchets de combustible nucléaire*, chacune de ces quatre sociétés a été tenue d'établir son propre fonds en fiducie et d'y verser annuellement une contribution pour faire en sorte que l'argent requis pour financer le projet soit disponible au moment voulu.

La contribution de chacune de ces sociétés à son fonds en fiducie est basée sur le nombre de grappes de combustible qu'elle a produites et qu'elle continuera de produire. Les sommes versées couvrent les coûts fixes que la SGDN devra payer, selon les estimations, pour construire, exploiter, surveiller et déclasser un dépôt géologique en profondeur, ainsi que les coûts variables liés à la gestion de chaque grappe de combustible. Ce processus est conçu pour assurer le financement à long terme du plan canadien.

Pour de plus amples informations sur les sommes versées aux fonds en fiducie, veuillez consulter le *Rapport triennal 2020-22 de la SGDN*. En sus de ces contributions aux fonds en fiducie, les propriétaires de déchets sont également tenus de financer le budget de fonctionnement annuel de la SGDN.

Contributions totales aux fonds en fiducie : Année 2023		
Propriétaire	**Soldes des fonds en fiducie (millions $)**	**Contributions aux fonds en fiducie (grappes engagées et futures) (millions $)***
	Décembre 2022	**2023**
OPG	4404	93
ÉNB	187	6
HQ	174	0
ÉACL	72	0,4
Total	**4837**	**99**

** Les versements annuels aux fonds en fiducie doivent se faire au plus tard 30 jours après la présentation du rapport annuel. La date de versement du 27 avril est supposée aux fins d'illustration.*

La SGDN a comme responsabilité de déterminer quels coûts devront être assumés, selon toute vraisemblance, pendant la durée du projet et de prévoir les fonds qui seront nécessaires pour couvrir les dépenses imprévues. Nous appliquons un système pour estimer les exigences de financement et pour les communiquer aux propriétaires de déchets afin qu'ils versent les sommes requises aux fonds en fiducie.

De nombreux facteurs influenceront le coût à long terme du plan canadien : le volume de combustible nucléaire irradié à gérer, l'emplacement de l'installation, l'infrastructure environnante, le type de roche du site d'accueil et ses caractéristiques, la conception du dépôt ainsi que le temps pendant lequel le site sera surveillé une fois tout le combustible stocké. Le Canada a jusqu'à maintenant produit approximativement 3,2 millions de grappes de combustible nucléaire irradié et d'autres grappes seront produites chaque année par les réacteurs nucléaires qui continueront de générer de l'électricité. Les décisions futures concernant la production nucléaire au Canada pourraient venir modifier le volume et les types de combustible à gérer.

La SGDN révise régulièrement l'estimation du coût du cycle de vie du projet et nous avons réalisé une mise à jour complète de cette estimation de coût en 2021. L'estimation sert de base à la planification financière et à l'établissement des sommes qui devront être versées dans les fonds en fiducie au cours des années à venir. À des fins de planification, l'estimation des coûts réalisée en 2021 est basée sur un volume prévu d'environ 5,5 millions de grappes de combustible, ce qui représente le volume qui devrait normalement avoir été accumulé à la fin de la vie utile prévue des réacteurs nucléaires existants au Canada. D'après ce volume, le coût du cycle de vie entier du projet – depuis le début du processus de sélection d'un site, en 2010, jusqu'à l'achèvement du projet approximativement 175 ans plus tard – serait approximativement de 26 milliards $ (en dollars de 2020). Ce chiffre couvre les nombreuses décennies du cycle de vie du projet, lequel se prolongera bien au-delà du début du siècle prochain.

Prise en compte du contexte externe et adaptation aux changements

À la SGDN, nous nous sommes engagés à surveiller les nouveaux faits à l'échelle locale, nationale et internationale qui pourraient changer le contexte dans lequel nous évoluons ou avoir une incidence directe sur le projet. Nous continuons de surveiller les avancées qui se font dans le secteur de l'énergie, les innovations qui touchent la gestion des déchets nucléaires, les changements apportés aux politiques énergétiques et environnementales, les développements potentiels liés à la construction de nouveaux réacteurs nucléaires, l'évolution des attentes, des valeurs et des idées de la société ainsi que les nouveaux développements liés aux autres initiatives canadiennes de gestion des déchets nucléaires.

Un des principes fondamentaux de la Gestion adaptative progressive est l'engagement d'adapter les plans en fonction des commentaires reçus dans le cadre des activités de concertation. Par exemple, notre cadre de planification du transport et notre *Plan de transport préliminaire* sont tous deux fondés sur ce que nous ont dit les collectivités et les personnes intéressées par le plan canadien. Ces deux documents de planification du transport ont été conçus pour faire avancer les discussions et fournir plus d'informations sur la façon dont nous planifions de transporter en toute sûreté le combustible nucléaire irradié.

En 2020, nous avons commencé à diffuser publiquement l'ébauche du cadre en vue d'une concertation plus large, et en 2022, nous avons publié les deux documents. Nous nous sommes engagés à réviser ces documents tous les trois ans en tenant compte des commentaires des Canadiens et des peuples autochtones, ainsi que des nouveaux développements en matière de pratiques exemplaires, de technologies, d'adaptation permanente et d'amélioration continue.

Nous avons également adapté nos plans liés au processus de décision réglementaire en réponse aux changements apportés à la *Loi sur l'évaluation d'impact* en 2019. Vous trouverez de plus amples renseignements sur le plan de prise de décision réglementaire dans la section *Processus de décision réglementaire*.

Comme les progrès technologiques associés aux petits réacteurs modulaires (PRM) se poursuivent au Canada, nous travaillons avec les concepteurs de PRM en vue de déterminer les types de combustible nucléaire irradié qui pourraient en résulter, puisque la SGDN sera responsable de leur gestion. Ces renseignements nous aideront à optimiser la gestion à long terme du combustible nucléaire irradié ainsi qu'à revoir la conception du dépôt et à adapter nos formules de financement en tenant compte des nouveaux combustibles que nous pourrions devoir gérer. Cela nous aidera également à mieux informer les collectivités hôtes potentielles sur la portée totale du projet.

La SGDN est au fait de deux projets de PRM qui sont en cours d'autorisation : Ontario Power Generation collabore avec GE-Hitachi Nuclear Energy en vue de déployer un PRM sur le nouveau site nucléaire de Darlington, et Global First Power travaille à la construction d'un PRM sur le site des Laboratoires de Chalk River, en Ontario. Bien que nous soyons au courant d'autres propositions de PRM et au fur et à mesure qu'elles avancent, nous apporterons les ajustements nécessaires à nos plans. Au fur et à mesure que d'autres projets de PRM progresseront vers le stade de l'obtention d'un permis, nous serons prêts à la SGDN à adapter nos plans et à identifier toute mesure qui pourrait être prise pour améliorer l'efficacité de la gestion de leur combustible irradié.

Le consensus international veut que les dépôts géologiques en profondeur constituent la meilleure pratique de gestion à long terme du combustible nucléaire irradié des PRM et des déchets de haute activité issus des procédés de retraitement. Le plan canadien est conçu pour pouvoir s'adapter aux changements technologiques, et nous pouvons intégrer une certaine souplesse dans la conception des dépôts afin d'être prêts à répondre aux décisions futures.

De plus, nous mettons régulièrement à jour un rapport de suivi sur les cycles de combustible avancés et les technologies de remplacement pour la gestion des déchets. Nous assurons aussi un suivi et la déclaration des quantités de combustible nucléaire irradié qui pourraient être produites pour en tenir compte dans la conception du dépôt.

Priorités de planification

À la SGDN, nous articulons nos plans de travail autour de sept priorités : l'ingénierie, l'évaluation des sites, la sûreté, la mobilisation, le processus de décision réglementaire, le partenariat et le transport. Dans cette section, nous décrivons nos plans en fonction de ces sept catégories de travaux.

Notre engagement de favoriser la réconciliation et d'aligner notre travail sur le savoir autochtone guide les efforts que nous menons dans tous nos domaines prioritaires.

Au cours des cinq prochaines années, nous passerons du stade du processus de sélection d'un site à celui du processus de décision réglementaire. Ces priorités de planification reflètent les nombreuses activités qui devront être menées au cours de cette période de transition.



INGÉNIERIE

La SGDN :

- Achèvera la conception des éléments de l'installation en fonction des sites potentiels afin de soutenir le processus de décision réglementaire;
- Entreprendra le travail de conception préliminaire du dépôt lié à la présentation de la demande de permis de construire;
- Poursuivra l'optimisation du système de barrières ouvragées en vue de la construction et de l'exploitation.

Le dépôt géologique en profondeur est une approche reconnue à l'échelle internationale, qui fait consensus au sein de la communauté scientifique pour ce qui est de la gestion à long terme sûre du combustible nucléaire irradié. De multiples barrières ouvragées seront mises en place dans une formation rocheuse stable pour confiner et isoler à grande profondeur sous terre le combustible nucléaire irradié.

Au fur et à mesure de l'avancement du processus de sélection d'un site et du processus de décision réglementaire, nous élaborerons des modèles conceptuels des éléments du dépôt propres aux sites potentiels à l'aide des données recueillies lors des forages et des études environnementales préliminaires de référence. Ce travail sous-tendra la prise de décision quant au choix du site. Une fois qu'un site aura été choisi, nous entreprendrons l'ingénierie préliminaire propre au site sélectionné afin de soutenir la préparation des dossiers et des évaluations réglementaires et de préparer la demande de permis de construire.

Nous continuerons d'optimiser nos processus et nos techniques pour renforcer la confiance dans la robustesse du système de barrières ouvragées. Nous intégrerons aussi dans nos modèles les informations que nous tirerons de nos activités en cours de recherche-développement par le biais d'examens interdisciplinaires menés par notre Comité d'examen de la recherche technique.

De plus, de 2023 à 2027, la SGDN :

- Exploitera une installation de mise à l'épreuve et de démonstration des prototypes pour l'évaluation des barrières ouvragées;
- Continuera de tenir à jour les informations sur l'estimation du coût du projet;
- Soutiendra la préparation de la description initiale du projet et des évaluations requises pour le processus réglementaire;
- Entreprendra l'ingénierie préliminaire en fonction du site sélectionné afin d'étayer la future demande de permis de construire;
- Organisera la tenue d'examens par des pairs indépendants des caractéristiques et aspects particuliers de la conception du dépôt et des barrières ouvragées.

ÉVALUATION DES SITES

La SGDN :

- Poursuivra nos études géoscientifiques et nos activités de surveillance environnementale de référence sur les deux sites;
- Entreprendra d'autres études géoscientifiques et la collecte de données de référence sur le site choisi.

La SGDN prévoit de choisir un site unique optimal d'ici l'automne 2024, puis de lancer le processus de décision réglementaire en 2025. À ce stade, les activités initiales d'évaluation des sites seront achevées et auront permis d'obtenir des informations suffisantes pour éclairer convenablement le choix du site. Une fois le site choisi, les études de caractérisation se poursuivront sur le site sélectionné afin d'étayer le processus de décision réglementaire et d'éclairer les travaux d'évaluation géoscientifiques, d'ingénierie, environnementales et de sûreté qui seront nécessaires pour présenter une demande de permis de construire.

Pour nous assurer que nous intégrons convenablement le savoir autochtone, nous sollicitons l'avis des détenteurs locaux du savoir autochtone concernant l'application des connaissances pertinentes à notre planification et à la réalisation de nos études. Des experts autochtones locaux veillent à ce que les protocoles autochtones guident nos activités sur le terrain. Jusqu'à maintenant, ces activités ont inclus des études de vérification culturelle des régions potentiellement touchées, au cours desquelles des cérémonies sont tenues, et des formations de sensibilisation culturelle données au personnel et aux sous-traitants qui travaillent sur le terrain.

Nous poursuivons notre travail avec les résidents des municipalités intéressées, des collectivités des Premières Nations et métisses, et des autres collectivités de la région. Nous encourageons la prise en compte des effets environnementaux, sociaux, culturels et économiques potentiels de la mise en oeuvre du dépôt géologique en profondeur. Faire participer les résidents de l'ensemble des régions hôtes potentielles garantira qu'un large éventail de retombées et d'incidences potentielles sera pris en considération lorsque nous progresserons au-delà du choix d'un site.

Le plan canadien est constamment adapté pour refléter les priorités des collectivités hôtes potentielles. Bien que le moment de la sélection d'un site ait été reporté, les activités géoscientifiques sur le terrain se sont poursuivies dans les deux régions hôtes potentielles.

De plus, de 2023 à 2027, la SGDN :

- Poursuivra nos études sur le terrain, effectuant notamment des forages géotechniques additionnels sur le site choisi, et intégrera les facteurs relevés par les détenteurs du savoir autochtone pour éclairer les évaluations géoscientifiques, d'ingénierie, environnementales et de sûreté;
- Poursuivra nos études géoscientifiques pour étayer le processus de sélection d'un site sûr pour l'établissement du dépôt géologique en profondeur;
- Travaillera en concertation avec les collectivités sur des sujets particuliers comme la protection des gens et de l'environnement, les retombées du projet et l'intendance du territoire;
- Soutiendra le processus de décision réglementaire et entreprendra des études de caractérisation supplémentaires pour confirmer que le site choisi est propice sur le plan technique à l'établissement du dépôt géologique en profondeur.

SÛRETÉ

La SGDN :

- Poursuivra l'élaboration des évaluations préliminaires de sûreté propres aux sites potentiels;
- Maintiendra notre engagement d'envisager la sûreté d'un point de vue social;
- Mettra à jour les modèles d'évaluation de la sûreté du site choisi, modèles qui serviront de base au processus de décision réglementaire;
- Poursuivra nos recherches afin d'étayer le dossier de sûreté et développera l'expertise nécessaire pour soutenir le processus de décision réglementaire.

La SGDN est résolue à protéger les gens et l'environnement pour les générations à venir. Protéger le public et nos employés est notre plus haute priorité dans tout ce que nous faisons, que ce soit sur le plan de la sûreté environnementale, classique, nucléaire ou radiologique.

Pendant que nous continuons d'améliorer notre connaissance des deux sites potentiels, nous partageons notre compréhension de la sûreté avec les collectivités par le biais de présentations et de nos plateformes numériques, de même qu'en mettant à leur disposition des spécialistes de la SGDN.

Le dépôt géologique en profondeur sera construit dans une formation rocheuse propice au confinement et à l'isolement sûrs et à long terme du combustible nucléaire irradié. Dans le cadre du futur processus d'autorisation, il faudra démontrer que la performance du dépôt sur ce site satisfera aux exigences réglementaires de la Commission canadienne de sûreté nucléaire ou les surpassera.

Alors que la sélection d'un site optimal approche pour l'automne 2024, les rapports *Confiance dans la sûreté* publiés en 2022 résument les données qui démontrent qu'un dépôt géologique en profondeur pourra être construit sur l'un ou l'autre des sites potentiels. Après la sélection d'un site associé à des hôtes informés et consentants, d'autres études techniques seront entreprises sur le site choisi. Celles-ci permettront de préciser encore davantage la conception du dépôt et le dossier de sûreté officiel qui seront soumis à l'examen des autorités de réglementation.

La sûreté d'un site proposé sera confirmée par un examen réglementaire rigoureux de la conception du dépôt et de son dossier de sûreté.

De plus, de 2023 à 2027, la SGDN :

- Continuera de réaliser des projets de recherche en collaboration avec des organisations internationales et des homologues d'autres pays – comme la Suède, la Suisse, la Finlande, la France, la Corée, le Japon et le Royaume-Uni – afin de tirer profit de l'expérience des autres pays et d'y contribuer, tout en se tenant au courant de l'état des connaissances scientifiques dans les domaines des géosciences et des dossiers de sûreté associés aux divers types de formations rocheuses hôtes;
- Nouera des partenariats de recherche avec des universités pour garantir la rigueur scientifique de nos travaux techniques et pour former de jeunes ingénieurs et scientifiques compétents dans la gestion des déchets. Par exemple, la SGDN continuera de tenir notre Symposium annuel sur les géosciences et un atelier sur la science des barrières ouvragées pour réunir des chercheurs des secteurs universitaire et industriel;
- Accroîtra le niveau de sensibilisation au rôle important que joue le savoir autochtone dans nos travaux, notamment en offrant des formations et en commanditant des ateliers sur le savoir autochtone et la science occidentale pour nos partenaires de recherche;
- Continuera d'instaurer, en amont du processus de décision réglementaire, une solide culture de la sûreté parmi les employés en créant et en maintenant un environnement dans lequel les employés assument de manière proactive la responsabilité de leur propre sûreté et de celle de leurs collègues et du public dans toutes nos activités.

L'accent sur la sûreté d'un point de vue social

Bien que le dépôt géologique en profondeur constitue un important projet d'infrastructure environnementale pour le Canada, la protection des gens est tout aussi essentielle pour nous. Mettre en oeuvre le projet de façon à ce que les gens se sentent en sûreté est un élément clé de cet engagement. La SGDN envisage la sûreté d'un point de vue social à trois niveaux – à l'échelle de la société, de la collectivité et personnelle.

La SGDN tient compte de la sûreté d'un point de vue social en veillant à ce que le projet soit largement accepté. Après la création de la SGDN en 2002, nous avions entrepris une étude de trois ans pour évaluer les approches et les solutions possibles de gestion à long terme sûre du combustible nucléaire irradié canadien afin que le public puisse comprendre les différentes options et faire des choix réfléchis.

Des discussions en personne avaient été tenues avec des milliers de citoyens et de représentants d'organisations aux niveaux local, provincial, national et international. Ceux-ci comprenaient notamment des représentants d'organisations autochtones, des travailleurs de centrales nucléaires, des jeunes, des résidents des collectivités hôtes de centrales nucléaires, des groupes environnementaux, des experts de l'industrie, des groupes confessionnels, des organismes gouvernementaux et des parlementaires. Le plan canadien est issu de ce dialogue. Il est basé sur les valeurs et les priorités définies par les Canadiens et les peuples autochtones.

Nous avons également travaillé avec le public à l'élaboration et à la conception de notre processus de sélection d'un site. La participation volontaire, la prise de décision partagée, l'ouverture et l'équité ont servi de base à ce processus, que nous avons décrit en détail dans notre processus de sélection d'un site de 2010 et que nous continuons d'observer aujourd'hui.

Notre processus de sélection d'un site a été volontaire dès le départ, 22 collectivités ayant initialement exprimé l'intérêt à en apprendre davantage sur le projet et d'explorer leur aptitude à l'accueillir. Progressivement, nous avons réduit le champ de nos études à deux régions hôtes potentielles, tout en faisant de la sûreté d'un point de vue social le fondement de nos efforts de concertation et du processus de sélection d'un site.

Nous avons maintenu notre engagement selon lequel le plan canadien n'avancera que dans une région où les hôtes sont informés et consentants, où la municipalité, les collectivités des Premières Nations et métisses et les autres de la région travaillent ensemble à sa mise en oeuvre.

Nous avons également démontré notre engagement de promouvoir la sûreté d'un point de vue social à l'échelle de la collectivité en nous alignant sur le savoir autochtone et en entreprenant une démarche de réconciliation (pour plus d'informations, veuillez consulter la section *Réconciliation et savoir autochtone*).

Afin de répondre à la sûreté d'un point de vue social à l'échelle personnelle, la SGDN sollicite régulièrement des commentaires individuels sur notre travail dans le cadre de nos activités de concertation sur le terrain et par le biais des médias sociaux et de sondages publics. Nous sommes à l'écoute des collectivités, des résidents, des dirigeants locaux et des personnes qui ont différentes opinions sur notre travail. À travers ce processus, nous cherchons à comprendre et à répondre aux préoccupations soulevées par les gens.

La transparence étant une valeur fondamentale de notre organisation, nous diffusons également chaque année les résultats de ces efforts de concertation en publiant nos rapports de la série « Ce qu'on nous a dit », qui résument les questions et les thèmes que nous entendons.

Dans le cadre des efforts que nous continuons de faire pour garantir que le projet prenne en compte la sûreté d'un point de vue social, nous avons entre autres :

- Utilisé les commentaires que nous recevons pour comprendre les préoccupations qui sont importantes pour les Canadiens et les peuples autochtones, ajusté notre travail pour répondre au besoin à ces préoccupations, et mis en évidence ces préoccupations dans nos rapports publics;
- Participé activement et volontairement à des débats publics présentant différents points de vue sur le projet;
- Utilisé les thèmes communs dégagés des commentaires que nous recevons pour guider la conception du dépôt et répondre à ces commentaires dans nos rapports, comme nous l'avons fait sur des sujets comme l'importance de la protection de l'eau;
- Renforcé les capacités des collectivités participant au processus de sélection d'un site afin qu'elles puissent élaborer leurs propres processus pour déterminer si elles sont prêtes à accueillir le projet;
- Affirmé auprès des collectivités autochtones notre engagement selon lequel aucun site ne sera choisi sans leur consentement;
- Suivi une approche collaborative pour élaborer des accords de partenariat et d'accueil du projet;
- Élargi la portée de nos activités de concertation aux collectivités régionales et voisines, c'est-à-dire au-delà des collectivités hôtes potentielles;
- Fait participer les collectivités à l'élaboration d'études locales et aux discussions sur les résultats en tenant compte d'une série de facteurs socioéconomiques, afin d'explorer les possibilités de créer des partenariats et de faire en sorte que le projet puisse être mis en oeuvre d'une façon qui favorise le bien-être des résidents de la région;
- Fait participer les collectivités à des programmes de surveillance de l'environnement;
- Considéré dans nos évaluations de la sûreté des modes de vie réalistes – comment et où vivent les habitants de la région;
- Mis de façon ponctuelle des experts en évaluation de la sûreté à la disposition du public dans les régions hôtes potentielles;
- Créé des occasions pour notre personnel d'entrer directement en contact avec les membres des collectivités des régions hôtes potentielles pour discuter de la sûreté du programme et connaître leurs préoccupations.

MOBILISATION

La SGDN :

- Mettra en oeuvre une stratégie des ressources humaines et veillera à ce que la sécurité et les plateformes informatiques nécessaires à l'organisation et au processus de décision réglementaire soient disponibles;
- Entreprendra la planification, la conception et la procédure aux appels d'offres en vue de la construction du Centre d'expertise.

Vu la complexité et la portée générationnelle du projet, nous avions prévu dès le départ qu'il nous faudrait sûrement adapter nos plans en cours de route, sans toutefois perdre de vue le long terme.

La sélection d'un site est une étape cruciale, qui marquera le début d'une nouvelle série d'activités. Une fois le site choisi, les activités s'accéléreront à l'échelle locale et régionale. Cette étape marquera aussi pour la SGDN le début d'une transformation organisationnelle en plusieurs phases.

La SGDN devra recruter du personnel et cherchera pour ce faire à mettre en place un effectif équitable, diversifié et inclusif, à maximiser les possibilités d'emplois dans la région d'établissement – dans la municipalité et la région environnante, y compris les collectivités des Premières Nations et métisses – et à renforcer les capacités des collectivités en investissant dans des initiatives de formation et d'éducation.

Le moment de la sélection d'un site approchant, nous nous préparons à déménager nos opérations vers le site choisi pour le dépôt. Nous planifions aussi d'accroître nos ressources dans cette région, de faire en sorte que nous ayons en place la technologie requise pour soutenir le plan canadien et d'acquérir les droits sur les terrains visés pour établir nos installations, y compris le Centre d'expertise.

À l'interne, nous nous préparerons à cette intensification de nos activités en mettant progressivement en place les ressources nécessaires pour poursuivre les travaux de caractérisation et d'ingénierie, pour présenter les demandes réglementaires et pour construire et exploiter le dépôt géologique en profondeur.

De plus, de 2023 à 2027, la SGDN :

- Déterminera les ressources dont nous aurons besoin pour réaliser et soutenir les travaux de caractérisation, d'évaluation environnementale, d'ingénierie et de préparation du dossier de sûreté à réaliser pour la région d'établissement choisie pour étayer les demandes d'autorisation;
- Continuera de renforcer notre présence dans les régions hôtes potentielles et d'offrir aux entrepreneurs locaux des possibilités de contrats liés à la mise en oeuvre du projet;
- Travaillera avec les collectivités afin de déterminer quelles ressources de logement et d'infrastructures devront être mises en place pour accueillir les effectifs de la SGDN sur le site choisi;
- Investira dans le développement des compétences et des capacités des jeunes et autres membres des municipalités et des collectivités des Premières Nations et métisses participant au processus de sélection d'un site afin de les aider à décrocher les emplois générés par le plan canadien;
- Continuera de renforcer notre culture organisationnelle en instaurant des comportements, des normes et des outils organisationnels appropriés, y compris des plateformes technologiques. Cette culture englobera la recherche de l'excellence dans la gestion des projets, la création de partenariats solides, la promotion de la diversité et de l'inclusion, et l'engagement de favoriser la réconciliation et d'aligner tout ce que nous faisons sur le savoir et les pratiques autochtones.

Plan de préparation opérationnelle

Pour garantir que nous serons prêts à passer à la phase suivante du projet, la SGDN élabore actuellement un plan de préparation opérationnelle qui comprendra les objectifs suivants :

- Élaborer et mettre en oeuvre les systèmes, les processus et les outils nécessaires à la phase suivante du projet, y compris pour la maintenance et le contrôle du site du projet dans la collectivité sélectionnée;
- Faire en sorte que la SGDN dispose des processus et des outils de gestion des projets, des contrats et des activités commerciales nécessaires pour assurer la mise en oeuvre de ce projet d'envergure complexe et des contrats pluriannuels.

À la SGDN, nous avons entrepris de nous doter des capacités et des compétences organisationnelles nécessaires pour soutenir le processus de décision réglementaire et préparer la construction des installations en tenant compte de nos priorités de planification. Nous procédons notamment à l'élaboration des processus, des systèmes et des outils qui seront nécessaires pour mettre en oeuvre le plan canadien dans le respect des délais et des budgets, ce qui comprend notre système de gestion, notre stratégie commerciale, notre infrastructure commerciale et de technologie de l'information, et nos systèmes de gestion de l'information.

La SGDN devra mener à bien des aspects plus complexes du projet au cours de la prochaine phase de travail et les risques d'incidences sur les coûts et le calendrier seront donc plus grands. Notre capacité à gérer ces projets et contrats et à assurer une pleine reddition de compte exigera que les ressources requises soient en place au moment où nous choisirons un site, afin que nous puissions passer efficacement à la phase suivante des travaux.

De plus, de 2023 à 2027, la SGDN :

- Poursuivra la transformation entreprise de notre système de gestion pour le rendre conforme aux exigences de la norme CSA N286-12, *Exigences relatives au système de gestion des installations nucléaires*, dans la mesure où elles s'appliquent à nos activités;
- Continuera d'utiliser les outils et technologies de l'information à notre disposition pour automatiser les processus, soutenir les initiatives stratégiques et numériser les informations, le contenu et les dossiers;
- Utilisera l'intelligence artificielle, l'intelligence d'affaires et l'analyse des données pour améliorer l'efficience de nos opérations et soutenir la prise de décisions importantes;
- Élaborera une stratégie commerciale pour nous doter des effectifs, des biens et des services nécessaires à la prochaine phase des travaux;
- Mettra en oeuvre le Système d'information pour la gestion des projets pour soutenir la réalisation et le suivi des projets de la SGDN;
- Appliquera à nos travaux une bonne approche de gouvernance en matière de gestion de projets et de stratégie d'affaires.

PROCESSUS DE DÉCISION RÉGLEMENTAIRE

La SGDN :

- Préparera, en collaboration avec les collectivités, les demandes destinées à amorcer le processus de décision réglementaire;
- Amorcera le processus de décision réglementaire avec les collectivités partenaires.

La protection des gens et de l'environnement pour les générations à venir reste au coeur de toutes nos activités. Comme nous nous dirigeons vers la sélection d'un site et les étapes subséquentes, il deviendra encore plus important de démontrer que le plan canadien pourra répondre aux rigoureuses exigences réglementaires encadrant la protection de la santé, de la sûreté et de la sécurité des gens et de l'environnement, tout en permettant de respecter les engagements internationaux du Canada.

Nous planifions d'aviser officiellement les autorités de réglementation que nous amorçons le processus de décision réglementaire peu après la sélection d'un site, puis de présenter nos premières demandes réglementaires en 2025.

Nos études des sites potentiels et études techniques associées, réalisées en amont de ce processus et lorsqu'il sera amorcé, devront répondre à toutes les exigences municipales, provinciales et fédérales pertinentes. Pour que cela soit le cas, la SGDN surveille et adapte nos activités en fonction de tous les changements réglementaires qui pourraient avoir une incidence sur le projet. Par exemple, nous avons adapté nos plans afin que nos études soient conformes à la *Loi sur l'évaluation d'impact* entrée en vigueur en 2019.

Nous continuons également de travailler en concertation avec la Commission canadienne de sûreté nucléaire (CCSN) en vue de la présentation future d'une demande de permis, conformément aux conditions d'un arrangement spécial déjà en place pour le projet.

De plus, de 2023 à 2027, la SGDN :

- Mettra au point des méthodologies d'évaluation d'impact, en collaboration avec les collectivités municipales et autochtones des régions hôtes potentielles, en prévision du lancement officiel du processus de décision réglementaire;
- Travaillera avec les collectivités et d'autres en vue de trouver des possibilités d'améliorer la compréhension des conditions locales et régionales actuelles, notamment en collaborant avec les collectivités autochtones pour aligner cette compréhension sur le savoir autochtone et ainsi poser les bases des évaluations environnementale, sociale, économique et de la santé;
- En nous appuyant sur le travail effectué sur la sûreté d'un point de vue social jusqu'à la sélection d'un site, continuera de travailler avec les membres de la collectivité pour comprendre leurs questions et leurs préoccupations, et pour en tenir compte dans la conception des installations et dans nos études;
- Établira des programmes de surveillance environnementale dans les régions hôtes potentielles, en collaboration étroite avec les membres des collectivités et les détenteurs du savoir autochtone;
- Travaillera avec les collectivités hôtes potentielles en vue de définir leur rôle dans le processus de décision réglementaire et faciliter leur participation au processus;
- Obtiendra de l'Agence d'évaluation d'impact du Canada (AEIC), de la CCSN et des autres autorités de réglementation des précisions sur les exigences de la *Loi sur l'évaluation d'impact* applicables à la mise en oeuvre;
- Préparera et présentera la documentation requise pour amorcer le processus fédéral d'évaluation d'impact et le processus d'autorisation de délivrance de permis de la CCSN;
- Amorcera le processus intégré d'évaluation d'impact et de délivrance de permis, et préparera les rapports nécessaires après avoir reçu de l'AEIC les Lignes directrices d'évaluation d'impact et le Plan de délivrance de permis pour le site choisi.

Le plan de prise de décision réglementaire

Une fois qu'un site aura été choisi en 2024, à la SGDN, nous nous concentrerons sur le processus de décision réglementaire qui permettra de passer à la construction du dépôt géologique en profondeur dans l'éventualité où les approbations seraient accordées.

Toutes les décisions réglementaires seront examinées de façon indépendante par les organismes de réglementation fédéraux et provinciaux de même que par un comité d'examen désigné. Le processus sera ouvert et transparent et permettra aux membres du public qui voudront y participer de le faire.

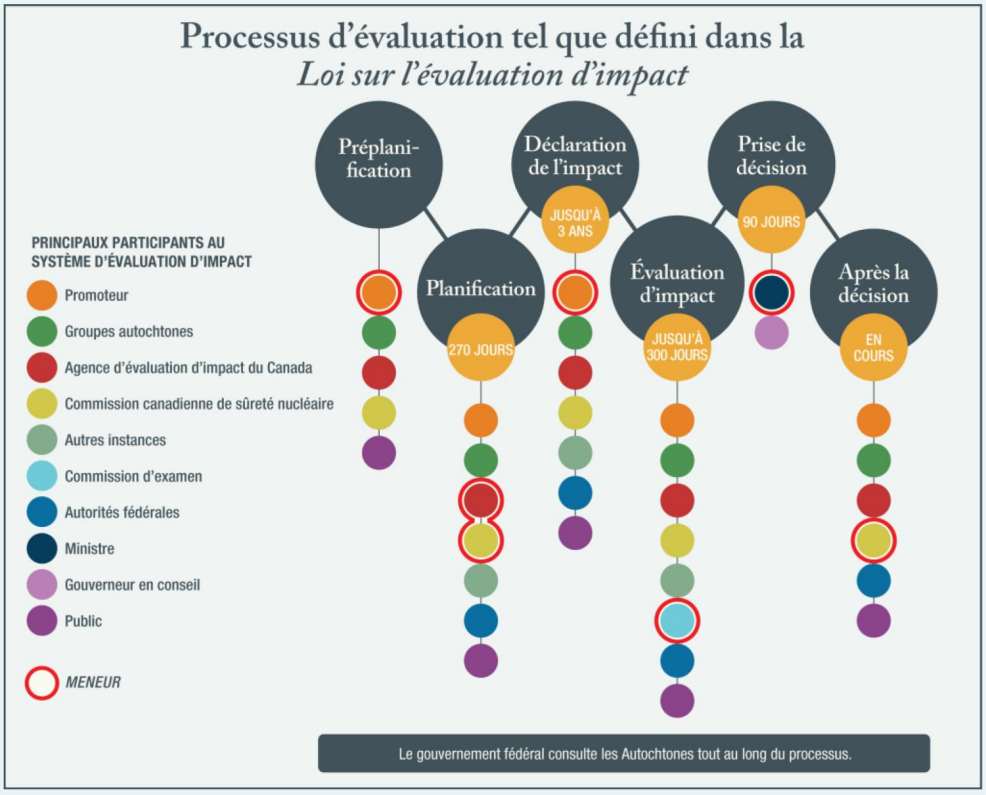
Deux processus intégrés de décision réglementaires seront mis en oeuvre :

- Une évaluation d'impact conforme à la *Loi sur l'évaluation d'impact*;
- La délivrance d'un permis en vertu de la *Loi sur la sûreté et la réglementation nucléaires*.

Ces deux processus aideront le gouvernement fédéral à évaluer divers aspects du projet, dont la sûreté, la durabilité, les effets négatifs, la sécurité nationale et la question de savoir s'il est dans l'intérêt public.

La SGDN et les collectivités hôtes du projet entreprendront un programme de travail substantiel, étudiant les impacts potentiels du projet, y compris les effets cumulatifs, et déterminant les mesures d'atténuation requises. Dans l'ensemble, notre objectif est d'avoir reçu les approbations réglementaires au moment voulu pour pouvoir passer à la préparation du site d'ici 2030.

Apprenez-en davantage sur le processus de décision réglementaire.



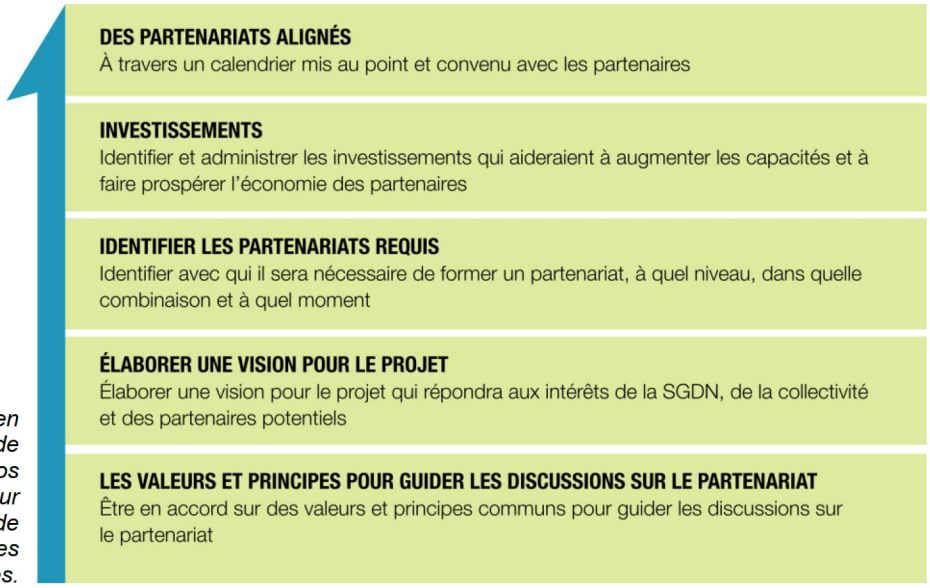
PARTENARIAT

La SGDN :

- Bâtira avec les collectivités des partenariats solidaires et résilients qui aboutiront à des accords de partenariat mutuellement acceptables;
- Choisira le site optimal pour le dépôt géologique en profondeur dans une région associée à des hôtes informés et consentants.

La SGDN est résolue à favoriser le bien-être des collectivités en allouant des fonds à chaque collectivité hôte potentielle pour faire avancer des projets entrepris à leur initiative. Ces fonds visent à soutenir les efforts poursuivis par la collectivité pour renforcer sa viabilité et favoriser son bien-être et à l'aider à se donner la capacité requise pour participer aux discussions sur l'établissement d'un partenariat avec la SGDN et accueillir éventuellement le projet par le développement de compétences transférables. Les municipalités qui participent au processus de sélection d'un site continuent d'exprimer leur intérêt d'améliorer leurs relations avec les collectivités autochtones voisines, ce que nous nous efforçons de faciliter par nos activités de concertation.

En 2023 et 2024, nous continuerons d'explorer la possibilité de nouer des partenariats avec les collectivités municipales et autochtones de chaque région hôte potentielle. Nous suivons une feuille de route qui aborde une série de sujets se rapportant à l'établissement d'un partenariat. Ces sujets seront examinés avec les collectivités.



En partant du bas et en remontant, la feuille de route guide nos discussions sur l'établissement de partenariats avec les collectivités.

À Ignace, la conversation autour d'un exercice mené pour définir les valeurs et les principes de la collectivité se poursuit avec l'administration municipale nouvellement élue, et des travaux supplémentaires pourraient être entrepris sur la base de ces discussions. À South Bruce, la municipalité a établi 36 principes directeurs qui reflètent les priorités et les attentes de la collectivité. Chaque sujet abordé dans notre feuille de route sur le partenariat s'appuie sur les valeurs et les principes que les collectivités ont établis pour guider nos discussions et s'assurer que le projet sera mis en oeuvre d'une manière qui améliorera le bien-être de leur collectivité.

Une fois le site choisi en 2024, notre travail passera de la phase de sensibilisation, de compréhension de la possibilité de favoriser le bien-être et de renforcement de la confiance à l'égard de la sûreté du projet, y compris la sûreté d'un point de vue social, à la mise en oeuvre et à la gouvernance des accords de partenariat. La participation des jeunes demeurera également une priorité, compte tenu de la nature intergénérationnelle du projet et de la nécessité d'une transmission intergénérationnelle des connaissances pour soutenir la mise en oeuvre du projet.

De plus, de 2023 à 2027, la SGDN :

- Continuera de travailler avec les municipalités, les collectivités des Premières Nations et métisses des régions hôtes potentielles et les collectivités environnantes pour les sensibiliser au projet et pour bâtir et entretenir des relations avec elles – en tenant compte de leurs lois, de leurs pratiques et de leur utilisation des terres traditionnelles;
- Travaillera avec les collectivités hôtes potentielles pour continuer de faire connaître le projet dans la région;
- Travaillera avec les collectivités des régions hôtes potentielles pour comprendre comment la sûreté d'un point de vue social peut être soutenue, y compris certains aspects comme la cohésion et le bien-être de la collectivité;
- Identifiera d'autres partenaires potentiels et établira avec eux des relations de soutien et de résilience;
- Fera en sorte que les collectivités participant au processus de sélection d'un site aient les ressources et les renseignements nécessaires pour participer pleinement aux activités de sélection d'un site et pour prendre une décision éclairée;
- Élaborera des accords mutuellement acceptables d'accueil dans chaque région hôte potentielle et, une fois le site choisi, entreprendra la mise en oeuvre de l'accord conclu avec la région hôte qui passera à la phase du processus de décision réglementaire;
- Fera en sorte, grâce aux partenariats établis, que les collectivités disposent de ressources suffisantes pour participer activement au processus de décision réglementaire.

TRANSPORT

La SGDN :

- Démontrera qu'un plan de transport pourra jouir d'une acceptation sociale au terme d'un dialogue sur le cadre de planification du transport;
- Continuera de travailler avec les peuples autochtones pour comprendre comment la SGDN peut aligner notre planification du transport sur le savoir autochtone;
- Continuera d'affiner le système de transport du combustible irradié;
- Commencera à mettre en oeuvre le cadre de planification du transport, qui sera mis à jour tous les trois ans.

On transporte du combustible nucléaire irradié quotidiennement dans le monde. En près de 60 ans, aucun accident n'a causé de tort à des personnes ou à l'environnement en raison d'un rejet radioactif.

La SGDN élabore actuellement des plans sûrs, sécuritaires et socialement acceptables qui encadreront le transport du combustible nucléaire irradié depuis les sites actuels d'entreposage provisoire jusqu'au dépôt géologique en profondeur. Cependant, nous reconnaissons la nécessité d'expliquer l'excellent bilan de sûreté et de répondre aux questions des gens sur les mesures que prendra la SGDN pour atteindre ce niveau d'excellence.

En 2021, nous avons publié un *Plan de transport préliminaire* qui décrit, sur le plan conceptuel, comment la SGDN prévoit d'acheminer en toute sûreté le combustible nucléaire irradié jusqu'au dépôt géologique en profondeur, ainsi que le cadre de planification du transport, qui décrit les valeurs, les objectifs et les priorités des gens au regard du transport sûr du combustible nucléaire irradié.

La planification et l'évaluation des dispositions de transport tiendront pleinement compte des exigences réglementaires encadrant le transport sûr du combustible nucléaire irradié entre les provinces. Les activités de planification de la concertation technique et sociale propres au site hôte se poursuivront après la sélection d'un site en 2024. Nous prévoyons de commencer à transporter le combustible irradié vers le site du dépôt géologique en profondeur au cours des années 2040, lorsque le dépôt sera en service.

En plus des exigences techniques, les considérations sociales sont importantes pour notre processus de planification. Nous sommes conscients que le transport du combustible nucléaire irradié est un sujet important pour les Canadiens et les peuples autochtones, et nous suivons une approche collaborative, dans le cadre de laquelle les décisions sont prises en commun. Plus précisément, nous avons conçu une approche itérative en matière de planification du transport qui intégrera les contributions des générations futures dans le processus de planification, reconnaissant l'importance du principe des sept générations dans la vision du monde autochtone.

Le cadre sera mis à jour et publié de nouveau tous les trois ans. Comme nous l'avons indiqué plus avant, il nous incombe de veiller à ce que des personnes représentant un large horizon d'intérêts participent à nos discussions de planification et que nous répondions à leurs questions et préoccupations.

Selon les exigences du processus de sélection d'un site, une route acceptable de transport doit exister ou pouvoir être aménagée. La SGDN continue de mener des évaluations techniques pour aider à tracer les routes de transport potentielles.

Nous avons reçu de nombreuses questions sur la sûreté au cours de la dernière année et nous avons lancé plusieurs programmes de travail pour répondre aux préoccupations exprimées par les gens :

- L'**évaluation des risques liés à la sûreté** examine les données nationales et provinciales sur les accidents. L'objectif est de comprendre les causes, les modèles et les tendances qui peuvent être dégagés des données sur les accidents impliquant des marchandises conventionnelles, des marchandises dangereuses et du combustible irradié afin que nous puissions trouver des moyens de prévenir les accidents ou d'en atténuer les conséquences dans notre planification actuelle et future. Ce programme examinera également la sûreté d'un point de vue social;
- L'**examen de la performance des colis de transport** fournit un éclairage sur les principaux éléments de la réglementation encadrant le transport des matières radioactives et sur la façon dont ces éléments permettront de prévenir les conséquences radiologiques des accidents de transport;
- Le **cadre d'intervention d'urgence** décrit les exigences en matière d'intervention d'urgence et les meilleures pratiques de transport du combustible nucléaire irradié.

De plus, de 2023 à 2027, la SGDN :

- Poursuivra la planification du transport en intégrant les valeurs, les principes et les objectifs des citoyens et en accordant une attention particulière à la sûreté d'un point de vue social;
- Entreprendra des études sur la logistique du transport ainsi que des évaluations des risques posés par le transport;
- Cherchera à obtenir auprès de la Commission canadienne de sûreté nucléaire des certificats d'approbation de la conception des colis de transport routier et ferroviaire, selon le cas;
- Examinera et déterminera à des fins de planification les principales exigences relatives à la gestion des urgences et à la sécurité du transport;
- Continuera d'élargir nos activités de concertation pour inclure les municipalités et les collectivités autochtones situées le long des routes potentielles de transport, ainsi que les personnes et les groupes intéressés;
- Tiendra les collectivités canadiennes actuellement hôtes d'installations nucléaires au courant de nos progrès, y compris en ce qui concerne la planification du transport eventuel du combustible nucléaire irradié depuis ces collectivités jusqu'au dépôt géologique en profondeur.

Élaboration d’une Stratégie intégrée canadienne pour les déchets radioactifs

En 2020, le ministre des Ressources naturelles a demandé à la SGDN de diriger l’élaboration d’une Stratégie intégrée pour les déchets radioactifs (SIDR) afin que des approches de gestion à long terme soient trouvées pour tous les déchets radioactifs canadiens.

Une équipe de la SGDN a dirigé l’élaboration de la stratégie, en partie en raison de nos 20 années d’expertise dans la concertation avec les Canadiens et les peuples autochtones sur les plans de gestion à long terme sûre du combustible nucléaire irradié. Ces travaux portaient sur les déchets de faible et moyenne activité pour lesquels aucun plan à long terme n’a été mis en place.

Tous les déchets radioactifs canadiens sont actuellement gérés de manière sûre dans des installations provisoires. Une stratégie intégrée garantira que ces matières continueront à long terme d’être gérées conformément aux meilleures pratiques internationales. S’appuyant sur plusieurs travaux réalisés antérieurement, cette stratégie représente une prochaine étape dans la détermination et la correction des lacunes qui existent dans la planification de la gestion des déchets radioactifs et jette un regard plus loin dans le futur.

Au cours du processus de concertation, nous avons recueilli l’avis de collectivités, des peuples autochtones, de jeunes, de chercheurs universitaires, d’organisations de la société civile et d’experts techniques de partout au Canada afin d’étayer les recommandations pratiques fournies au gouvernement du Canada pour l’établissement d’une stratégie plus exhaustive de gestion des déchets radioactifs.

Après ce processus de concertation intégrant les valeurs et les intérêts du public, une ébauche de stratégie a été publiée au cours de l’été 2022 à des fins de commentaires publics. Cette stratégie a été éclairée par ce que nous ont dit les Canadiens et les peuples autochtones qui ont participé à des sondages ou à l’une des 70 séances de concertation organisées depuis mars 2021. Les Canadiens et les peuples autochtones ont pu faire part de leur point de vue sur le projet de stratégie sur le site Web et par courriel.

Nous examinons actuellement ces points de vue afin d’étayer les recommandations finales sur la SIDR. La stratégie et les recommandations ne seront publiées qu’après la publication par Ressources naturelles Canada (RNCan) de la politique révisée, qui est prévue pour le premier trimestre de 2023, afin de nous assurer que nous respectons bien les nouvelles exigences de cette politique.

Si les recommandations sur la SIDR sont acceptées par RNCan, la SGDN assumera la responsabilité de la planification et de la gestion des déchets de moyenne activité. Nous élaborerions alors un plan détaillé établissant la meilleure façon d’intégrer ce volet, à notre programme actuel, pour la gestion à long terme sûre des déchets de moyenne activité. Nous prévoyons que RNCan prendra cette décision en 2023.

Assurer la gouvernance et la reddition de comptes

La SGDN maintient une structure de gouvernance responsable afin que le public canadien puisse avoir confiance dans la conduite de nos affaires. La gouvernance de la SGDN comprend les organisations membres, le Conseil d'administration et le Conseil consultatif. La SGDN doit se conformer aux exigences de la *Loi sur les déchets de combustible nucléaire* (*LDCN*) et est assujettie à la surveillance du ministre des Ressources naturelles du Canada.

Membres

Ontario Power Generation, la Société d'énergie du Nouveau-Brunswick et Hydro-Québec sont les membres fondateurs de la SGDN. La convention d'affiliation et les règlements généraux définissent les rôles et les responsabilités des membres au regard des objectifs de la *LDCN* et du mandat de mise en oeuvre de la SGDN. La SGDN fait rapport régulièrement à nos sociétés membres.

Conseil d'administration

Le Conseil d'administration est chargé de la surveillance et d'exercer un leadership en ce qui a trait à l'élaboration des orientations stratégiques de la Société. Les membres du Conseil d'administration sont nommés par les sociétés membres. Le Conseil d'administration est actuellement formé de neuf personnes représentant un large éventail de compétences reliées à l'industrie nucléaire et à d'autres domaines, y compris à la culture autochtone et à la gestion financière.

Conseil consultatif

En vertu de la *LDCN*, le Conseil d'administration doit s'adjoindre un Conseil consultatif chargé d'examiner et de commenter les travaux de la SGDN. Le Conseil consultatif se réunit régulièrement avec la haute direction de la SGDN, examinant de près les plans et les activités de la Société et fournissant en continu des conseils et des avis.

L'expertise des membres du Conseil consultatif couvre une vaste gamme de domaines, dont le génie, la concertation avec les collectivités, les affaires publiques, l'environnement, le droit, le développement durable, les relations avec les Autochtones, le savoir autochtone et la recherche axée sur les collectivités. Les membres du Conseil consultatif possèdent de bonnes connaissances dans un éventail de sujets, dont les questions liées à la gestion des déchets nucléaires, et sont expérimentés dans le travail avec les citoyens et les collectivités sur des questions de politiques publiques très variées.

Conseil des détenteurs du savoir autochtone (anciennement le Conseil des aînés et des jeunes)

Le Conseil des détenteurs du savoir autochtone est un organe consultatif indépendant composé d'aînés et de jeunes des Premières Nations et des peuples métis. Il se réunit régulièrement au cours de l'année pour conseiller la SGDN sur la façon d'aligner la mise en oeuvre du projet de la Gestion adaptative progressive sur le savoir autochtone. De plus, ce conseil offre des recommandations à la SGDN sur les mesures qui pourraient contribuer au développement et au maintien de bonnes relations avec les collectivités et organisations des Premières Nations et métisses.

Système intégré de gestion

La SGDN utilise un système intégré de gestion des activités qui soutiennent la gestion à long terme sûre du combustible nucléaire irradié. La SGDN veille à ce que notre système de gestion soit conforme aux normes canadiennes et internationales en matière de qualité, d'environnement, de santé et de sécurité.

Le système de gestion de la SGDN est également conforme à la norme CSA N286-12, *Exigences relatives au système de gestion des installations nucléaires*, qui couvre les installations de déchets nucléaires et s'appuie sur les normes internationales.

Le système intégré de gestion de la SGDN a pour but de garantir que notre organisation s'appuie sur des bases solides pour mener à bien notre mission et mettre en pratique nos valeurs. L'accent mis sur la protection des gens et de l'environnement pour les générations à venir est entièrement conforme au principe de gestion de la norme CSA N286-12 selon lequel la sûreté doit constituer le fondement premier de nos décisions et de nos actions.

Examens indépendants

Conformément aux recommandations du Conseil consultatif, la SGDN continuera de solliciter l'avis et les commentaires d'experts externes sur notre programme technique. Comme le programme continue d'évoluer d'une phase de recherche vers une phase de conception, de fabrication et de démonstration, les examens portent de plus en plus sur des aspects et des éléments précis de la conception. Ces examens permettent de nous assurer du bien-fondé scientifique de notre approche, contribuent à la conception et à la qualité de l'ensemble du programme et aident à accroître la confiance du public dans les plans de mise en oeuvre et le processus décisionnel de la SGDN. Un certain nombre de comités externes ont été créés pour examiner le travail de la SGDN :

- le Forum municipal;
- le Groupe d'examen géoscientifique;
- le Groupe d'examen environnemental;
- le Groupe d'examen pour la sélection d'un site.

En plus de ces groupes officiels de pairs examinateurs, la SGDN a créé en fonction des besoins des groupes consultatifs et des forums communautaires pour recueillir des commentaires, des conseils et des compétences externes pour le projet. Des examens par des pairs sont également souvent appliqués directement aux travaux techniques réalisés par des tiers et gérés comme faisant partie intégrante de ces travaux sous-traités. Un examen indépendant est de plus assuré par la publication régulière de recherches et de résultats techniques dans des revues scientifiques et dans le cadre de conférences.

Présentation de rapports

À la SGDN, nous nous conformons à des normes très rigoureuses pour ce qui est de présenter sur nos activités des rapports qui démontrent la sûreté, l'intégrité, l'excellence, la collaboration, la responsabilité et la transparence que nous exerçons dans la mise en oeuvre du projet. Nous faisons régulièrement état de nos progrès, particulièrement en réponse aux commentaires des Canadiens et des peuples autochtones et à l'évolution de l'environnement.

Nous sommes tenus, en vertu de la *LDCN*, de publier des rapports annuels et triennaux. Chacun de ces rapports doit être présenté en même temps au ministre des Ressources naturelles et au public. Le ministre dépose chaque rapport au Parlement et publie une déclaration à son égard.

Transparence

À la SGDN, nous sommes résolus à faire preuve d'ouverture et de transparence dans nos processus, nos communications et notre processus décisionnel afin que les Canadiens et les peuples autochtones comprennent clairement l'approche que nous mettons en oeuvre. Pour démontrer cet engagement, nous appliquons une *Politique sur la transparence* (2020). Transmettre l'information et encourager l'échange des points de vue sont essentiels à notre mandat et nous veillons à ce que nos pratiques soient conformes à l'esprit de la *Politique sur la réconciliation* (2019) de la SGDN et de tous les textes législatifs portant sur la liberté de l'information, l'accès à l'information et la protection de la vie privée.

Glossaire

Combustible nucléaire irradié : le combustible retiré d'un réacteur à fission nucléaire commercial ou de recherche. Le combustible nucléaire irradié est classé déchet radioactif de haute activité.

Consentement : élément fondamental du processus de sélection d'un site. Depuis le tout début de nos activités, la SGDN a établi un certain nombre de principes relatifs au consentement. Ceux-ci comprennent l'engagement de n'établir le projet que dans une région comprenant des hôtes informés et consentants, d'offrir le temps et les ressources nécessaires pour qu'elles puissent prendre une décision sur le projet en toute connaissance de cause et de faire la démonstration convaincante du consentement de la collectivité.

Au-delà de la démonstration fournie par les collectivités, à la SGDN, nous devons également nous assurer que les autres exigences et engagements énoncés dans le processus de sélection d'un site pourront être remplis avant que le projet ne soit mis en oeuvre dans la région en question.

Dépôt géologique en profondeur : installation pour le stockage à grande profondeur sous terre du combustible nucléaire irradié, où des barrières tant naturelles qu'ouvragées le confinent et l'isolent des gens et de l'environnement pour des générations à venir. Sa conception peut permettre la récupération du combustible nucléaire irradié.

Gestion à long terme du combustible nucléaire irradié : comprend le confinement et l'isolement des substances radioactives. La radioactivité diminue substantiellement avec le temps, principalement en raison de la désintégration des radionucléides à vie courte. La radioactivité du combustible nucléaire irradié diminue jusqu'à environ un pour cent de sa valeur initiale au bout d'un an, à environ 0,1 pour cent au bout de 10 ans et à environ 0,01 pour cent au bout de 100 ans. Après environ un million d'années, la radioactivité du combustible nucléaire irradié est sensiblement équivalente à celle de l'uranium naturel.

Grappe de combustible : utilisée dans les réacteurs nucléaires CANDU, elle est fabriquée en agglomérant de l'oxyde d'uranium pour en faire des pastilles. Les pastilles sont insérées dans des tubes en Zircaloy (un alliage du métal zirconium résistant à la corrosion), lesquels sont soudés les uns aux autres pour former une grappe de combustible. Chaque grappe contient environ 1000 pastilles d'oxyde d'uranium.

Installation facultative de stockage souterrain à faible profondeur : consisterait en la construction d'une installation de stockage au sein d'une caverne rocheuse à faible profondeur sur le site choisi pour le dépôt géologique en profondeur. Cette option n'est pas présentée dans le plan de mise en oeuvre parce que le combustible irradié restera dans les installations d'entreposage provisoire jusqu'à ce que le dépôt soit en service.

Petits réacteurs modulaires (PRM) : ces réacteurs constituent une solution de rechange aux réacteurs nucléaires de grande puissance. Les PRM peuvent être achetés et construits selon une approche modulaire. La SGDN sera responsable de la gestion à long terme du combustible nucléaire irradié créé par toute technologie nouvelle ou émergente qui pourrait être mise en oeuvre au Canada, comme les PRM.

Récupérabilité : la possibilité de retirer le combustible nucléaire irradié de l'endroit où il a été placé. La récupérabilité est un élément important de la Gestion adaptative progressive et a été incorporée au plan à la demande des Canadiens et des peuples autochtones. Elle fait partie d'une approche de gestion des risques qui permettra la prise de mesures correctives si le dépôt ne fonctionne pas comme prévu ou si, un jour, de nouvelles technologies permettant d'améliorer considérablement la sûreté de la gestion à long terme du combustible nucléaire irradié étaient mises au point. Même si le combustible nucléaire irradié sera récupérable dans le cadre du projet, le processus de récupération posera un défi de plus en plus grand à mesure que les conteneurs de combustible nucléaire irradié seront scellés dans les salles de mise en place et que, plusieurs années plus tard, les tunnels et puits d'accès seront remblayés et scellés.

Sûreté : dans ce document, c'est la protection des gens et de l'environnement contre les effets dommageables ou dangereux du combustible nucléaire irradié, maintenant et dans l'avenir.

Note sur la terminologie utilisée : dans ce document, nous employons les termes « autochtone », « Premières Nations » et « métis ». Notre intention est d'honorer et de respecter les peuples, les nations et les collectivités, ainsi que les conceptions ancestrales et contemporaines qu'ils peuvent avoir.

Ce qu’on nous a dit

En mars 2022, la SGDN a publié *Mise en oeuvre de la Gestion adaptative progressive 2022 à 2026* – qui constituait la mise à jour de la version précédente de ce plan quinquennal révisé annuellement. En publiant également notre sondage sur le plan de mise en oeuvre sous forme numérique, nous avons facilité l’examen et les commentaires du public sur le plan canadien, conformément à notre engagement de transparence. Nous avons reçu des commentaires de centaines de personnes des deux régions toujours à l’étude, ainsi que de Canadiens et de peuples autochtones de l’extérieur de ces régions.

Toutefois, ce document et le sondage à son sujet ne constituent qu’un moyen parmi d’autres de recueillir des commentaires pour éclairer nos travaux. La SGDN sollicite également des contributions par le biais d’activités comme les efforts de concertation sur le terrain et en ligne, des comités de liaison communautaire, d’événements éducatifs, de groupes consultatifs, de publications dans des revues évaluées par des pairs, de notre participation à des conférences et de nos rencontres avec des représentants de tous les ordres de gouvernement.

Le sondage offre un instantané de ce que pensent les répondants, nous éclaire sur la confiance qu’ils ont dans notre capacité à mettre en oeuvre le plan canadien et relève les possibilités qui s’offrent à la SGDN. Le sondage a été conçu pour solliciter un vaste éventail de commentaires auprès des personnes intéressées, et il a été diffusé sur les médias sociaux et par le biais d’autres plateformes numériques. Comme le sondage était ouvert à toutes les parties intéressées, les résultats ne doivent pas être considérés comme statistiquement fiables. Ces résultats doivent plutôt être interprétés comme étant qualitatifs et indicatifs de tendances plus larges.

Le nombre total de participants en 2022 a été légèrement supérieur à celui de 2021. Nous avons reçu 757 sondages partiellement et entièrement remplis en 2022, contre 729 en 2021. Cependant, nous avons noté un écart entre les régions quant au taux de réponse, alors que deux fois plus de sondages nous sont parvenus du sud de l’Ontario que du nord-ouest de l’Ontario (191 et 86 respectivement). En réponse à cet écart, nous allons intensifier notre promotion du sondage sur le plan de mise en oeuvre de 2023-27 dans le nord-ouest de l’Ontario en augmentant nos efforts de concertation publique et en ayant recours à des communications numériques ciblées.

Ce type de contribution publique éclaire et guide notre travail et les commentaires reçus nous ont aidés à réviser le présent plan d’année en année. Voici un résumé des propos que nous avons entendus.

Confiance dans la SGDN

Dans l'ensemble, plus de la moitié des répondants ont déclaré avoir « confiance » ou « une grande confiance » dans la SGDN après avoir lu le plan. Les répondants ont déclaré en grande majorité qu'ils trouvaient le plan de la SGDN compréhensible, clair et transparent. En revanche, près d'un tiers des répondants ont trouvé le plan peu clair, trop technique ou incompréhensible.

Dans l'ensemble, les perceptions à l'égard de la SGDN étaient plus favorables dans le sud de l'Ontario que dans le nord-ouest de la province. À la question de savoir s'ils avaient confiance dans le plan canadien, plus de trois quarts des répondants du sud de l'Ontario ont répondu qu'ils avaient confiance en lui, comparativement à un peu plus de la moitié dans le nord-ouest de l'Ontario.

Cet écart régional nous a incité à nous pencher sur la façon dont nous communiquons nos informations aux résidents de chaque région. En 2022, la SGDN a poursuivi nos efforts de communication, en cherchant à diversifier et à élargir nos activités de sensibilisation auprès des Canadiens et des peuples autochtones de tout le pays, et en menant également des activités ciblées de sensibilisation dans les deux dernières régions hôtes potentielles. La SGDN a lancé des campagnes pour fournir des informations factuelles sur les aspects techniques du plan canadien, sur notre engagement d'intendance de l'eau, ainsi que sur les retombées tangibles associées à l'accueil du dépôt.

Dans le cadre de nos efforts continus de communication, nous continuerons de diversifier et d'élargir nos activités de sensibilisation à partir du bureau rénové de la SGDN de la région de la Nation ojibwée de Wabigoon Lake-Ignace et en augmentant le nombre de visiteurs à notre Centre mobile *En savoir plus*, notre unité d'exposition itinérante conçue pour parcourir le pays afin de faire connaître le plan canadien. En 2022, nous avons accru le temps durant lequel notre Centre mobile *En savoir plus* était sur la route pour rendre visite aux collectivités, ainsi que le nombre de visites effectuées, qui se sont élevées à 61, comparativement à 48 en 2021. Nous avons également ouvert de nouveaux bureaux à Dryden et à Teeswater et rénové notre bureau existant de Teeswater pour soutenir les efforts de concertation dans les régions hôtes potentielles.

Réconciliation

Comme les années précédentes, les répondants nous ont dit en majorité qu'ils considéraient la réconciliation comme une priorité et qu'ils souhaitaient que nous communiquions davantage les mesures que nous prenons pour favoriser la réconciliation.

Notre engagement a toujours été de rendre compte publiquement de nos progrès en matière de réconciliation. En 2022, nous avons franchi une étape importante dans notre démarche de réconciliation. Nous avons publié notre premier Rapport sur la réconciliation (2021), qui fournit une évaluation des effets de la *Politique sur la réconciliation* de la SGDN depuis son officialisation en 2019. Les éléments évalués comprenaient la formation obligatoire du personnel sur la réconciliation ainsi que les occasions continues d'apprentissage, les occasions informelles de formation, les systèmes de soutien du personnel et les plans de travail axés sur les collectivités.

Nous sommes résolus à poursuivre notre démarche de réconciliation. La SGDN a été l'une des premières organisations en Amérique du Nord à nous doter d'une politique officielle en matière de réconciliation, alignant ainsi nos efforts sur ceux d'autres entreprises qui se sont engagées à prendre des mesures concrètes pour répondre aux appels à l'action de la Commission de vérité et réconciliation (publiés en 2015). Nous sommes résolus à contribuer à la réconciliation dans toutes nos activités en créant, en collaboration, un avenir commun fondé sur les droits, l'équité et le bien-être.

Cette année encore, nous avons entendu que les peuples autochtones doivent participer aux travaux de mise en oeuvre du plan canadien. Nous savons toutefois que cette participation ne suffira pas à elle seule. Nous devons travailler avec les peuples autochtones, tirer des enseignements du savoir autochtone et appliquer ces enseignements à nos travaux si nous souhaitons réussir la mise en oeuvre du plan de gestion à long terme sûre du combustible nucléaire irradié. Il s'agit là d'engagements sérieux et de valeurs importantes pour notre organisation.

Transport

Plusieurs commentaires exprimaient des préoccupations quant à la sûreté du transport du combustible nucléaire irradié ou la croyance pure et simple que son transport est dangereux. Des répondants, en particulier certains du nord-ouest de l'Ontario, se sont dits inquiets de la possibilité qu'il y ait des collisions routières ou que les infrastructures de transport de la collectivité choisie soient inadéquates.

Le combustible nucléaire irradié devra être acheminé des installations d'entreposage provisoire situées près des sites des réacteurs du pays jusqu'au site du dépôt géologique en profondeur. L'approche du plan canadien en matière de transport fera l'objet d'un examen continu et de rapports publics, le programme de transport devant débuter au cours des années 2040, une fois le dépôt en service.

La SGDN a publié au cours de la dernière année deux documents de planification qui prenaient en compte le large éventail de priorités, de questions et de préoccupations exprimées à ce jour par les Canadiens et les peuples autochtones sur le transport du combustible nucléaire irradié. Le cadre de planification du transport et le *Plan de transport préliminaire* ont été conçus pour clarifier et faire avancer les discussions sur les moyens que nous prendrons pour transporter en toute sûreté le combustible nucléaire irradié.

L'approche de la SGDN en matière de transport continuera de faire l'objet d'un examen continu et de rapports publics. Tous les trois ans, le cadre de planification du transport sera examiné et révisé au besoin. Cette révision tiendra compte de facteurs tels que l'évolution des meilleures pratiques, les nouvelles technologies, l'adaptation permanente et l'amélioration continue.

Sûreté

À la question « Quelles sont pour vous les plus importantes priorités? », la sûreté est demeurée en tête de liste. Elle a été citée par 42 pour cent des répondants au sondage comme leur plus haute priorité, et 32 pour cent l'ont classée comme leur deuxième. La protection des gens et de l'environnement pour les générations à venir est à la base de tout ce que nous faisons et de toutes les décisions que nous prenons dans le cadre de la mise en oeuvre du plan canadien.

Nous vérifions et évaluons constamment notre conception et nos hypothèses. En juin 2022, nous avons publié des rapports *Confiance dans la sûreté* pour chaque site potentiel. Ces rapports sont le fruit de plusieurs années de recherche et de travail sur le terrain. Ils fournissent des renseignements détaillés qui montrent pourquoi nous estimons que les deux régions hôtes potentielles où des collectivités réfléchissent à la possibilité d'accueillir le projet seraient propices à la gestion à long terme sûre du combustible nucléaire irradié.

La levée des restrictions liées à la pandémie cette année a permis à la SGDN de faire revenir les spécialistes dans les collectivités. Lorsque la situation est devenue sûre, nous avons pu avoir des contacts directs avec les résidents et leur donner l'occasion de soulever leurs questions et préoccupations. Nos campagnes et notre personnel nous ont également permis d'aborder davantage les questions liées à la sûreté.

Nous sommes également résolus à faire en sorte que le projet soit sûr d'un point de vue social et culturel. Nous respectons cet engagement en écoutant les commentaires que nous recevons à l'échelle de la société, de la collectivité et personnelle et en adaptant nos travaux en conséquence. C'est également pourquoi tous nos travaux s'appuient sur la sagesse de notre Conseil des détenteurs du savoir autochtone. Ce groupe consultatif indépendant est composé d'aînés et de jeunes Autochtones qui contribuent à façonner le travail de la SGDN en guidant nos efforts visant à l'aligner respectueusement sur le savoir autochtone, en nous ouvrant à de nouvelles perspectives et façons de penser et en aidant notre organisation à cheminer sur la voie de la réconciliation.

Confiance dans l'ingénierie

Cette année, le sondage a montré que la plupart des répondants comprennent le volet ingénierie de la SGDN et ont une opinion favorable à son égard, le classant comme la priorité la mieux comprise. Plus précisément, 86 pour cent des répondants ont dit comprendre cette priorité, et 75 pour cent ont exprimé une opinion favorable ou neutre à son endroit. L'expertise géotechnique de la SGDN, notre approche robuste en matière d'ingénierie et le leadership du Canada dans ce domaine ont été cités dans les commentaires des répondants comme raisons expliquant leur confiance et leurs opinions favorables.

En 2022, la SGDN a réalisé avec succès une démonstration à pleine échelle des barrières ouvragées qui permettront de confiner et d'isoler en toute sûreté le combustible nucléaire irradié canadien dans un dépôt géologique en profondeur. Cette importante réussite sur le plan de la sûreté et de l'ingénierie est l'aboutissement de plus de huit ans de préparation, au cours desquels l'équipe de spécialistes techniques et de partenaires d'ingénierie de la SGDN a entre autres conçu et fabriqué les équipements et composants prototypes spécialisés nécessaires.

Le recours au Canada à un dépôt géologique en profondeur est conforme aux meilleures pratiques en vigueur dans le monde. Cette approche est le fruit de plus de 30 années de recherche-développement-démonstration de diverses technologies et techniques. Les grandes organisations de réglementation et de surveillance nucléaire s'entendent aussi sur le fait que les dépôts géologiques en profondeur constituent la voie responsable à suivre dans ce domaine.

Faites-nous part de vos réflexions

Vos commentaires sont essentiels à la mise en oeuvre du plan canadien de gestion à long terme sûre du combustible nucléaire irradié.

Répondez au sondage sur le plan de mise en oeuvre

Chaque année, nous demandons aux Canadiens et aux peuples autochtones de fournir des commentaires sur le plan de mise en oeuvre afin de contribuer à éclairer et à orienter nos travaux. Nous tenons ensuite compte de ces commentaires lors de notre planification et nous décrivons chaque année dans le plan de mise en oeuvre ce que le public nous a dit l'année précédente. Cette année, nous vous invitons à nous transmettre vos réflexions avant le 9 juin 2023.

Autres moyens de donner votre avis (vous pouvez toujours indiquer que vous souhaitez que votre réponse reste anonyme) :

- Envoyez-nous un courriel à l'adresse learnmore@nwmo.ca
- Envoyez-nous une lettre (comportant votre nom et votre adresse postale) à :

  Lisa Frizzell
  Vice-présidente des communications, SGDN
  Sujet : Plan de mise en oeuvre 2023-27
  22, avenue St. Clair Est, 4e étage
  Toronto (ON) M4T 2S3
  Canada

Pour plus de renseignements, veuillez contacter :

Société de gestion des déchets nucléaires
22, avenue St. Clair Est, 4e étage
Toronto (ON) M4T 2S3, Canada
Tél. : 416.934.9814 Sans frais : 1.866.249.6966
Courriel : contactus@nwmo.ca
Site Web : www.nwmo.ca

@LaSGDN
/company/nwmocanada

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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Implementing Adaptive Phased Management 2023-27

March 2023

Check out the digital version of this implementation plan for more interactive and multimedia content.

nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Land acknowledgment

The Nuclear Waste Management Organization (NWMO) acknowledges that we have worked in many different Indigenous territories since the inception of the organization. We are grateful to the Indigenous and municipal communities that have worked with us over the past 20 years.

We further acknowledge that today we are working in northwestern Ontario in the traditional territory of Wabigoon Lake Ojibway Nation with the community of Wabigoon Lake Ojibway Nation and the Township of Ignace.

In southern Ontario, we are working in the traditional territory of Saugeen Ojibway Nation (SON) with the two SON communities – Chippewas of Nawash Unceded First Nation and Chippewas of Saugeen First Nation – and the Municipality of South Bruce.

We further acknowledge that in both the northwest and the south, we have the privilege of working with other First Nations and organizations, with Métis communities and the Métis Nation of Ontario, and many municipal communities that have all expressed an interest in learning about our work.

As part of our commitment to Reconciliation, we recognize both the historic and current injustices far too many Indigenous communities endure. We pledge to do our part to encourage well-being in communities with which we work.

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Welcome

Welcome to *Implementing Adaptive Phased Management 2023-27*.

This is the five-year strategic plan for the NWMO as we implement Canada's plan for the safe, long-term management of used nuclear fuel.

Vision, mission and values

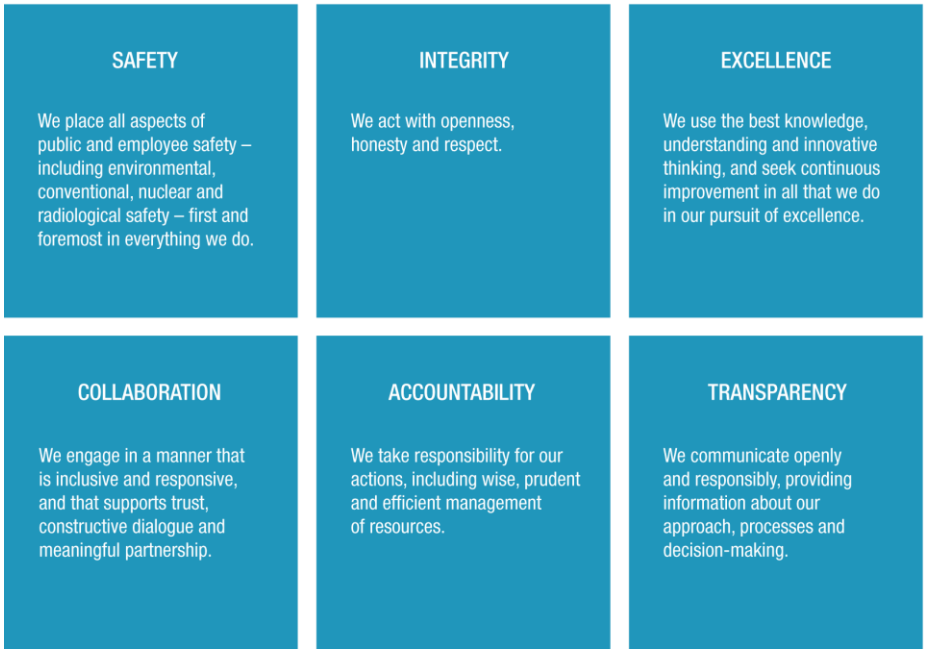
Vision

Our vision is the long-term management of Canada's nuclear waste in a manner that safeguards people and respects the environment, now and in the future.

Mission

The purpose of the NWMO is to develop and implement, collaboratively with Canadians, a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible.

Values



Commitment to transparency

At the NWMO, commitment to transparency is part of our culture. It is entrenched in everything we do.

This annual implementation plan is one way we demonstrate that commitment. This plan is a living document that evolves and grows over time. Each year, we update our plan to reflect progress in our work, input from communities and the public, advances in science and technology, insight from Indigenous Knowledge, evolving societal values and changes in public policy.

We are resilient and focused. We anticipate the ups and downs that accompany advancing Canada's plan for the safe, long-term management of used nuclear fuel, while protecting people and the environment. Canada's plan is designed to be adaptive. In 2022, we adapted.

Once again this year, we took cues from our employees and the communities we work with. Our collaborative work took place virtually and in person. We conducted a range of activities online, from environmental workshops and transportation engagement sessions in potential siting areas, to knowledge-exchange meetings with international counterparts. The lessons we learned will help guide our implementation plan should we face similar challenges in the future.

Our face-to-face time engagement with the communities with which we work continued to be affected in 2022 by provincial lockdowns associated with the COVID-19 pandemic. We have always anticipated the need to adapt over the course of the process, while keeping an eye on the long view. In reviewing progress against last year's version of this annual implementation plan, it became clear we needed to adjust the timing for selecting a preferred site for the deep geological repository. As we announced in August 2022, we now expect to identify a preferred site by fall 2024. This adjustment in timing is not expected to impact the long-term timelines for construction or the start of operations in the early 2040s.

Efforts in the potential siting area communities continue, ensuring Canada's plan respects the unique character of the future repository site. As we have always maintained, the project will only proceed in an area with informed and willing hosts, where the municipality, First Nation and Métis communities, and others in the area are working together to implement it.

In 2022, in collaboration with the potential siting area communities, we released the findings from a series of community studies. These findings cover a wide range of topics, including employment and workforce growth, opportunities for businesses, infrastructure improvements and construction of a Centre of Expertise that will attract world-class academics from around the globe.

We also published the *Confidence in Safety* reports for each potential site, reflecting years of research and fieldwork. These reports summarize why we are confident that a deep geological repository can be safely constructed and operated at either siting area.

The NWMO successfully completed a full-scale demonstration of the engineered barriers that will safely contain and isolate Canada's used nuclear fuel in the repository. We also released our revised transportation planning framework and *Preliminary transportation plan* that are designed to advance conversations and provide more details on how we plan to safely transport used nuclear fuel.

The momentum at the NWMO is palpable and will undoubtedly continue into the next phase of implementing Canada's plan.

Your feedback is essential to the implementation of Canada's plan. Every year, we ask Canadians and Indigenous peoples for their input on our implementation plan to inform and guide our work. We invite you to share your thoughts until June 9, 2023.

Other ways to provide feedback (you may indicate that you wish for your response to remain anonymous):

- Email us at learnmore@nwmo.ca
- Send us a letter (with your name and mailing address) to:

  Lisa Frizzell
  Vice-President of Communications, NWMO
  RE: Implementation Plan 2023-27
  22 St. Clair Avenue East, Fourth Floor
  Toronto, ON M4T 2S3
  Canada

Take the implementation plan survey

Introduction to the NWMO

Canada has been using nuclear energy as a reliable, low-carbon power source for our homes and businesses for nearly 60 years. Now, as worldwide energy demand grows and the need to address climate change intensifies, nuclear power has become an increasingly important part of the conversation. The Nuclear Waste Management Organization (NWMO) plays a vital role by closing the fuel cycle.

We are entrusted with implementing Canada's plan for the safe, long-term management of used nuclear fuel inside a deep geological repository, in a manner that protects people and the environment for generations to come.

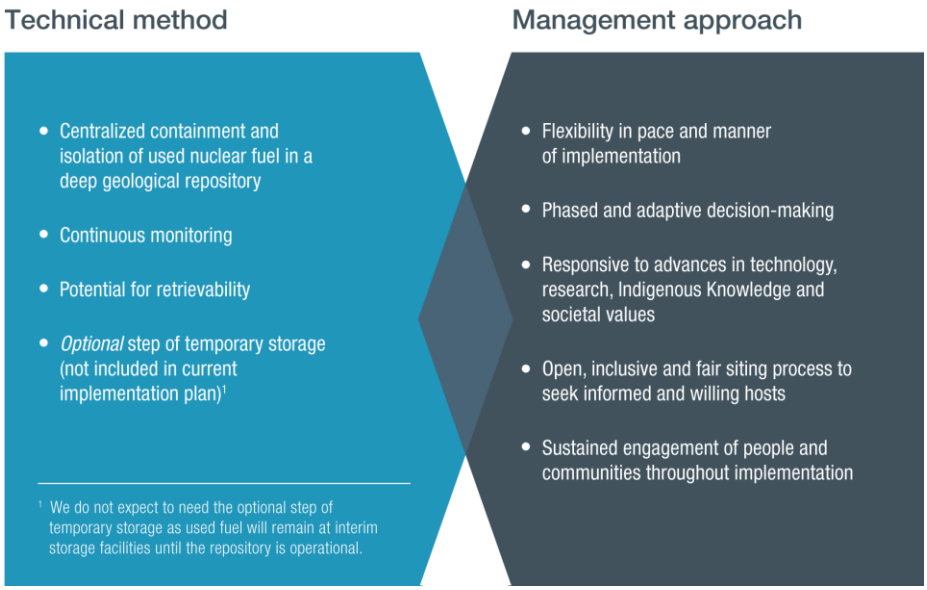
In 2002, the Government of Canada mandated the establishment of the NWMO through the *Nuclear Fuel Waste Act*. Following the "polluter pays" principle, we are an independent, non-profit organization that is funded by the waste owners in Canada: Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited.

Currently, Canada's used nuclear fuel is stored at licensed, above-ground facilities. While this approach is safe, it is temporary and widely recognized as inappropriate over the long term. Canadians and Indigenous peoples have clearly told us they recognize the importance of taking action on a long-term approach today and not leaving used nuclear fuel as a burden for future generations to manage.

Canada's plan for used nuclear fuel, which follows an approach known as Adaptive Phased Management (APM), emerged through a three-year dialogue with Canadians and Indigenous peoples, including specialists and the public. It is based on the values and objectives they identified as important. In 2007, the Government of Canada selected APM as the country's plan for the safe, long-term management of Canada's used nuclear fuel.

A significant milestone is now on the horizon as we expect to select the site for the repository in 2024. Getting to site selection will require building on all the work we have done for the past 20 years. With a project of such complexity and generational scope, we must always stay focused on reaching our upcoming milestones, while also keeping an eye on the long view.

Canada's plan: Adaptive Phased Management (APM)



APM is both a technical method (what we plan to build) and management approach (how we will work with people to get it done). The technical method involves building a deep geological repository in a suitable rock formation to safely contain and isolate used nuclear fuel. The management approach involves phased and adaptive decision-making, supported by public engagement and continuous learning.

A safe and secure transportation system will be developed to transport used nuclear fuel to the repository site from the facilities where it is currently stored on an interim basis.

The project also includes plans for a Centre of Expertise, which will be established at or near the site. Initially, it will support multi-year testing and assessment of the site, with a focus on safety and community well-being. Eventually, it will become a hub for knowledge sharing across Canada and internationally.

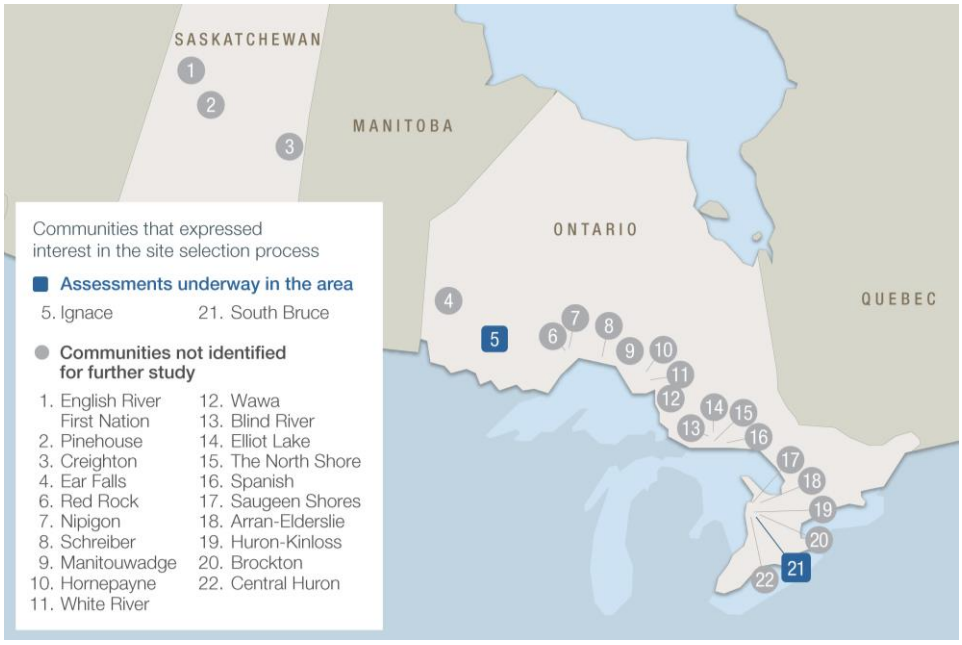
Planning timelines

Great strides were taken in 2022, despite continued unknowns created by the pandemic. The NWMO's work moved forward and adapted. Like all organizations and businesses, several provincial lockdowns associated with the pandemic impacted our work. The lockdowns led to a significant loss of time for the face-to-face interactions that are critical to the engagement process, especially in the communities exploring their potential to host the project. In reviewing our rolling five-year implementation plan and considering the impacts of the pandemic, we made the decision to shift the timing for site selection. Although we decided to adjust the timing for site selection by one year, we remain on track to meet our construction and operations timelines.

Developing Canada's plan	2002	The NWMO is created.
	2005	As required by the *Nuclear Fuel Waste Act*, the NWMO completes ***Choosing a way forward***, a three-year study of the alternatives for the safe, long-term management of Canada's used nuclear fuel. The study involved interested individuals, leading scientists and other experts, Indigenous peoples and the Canadian public.
	2007	Government of Canada selects Adaptive Phased Management (APM) and mandates the NWMO to begin implementation.
Developing the siting process	2008-09	Work takes place with citizens to design a process for selecting a central, preferred site for the deep geological repository and Centre of Expertise.
Identifying a site using the siting process	2010	The siting process is initiated.
	2010-15	Twenty-two communities initially express interest.
		In collaboration with interested communities, the NWMO conducts initial screenings, followed by preliminary assessment desktop studies and community engagement.
		Areas with less potential to meet project requirements are eliminated from further consideration.
	2015-24	The NWMO expands assessment to include field investigations. Areas with less potential are eliminated from further consideration as the narrowing down process continues.
	2022	The Government of Canada reaffirms that a deep geological repository is the best solution for Canada's used nuclear fuel.
	2024	A single, preferred site is identified.
Towards construction	2025	Additional site characterization activities are initiated at selected site.
		The NWMO begins the federal impact assessment process and the Canadian Nuclear Safety Commission's (CNSC) regulatory decision-making process.
		An updated transportation planning framework is issued (updated every three years).
	2028	Impact assessment studies are submitted as part of the regulatory decision-making process.
		The grand opening of the Centre of Expertise is held.
	2030	The impact assessment is approved (estimate).
		The Licence to Prepare Site is granted (estimate).
		The Licence to Construct application is submitted to the CNSC.
	2032	The Licence to Construct is granted (estimate).
	2033	Construction begins.
Beginning operations	2040-45	Operations of the deep geological repository begin.
		Transportation of used nuclear fuel to the repository begins.
Extended monitoring	Post-operations	Decades of monitoring are initiated.

Selecting a site

The NWMO has been engaged in a multi-year, community-driven process to identify a site that will safely contain and isolate Canada's used nuclear fuel in a deep geological repository.



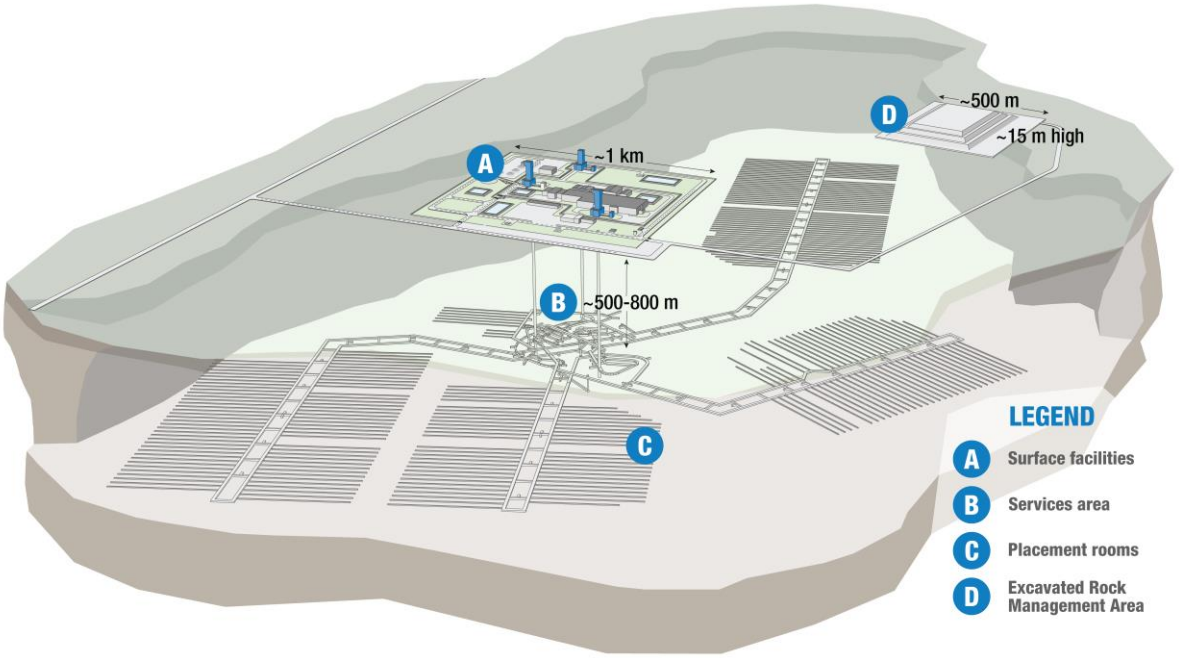
We initiated the site selection process in 2010. Over the following two years, 22 municipalities and Indigenous communities voluntarily expressed interest in learning more and exploring their potential to host the project. We gradually narrowed our focus to two potential sites through extensive social engagement and technical site evaluations to assess the safety of those sites and transportation of used nuclear fuel to them, and the potential to build supportive and resilient partnerships. Both potential sites are in Ontario – one in the Wabigoon Lake Ojibway Nation (WLON)-Ignace area in northwestern Ontario and one in the Saugeen Ojibway Nation (SON)-South Bruce area in southern Ontario.

Throughout 2022, we implemented more detailed technical evaluations at both potential sites and engaged in meaningful discussions with communities around partnerships and community well-being investments.

As we advance the siting process, we maintain the fundamental principle that the project will only proceed in an area with informed and willing hosts, where the municipality, First Nation and Métis communities, and others in the area are working together to implement it.

Learn more about the site selection process.

Key components of the repository



This diagram shows a conceptual layout for the surface facilities, as well as an approximate area of 1,500 acres (600 hectares) for the underground services area and placement rooms in the deep geological repository, at the proposed site with crystalline rock.

This design will continue to evolve as the project progresses and will adapt to changes in technology and future decisions about nuclear power generation that may change the volume or type of fuel to be managed.

For example, in Canada, there is an active research sector exploring new technologies such as small modular reactors (SMRs), fuel reprocessing and other types of advanced reactors. New nuclear technologies may result in different types of used fuel. However, there is international consensus that deep geological repositories represent the best practice for the long-term management of used nuclear fuel resulting from SMRs as well, including any high-level waste from reprocessing.

The repository design is currently sized to account for the existing inventory of used fuel, as well as projected inventories from planned reactor life extensions and refurbishments of operating reactors. Both potential sites have the capability for expansion of the underground to accommodate additional inventory. For more information about how the NWMO will account for the potential for used fuel created by SMRs, please see the section *Keeping abreast of the external landscape and adapting to change*.

The deep geological repository uses a multiple-barrier system designed to safely contain and isolate used nuclear fuel over the very long term. Constructed more than 500 metres below ground, the repository will consist of a network of placement rooms that will store the used nuclear fuel. This approach aligns with international best practices.

At the surface, there will be facilities where the used fuel is received, inspected and repackaged into purpose-built containers encased in a buffer box of bentonite clay before being transferred to the main shaft for underground placement. Work is underway on the design of the repository surface facilities, including the Used Fuel Packaging Plant.

The repository underground will be accessed through three shafts, which will be located within a single centralized and secure services area. This services area will also include an underground demonstration facility for initial testing of the future engineered barrier emplacement equipment. The layout also includes multiple access tunnels that enable the placement rooms to be situated in areas with the most suitable host rock. The buffer boxes, with the used fuel containers inside, will be arranged in the horizontal placement rooms, and any spaces left over will be backfilled with granular bentonite pellets or chips.

In 2022, we successfully completed a full-scale demonstration of the engineered barriers that will safely contain and isolate Canada’s used nuclear fuel in a deep geological repository. This important safety and technical achievement was the culmination of more than eight years of preparation, including the design and fabrication of specialized prototype equipment and components by the NWMO’s team of leading technical specialists and engineering partners.

Work has started on site-specific conceptual designs of the repository layout based on information from geoscience assessments and borehole drilling in the potential siting areas. The NWMO will be completing assessments of site-specific transportation systems and developing the preliminary design of the Used Fuel Transportation System. We will continue to evolve the design of the repository using the site-specific information we obtain from additional site characterization after site selection, with an objective to develop the updated repository design for the construction licence around 2030. The proposed site in the WLON-Ignace area would be located in crystalline rock, while the proposed site in the SON-South Bruce area would be in sedimentary rock.

Learn more about the project.

Centre of Expertise

A Centre of Expertise will be established at or near the repository location, after the site is selected. The specific location will be determined in collaboration with the host communities.

The centre will become a hub for knowledge sharing across Canada and internationally and a focal point for those living in the area to learn about the project through public viewing galleries and interactive displays. The centre may also serve as a hub for sharing Indigenous Knowledge, culture, history and traditions.

The design and use of the centre will be developed collaboratively with those living in the area, including First Nation and Métis communities. In 2022, the NWMO began working with local communities to develop a vision for the centre in a manner that aligns with their requirements and aspirations. This visioning process and continued dialogue around community interests for the facility will continue in both siting regions in the coming years, supporting ongoing dialogue and the unique opportunities the centre could provide.

For the NWMO's needs, the centre will initially be used to support the continued site characterization work related to technical safety, ongoing education and dialogue, and community well-being. It will be home to active technical and social research, as well as technological demonstration programs, with contributions from scientists and other experts in a wide variety of disciplines from both the NWMO and around the world.
An engineering test facility will be located within the Centre of Expertise to continue the development of materials and equipment to be used in the repository, and to support the construction and operation of the facility in the future.

Once both community and the NWMO's requirements are finalized, the project will begin.



This artist rendering shows one possible design for a Centre of Expertise in the Wabigoon Lake Ojibway Nation-Ignace area.



This artist rendering shows one possible design for a Centre of Expertise in the Saugeen Ojibway Nation-South Bruce area.

Reconciliation and Indigenous Knowledge

The NWMO is committed to understanding, honouring and aligning with Indigenous Knowledge in our work. This commitment is reflected in many ways – through oversight by our Indigenous Relations team, advice from the NWMO's Council of Knowledge Holders, Indigenous representation in our organization (including in our executive team and Board of Directors), meaningful policies to guide our work and regular engagement with First Nation and Métis communities. In all areas that we operate, this commitment is an essential part of doing good work and maintaining positive relations.

Over the next five years and into the future, the NWMO will continue to implement our *Reconciliation Policy* (2019), measure progress and align Indigenous Knowledge with our work. Measured annually and reported publicly, this work affirms our commitment to acting on the Truth and Reconciliation Commission's call to action #92, which calls upon the corporate sector to build respectful relationships with Indigenous peoples and provide valuable learning opportunities for staff on the history of Indigenous peoples.

In 2022, the NWMO published our first *Reconciliation Report* (2021), which provides an evaluation of the NWMO's *Reconciliation Policy*'s impacts since its formalization in 2019. Activities tracked have included mandatory staff Reconciliation training or continuous learning opportunities, informal training opportunities, staff support systems and community-driven work plans.

Reconciliation

Reconciliation matters. For Canadians, it ensures that we learn from and address historic and ongoing wrongs, and that we work together to co-create a better future. The NWMO is committed to our Reconciliation journey. As we move forward, we ensure Reconciliation is considered in all our work.

Our *Reconciliation Policy* was released in 2019 as part of establishing a solid foundation for working with Indigenous peoples. In step with our policy, the NWMO continues to engage meaningfully with First Nation, Métis and municipal communities and organizations as we work together to implement Canada's plan.

The NWMO recognizes the truth of the historic wrongs and the challenges we have today and seeks opportunities to co-create a better future. Our policy requires that the NWMO build relationships with First Nation and Métis communities on a foundation of respect for languages and customs, culture and institutions.

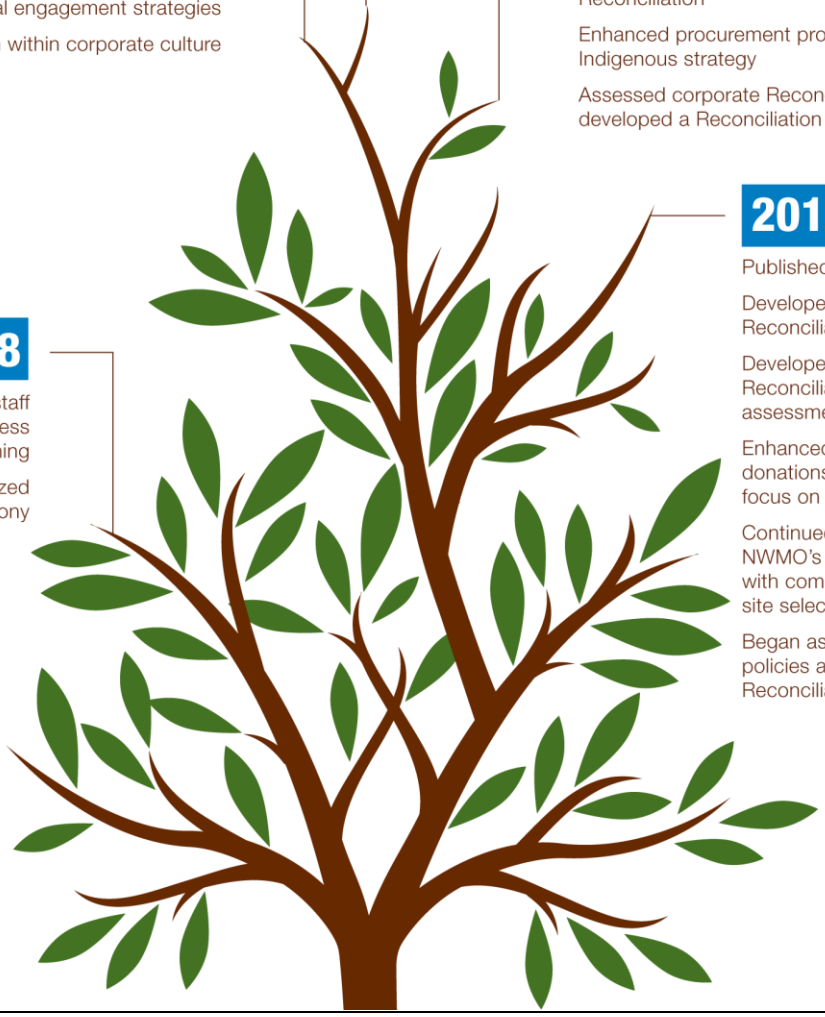
The NWMO's Indigenous Relations team works with Reciprocal Consulting – an Indigenous-owned firm specializing in Indigenous evaluation and monitoring – to publish our annual Reconciliation report. It evaluates the NWMO against the Reconciliation baseline to ensure we are meeting the commitments outlined in the *Reconciliation Policy* (2019). The Reconciliation baseline is used to evaluate our contributions to Reconciliation, identify gaps and determine how we should move forward as an organization. Measuring our progress helps instill Reconciliation as a core value, which is reflected in how we act as an organization.

We continue to apply our Reconciliation assessment tool to key documents. We have completed 18 Reconciliation assessments of the NWMO's policies, as well as applied the tool to both regional engagement strategies and the draft Integrated Strategy for Radioactive Waste. We have also taken the assessment tool outside the organization, using it with some of our partner universities to apply this lens as they expand research programs related to our work.

Cultural awareness training is one way the NWMO supports our learning. To date, more than 80 per cent of the NWMO's staff have completed the first two Reconciliation training modules, which include space for learning circles and Indigenous-led dialogue. Part three of our Reconciliation training program was rolled out in fall 2021, with a focus on historic and contemporary understandings of treaties, as our Reconciliation continuous learning stream continues to evolve. In 2022, we introduced a new Métis awareness training module.

As the NWMO implements the *Reconciliation Policy* (2019), we demonstrate our contribution to this important movement towards change.

NWMO RECONCILIATION STRATEGY



2022

Enhanced Reconciliation Training Program to include learning specific to treaties and Métis peoples

Publicly released the first annual Reconciliation Report

Applied the Reconciliation assessment tool to governance as part of our Integrated Management System transformation

Expanded Reconciliation Training Program to communities and external partners

2021

Continued to enhance Reconciliation Training Program to include unconscious bias training

Included Indigenous Knowledge in water protection plans

Applied the Reconciliation assessment tool to regional engagement strategies

Embedded Reconciliation within corporate culture

2020

Enhanced policies and procedures to address Reconciliation

Enhanced procurement program to include an Indigenous strategy

Assessed corporate Reconciliation baseline and developed a Reconciliation measurement matrix

2019

Published *Reconciliation Policy*

Developed and delivered Reconciliation Training Program

Developed a corporate Reconciliation baseline assessment tool

Enhanced sponsorships and donations program to include a focus on Reconciliation

Continued to communicate the NWMO's Reconciliation program with communities involved in the site selection process

Began assessment of NWMO policies and procedures against Reconciliation assessment tool

2018

85 per cent of NWMO staff received cultural awareness training

Reconciliation Statement finalized through Indigenous ceremony

Indigenous Knowledge

The NWMO's commitment to aligning with Indigenous Knowledge and the important teachings from Indigenous Knowledge Holders guide our work. These teachings include the role and significance of spirit and ceremony, understanding natural laws, respecting Mother Earth and creating space for Indigenous voices.

Internal workshop discussions explore the sacred relationship and stewardship role Indigenous Knowledge Holders have with water and the commonalities that exist within western science perspectives. Participants at these workshops include Indigenous Knowledge Holders, Elders, scientists, industry professionals and NWMO employees. Together, we explore how water is a life force that sustains us, flows between and within us, and shapes the land.

> "Water is a unifying and transformational being that brings us all together. It is also a great teacher, with a voice and a story to tell."
>
> **– Elder Diane Longboat**

It is our duty and responsibility to listen to and learn from water so that we always respect, protect and nurture it. That is why protecting water, people and the environment is so important to us. It is at the core of what we do and a commonality we share with Canadians and Indigenous peoples because we all have a personal relationship with water.

Understanding the water, its quality, its memory and where it is flowing is essential for us to be able to make good decisions as we assess the geology and other environmental features in our potential siting communities, conducting environmental and geological studies.

Through collaboration with Indigenous Knowledge Holders, Elders, scientists, industry professionals, conservation authorities, youth and others, we continue to learn about water and can share our knowledge with one another and others around the world.

Several communities in our site selection process asked us to provide more information about how our work will protect water. Since 2017, we have engaged with communities through our "Journey of water" presentation series. We align with Indigenous Knowledge in these presentations about water, a subject of vital importance to all people. Developed collaboratively with the Council of Knowledge Holders, Wabigoon Lake Ojibway Nation Women's Circle and Indigenous community groups, this series helps tell the story of water and how it interacts with materials proposed to be used in the multiple-barrier system. The NWMO continues to seek opportunities to present these vital teachings in the future.

In the next five years, our commitment will endure, as we seek to align with Indigenous Knowledge in everything we do, creating space to learn from ceremony and applying pertinent learnings to how decisions are made at the NWMO.

Cost and funding

Canadians and Indigenous peoples expect that the money necessary to pay for the long-term management of used nuclear fuel will be available when needed. This expectation is being met.

Consistent with the “polluter pays” principle, Canada’s plan for used nuclear fuel is funded by the waste owners in Canada: Ontario Power Generation (OPG), New Brunswick Power (NBP), Hydro-Québec (HQ) and Atomic Energy of Canada Limited (AECL). The *Nuclear Fuel Waste Act* requires each of these four companies to establish independently managed trust funds and make annual deposits to ensure the money to fund this project will be available when needed.

Each company pays into the trust fund based on the number of fuel bundles it has and continues to create. The amounts cover estimated fixed costs for the NWMO to construct, operate, monitor and decommission a deep geological repository, as well as variable costs associated with managing each fuel bundle. This process is designed to ensure Canada’s plan is funded over the long term.

For more information on trust fund deposits, please refer to the *NWMO Triennial Report 2020-22*. In addition to these trust fund contributions, waste owners are also responsible for funding the NWMO’s annual operating budget.

Total trust fund deposits: Year 2023		
Owner	**Trust fund balance ($ million)**	**Deposit to trust funds (committed and future bundles) ($ million)***
	December 2022	**2023**
OPG	4,404	93
NBP	187	6
HQ	174	0
AECL	72	0.4
Total	**4,837**	**99**

** Annual trust fund deposits are required to be made within 30 days of the submission of the annual report. A deposit date of April 27 is assumed for illustrative purposes.*

The NWMO is responsible for determining what costs can reasonably be expected to arise over the life of the project, along with a contingency for unexpected events. We maintain a system to estimate funding requirements and communicate with waste owners to ensure they provide the required deposits to the trust funds.

Many factors will affect the long-term cost of Canada's plan: the volume of used nuclear fuel to be managed, the location of the facility, the surrounding infrastructure, rock type and characteristics, the design of the repository, and the length of time allocated to monitoring the site following fuel placement. The existing inventory of used nuclear fuel in Canada is approximately 3.2 million bundles, and more bundles are produced each year as nuclear reactors continue to generate electricity. Future decisions about nuclear generation in Canada may change the volume and type of fuel to be managed.

The NWMO regularly updates the lifecycle cost estimate and completed a full update of the cost estimate for the project in 2021. These estimates provide the basis for financial planning and trust fund deposits for future years. For planning purposes, our 2021 cost estimate is based on an expected volume of about 5.5 million fuel bundles, which is the anticipated volume at the end of the planned operation of Canada's existing nuclear reactors. With this expected volume, the total lifecycle cost of the project – from the launch of the site selection process in 2010 to the completion of the project about 175 years later – is approximately $26 billion (in 2020 dollars). This figure covers many decades of lifecycle activity, stretching well into the next century.

Keeping abreast of the external landscape and adapting to change

The NWMO is committed to staying abreast of local, national and international developments that may change the landscape in which we operate or impact the project directly. We continue to monitor advances in the energy sector, innovations in nuclear waste management, changes in energy and environmental policies, potential developments involving new nuclear reactor units, changes in society's expectations, values and insights, and developments with other Canadian nuclear waste initiatives.

A core principle of Adaptive Phased Management is a commitment to adapt plans in response to input obtained through engagement activities. For example, our transportation planning framework and *Preliminary transportation plan* are both based on what we heard from communities and people interested in Canada's plan. Both transportation planning documents were designed to advance conversations and provide more information on how we plan to safely transport used nuclear fuel.

Beginning in 2020, we shared the draft of the framework publicly for broader engagement, and in 2022, we published both documents. We have committed to updating these documents every three years, based on feedback from Canadians and Indigenous peoples, as well as new developments in best practice, technologies, ongoing adaptation and continuous improvement.

We have also adapted our plans for the regulatory decision-making process in response to changes in the *Impact Assessment Act* passed in 2019. More information about the regulatory decision-making plan can be found in the section *Regulatory decision-making process*.

As advancements in small modular reactor (SMR) technology continue to progress in Canada, we have been working with SMR developers to identify the types of used nuclear fuel that may result, as the NWMO will be responsible for managing it. This information will help us optimize how to handle the used nuclear fuel for long-term management, how to handle the potential impacts to the repository design and how our funding formulas can be adapted to include new entrants. It will also help us better inform the potential host communities about the total scope of the project.

The NWMO is currently aware of two SMR projects in the licensing process – Ontario Power Generation is working together with GE-Hitachi Nuclear Energy to deploy an SMR at the Darlington new nuclear site, and Global First Power is working to construct an SMR at Chalk River Laboratories in Ontario. While we are aware of other SMR proposals and as these advance, we will make appropriate changes to our plans. As more SMR projects advance towards licensing, the NWMO will be prepared to adapt and identify any potential efficiencies in managing the used fuel they produce.

There is international consensus that deep geological repositories represent the best practice for the long-term management of used nuclear fuel resulting from SMRs, including any high-level waste from reprocessing. Canada's plan is designed to adapt to changes in technology, and we can build flexibility into repository designs so we can be ready for future decisions.

We further regularly update a watching brief on advanced fuel cycles and alternative waste management technology. We also monitor and report on potential inventories of used nuclear fuel quantities for implications to the repository design.

Planning priorities

At the NWMO, we structure our work plans around seven priorities: engineering, site assessment, safety, mobilization, regulatory decision-making process, partnership and transportation. In this section, we outline our plans within these seven work streams.

Our commitment to Reconciliation and aligning with Indigenous Knowledge guides our efforts in all priority areas.

Over the next five years, we will transition from the site selection process to the regulatory decision-making process. These planning priorities reflect the many activities required during this transitional period.



ENGINEERING

The NWMO will:

- Complete conceptual site-specific facility designs to support regulatory decision-making;
- Initiate preliminary repository design work to complete a future construction licence application; and
- Continue optimization of engineered-barrier system for construction and operations.

The deep geological repository is an internationally recognized approach, based on scientific consensus, for the safe, long-term management of used nuclear fuel. Multiple engineered barriers will be emplaced in a stable rock formation to contain and isolate the used nuclear fuel deep underground.

As we move through the siting process and into the regulatory decision-making process, we will develop site-specific repository designs using data collected through borehole drilling and preliminary environmental baseline investigations. This work will support the site selection decision. Once a site has been selected, we will begin preliminary engineering at the selected site to support the preparation of regulatory submissions and assessments and achieve a future construction licence application.

We will continue to optimize our processes and techniques to enhance confidence in the strength of the engineered-barrier system design. We will also integrate the latest information from our ongoing research and development activities into our designs through interdisciplinary reviews, as part of our Technical Research Review Committee.

In the period from 2023 to 2027, the NWMO will also:

- Maintain a prototype test and demonstration facility for engineered-barrier evaluations;
- Continue to update cost estimate information for the project as required;
- Support the preparation of the initial project description and assessments needed for the regulatory process;
- Begin preliminary engineering for the selected site to support the future construction licence application; and
- Arrange independent peer reviews of specific aspects and features of the repository and engineered-barrier design.

SITE ASSESSMENT

The NWMO will:

- Continue geoscientific investigations and environmental baseline monitoring at both sites; and
- Begin additional geoscientific investigations and baseline data collection at the selected site.

The NWMO anticipates identifying a single, preferred site by fall 2024 and then moving into the regulatory decision-making process in 2025. At this point, initial site assessment activities have been completed with suitable information to inform site selection. After site selection, site characterization will continue at the selected site to support the regulatory decision-making process and inform geoscientific, engineering, environmental and safety assessments work that will be needed to apply for a construction licence.

To ensure we appropriately include Indigenous Knowledge, we seek guidance from local Knowledge Holders to incorporate applicable learnings into our planning and the execution of our studies. Local Indigenous experts ensure Indigenous protocols guide our field activities. To date, these activities have included cultural verification studies of potentially affected areas, including ceremony, and cultural awareness training for staff and contractors working in the field.

Our work with people in interested municipalities, First Nation and Métis communities, and others in the area continues. We encourage consideration of the potential environmental, social, cultural and economic effects of hosting the deep geological repository. Involving people in the broader siting areas ensures a wide range of potential benefits and impacts are considered as we move beyond site selection.

Canada's plan is constantly being adapted to reflect the priorities of siting communities. While our timeline for identifying a site has shifted, the geoscience fieldwork activities have continued in both siting areas.

In the period from 2023 to 2027, the NWMO will also:

- Continue field studies, including additional borehole drilling at the selected site, and consideration of factors identified by Indigenous Knowledge Holders to inform geoscientific, engineering, environmental and safety assessments;
- Continue geoscientific studies to support the process to select a suitable site for hosting the deep geological repository in a safe location;
- Engage communities on specific topics such as safety of people and the environment, project benefits and stewardship of the land; and
- Provide support for regulatory decision-making and initiate additional site characterization studies to confirm the site is technically suitable for hosting the deep geological repository.

SAFETY

The NWMO will:

- Continue development of preliminary site-specific safety assessments;
- Maintain our commitment to considering safety from a social perspective;
- Develop updated safety assessment models for the selected site that will be the basis for the regulatory decision-making process; and
- Continue research to support the safety case and build expertise to support the regulatory decision-making process.

The NWMO is committed to keeping people and the environment safe for generations to come. The safety of the public and our employees comes first in everything we do, including environmental, conventional, nuclear and radiological safety.

As we continue to improve our knowledge of the two potential sites, we share our understanding of safety with communities through presentations, on our digital platforms and by making the NWMO's specialists available.

The deep geological repository will be placed in a rock formation that supports the safe, long-term containment and isolation of used nuclear fuel. Repository performance in this site must be shown to meet or exceed the regulatory expectations of the Canadian Nuclear Safety Commission as part of the future licensing process.

As we look to identify a preferred site by fall 2024, the *Confidence in Safety* reports released in 2022 provide a summary of evidence that a deep geological repository can be constructed at either potential site. After a site with willing and informed hosts is selected, further technical studies will be undertaken at the selected site. These will provide even greater clarity for the repository design and formal safety case that will be submitted to regulators.

The safety of a proposed site will be confirmed through a rigorous regulatory review of the repository design and safety case.

In the period from 2023 to 2027, the NWMO will also:

- Continue to conduct joint research projects with international organizations and counterparts in other countries – including Sweden, Switzerland, Finland, France, Korea, Japan and the United Kingdom – to learn from and contribute to the experience of other countries, while keeping abreast of the state-of-science in geoscience and safety cases for various host rock formations;
- Engage universities in research partnerships that ensure our technical work is scientifically rigorous and develop young engineers and scientists knowledgeable in waste management. This will include continuing to host an annual Geoscience Seminar and an Engineered-Barrier Science Workshop to bring together researchers from academia and industry;
- Increase awareness of the important role of Indigenous Knowledge in our work, in part by offering training and sponsoring workshops on Indigenous Knowledge and western science for our research partners; and
- Continue building a strong safety culture among employees as we prepare for the regulatory decision-making process, by creating and sustaining an environment where employees take proactive responsibility for their safety and that of their colleagues and the public in all activities.

Focus on safety from a social perspective

While the deep geological repository represents an important environmental infrastructure project for Canada, just as core to our work is protecting people. Key to that commitment is our focus on implementing the project in a way that makes people feel safe. The NWMO considers safety as seen from a social perspective at three levels – societal, community and personal.

The NWMO considers safety from a social perspective at the societal level by ensuring we seek broad acceptance for the project. When the NWMO was founded in 2002, we began a three-year study designed to assess possible approaches and alternatives for the safe, long-term management of Canada's used nuclear fuel, so that the public could understand the options and make considered choices.

Face-to-face conversations were held with thousands of individuals and representatives of organizations at local, provincial, national and international levels. These included representatives of Indigenous organizations, nuclear power plant workers, youth, residents of nuclear power plant communities, environmental groups, industry experts, faith communities, government agencies and parliamentarians. Canada's plan emerged from this dialogue and was based on the values and priorities that Canadians and Indigenous peoples identified.

We also engaged the public in order to develop and design our site selection process. Voluntary participation, shared decision-making, openness and fairness formed the basis of that process, which we detailed in our 2010 site selection process and continue to follow today.

Our site selection process has been voluntary from the outset, with 22 communities initially expressing interest in learning more and exploring their potential to host the project. As we have continued to move forward in our site selection process, narrowing down to the two remaining siting areas, safety from a social perspective has been built into the foundation of our engagement efforts and the site selection process.

We have maintained our commitment that Canada's plan will only proceed in an area with informed and willing hosts, where the municipality, First Nation and Métis communities, and others in the area are working together to implement it.

We have also demonstrated our commitment to safety from a social perspective at the community level by aligning with Indigenous Knowledge and working towards Reconciliation (for more information, please see the section *Reconciliation and Indigenous Knowledge*).

To ensure we address safety from a social perspective at the personal level, the NWMO regularly solicits individual feedback on our work through our on-the-ground engagement efforts, social media and public surveys. We listen to communities, residents, community leadership and those expressing a diversity of views about our work. Through this process, we seek to understand and address the concerns people raise.

Since transparency is a core value of our organization, we also publish annually the results of these engagement efforts through a series of “What we heard” reports that summarize the questions and themes we are hearing.

Our ongoing efforts to ensure that the project considers safety from a social perspective include:

- Using the feedback we receive to understand the issues of importance to Canadians and Indigenous peoples, adjusting our work to address those concerns if needed, and highlighting those concerns in our public reporting;
- Actively and willingly participating in public panels featuring different perspectives on the project;
- Using common themes from the feedback we receive to guide the design of the repository and respond to that feedback in our reporting, as we have done on topics such as the importance of protecting water;
- Providing capacity to communities engaged in the site selection process so they can develop their own processes for determining if they are willing to host the project;
- Affirming our commitment to Indigenous communities that a site will not be selected without their consent;
- Following a collaborative approach to developing partnership and hosting agreements;
- Extending our engagement to regional and neighbouring communities, beyond the potential host communities;
- Involving communities in the development of community studies and the discussion of results considering a range of socio-economic factors, to explore the potential for partnership and ensure the project can be implemented in a way that fosters well-being in the area;
- Including communities in participatory environmental monitoring programs;
- Considering realistic lifestyles in our safety assessments – how and where people in the area live;
- Making safety assessment experts available to the public on a drop-in basis in the siting areas; and
- Creating opportunities for our staff to directly engage community members in the siting areas to discuss the safety of the program and learn about concerns they may have.

MOBILIZATION

The NWMO will:

- Implement a human resources strategy, and ensure the information technology security and platforms required for the organization and regulatory decision-making process are available; and
- Begin planning, design and tendering for construction of the Centre of Expertise.

With a project of such complexity and generational scope, we have always anticipated the need to adapt over the course of the process, while also keeping an eye on the long view.

Site selection is a critical milestone, marking the beginning of a new series of activities. After the site is selected, there will be increased activity in the local and regional area. It will also mark the beginning of a multi-phase organizational transformation for the NWMO.

As we look to expand our team, the NWMO will seek to build an equitable, diverse and inclusive workforce, maximize job opportunities in the siting area – the municipality and surrounding region, including First Nation and Métis communities – and develop capacity in communities through investments in training and education.

With site selection drawing closer, we are preparing to move our operations to be based in the location selected for the repository. We are also making plans to increase resources within the region, ensure we have the technology in place to support Canada's plan, and secure land for our facilities, including the Centre of Expertise.

Internally, we are preparing for this increased activity by putting in place the resources needed to undertake continued site characterization, engineering designs, regulatory submissions, and construction and operation of the deep geological repository.

In the period from 2023 to 2027, the NWMO will also:

- Assess resource requirements to advance and support continued site characterization, environmental assessments, engineering designs and safety case development for the selected siting area in support of the licensing application;
- Continue to build a strong local presence in potential siting areas and provide local contracting opportunities for the project;
- Work with communities to understand the housing and infrastructure needs that will be required to support the transition of the NWMO workforce to the selected site;
- Invest in building up the skills and capacity of youth and community members in the municipalities and First Nation and Métis communities engaged in the site selection process, to help them secure jobs related to the plan; and
- Continue to strengthen our corporate culture through appropriate organizational behaviours, standards and tools, including the use of technology platforms. This includes striving for excellence in project management, achieving meaningful partnerships, embracing diversity and inclusion, committing to Reconciliation, and aligning with Indigenous Knowledge and practices in all our work.

The operational readiness plan

To ensure we are ready to move into the next phase of the project, the NWMO is developing an operational readiness plan that will include:

- Developing and implementing the systems, processes and tools required for the next phase of the project, including care and control of the project site in the selected community; and
- Ensuring the NWMO has the project, contract management, and commercial processes and tools to execute large, complex projects and multi-year contracts.

To align with the planning priorities, the NWMO is developing organizational capabilities and competencies for the regulatory decision-making process and preparing for construction. This includes further developing the processes, systems and tools that will be required to implement Canada's plan on time and on budget, including our management system, commercial strategy, business and information technology infrastructure, and information management systems.

The NWMO will also be delivering more complex aspects of the project in the next phase of work, with increased risk for impacts to the cost and schedule. Our ability to manage and report on these projects and contracts will require the right resources to be in place by the time we select a site, so that we can transition effectively into the next phase of work.

In the period from 2023 to 2027, the NWMO will also:

- Continue the transformation of our management system to be consistent with the requirements of CSA N286-12, *Management System Requirements for Nuclear Facilities*, as it applies to our activities;
- Continue to use information technology tools and technology to automate processes, support strategic initiatives, and digitize information, content and records;
- Use artificial intelligence, business intelligence and data analytics to drive operational efficiencies and aid in critical decision-making;
- Develop a commercial strategy for the labour, goods and services necessary for the next phase of work;
- Implement the Project Management Information System to support the execution and monitoring of the NWMO's projects; and
- Apply the project management and commercial strategy governance to our work.

REGULATORY DECISION-MAKING PROCESS

The NWMO will:

- Prepare with community input the submissions to start the regulatory decision-making process; and
- Start the regulatory decision-making process with partner communities.

Protecting people and the environment for generations to come remains at the heart of all our work. As we head towards site selection and beyond, it will become even more important to demonstrate that Canada's plan meets strict regulatory requirements to protect the health, safety and security of people and the environment, while also respecting Canada's international commitments.

We expect to formally notify the regulators that we will be starting the regulatory decision-making process shortly after site selection and target our initial submissions for 2025.

Our site investigations and associated technical studies, in advance of this process and once it is underway, must follow all relevant municipal, provincial and federal requirements. To ensure we achieve this, the NWMO monitors and adapts our activities to all regulatory changes that affect the project. For example, we adapted our plans to conduct studies that are consistent with the *Impact Assessment Act* that came into force in 2019.

We also continue to engage with the Canadian Nuclear Safety Commission (CNSC) in preparation for the eventual submission of a licence application, consistent with the terms of a special project arrangement already in place.

In the period from 2023 to 2027, the NWMO will also:

- Develop impact assessment methodologies in collaboration with municipal and Indigenous siting area communities in preparation for formally launching the regulatory decision-making process;
- Work with communities and others to identify opportunities to enhance our understanding of the current local and regional conditions, including collaboration with Indigenous communities to align Indigenous Knowledge with this understanding as a foundation for the environmental, social, health and economic assessments;
- Building on the work completed on safety from a social perspective up to site selection, continue to work with community members to understand their issues and concerns, and address them in our designs and studies;
- Establish environmental monitoring programs in potential siting areas in close collaboration with community members and Indigenous Knowledge Holders;
- Work with potential host communities to define their role in the regulatory decision-making process and then facilitate their participation;
- Obtain from the Impact Assessment Agency of Canada (IAAC), the CNSC and other regulatory authorities clarity regarding the requirements of the *Impact Assessment Act* and implementation under the act;
- Prepare and submit materials required to initiate the federal impact assessment and CNSC licensing; and
- Begin the integrated impact assessment and licensing process, and prepare the necessary reports after we have received the Site-Specific Impact Assessment Guidelines and Permitting Plan from the IAAC.

The regulatory decision-making plan

Once a site has been selected in 2024, the NWMO will shift our focus to the regulatory decision-making process that will allow construction of the deep geological repository to move forward if approvals are granted.

All regulatory decisions will involve independent review by federal and provincial regulators and an appointed review panel. The process will be open and transparent and involve members of the public who choose to participate.

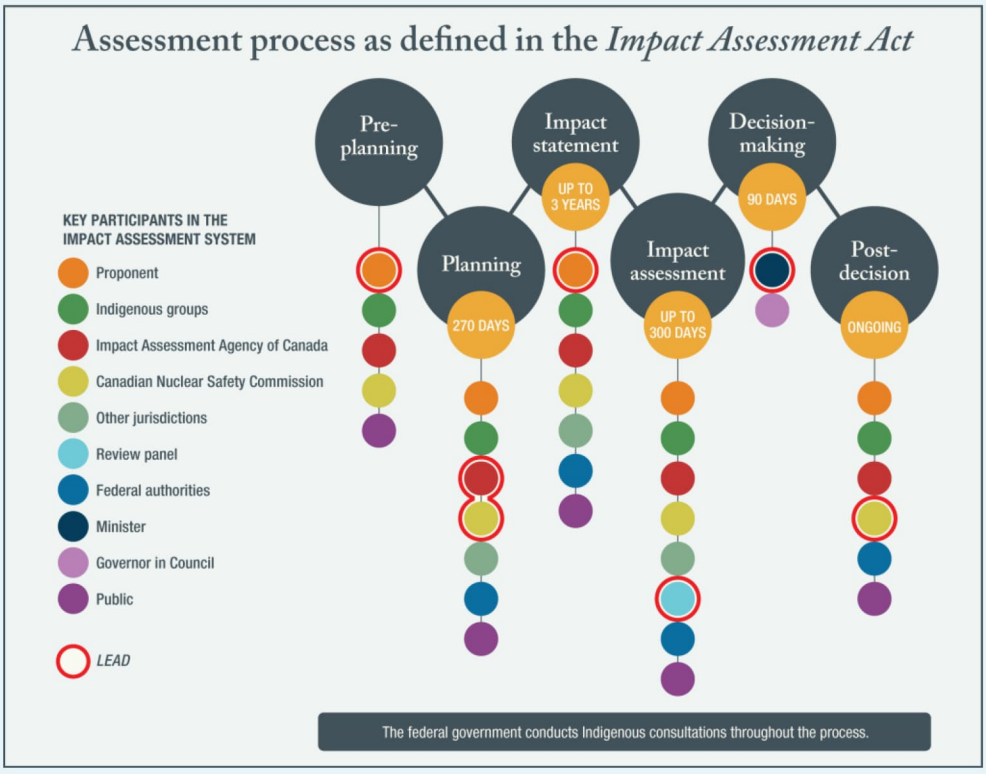
There are two integrated regulatory decision-making processes:

- An impact assessment under the *Impact Assessment Act*; and
- Licensing under the *Nuclear Safety and Control Act*.

Together, these processes will help the federal government assess various aspects of the project, including safety, sustainability, adverse effects, national security and whether it is in the public interest.

The NWMO and host communities for the project will undertake a substantial work program, studying the potential impacts of the project, including cumulative effects, and identifying any necessary mitigations. Overall, our target is to have received the necessary regulatory approvals to transition to site preparation by 2030.

Learn more about the regulatory decision-making process.



PARTNERSHIP

The NWMO will:

- Build supportive and resilient partnerships with communities leading to mutually agreeable partnership agreements; and
- Select the preferred site for the deep geological repository in an area with informed and willing hosts.

The NWMO is committed to supporting community well-being by allocating funding to each potential host community to advance community-led projects. These funds are intended to support the community's continuing efforts to build community sustainability and well-being, to support capacity-building to participate in discussions to explore partnership with the NWMO, and to host the project in the future through the development of transferable skills. Municipalities in the siting process continue to express interest in enhancing relationships with their Indigenous neighbours, which we are working to facilitate through our engagement efforts.

In 2023 and 2024, we will continue to work with municipal and Indigenous communities in each siting area to explore the potential for partnership. We follow a partnership road map outlining a sequence of partnership-building topics to examine alongside the communities.



Starting from the bottom and moving upwards, the road map guides our discussions about partnership with communities.

In Ignace, the conversation around a values and principles exercise continues with the newly elected municipal government, with the potential for additional work to be initiated based on those discussions. In South Bruce, the municipality established 36 guiding principles that reflect the community's priorities and expectations. Each topic in our partnership road map builds on the values and principles the communities identify to guide our discussions, ensuring the project is implemented in a manner that enhances community well-being.

After a site is identified in 2024, our work will shift from building awareness, understanding the potential to support well-being and gaining confidence in the safety of the project, including safety from a social perspective, to implementation and governance of the partnership agreements. Youth engagement will remain a priority, given the intergenerational nature of the project and the need for intergenerational transfer of knowledge to support implementation of the project.

In the period from 2023 to 2027, the NWMO will also:

- Continue engaging municipalities, First Nation and Métis communities in the siting areas, and surrounding communities to build awareness of the project and develop and sustain relationships, taking into account traditional laws, practices and use of land;
- Work with the siting communities to continue to build awareness of the project in the region;
- Engage communities within the siting areas to understand how safety from a social perspective can be supported, including aspects such as community cohesion and well-being;
- Identify other potential partners and build supportive and resilient relationships;
- Ensure communities engaged in the siting process have the resources and information they need to fully participate in siting activities and make an informed decision;
- Develop mutually agreeable hosting agreements in each siting area, and after a site is selected, begin implementing the agreements in the siting area that is continuing into the regulatory decision-making process; and
- Ensure through partnership that communities have sufficient resources to actively participate in the regulatory decision-making process.

TRANSPORTATION

The NWMO will:

- Demonstrate the potential for a socially acceptable transportation plan through dialogue on the transportation planning framework;
- Continue to work with Indigenous peoples to understand how the NWMO can align our transportation planning with Indigenous Knowledge;
- Continue refinement of the Used Fuel Transportation System; and
- Begin implementing the transportation planning framework, which will be updated every three years.

Transportation of used nuclear fuel occurs on a daily basis worldwide. In almost 60 years, there has never been an accident resulting in human or environmental harm as a result of radioactive release.

The NWMO is developing safe, secure and socially acceptable plans for transporting used nuclear fuel from the current interim storage sites to the deep geological repository. However, we recognize the need to explain this good safety track record and answer peoples' questions about how the NWMO will uphold this standard.

In 2021, we released a *Preliminary transportation plan* that describes, conceptually, how the NWMO plans to safely transport used nuclear fuel to the deep geological repository, as well as the transportation planning framework, which describes peoples' values, objectives and priorities associated with the safe transportation of used nuclear fuel.

Transportation planning and evaluations will fully address regulatory requirements for safely transporting used nuclear fuel through different provinces. Site-specific technical and social engagement planning activities will continue after site selection in 2024. We plan to start transporting used fuel to the deep geological repository site in the 2040s, once the repository is operational.

In addition to the technical requirements, social considerations are important to our planning process. We understand that the transportation of used nuclear fuel is an important topic to Canadians and Indigenous peoples, and we are taking a collaborative approach that includes shared decision-making. More specifically, we have designed an iterative approach to transportation planning that will incorporate future generations' inputs into the planning process, acknowledging the importance of seven generations in Indigenous worldview.

The framework will be updated and reissued every three years. As identified earlier, it is our responsibility to ensure that people with a broad range of interests are included in our planning discussions and that we address their questions and concerns.

As part of the site selection process, an acceptable transportation route must have the potential to be developed. The NWMO continues to conduct technical assessments to help define potential routes.

We have heard many questions about safety over the past year and have begun several work programs to address concerns people have expressed:

- **Safety risk assessment** looks at national and provincial accident data. The objective is to understand the causes, patterns and trends associated with conventional, dangerous goods and used fuel accident data so that we can identify ways to prevent and mitigate accidents in our current and future planning. This program will also consider safety from a social perspective;
- **Transportation package performance review** provides insight into key aspects of the regulations governing transport of radioactive materials and how those aspects are designed to prevent radiological consequences of transport accidents; and
- **Emergency Response Framework** outlines emergency response requirements and best practices for transportation of used nuclear fuel.

In the period from 2023 to 2027, the NWMO will also:

- Continue transportation planning that is reflective of citizens' values, principles and objectives, including an emphasis on safety from a social perspective;
- Undertake transportation logistics studies and risk assessments;
- Seek from the Canadian Nuclear Safety Commission design approval certificates for road and rail transport packages as appropriate;
- Research and establish key requirements for emergency management and transportation security for future planning purposes;
- Continue to expand engagement to include municipalities and Indigenous communities along potential transportation routes, as well as interested individuals and groups; and
- Brief Canada's nuclear host communities about our progress, including planning for eventual transportation of used nuclear fuel from their communities to the deep geological repository.

Developing a Canadian Integrated Strategy for Radioactive Waste

In 2020, the NWMO was asked by the Minister of Natural Resources to lead the development of an Integrated Strategy for Radioactive Waste (ISRW) to ensure that all Canada's radioactive waste has long-term management approaches.

A team from the NWMO led the strategy development, in part to leverage our 20 years of recognized expertise in the engagement of Canadians and Indigenous peoples on plans for the safe, long-term management of used nuclear fuel. The focus of this work is on low- and intermediate-level waste for which there are no long-term plans in place.

All Canada's radioactive waste is safely managed today in interim storage. An integrated strategy will ensure these materials continue to be managed in accordance with international best practices over the long term. Building on previous work, this strategy represents a next step to identify and address any gaps in radioactive waste management planning, while looking further into the future.

Through the engagement process, we heard from communities across Canada, Indigenous peoples, youth, academics, civil society organizations and technical experts to help inform practical recommendations to the Government of Canada on a more comprehensive radioactive waste management strategy.

Following the engagement process reflecting on the values and interests of the public, a draft strategy was released in summer 2022 for public comment. This strategy has been informed by what we heard from Canadians and Indigenous peoples who participated in surveys or in one of more than 70 engagement sessions since March 2021. Canadians and Indigenous peoples were able to share their perspectives on the draft strategy via the website and email.

These perspectives are currently being reviewed to further inform the final ISRW recommendations. The strategy and recommendations will only be issued after an updated policy release by Natural Resources Canada (NRCan), which is expected in the first quarter of 2023, to ensure we are consistent with the updated policy.

If the ISRW recommendations are accepted by NRCan, the NWMO would be responsible for the planning and management of intermediate-level waste. We would then develop a detailed plan on how best to integrate this work into our existing program for the safe, long-term management of intermediate-level waste. We are anticipating that NRCan will make this decision in 2023.

Sound governance and accountability

The NWMO maintains an accountable governance structure intended to provide confidence to the Canadian public in the conduct of our work. Our governance structure comprises the member organizations, Board of Directors and Advisory Council. The NWMO is subject to the requirements of the *Nuclear Fuel Waste Act* (*NFWA*) and oversight by the Minister of Natural Resources.

Members

Ontario Power Generation, New Brunswick Power Corporation and Hydro-Québec are the founding members of the NWMO. The Membership Agreement and bylaws set out member roles and responsibilities in supporting the objectives of the *NFWA* and the NWMO's implementation mandate. The NWMO regularly briefs our member organizations.

Board of Directors

The Board of Directors is responsible for oversight and taking a leadership role in developing the corporation's strategic direction. The member organizations elect the Board of Directors. There are currently nine directors on the Board, representing a range of perspectives from both within and outside the nuclear industry, including capabilities in Indigenous culture and financial management.

Advisory Council

The *NFWA* requires that the Board of Directors appoint an Advisory Council to review and comment on the NWMO's work. The council meets regularly with the NWMO's senior management, closely following the organization's plans and activities, and providing ongoing counsel and advice.

Advisory Council members represent a broad range of expertise, including engineering, community engagement, public affairs, environment, law, sustainable development, Indigenous relations, Indigenous Knowledge and community-based research. Members of the council are knowledgeable in a range of topics, including nuclear waste management issues, and experienced in working with citizens and communities on a range of public policy issues.

Council of Knowledge Holders (formerly the Council of Elders and Youth)

The Council of Knowledge Holders is an independent advisory body made up of First Nation and Métis Elders and youth. It meets regularly throughout the year and provides counsel to the NWMO on how to align with Indigenous Knowledge in implementing the Adaptive Phased Management project. Additionally, the council provides advice on issues that could enhance the development and maintenance of good relations with First Nation and Métis communities and organizations.

Integrated management system

The NWMO uses an integrated management system for activities supporting the safe, long-term management of used nuclear fuel. The NWMO maintains our management system to be compliant with Canadian and international standards for quality, environment, and health and safety.

The NWMO management system also satisfies the CSA N286-12, *Management System Requirements for Nuclear Facilities*, which includes nuclear waste facilities and builds on international standards.

The NWMO's integrated management system ensures the organization has a strong foundation for implementing our mission and values. The focus on protecting people and the environment for generations to come fully aligns with the CSA N286-12 management principle that safety is the paramount consideration guiding our decisions and actions.

Independent reviews

Consistent with recommendations from our Advisory Council, the NWMO will continue to seek external expert review of and comment on our technical program. As the program continues to move from research into design, fabrication and demonstration, the reviews are increasingly focused on specific design aspects and features. These reviews ensure the science is sound, contribute to the design and overall program quality, and help enhance public confidence in the NWMO's implementation plan and decision-making. A number of external committees have been established to review the NWMO's work:

- Municipal Forum;
- Geoscience Review Group;
- Environmental Review Group; and
- Site Selection Review Group.

In addition to these formal peer-review groups, the NWMO has also created advisory groups and community forums on an as-needed basis to receive external input, guidance and expertise for the project. Peer review is also often incorporated directly in third-party technical work scopes and managed as part of the contracted work. Independent review is further achieved by regularly publishing technical research and results in scientific journals and at conferences.

Reporting

The NWMO maintains high standards for reporting to demonstrate safety, integrity, excellence, collaboration, accountability and transparency in the implementation of the project. We report regularly on our progress, especially in response to the advice of Canadians and Indigenous peoples, and the evolving environment.

The *NFWA* requires us to issue annual and triennial reports. In each case, reports must be submitted to the Minister of Natural Resources and to the public at the same time. The minister tables each report in Parliament and issues a statement on it.

Transparency

The NWMO is committed to being open and transparent in our processes, communications and decision-making, so that the approach we are implementing is clear to Canadians and Indigenous peoples. To demonstrate this commitment, we maintain a *Transparency Policy* (2020). Sharing information and encouraging an exchange of perspectives are fundamental to our mandate, and we strive to ensure our practices are aligned with the spirit of the NWMO *Reconciliation Policy* (2019), as well as all relevant freedom of information, access to information and privacy legislation.

Glossary

Deep geological repository is a facility for the placement of used nuclear fuel deep underground where both natural and engineered barriers contain and isolate it from people and the environment for generations to come. There is the potential for retrieving the used nuclear fuel.

Fuel bundle for CANDU nuclear reactors is manufactured by sintering uranium oxide powder into pellets. The pellets are loaded into Zircaloy (a corrosion-resistant alloy of the metal zirconium) tubes, which are then welded into a bundle of tubes – a fuel bundle. Each bundle contains about 1,000 uranium oxide pellets.

Long-term management of used nuclear fuel involves containment and isolation of the radioactive material. The radioactivity decreases substantially with time, due primarily to the decay of short-lived radionuclides. The radioactivity of used nuclear fuel decreases to about one per cent of its initial value after one year, decreases to about 0.1 per cent after 10 years, and decreases to about 0.01 per cent after 100 years. After approximately one million years, the radioactivity in used nuclear fuel approaches that of natural uranium.

Optional shallow underground storage facility would involve building a shallow rock cavern storage facility at the chosen site for the deep geological repository. This is not included in the implementation plan as used fuel will remain at interim storage facilities until the repository is operational.

Retrievability is the ability to remove the used nuclear fuel from where it has been placed. Retrievability is an important component of Adaptive Phased Management and was included on the direction of Canadians and Indigenous peoples. It is part of a risk management approach to allow corrective action to be taken if the repository does not perform as expected, or if new technologies emerge in the future that could significantly improve the safety of used nuclear fuel long-term management. While used nuclear fuel will be retrievable as part of the project, the process will become progressively more demanding as the used nuclear fuel containers are sealed in the placement rooms, and then years later when access tunnels and shafts are eventually backfilled and sealed.

Safety in this report refers to the protection of people and the environment from the harmful or dangerous effects of used nuclear fuel, now and in the future.

Small modular reactors (SMRs) provide an alternative to large-scale nuclear reactors. SMRs can be purchased and constructed in a modular way. The NWMO would be responsible for the long-term management of used nuclear fuel created through new or emerging technology such as SMRs, if it is implemented in Canada.

Used nuclear fuel is the irradiated fuel removed from a commercial or research nuclear fission reactor. Used nuclear fuel is classified as a high-level radioactive waste.

Willingness is fundamental to the siting process. From the very beginning, the NWMO outlined a number of principles regarding willingness. These include a commitment to only site the project in an area with informed and willing hosts, time and resources for communities to learn about the project before making a decision, and a compelling demonstration of community willingness.

Beyond the demonstration from the communities, the NWMO also needs to ensure the other requirements and commitments outlined in the siting process can be met in order to implement the project in an area.

Note about terminology: In this document, we use the terms Indigenous, First Nation and Métis. Our intention in the writing is to honour and respect peoples, nations and communities, as well as historical and contemporary understandings.

What we heard

In March 2022, the NWMO published *Implementing Adaptive Phased Management 2022 to 2026*, updating the previous five-year version of this annually updated plan. By also publishing our survey about the implementation plan digitally, we have made it easier for the public to review and comment on Canada's plan, supporting our commitment to transparency. We heard from hundreds of individuals from the two remaining siting areas, as well as Canadians and Indigenous peoples living outside those areas.

However, this document and the survey about it is only one way that we gather input that informs our work. The NWMO also solicits feedback through activities such as on-the-ground and digital engagement efforts, community liaison committees, educational events, advisory groups, publishing in peer-reviewed journals, attending conferences and meeting with all levels of government representatives.

The survey offers a snapshot of respondents' thinking and provides insight into confidence in our ability to implement Canada's plan, as well as identifying areas of opportunity for the NWMO. The survey was designed to solicit broad feedback from interested individuals, and it was disseminated through social media and other digital channels. As the survey was open to all interested parties, the results should not be viewed as statistically reliable. Instead, these results should be interpreted as qualitative and indicative of broader trends.

Overall participation numbers in 2022 were slightly greater than in 2021. We received 757 partial and completed surveys in 2022, versus 729 partial and completed surveys in 2021. However, we noted an imbalance in responses across regions, with more than twice as many responses coming from southern Ontario than northwestern Ontario (191 and 86 respectively). In response to this imbalance, we will step up efforts to promote the survey for the 2023-27 implementation plan in northwestern Ontario, by increasing public engagement on its promotion and using targeted digital communications.

This type of public input informs and guides our work, and comments received have helped us update this plan year after year. This is a summary of what we heard.

Confidence in the NWMO

Overall, more than half of respondents said they were “confident” or “very confident” in the NWMO after reading the plan. A strong majority said they found the NWMO plan understandable, clear and transparent. On the other hand, less than a third of respondents found the plan unclear, too technical or not understandable.

Overall, perceptions of the NWMO were more positive in southern Ontario than in northwestern Ontario. On the question of whether they had confidence in Canada’s plan, more than three-quarters of respondents in southern Ontario said they were confident, compared to just over half in northwestern Ontario.

This regional difference prompted the NWMO to consider how we are communicating with people living in each area. In 2022, the NWMO continued ongoing communications efforts, as we sought to diversify and extend our outreach to Canadians and Indigenous peoples across the country, and also targeted outreach within the two remaining potential siting regions. The NWMO launched campaigns to share fact-based information regarding the technical aspects of Canada’s plan, our commitment to water stewardship, as well as the tangible benefits associated with hosting the repository.

As part of our ongoing communications efforts, we will continue to diversify and extend our outreach through the revamped NWMO office in the Wabigoon Lake Ojibway Nation-Ignace area and more visits from our Mobile Learn More Centre, our rolling exhibit designed to travel across the country to share Canada’s plan. In 2022, we increased both the length of time our Mobile Learn More Centre was on the road visiting communities and the number of stops we made, with a total of 61 events compared to 48 in 2021. We also opened new offices in Dryden and Teeswater and renovated our existing Teeswater office to support engagement efforts in the siting areas.

Reconciliation

As in years past, the majority of respondents told us they share Reconciliation as a priority, and they want us to communicate more about the steps in our Reconciliation journey.

Our commitment has always been to publicly report our progress on Reconciliation. In 2022, we reached an important milestone in our ongoing Reconciliation journey. Our first Reconciliation Report (2021) was published, providing an evaluation of the NWMO's *Reconciliation Policy*'s impacts since its formalization in 2019. Activities tracked have included mandatory staff Reconciliation training and continuous learning opportunities, informal training opportunities, staff support systems and community-driven work plans.

We are committed to an ongoing Reconciliation journey. The NWMO was one of the first North American organizations with a formal Reconciliation policy, aligning with other corporations that are dedicated to taking concrete action in terms of meeting the Truth and Reconciliation Commission's calls to action (released in 2015). We are committed to contribute to Reconciliation in all our work by co-creating a shared future built on rights, equity and well-being.

Again this year, we heard Indigenous peoples must be engaged in the work we are doing to implement Canada's plan. We know, however, engagement is not enough. Working with Indigenous peoples, learning from Indigenous Knowledge and applying learnings to our work are critical to successfully implementing the safe, long-term management of used nuclear fuel. These are serious commitments and important values in our organization.

Transportation

Several comments expressed concern about the safety of transporting used nuclear fuel or the outright belief that transportation is dangerous. Some respondents, particularly those in northwestern Ontario, said they were worried about the possibility of traffic collisions and inadequate transportation infrastructure in the community selected.

Used nuclear fuel will need to be moved from interim storage facilities near reactor sites across Canada to the deep geological repository site. The transportation approach of Canada's plan will be subject to ongoing review and public reporting, with the transportation program expected to begin in the 2040s, once the repository is operational.

The NWMO released two planning documents in the last year addressing the wide range of priorities, questions and concerns heard to date from Canadians and Indigenous peoples about the transportation of used nuclear fuel. The transportation planning framework and the Preliminary transportation plan were designed to give clarity and advance conversations about how we plan to safely transport used nuclear fuel.

The NWMO's transportation approach will continue to undergo review and public reporting. Every three years, the transportation planning framework will be reviewed and revised as necessary. This will take into consideration factors such as evolving best practice, new technologies, ongoing adaptation and continuous improvement.

Safety

When asked “what priorities are most important to you?”, safety remained in the top spot. It was identified by 42 per cent of survey respondents as their most important priority, with a further 32 per cent ranking it as their second highest. Protecting people and the environment for generations to come underscores everything we do and every decision we make as we work to implement Canada’s plan.

We are constantly testing and evaluating our design and assumptions. In June 2022, we published the *Confidence in Safety* reports for each potential site. These reports reflect years of research and fieldwork. They provide detailed results that show why we are confident that both siting areas, where communities are considering hosting the project, are suitable for the safe, long-term management of used nuclear fuel.

The lifting of pandemic restrictions this year allowed the NWMO to get specialists back into communities. When it was safe to do so, we were able to engage directly with residents, giving them an opportunity to address questions and concerns. Through our campaigns and our people, we also increased our communications around safety-related topics.

We are also committed to ensuring the project is safe from a social and cultural perspective. We support this commitment by listening to the feedback we receive at the societal, community and personal levels and adjusting our work accordingly. That is also why all our work is supported by the wisdom of our Council of Knowledge Holders. This independent advisory body is comprised of Indigenous Elders and youth that help shape the NWMO’s work by guiding us on how to respectfully align with Indigenous Knowledge, inspiring new outlooks and perspectives, and helping our organization walk a path towards Reconciliation.

Trust in engineering

This year's survey showed most respondents understand and feel positive about the NWMO's engineering, ranking it as the highest understood priority. Specifically, 86 per cent of respondents said they understand this priority, and 75 per cent expressed a positive or neutral sentiment about it. The NWMO's geotechnical expertise and robust engineering approach and Canada's engineering leadership were cited in respondents' comments as some of the reasons for their confidence and positive sentiments.

As of 2022, the NWMO has successfully completed the full-scale demonstration of the engineered barriers that will safely contain and isolate Canada's used nuclear fuel in a deep geological repository. This important safety and technical achievement was the culmination of more than eight years of preparation, including the design and fabrication of specialized prototype equipment and components by the NWMO's team of leading technical specialists and engineering partners.

Canada's use of a deep geological repository is consistent with international best practice. This approach is the culmination of more than 30 years of research, development and demonstration of technologies and techniques. There is also consensus among major nuclear regulatory and monitoring organizations that deep geological repositories are the responsible way forward.

Share your thoughts

Your feedback is essential to the implementation of Canada's plan for the safe, long-term management of used nuclear fuel.

Take the implementation plan survey

Every year, we ask Canadians and Indigenous peoples for their input on our implementation plan to inform and guide our work. We then take that feedback into account in our planning activities, and in each year's implementation plan, we report on what we heard from the public about the previous year's plan. We invite you to share your thoughts until June 9, 2023.

Other ways to provide feedback (you may indicate that you wish for your response to remain anonymous):

- Email us at learnmore@nwmo.ca
- Send us a letter (with your name and mailing address) to:

  Lisa Frizzell
  Vice-President of Communications, NWMO
  RE: Implementation Plan 2023-27
  22 St. Clair Avenue East, Fourth Floor
  Toronto, ON M4T 2S3
  Canada

For more information, please contact:

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NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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Le transport sûr et sécuritaire du combustible nucléaire irradié canadien

MAI 2015

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Le transport sûr et sécuritaire du combustible nucléaire irradié canadien

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Points saillants

LE TRANSPORT SÛR ET SÉCURITAIRE DU COMBUSTIBLE NUCLÉAIRE IRRADIÉ EST UNE PRIORITÉ

Le système de transport est un élément important du plan canadien de gestion à long terme du combustible nucléaire irradié. Pour qu'un site potentiel puisse être considéré techniquement propice à l'accueil du dépôt pour combustible irradié canadien, il doit être accessible par des routes sûres et sécuritaires pour le transport du combustible nucléaire irradié depuis les installations provisoires d'entreposage au Canada.

LE TRANSPORT EST ENCADRÉ PAR UNE RÉGLEMENTATION ET UNE SURVEILLANCE RIGOUREUSES

Des exigences réglementaires strictes doivent être satisfaites avant que le combustible nucléaire irradié puisse être transporté. Le transport du combustible nucléaire irradié est réglementé par la Commission canadienne de sûreté nucléaire et par Transports Canada. Les expéditions de combustible nucléaire irradié répondront aux exigences de l'Agence internationale de l'énergie atomique en matière de garanties de sécurité. Les opérations de transport répondront aux exigences juridiques fédérales, provinciales et locales en matière de sûreté et feront l'objet d'inspections de conformité. La Société de gestion des déchets nucléaires (SGDN) devra démontrer auprès des autorités de réglementation la sûreté et la sécurité du système de transport avant que l'expédition de combustible irradié puisse commencer.

LES PLANS DE TRANSPORT SERONT CONÇUS EN TENANT COMPTE DE L'INTÉRÊT DES CITOYENS

Dans le cadre du processus de sélection d'un site pour le dépôt de combustible nucléaire irradié, la SGDN déterminera les modes de transport préférables ainsi que les itinéraires potentiels associés à chaque site considéré pour l'établissement du dépôt. Les décisions concernant les routes et modes de transport appropriés nécessiteront la participation et l'avis dans le processus de planification de tous les groupes potentiellement touchés par le transport futur et qui veulent voir leurs questions ou préoccupations prises en compte au cours du processus.

LE BILAN INTERNATIONAL DE SÛRETÉ DU TRANSPORT DU COMBUSTIBLE NUCLÉAIRE IRRADIÉ EST TRÈS SOLIDE

Le transport des substances radioactives est une pratique bien établie. Au cours des 50 dernières années, plus de 20 000 expéditions de combustible nucléaire irradié ont été effectuées dans le monde, par camion, par train et par bateau. Le Canada a démontré et continue de démontrer sa capacité à transporter de manière sûre du combustible irradié, ayant effectué des centaines d'expéditions depuis les années 60. Au Canada ou ailleurs dans le monde, on n'a signalé aucune blessure grave, aucune incidence sur la santé, aucun décès ou aucune incidence environnementale attribuable à la nature radiologique des expéditions du combustible nucléaire irradié.

1 Introduction

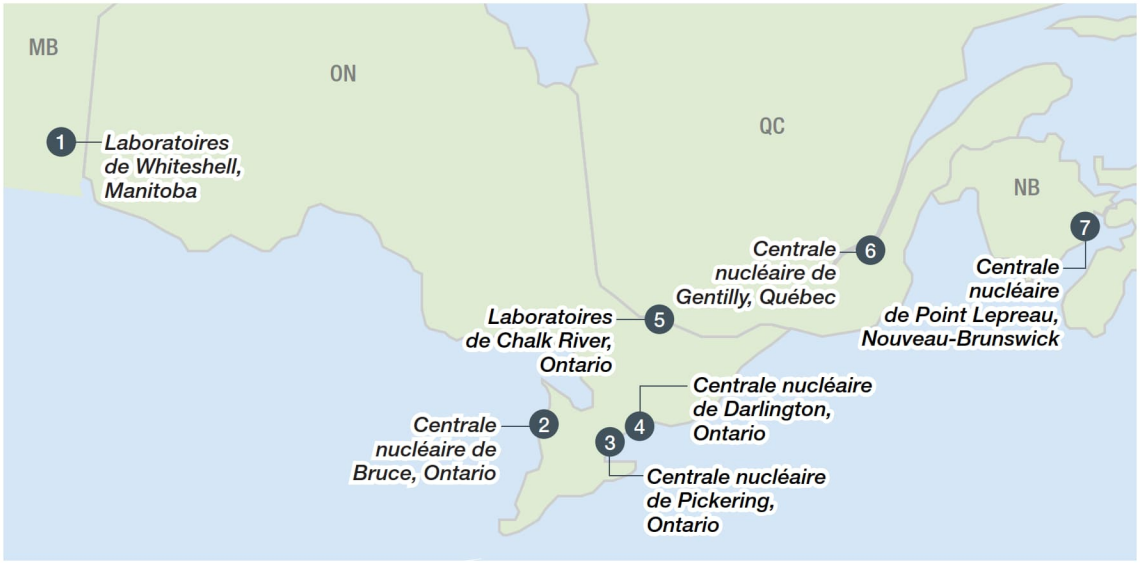
Cette brochure fournit un aperçu des activités de transport associées au plan canadien de gestion du combustible nucléaire irradié généré par la production d'électricité.

La Société de gestion des déchets nucléaires (SGDN) a été mise sur pied en 2002 par les producteurs canadiens d'énergie nucléaire, conformément à la *Loi sur les déchets de combustible nucléaire* (*LDCN*). Elle a pour mandat d'élaborer et de mettre en oeuvre, de concert avec le public canadien, une méthode de gestion à long terme du combustible nucléaire irradié canadien, qui soit socialement acceptable, techniquement sûre, écologiquement responsable et économiquement viable.

La *LDCN* exige que les producteurs de déchets de combustible nucléaire établissent des fonds en fiducie pour financer la gestion à long terme du combustible nucléaire irradié. Conformément à cette loi, Ontario Power Generation, Hydro-Québec, Énergie Nouveau-Brunswick et Énergie atomique du Canada limitée (ÉACL) ont institué des fonds en fiducie en 2002 et ont commencé à y verser des contributions annuelles. Ces fonds seront utilisés pour financer tous les volets du plan canadien, y compris le transport du combustible nucléaire irradié.

Le combustible nucléaire irradié canadien est actuellement provisoirement entreposé de manière sûre dans des installations autorisées qui se trouvent sur les sites des réacteurs nucléaires, en Ontario, au Québec et au Nouveau-Brunswick, et sur les sites des installations de recherche nucléaire d'ÉACL, en Ontario et au Manitoba.

La SGDN est chargée de concevoir et de mettre en oeuvre un système de transport qui permettra d'acheminer de manière sûre et sécuritaire le combustible nucléaire irradié depuis les sites provisoires d'entreposage actuels jusqu'à un dépôt géologique en profondeur centralisé.



Les sept sites nucléaires du Canada

2 Travailler ensemble à la planification du transport sûr du combustible nucléaire irradié

La gestion à long terme du combustible nucléaire irradié est une responsabilité que nous partageons tous. Le plan canadien de gestion à long terme du combustible nucléaire irradié prévoit le transport du combustible irradié depuis les installations actuelles d'entreposage jusqu'à un site centralisé. Les plans de transport du combustible nucléaire irradié doivent garantir la protection de la population et de l'environnement en tout temps. Le programme de transport de la Société de gestion des déchets nucléaires (SGDN) comprend des volets techniques, lesquels sont assujettis à des exigences réglementaires, ainsi qu'un volet d'activités d'engagement du public, qui sert à comprendre et à aborder les priorités, les questions et les préoccupations du public. Nous vous invitons à participer.

Le site du dépôt géologique en profondeur n'a pas encore été choisi et le transport du combustible irradié ne commencera pas avant plusieurs décennies. Malgré cela, des conversations sur la façon dont nous devrions planifier le transport du combustible irradié ont débuté. Afin d'amorcer cette conversation, nous avons préparé ce document pour :

- Vous fournir des informations concernant le transport sûr et sécuritaire du combustible nucléaire irradié au Canada;
- Répondre à des questions que nous avons entendu se rapportant au transport futur du combustible nucléaire irradié prévu dans le plan canadien;
- Vous inciter à participer à la conversation.

Joignez-vous à nous à une de nos journées portes ouvertes ou à un de nos ateliers près de chez vous, venez discuter avec des spécialistes de la SGDN à un bureau local de la SGDN de votre région ou consultez le site Web de la SGDN pour en apprendre davantage ou nous exprimer votre point de vue.







3 Qu’est-ce que le plan canadien?

Le plan canadien de gestion à long terme du combustible nucléaire irradié s’appelle la Gestion adaptative progressive (GAP). Ce plan est le résultat d’un dialogue mené pendant trois ans avec les Canadiens, de 2002 à 2005, et traduit les meilleures pratiques internationales et les aspects considérés importants par les citoyens. Le gouvernement fédéral a fait de la GAP le plan canadien en juin 2007.

Le premier objectif de la Société de gestion des déchets nucléaires (SGDN) est la sûreté – afin de protéger la population et l’environnement contre le combustible nucléaire irradié hautement radioactif. Le combustible irradié devra être confiné et isolé de la population et de l'environnement pour une période essentiellement indéfinie. Nous avons commencé à planifier le confinement et l’isolement sûrs du combustible nucléaire irradié canadien au sein d’un dépôt géologique en profondeur centralisé situé dans une formation rocheuse appropriée.

Cette installation comprendra un dépôt et un centre d’expertise, lequel constituera un carrefour national et international de collaboration scientifique.

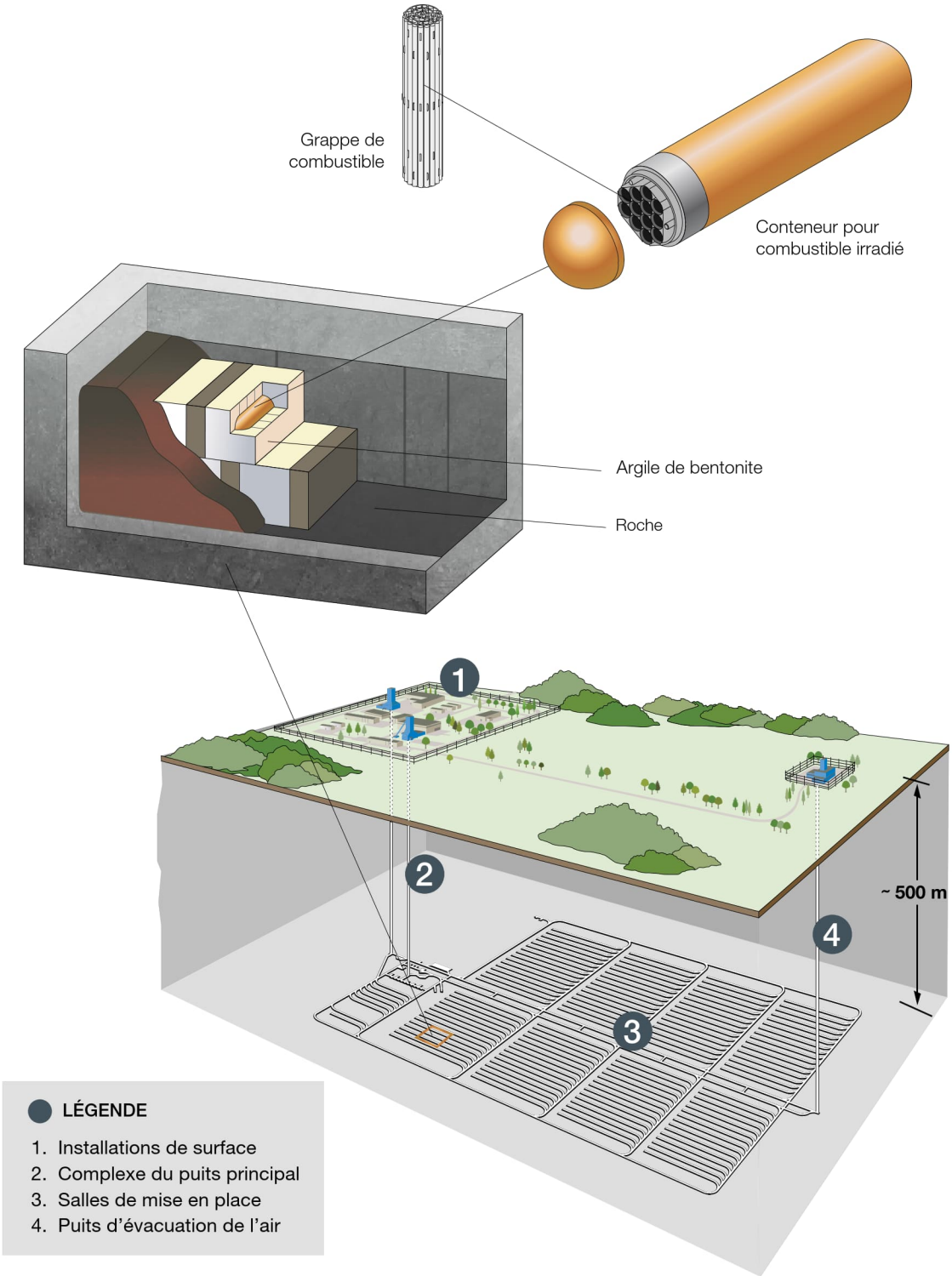
Conformément au plan canadien, la SGDN cherche une collectivité informée qui consentira à accueillir l’installation. La SGDN a lancé un processus de sélection d’un site en mai 2010 pour identifier un site propice pour le dépôt. Le processus de sélection d’un site prévoit un long processus d’apprentissage et de dialogue avec les collectivités et la réalisation d’évaluations techniques exhaustives avant qu’un site de prédilection soit établi.

Ce grand projet national d’infrastructure générera des retombées économiques importantes pour la région et la province où il sera mis en oeuvre. Le plan doit être réalisé en collaboration avec une région qui possède une formation rocheuse appropriée. Le projet n’ira de l’avant qu’avec la participation en partenariat de la collectivité intéressée, des collectivités des Premières nations et métisses touchées de la région et des collectivités voisines à sa mise en oeuvre.

La SGDN s’est engagée à satisfaire à toutes les normes et exigences réglementaires en vigueur en matière de protection de la santé, de la sûreté et de la sécurité de la population et de l’environnement, ou à les dépasser.

Le transport du combustible irradié est une activité réglementée. Pour que le combustible irradié puisse être acheminé depuis les sept installations provisoires d’entreposage jusqu’au dépôt, il faudra préalablement que la Commission canadienne de sûreté nucléaire autorise le transport du combustible nucléaire irradié et l’exploitation de l’installation. Pour en savoir plus sur la GAP et sur le projet, veuillez visiter le www.nwmo.ca.

Exemple d'un dépôt géologique en profondeur



LÉGENDE

1. Installations de surface
2. Complexe du puits principal
3. Salles de mise en place
4. Puits d'évacuation de l'air

4 Planification du transport

La Société de gestion des déchets nucléaires (SGDN) devra démontrer auprès des autorités de réglementation et des citoyens la sûreté et la sécurité du système de transport avant que l'expédition de combustible nucléaire irradié puisse commencer.

Pour qu'un site potentiel puisse être considéré techniquement propice à l'accueil d'un dépôt, il faut qu'une route de transport puisse être identifiée ou aménagée pour y acheminer le combustible nucléaire irradié depuis les installations provisoires d'entreposage au Canada vers le site du dépôt.

Si les réacteurs canadiens existants fonctionnent jusqu'à la fin de leur durée de vie prévue, toute réfection prévue comprise, la quantité de combustible irradié qui devra être expédiée au dépôt s'élèvera approximativement à 4,6 millions de grappes, ce qui pourrait varier en fonction de l'expérience future d'exploitation. Le plan canadien a été élaboré pour gérer le combustible nucléaire irradié canadien. Aucune quantité de combustible irradié de l'extérieur du Canada ne sera stockée dans le dépôt de la Gestion adaptative progressive (GAP).

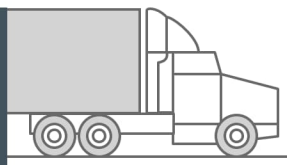
La SGDN a établi un processus pour évaluer l'aptitude des régions potentielles d'établissement du dépôt. Ce processus comprend l'évaluation de l'infrastructure de transport associée à la région d'accueil potentielle, y compris les routes, les liaisons et les points de transfert intermodal. La SGDN a amorcé le processus d'évaluation pour ces régions, y compris les collectivités ayant exprimé l'intérêt d'en apprendre davantage et les autres collectivités de la région. La première étape consiste à utiliser les sources d'information existantes pour déterminer si l'infrastructure de transport nécessaire existe ou peut être aménagée. Les étapes d'évaluation suivantes comprendront une exploration plus détaillée et des études sur le mode, l'itinéraire et la logistique.

Au cours des 50 dernières années, plus de 20 000 expéditions de combustible nucléaire irradié ont été effectuées dans le monde, par camion, par train et par bateau. La SGDN étudie les voies de transport routier ou ferroviaire possibles entre les sites provisoires d'entreposage et chacune des collectivités hôtes potentielles. Les évaluations préliminaires indiquent qu'un de ces modes ou les deux pourraient constituer des options envisageables pour le transport du combustible irradié vers chacune des régions participant au processus de sélection d'un site.

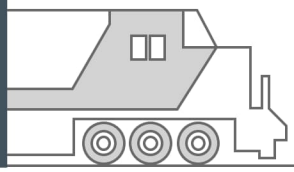
Dans le cadre du processus de sélection d'un site, la SGDN déterminera les modes de transport préférables ainsi que les itinéraires potentiels associés à chaque site considéré pour l'établissement du dépôt. Le processus comprendra un volet d'activités d'engagement et de participation des collectivités et personnes partageant un intérêt commun dans le transport futur et qui ont des questions ou des préoccupations à ce sujet.

Nombre moyen d'expéditions par année

Le programme de transport est prévu de s'étendre sur environ 38 années, d'après l'inventaire prévu actuellement dans les installations nucléaires existantes.



» **620** expéditions/année » **1 ou 2** expéditions/année » **1** conteneur/camion



» **62** expéditions/année » **1** expédition/6 jours » **10** colis/train

Lorsque l'exploitation du dépôt débutera dans plusieurs années, le combustible nucléaire irradié sera livré au site du dépôt à un rythme qui permettra une mise en place dans le dépôt au fur et à mesure qu'il est reçu. Des options d'expédition combinant différents modes de transport pourraient aussi être envisagées selon le site choisi pour accueillir le dépôt.

Une fois le site choisi, la SGDN devra démontrer que le mode et les itinéraires privilégiés répondent à toutes les exigences réglementaires. La SGDN s'est engagée à mettre en oeuvre un système de transport sûr et sécuritaire et des mesures d'intervention d'urgence efficaces au cas où surviendrait un accident. Le premier objectif est de protéger le public et l'environnement et de répondre aux questions et aux préoccupations des citoyens. Il faudra donc démontrer les éléments suivants :



Un colis de transport robuste, éprouvé et homologué

Satisfaction aux exigences de sûreté et de sécurité applicables aux véhicules commerciaux et ferroviaires

La mise en place d'un plan de sécurité du transport

La mise en place d'un plan d'intervention d'urgence

Satisfaction aux exigences relatives à l'obtention d'un permis de transport

La planification d'examens et de vérifications périodiques

Pour orienter le processus de planification, le Canada suit les directives et les normes de l'Agence internationale de l'énergie atomique et surveille les programmes de transport de matières radioactives mis en oeuvre au Royaume-Uni, en Suède, en Allemagne, en France et aux États-Unis.

En vertu de ces normes internationales, la Commission canadienne de sûreté nucléaire (CCSN) et Transports Canada exigent de la SGDN qu'elle démontre qu'elle satisfait à tous les règlements de sûreté et de sécurité avant que la CCSN autorise par permis l'expédition de combustible nucléaire irradié vers un dépôt (voir la section 9, *Réglementation et surveillance du transport*). En plus de satisfaire à ces exigences réglementaires, la SGDN devra aussi présenter ses plans en matière de pratiques de sécurité, de formation et d'intervention d'urgence.

La SGDN reconnaît qu'un programme de transport sûr et sécuritaire comporte plusieurs aspects, notamment (autre que les aspects déjà évoqués) :



Des travailleurs et des chauffeurs de véhicules compétents et bien formés

Des pratiques de travail sécuritaires, y compris des protocoles applicables aux mauvaises conditions météorologiques et routières, au stationnement sécuritaire et au contrôle des routes

Des formations et des exercices conjoints destinés aux intervenants d'urgence provinciaux et locaux

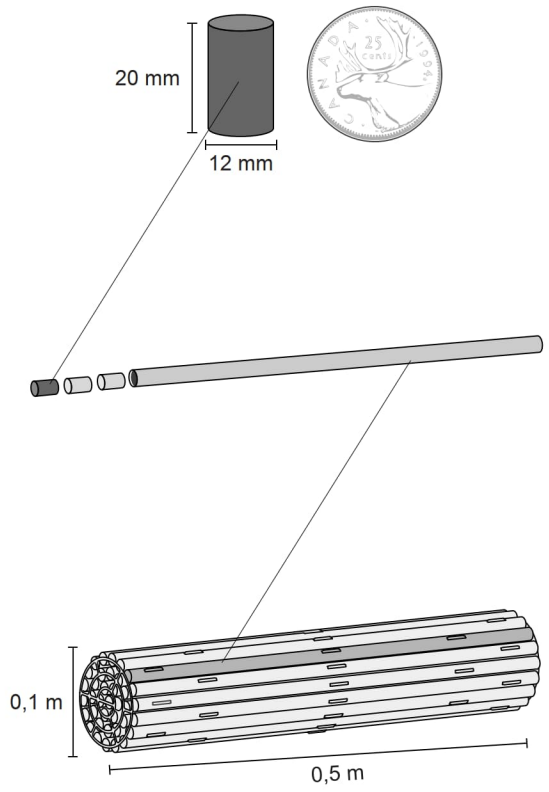
Information et engagement du public pendant les phases de planification et d'exploitation

Un processus d'évaluation et d'amélioration du programme de la GAP

5 Qu'est-ce que le combustible nucléaire irradié?

Le combustible nucléaire irradié est un sous-produit de l'électricité produite par les centrales nucléaires. Il demeure radioactif pendant une longue période et doit être confiné et isolé de la population et de l'environnement de manière essentiellement indéfinie. Bien que sa radioactivité initiale décroisse rapidement avec le temps, sa radioactivité résiduelle et sa toxicité chimique persisteront et le combustible irradié continuera de poser un risque pendant encore très longtemps. Par conséquent, il nécessitera une gestion rigoureuse, essentiellement indéfiniment.

Le combustible nucléaire irradié CANDU n'est ni un liquide ni un gaz – il est un solide stable. Selon les règlements canadiens et internationaux, il n'est pas classifié comme étant une matière inflammable, explosive ou fissile.



Pour en savoir plus à ce sujet, veuillez visiter le site Web de la CCSN à l'adresse : www.nuclearsafety.gc.ca/fra/resources/radiation/index.cfm. Le but de cette section est de fournir des renseignements de base sur les rayonnements ionisants.

La pastille de combustible nucléaire

Les pastilles de combustible sont composées de poudre de dioxyde d'uranium qui est cuite dans un four afin de produire une céramique dure de haute densité. Cette céramique ne se dissout pas facilement dans l'eau et résiste à l'usure et aux températures élevées.

Le crayon de combustible

Les pastilles de combustible sont contenues dans des tubes scellés en métal de zircaloy, appelés crayons, qui sont soudés ensemble pour former une grappe de combustible cylindrique.

La grappe de combustible

Chaque grappe regroupe plusieurs crayons de combustible et est faite d'un métal robuste, résistant à la corrosion appelé zircaloy. Les grappes de combustible sont à peu près de la taille d'une bûche de bois de chauffage et pèsent approximativement 24 kilogrammes. Avant qu'elles soient placées dans un réacteur, les grappes de combustible ne sont pas irradiées et les risques radiologiques qui y sont associés sont relativement faibles. Le débit de dose émis par une grappe de combustible non irradiée est de l'ordre de 0,05 mSv/h. Dans un réacteur nucléaire, chaque grappe produit suffisamment d'électricité pour alimenter jusqu'à 100 maisons pendant une année.

Gérer de manière sûre les risques pendant toutes les phases du cycle de vie du combustible nucléaire

Lorsque le combustible nucléaire irradié est retiré d'un réacteur, il est hautement radioactif. Bien que sa radioactivité initiale décroisse avec le temps, le combustible irradié continuera de poser un risque pour la santé pendant encore plusieurs centaines de milliers d'années. Ce risque devra être géré de manière appropriée.

La radioactivité du combustible irradié décroît rapidement initialement lorsqu'il est retiré du réacteur. Il aura perdu plus de 99 pourcent de sa radioactivité au bout de 10 ans. Cette radioactivité continuera de décroître au fil du temps.

Le Canada s'est doté d'un cadre réglementaire robuste qui régit la manutention du combustible nucléaire irradié. Le combustible nucléaire irradié est en tout temps géré avec soin et blindé afin qu'aucune personne ne soit exposée à une grappe non blindée. Au Canada, le combustible irradié est géré de manière sûre depuis plusieurs décennies dans plusieurs types d'installations nucléaires. Sur les sites des réacteurs, le combustible est refroidi, confiné et blindé en toute sûreté dans des piscines d'entreposage. Dans les installations provisoires de gestion des déchets, ce confinement et ce blindage sont assurés par l'utilisation de grands conteneurs en béton et en acier. L'eau et le béton constituent tous deux des barrières efficaces contre les rayonnements. Pendant le transit, la conception du robuste colis permettra de confiner et d'isoler le combustible irradié. Finalement, il sera confiné et isolé en toute sûreté au sein d'un dépôt géologique en profondeur doté de multiples barrières naturelles et ouvragées.

Les mesures utilisées pour protéger la population et l'environnement contre les risques radiologiques sont de limiter le temps d'exposition, de maximiser la distance et de fournir un blindage adéquat. Ces mesures sont incorporées à tous les stades de gestion du combustible irradié, y compris le transport.

6 Comment est-il actuellement entreposé?

Le combustible nucléaire irradié est entreposé de manière provisoire dans des piscines ou dans des conteneurs d'entreposage à sec sur les sites des réacteurs.

Lorsque le combustible nucléaire irradié est retiré d'un réacteur, il est considéré comme un déchet. Il est radioactif et doit être géré avec soin. Le combustible irradié est d'abord placé dans une piscine specialement conçue remplie d'eau sur le site du réacteur, où sa chaleur et sa radioactivité décroîtront. Au bout de sept à 10 ans, on le conservera en piscine ou, à certains endroits, on le retirera pour le placer et le gérer de manière sûre dans des installations d'entreposage à sec autorisées pour un usage d'une durée limitée sur le site de chaque réacteur. Le site de chaque réacteur nucléaire dispose d'une installation de gestion de déchets radioactifs autorisée par la Commission canadienne de sûreté nucléaire pour l'entreposage à sec du combustible nucléaire irradié en toute sûreté. Ces installations sont surveillées pour empêcher toute menace à la sécurité du public et de l'environnement et pour confirmer qu'elles répondent à toutes les exigences de sécurité liées aux accords nationaux et internationaux.

Actuellement au Canada, approximativement 2,5 millions de grappes de combustible irradié sont entreposées de manière sûre dans des piscines remplies d'eau ou dans des conteneurs, des silos ou des modules d'entreposage à sec.



Combustible nucléaire irradié dans une piscine d'entreposage – l'eau refroidit les grappes de combustible et constitue une barrière efficace contre les rayonnements.

Installation d'Ontario Power Generation utilisée pour l'entreposage à sec du combustible nucléaire irradié



Silos d'entreposage à sec du site de Point Lepreau



Enceintes d'entreposage à sec sur le site de Gentilly-2



7 La clé de la sûreté : les Colis de transport du combustible irradié

La sûreté est intégrée à chaque élément du système de transport de combustible nucléaire irradié, à commencer par la conception du colis de transport. Les colis de transport de combustible nucléaire irradié sont conçus et éprouvés de façon à protéger le public pendant les opérations normales de transport ainsi que dans l'éventualité d'un accident. La Commission canadienne de sûreté nucléaire (CCSN), appliquant des normes éprouvées à l'échelle internationale, est responsable de l'évaluation du colis de transport et de l'homologation de sa conception, de l'enregistrement de l'utilisation des colis individuels et de la surveillance du processus d'entretien des colis.

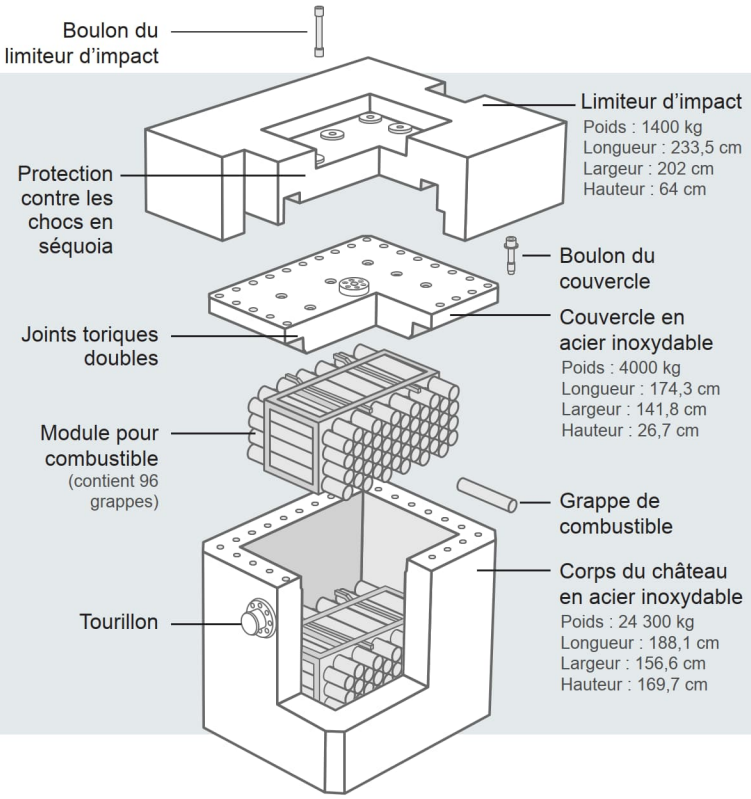
Plusieurs colis de transport de combustible nucléaire irradié sont homologués en vue d'une utilisation au Canada, y compris le Colis de transport du combustible irradié (CTCI) et l'Emballage de transport du conteneur de stockage à sec (ETCSS), qui sont illustrés dans les figures à la page 15. Avant de pouvoir être utilisé au Canada, tout colis de transport doit être certifié par la CCSN pour répondre aux exigences réglementaires, qui incluent les normes internationales de sûreté. Les exigences incluent des épreuves qui visent à démontrer la capacité du colis à résister à une collision violente, à un incendie et à une immersion.

Lorsque toutes les exigences en matière de conception et de mise à l'épreuve sont satisfaites, la CCSN délivre un certificat pour la conception du colis. Ce certificat décrit les procédures de fabrication, d'utilisation et d'entretien du colis de transport. Il définit également ce qui est autorisé à être transporté dans le colis. Le certificat est valide pour une durée de cinq ans. Au terme de cette période, la Société de gestion des déchets nucléaires (SGDN) devra présenter une demande de réhomologation et de renouvellement de la certification du colis.

La SGDN évalue le transport de combustible irradié en fonction des modèles du CTCI et de l'ETCSS certifiés.

Le Colis de transport du combustible irradié

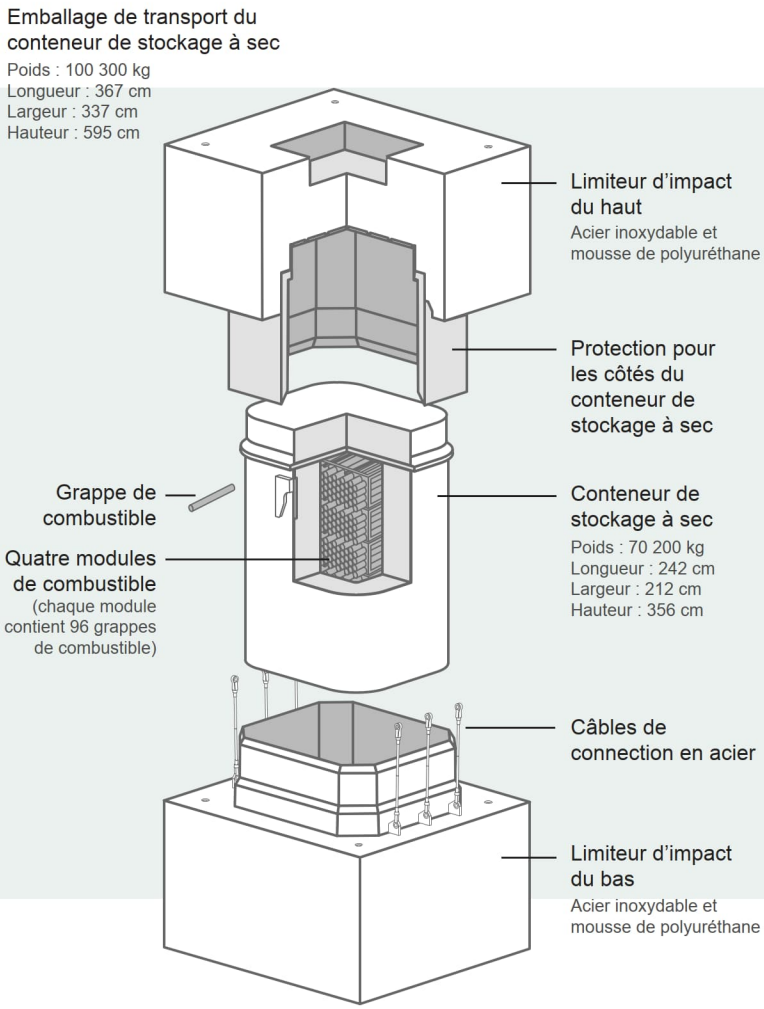
Le CTCI est constitué de trois principaux composants : le corps, le couvercle et le limiteur d'impact. Le corps et le couvercle sont faits d'acier inoxydable robuste d'une épaisseur de près de 30 centimètres. Le couvercle est fixé au corps à l'aide de 32 boulons. Le limiteur d'impact est constitué d'un noyau de séquoia enchâssé dans une enveloppe d'acier inoxydable. Le corps et le couvercle en acier inoxydable confèrent au conteneur des propriétés de confinement, de blindage et de résistance aux chocs. Le limiteur d'impact est conçu pour protéger le corps et la fermeture du couvercle en cas d'accident. Le colis réutilisable peut contenir 192 grappes de combustible irradié et pèse près de 35 tonnes lorsque rempli.



L'Emballage de transport du conteneur de stockage à sec

Le combustible nucléaire irradié d'Ontario Power Generation est actuellement entreposé de manière provisoire dans des conteneurs de stockage à sec (CSS), dans ses installations de gestion de déchets. L'ETCSS consiste en un CSS muni à chaque extrémité d'un limiteur d'impact.

Le CSS est constitué d'un corps et d'un couvercle composés de béton à haute densité enchâssés dans une enveloppe d'acier au carbone. Le corps et le couvercle du CSS sont scellés par soudage une fois le CSS rempli de combustible irradié. Les limiteurs d'impact réutilisables sont des coquilles d'acier inoxydable remplies d'une mousse de polyuréthane rigide. Les limiteurs d'impact sont assemblés à l'aide de câbles en acier. Le CSS sert de confinement et de blindage et les limiteurs d'impact sont conçus pour protéger le CSS en cas d'accident. Le CSS peut contenir 384 grappes de combustible irradié et pèse approximativement 100 tonnes une fois rempli.



Le CTCI et l'ETCSS sont conçus, mis à l'épreuve et homologués de façon à garantir qu'ils seront en mesure de conserver leur contenu en temps normal d'utilisation et en cas d'accident.

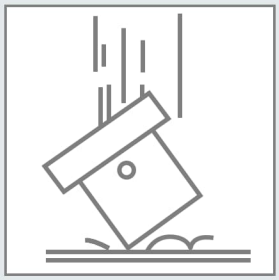
La CCSN applique un processus à trois volets pour s'assurer que le transport du combustible nucléaire irradié se fasse d'une manière sûre et sécuritaire.

1. La CCSN délivre un certificat pour la conception.
2. La CCSN enregistre les utilisateurs du colis.
3. La CCSN délivre un permis de transport.

L'homologation de la conception du colis est basée sur sa capacité à répondre à un nombre d'exigences, comprenant la démonstration de sa capacité à confiner son contenu malgré des conditions d'accident. Le *Règlement sur l'emballage et le transport des substances nucléaires* et le *Règlement de transport des matières radioactives* de l'Agence internationale de l'énergie atomique (AIEA) autorisent la réalisation d'épreuves simulées à l'ordinateur, à échelle réduite ou à pleine échelle, pour démontrer qu'un colis est apte à être certifié pour le transport. Une combinaison d'épreuves sur un modèle à échelle réduite et d'épreuves simulées à l'ordinateur a été utilisée pour certifier le CTCI et l'ETCSS.

Afin de mesurer les effets cumulatifs sur la conception du colis de transport, les deux premières épreuves sont menées dans l'ordre qui entraînera le plus de dégâts au colis, suivies par l'épreuve thermique.

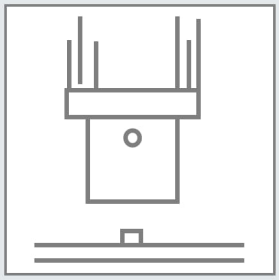
Épreuve de chute libre



On laisse tomber le colis d'une hauteur de neuf mètres (30 pieds) sur une surface dure non élastique (telle qu'une plateforme de béton armé ferraillé). La collision se fait dans un angle qui entraînera le plus de dégâts au colis.

Cette épreuve détermine la performance du colis lorsqu'il éprouve des charges comparables à la plus grave collision potentielle de transport. Les charges associées à cette épreuve sont de plusieurs fois plus grandes que celles éprouvées lorsqu'un train voyageant à 160 kilomètres à l'heure percute le colis de transport. Un examen détaillé est disponible dans le rapport technique de la SGDN *: Pourquoi l'épreuve de chute libre d'une hauteur de neuf mètres sert de limite d'évaluation des effets d'un accident grave* (NWMO TR-2014-04).

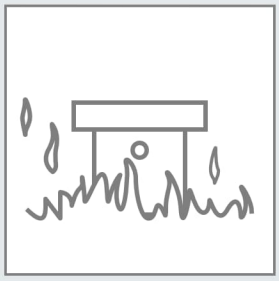
Épreuve de perforation



Après l'épreuve de chute, le même colis est soumis à une chute libre d'une hauteur d'un mètre (40 pouces) sur une tige d'acier d'un diamètre de 15 centimètres (six pouces) et d'une longueur d'au moins 20 centimètres (huit pouces).

Alors que l'épreuve de chute libre simule un impact répandu sur une plus grande surface, cette épreuve examine ce qui se passerait en cas de collision avec un objet pointu. Cette épreuve démontre que le conteneur ne sera pas percé.

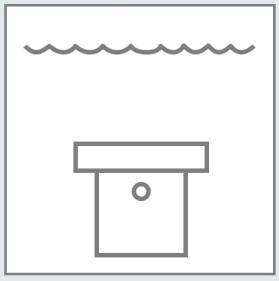
Épreuve thermique



Le même colis qui a subi les épreuves de chute et de perforation est ensuite complètement enveloppé dans un feu pétrolier. Le feu doit atteindre une température de 800 degrés Celsius (1475 degrés Fahrenheit) pendant 30 minutes.

Cette épreuve recrée les conditions d'un potentiel grave accident impliquant des liquides inflammables à proximité du colis. Le feu doit envelopper entièrement le colis pendant toute la durée de l'épreuve. Les flammes doivent atteindre 800 degrés Celsius, une température typiquement associée aux incendies alimentés par des hydrocarbures. Dans un accident réel, l'exposition à un feu alimenté par des liquides inflammables ne dure généralement pas 30 minutes, parce que l'alimentation en combustible diminue et la zone d'incendie se déplace.

Épreuve d'immersion



Utilisant des analyses par ordinateur ou des méthodes d'essais physiques, le colis est soumis à une pression externe correspondant à une immersion sous 15 mètres (50 pieds) d'eau pendant une période d'au moins huit heures afin de voir s'il y a des fuites. Le colis est également soumis à une épreuve d'immersion sous 200 mètres (650 pieds) pour vérifier sa capacité à résister à des pressions externes extrêmes.

La profondeur des étendues d'eau situées à proximité de la plupart des ponts, des routes et des ports est inférieure à 15 mètres. La période de huit heures est suffisant pour permettre au colis submergé d'atteindre un état qui n'évoluerait plus, peu importe le temps requis pour le récupérer. L'épreuve d'immersion améliorée (200 mètres) recrée l'éventualité improbable d'une immersion du colis dans une zone particulièrement profonde, par exemple sur certains points du plateau continental. Elle soumet le colis à une pression maximale.

Épreuves de démonstration menées au fil des années

Les colis de transport de combustible nucléaire irradié, qui doivent répondre aux mêmes exigences que le CTCI et l'ETCSS, ont été soumis au fil des années à des épreuves de démonstration extrêmes dont la portée dépasse considérablement celle de ces exigences réglementaires.

Par exemple:

» Un essai indépendant à pleine échelle réalisé en 1984 par le Central Electricity Generating Board, au Royaume-Uni, a démontré qu'un colis conçu pour satisfaire aux exigences de l'AIEA pouvait résister avec succès aux forces résultant de l'impact d'une locomotive voyageant à 160 kilomètres à l'heure.



» En 1999, l'Institut fédéral d'Allemagne pour la recherche et l'essai des matériaux a fait exploser un wagon-citerne rempli de propane près d'un conteneur de transport de déchets nucléaires. Lorsque le wagon a explosé, il a heurté le conteneur, et celui-ci s'est renversé et s'est logé dans le sol approximativement 10 mètres plus loin. Le contenu est resté intact avec des égratignures superficielles au colis.



Les colis de transport ont survécu à toutes les épreuves sans laisser échapper leur contenu.

Les activités de la SGDN se poursuivent

La SGDN continuera de mettre à l'épreuve le comportement du colis dans de multiples conditions et de tester les nouvelles technologies afin d'optimiser la conception et le comportement du colis.

8 Gestion des risques

La Société de gestion des déchets nucléaires (SGDN) doit démontrer que le transport du combustible nucléaire irradié des lieux d'entreposage provisoires vers le site du dépôt définitif sera sécuritaire et que le public et l'environnement seront protégés en tout temps.

Les rayonnements existent sous plusieurs formes. La population est exposée quotidiennement aux rayonnements naturels émis par le sol, les matériaux de construction, l'air, la nourriture, l'espace (rayons cosmiques) et même par certains éléments présents naturellement dans le corps.

L'expression « dose de rayonnements » est généralement utilisée pour désigner la quantité de rayonnements à laquelle une personne est exposée. *Le Règlement sur la radioprotection* de la Commission canadienne de sûreté nucléaire (CCSN) fixe la limite annuelle de dose de rayonnements à 1 millisievert (mSv) par année pour les membres du public pour limiter l'exposition liée à des activités de l'industrie nucléaire. Cette dose de rayonnements correspond approximativement à la moitié de la dose moyenne de rayonnements naturels reçue par les Canadiens (1,8 mSv par année).

Le *Règlement sur la radioprotection* de la CCSN établit aussi les limites de dose efficace pour les travailleurs du secteur nucléaire. Ce règlement fixe la limite de dose annuelle à 50 mSv par année et la dose maximale pour une période de cinq ans à 100 mSv.

La CCSN se fonde sur des études épidémiologiques et la science internationale sur les rayonnements pour garantir que sa réglementation protège adéquatement les Canadiens. La CCSN et d'autres organismes de réglementation établissent des limites de doses et des règlements qui limitent l'exposition.

Le tableau suivant présente les limites fixées et les possibles effets des rayonnements sur la santé.

Qu'est-ce qu'un mSv?

Un millisievert est le millième d'un sievert, une unité de dose qui traduit les effets biologiques relatifs de divers types de rayonnements.

Dose	Limite ou effets sur la santé
Supérieure à 5000 mSv	Dose qui peut entraîner la mort lorsque reçue en une seule occasion
1000 mSv	Dose qui peut causer les symptômes de la maladie des rayons (p. ex., fatigue et nausées) lorsque reçue sur une période de 24 heures
100 mSv	Plus faible dose aiguë associée au cancer
30 à 100 mSv	Dose de rayonnements reçue lors d'une tomodensitométrie corps entier
50 mSv	Limite de dose annuelle pour les travailleurs du secteur de l'énergie nucléaire
1,8 mSv	Dose de rayonnements naturels reçue en moyenne annuellement par les Canadiens
1 mSv	Limite annuelle de doses de rayonnements pour le public
0,1 à 0,12 mSv	Dose reçue lors d'un examen par rayon X des poumons
0,01 mSv	Dose reçue lors d'un examen dentaire par rayon X
0,01 mSv	Dose annuelle moyenne résultant des voyages en avion

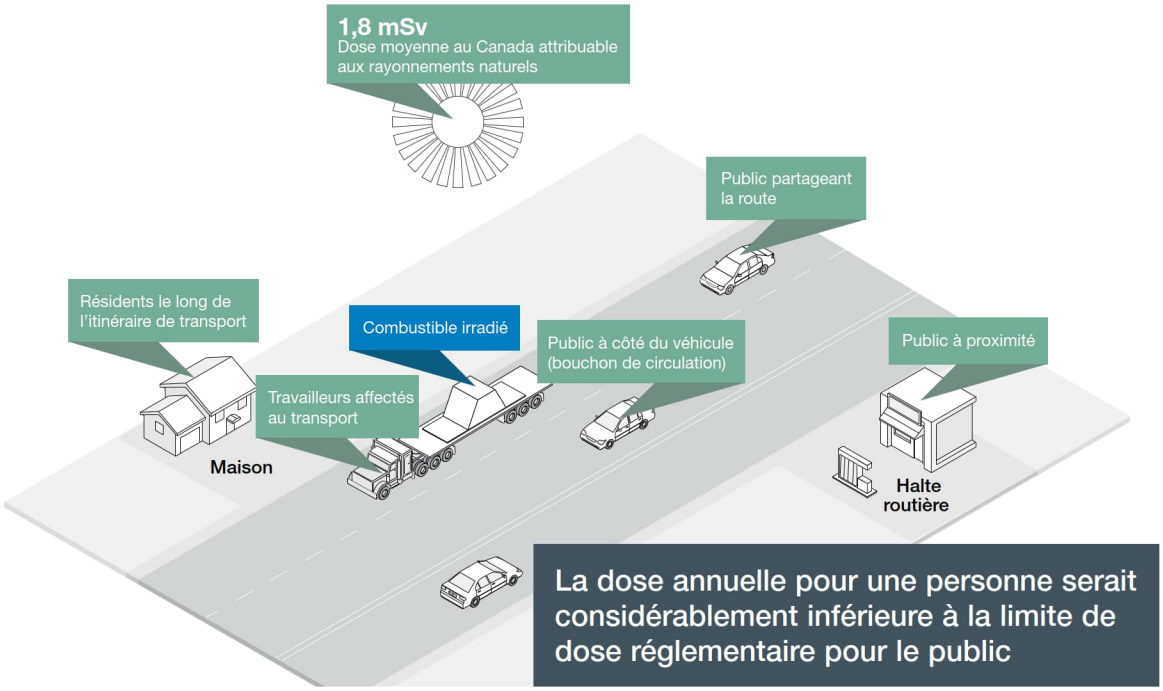
Source : site Web de la CCSN – Effets biologiques du rayonnement
www.nuclearsafety.gc.ca/fra/resources/radiation/introduction-to-radiation/radiation-health-effects.cfm

Dose de rayonnements reçue par le public pendant le transport

Avant que toute expédition de combustible irradié soit autorisée par les autorités de réglementation, que ce soit pour un Colis de transport du combustible irradié (CTCI) ou pour un Emballage de transport du conteneur de stockage à sec, la SGDN devra démontrer que l'exposition potentielle du public situé le long des itinéraires de transport est inférieure à la limite réglementaire (1 mSv par année).

Compte tenu du nombre annuel d'expéditions prévu et de la conception actuelle du CTCI, on prévoit que l'exposition potentielle des personnes situées le long des itinéraires de transport sera inférieure à la limite réglementaire.

Une étude générique récente a été menée pour déterminer l'exposition potentielle des personnes situées le long des itinéraires de transport. Le colis utilisé était le CTCI. L'étude portait sur les personnes résidant aux abords ou à proximité de l'itinéraire de transport, les personnes partageant l'itinéraire de transport et les personnes se trouvant à des arrêts routiers le long de l'itinéraire de transport. Selon cette étude, la dose annuelle reçue par ces personnes sera inférieure à la limite de dose réglementaire pour le public.



Dose de rayonnements reçue par les travailleurs affectés au transport

Pour compléter l'évaluation des doses subies par le public, une autre étude a été menée pour fournir une évaluation générique de la dose potentielle que recevront les travailleurs affectés au transport du combustible irradié au moyen du CTCI.

Les activités de transport évaluées dans cette étude comprenaient les activités menées par les travailleurs depuis le moment où la cargaison de combustible nucléaire irradié quitte l'installation provisoire d'entreposage jusqu'à son arrivée au site du dépôt. L'étude a démontré que les doses reçues par les travailleurs seront inférieures à la limite réglementaire de dose fixée pour le public, qui est de 1 mSv par année.

9 Réglementation et surveillance du transport

Au Canada, le transport sûr et sécuritaire des matières radioactives est réglementé conjointement par la Commission canadienne de sûreté nucléaire (CCSN) et par Transports Canada.

La CCSN réglemente le transport des matières radioactives par le biais du *Règlement sur l'emballage et le transport des substances nucléaires* (*RETSN*).

Le *RETSN* comprend une série d'exigences réglementaires liées à la sécurité qui couvrent l'ensemble d'une expédition, de l'emballage initial à l'arrivée à destination. Le contrôle réglementaire de l'emballage et du transport du combustible nucléaire irradié s'effectue :

- En établissant des exigences par rapport au comportement du colis de transport;
- En homologuant la conception des colis de transport;
- En enregistrant tous les utilisateurs des colis de transport homologués;
- En établissant un programme de protection contre les rayonnements et en veillant à son application par les transporteurs;
- En délivrant un permis de transport pour le combustible nucléaire irradié uniquement lorsque le plan d'intervention d'urgence et le plan de sécurité du transport ont été établis et approuvés;
- En fournissant des agents en service tous les jours 24 heures par jour pour toute urgence;
- En enquêtant de façon appropriée en cas d'incident ou d'urgence;
- En supervisant tous les aspects des mesures physiques de sécurité;
- En réalisant des inspections de conformité.

Avant de transporter le combustible irradié au Canada, le cadre réglementaire exhaustif de la CCSN requiert un certificat pour le colis de transport et un permis de transport. La CCSN examine les demandes pour s'assurer que les mesures de sécurité sont techniquement et scientifiquement valables, que toutes les exigences ont été respectées et que les dispositions de sécurité appropriées sont en place pour protéger la population et l'environnement. Les éléments d'un programme de transport couverts par cette évaluation incluent :

- La formation des travailleurs et des intervenants d'urgence;
- La mise en oeuvre d'un programme de protection contre les rayonnements;
- La gestion d'un plan d'intervention d'urgence;
- La mise en oeuvre de mesures de sécurité;
- Le maintien de registres;
- Le respect de toutes les exigences réglementaires.

Une fiche d'information de la CCSN appelée la *Réglementation de l'emballage et du transport des substances nucléaires au Canada* est disponible à l'adresse www.nuclearsafety.gc.ca.

La CCSN offre également une foire aux questions sur le transport du combustible nucléaire irradié sur son site Web.

Le *RETSN* est basé sur les normes publiées par l'Agence internationale de l'énergie atomique (AIEA). De plus amples renseignements sur l'AIEA sont disponibles à l'adresse www.iaea.org.

Le *Règlement sur le transport des marchandises dangereuses* de Transports Canada établit des exigences en matière de formation, de planification des urgences, de signalisation de sécurité et de documentation.

Les responsabilités de Transports Canada concernant l'expédition de matières radioactives incluent :

- L'établissement d'exigences en matière de transport et l'imposition de leur respect par les expéditeurs et les transporteurs;
- L'établissement d'exigences et la réalisation d'inspections de conformité pour des domaines comme la formation et la documentation;
- L'établissement d'exigences en matière de plans d'intervention d'urgence et l'imposition de leur respect.

Le Centre canadien d'urgence transport (CANUTEC) de Transports Canada est un service national de consultation qui fournit une assistance à toute heure du jour ou de la nuit au personnel d'intervention d'urgence qui doit gérer des incidents se rapportant à des matières dangereuses. Le centre d'urgence est doté d'un personnel scientifique bilingue spécialisé en chimie ou dans un domaine connexe et formés pour répondre aux urgences. Les conseillers en intervention d'urgence sont expérimentés dans l'interprétation des renseignements techniques provenant de diverses sources scientifiques, dont les fiches signalétiques (MSDS, pour Material Safety Data Sheets), afin de pouvoir fournir en temps utile des conseils pertinents.

Le *Règlement sur le transport des marchandises dangereuses* de Transports Canada a été adopté à l'échelle des provinces et des territoires par le biais d'accords d'application.



Les gouvernements/autorités de réglementation/ministères des provinces ont la responsabilité de faire appliquer les règlements provinciaux, de mener des inspections et d'intervenir en cas d'incident de transport impliquant des matières radioactives.

Le cadre réglementaire

Transport Canada / Transports Canada

Lois provinciales / territoriales sur le transport des marchandises dangereuses

Loi sur le transport des marchandises dangereuses

Ententes administratives relatives au transport des marchandises dangereuses Province/Territoire – Canada

Règlement sur le transport des marchandises dangereuses

Canadian Nuclear Safety Commission / Commission canadienne de surete nucleaire

Loi sur la sûreté et la réglementation nucléaires

Règlement général sur la sûreté et la réglementation nucléaires

Règlement sur la sécurité nucléaire

Règlement sur l'emballage et le transport des substances nucléaires

Règlement de transport des matières radioactives (TS-R-1)

IAEA
Agence internationale de l'énergie atomique

10 Les rôles et les responsabilités de la SGDN

La Société de gestion des déchets nucléaires (SGDN) sera globalement responsable du transport sûr du combustible nucléaire irradié des sites provisoires d'entreposage actuels jusqu'au dépôt géologique en profondeur. La Commission canadienne de sûreté nucléaire (CCSN) et Transports Canada ont la responsabilité de veiller à l'application de la réglementation.



Communications

La SGDN exploitera un centre de commandement centralisé qui servira de point de contact unique à tous les organismes pour les communications liées au transport. Ce centre permettra d'accéder rapidement aux renseignements associés à chaque expédition, notamment à tout ce qui concerne l'emplacement du chauffeur du véhicule, les conditions météorologiques, la circulation et l'itinéraire et assurera les communications avec le chauffeur, le personnel de sécurité et, le cas échéant, les organismes de réglementation et d'intervention d'urgence, tels que Transports Canada, CANUTEC (le Centre canadien d'urgence transport de Transports Canada) et la CCSN.

Les communications seront assurées pendant toute la durée du transport du combustible irradié, conformément aux dispositions du Plan de sécurité du transport. Cela comprend les communications entre :

- Le centre de commandement du transport;
- L'escorte de sécurité accompagnant le combustible irradié;
- Les sites d'où proviendront les expéditions;
- Le site du dépôt;
- Tous les centres de commandement des interventions d'urgence des provinces par où transiteront les expéditions.

Dans le cas d'un incident, le centre de commandement du transport serait avisé. Une fois avisé, le responsable des expéditions en devoir communiquerait avec le centre de commandement des interventions d'urgence de la province où l'incident a eu lieu. Le centre de commandement des interventions d'urgence de la province communiquerait avec les équipes d'intervention d'urgence le long de l'itinéraire de transport.



Intervention d'urgence

La SGDN fournira un plan d'intervention d'urgence à la CCSN, à Transports Canada et aux provinces, en veillant à ce que les informations soient exactes et accessibles aux organismes publics d'intervention d'urgence concernés. La SGDN aidera également les organismes d'intervention à élaborer leurs plans d'intervention concernant le combustible nucléaire irradié, selon leurs besoins.

Le plan d'intervention d'urgence a pour but d'améliorer la coordination entre la SGDN, les premiers intervenants provinciaux et locaux, les dirigeants des collectivités concernées et les organismes fédéraux. Selon le *Cadre de sécurité civile pour le Canada* (2e édition – janvier 2011), tous les ordres de gouvernement peuvent être appelés à participer à la gestion des urgences. Les gouvernements provinciaux ainsi que les administrations et les autorités locales sont responsables des services d'intervention. Les organismes fédéraux peuvent fournir des ressources supplémentaires à la demande de la province ou de la municipalité.

En collaboration avec les provinces, la SGDN coordonnera sa planification, fournira de la formation propre au combustible irradié et dirigera des exercices aux abords des routes désignées. Les exercices constituent un outil de formation, servent à améliorer les communications, et aident à coordonner et améliorer les programmes d'intervention d'urgence. Les exercices peuvent comprendre des exercices à pleine échelle ainsi que des exercices sur papier, pour évaluer la performance intégrée du système. Afin d'atteindre le plus haut niveau de sécurité possible lors des conditions d'incident de transport, la SGDN s'engage à une préparation aux urgences robuste. La coordination des plans et des procédures d'intervention est rigoureusement vérifiée par le biais d'activités de formation multiniveaux, de communications entre les organismes, d'exercices de processus et d'exercices conjoints.

Au Canada, le milieu de la gestion des urgences a adopté une approche normalisée d'intervention pour les accidents de transport, quelle qu'en soit la cause. Les instances fédérales, provinciales et municipales ont adopté une approche globale pour gérer les urgences, qui comprend la mise en place de mesures de prévention, d'atténuation, de préparation et d'intervention et des activités de rétablissement. La SGDN travaillera en collaboration avec les instances provinciales et locales pour faire en sorte que la formation et les équipements des premiers intervenants répondent aux normes applicables le long des itinéraires de transport. La SGDN suivra ce processus dans sa planification et sa préparation aux abords des itinéraires désignés pour l'expédition du combustible nucléaire irradié.

Considérations liées à la sécurité

La SGDN est responsable de l'élaboration du plan de sécurité du transport. Le premier objectif de ce plan est de garantir que le combustible nucléaire irradié bénéficie d'une protection physique adéquate contre les menaces crédibles qui pourraient se poser pendant le transport. Les risques seront continuellement réévalués pour faire en sorte que les mesures de sécurité correspondent aux circonstances particulières de chaque expédition.

Les mesures de sécurité ont pour but de contrer les possibilités de détournement et de sabotage des colis de transport et incluent une combinaison de mesures techniques, physiques et de surveillance destinées à assurer la protection des cargaisons et la détection des menaces, à sonner l'alarme et à enregistrer et à transmettre les informations en cas d'incident. Les mesures de sécurité pendant le transport feront en sorte que le combustible irradié soit adéquatement protégé contre les menaces crédibles et seront conformes à l'article 5 du *Règlement sur la sécurité nucléaire* de la CCSN.

Les Plans de sécurité du transport seront maintenus à jour et pourront être soumis à l'examen périodique de la CCSN pour s'assurer qu'ils prennent en compte les niveaux de menace pressentis.

Le règlement de la CCSN prévoit l'application de mesures de sécurité particulières au transport du combustible irradié, dont les suivantes :

- Les expéditions doivent inclure une escorte de sécurité et faire l'objet d'une surveillance constante;
- Un Plan de sécurité du transport pour les expéditions de combustible irradié doit être fourni. Un plan est préparé pour détailler les mesures de sécurité proposées et les dispositions prévues pour l'expédition;
- Les mesures de sécurité telles que le personnel d'escorte, les dispositions de communication avec les forces d'intervention, les contrôles de sécurité préalables au transit, les dispositions en cas de retards ou de pannes mécaniques et les procédures à suivre pendant les haltes programmées ou les retards inattendus, doivent être précisées;
- Une évaluation de la sécurité, des menaces et des risques doit être réalisée par des organismes publics et privés compétents afin de relever les points à améliorer ainsi que les mesures d'atténuation possibles et de cerner les risques crédibles qui peuvent se poser;
- La CCSN a fourni des directives concernant les informations qui doivent être protégées pour la sécurité et la sûreté des expéditions. Tous les renseignements relatifs aux mesures et aux dispositions de sécurité prises pour ce type d'expédition seront considérés comme des renseignements réglementés et ne seront pas accessibles au public. Les renseignements réglementés ne seront fournis qu'aux personnes ou aux organismes qui doivent légitimement avoir recours à ces renseignements, comme les forces d'intervention policières.

11 Expérience internationale

Plusieurs pays élaborent actuellement des plans ou travaillent à la mise en oeuvre de programmes de gestion à long terme du combustible nucléaire irradié ou d'autres matières radioactives. Une solide expérience a été acquise au Canada et dans le monde dans le transport sûr de ces substances.

En plus de 50 années, dans le monde et au Canada, on n'a signalé aucune blessure grave, aucune incidence sur la santé, aucun décès ou aucune incidence environnementale attribuable à la nature radiologique des expéditions du combustible nucléaire irradié.

Les gouvernements, les autorités de réglementation et les organisations commerciales au Canada et dans le monde ont acquis une vaste expérience dans le domaine du transport sûr et sécuritaire des matières radioactives. Au Canada, on transporte approximativement un million de colis de matières radioactives chaque année. Depuis les années 70, le Canada a effectué approximativement cinq expéditions de combustible irradié par année depuis ses centrales nucléaires jusqu'aux Laboratoires de Chalk River d'Énergie atomique du Canada limitée à des fins de recherche et d'examen post-irradiation.

L'Agence internationale de l'énergie atomique, des agences gouvernementales et des experts indépendants de plusieurs pays, notamment les États-Unis, le Royaume-Uni, l'Europe et le Japon, ont régulièrement examiné et étudié les questions liées à la sécurité du transport des substances radioactives.

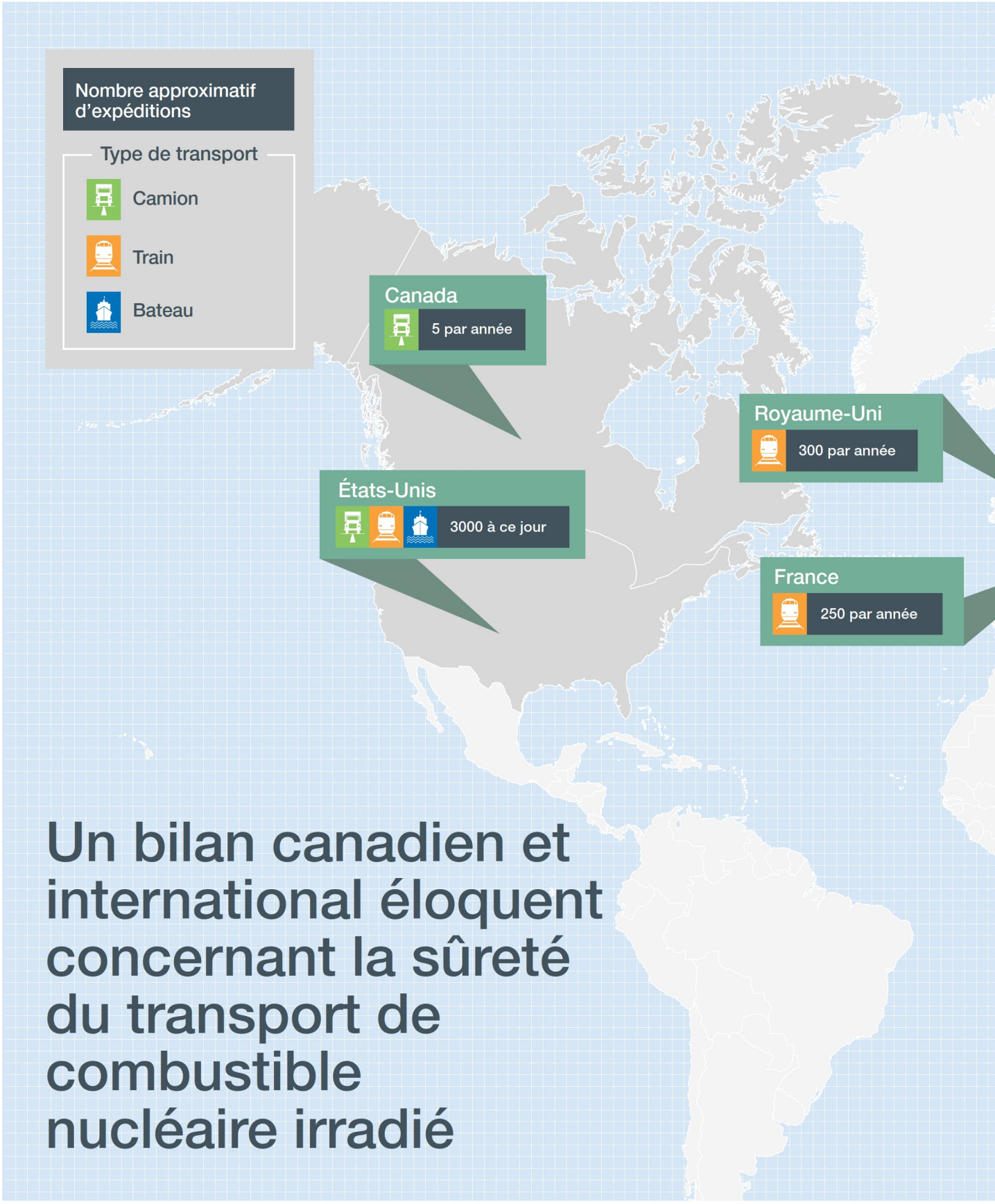
Aux États-Unis, près de 3000 expéditions de combustible irradié commercial ont été effectuées sur plus de 2,5 millions de kilomètres au cours des 40 dernières années, principalement par camion et en partie par train. Au Royaume-Uni et en France, 550 expéditions de déchets hautement radioactifs sont effectuées en moyenne chaque année, principalement par train. En Suède, on effectue approximativement 40 expéditions par année par bateau, alors qu'au Japon on en effectue approximativement 200.



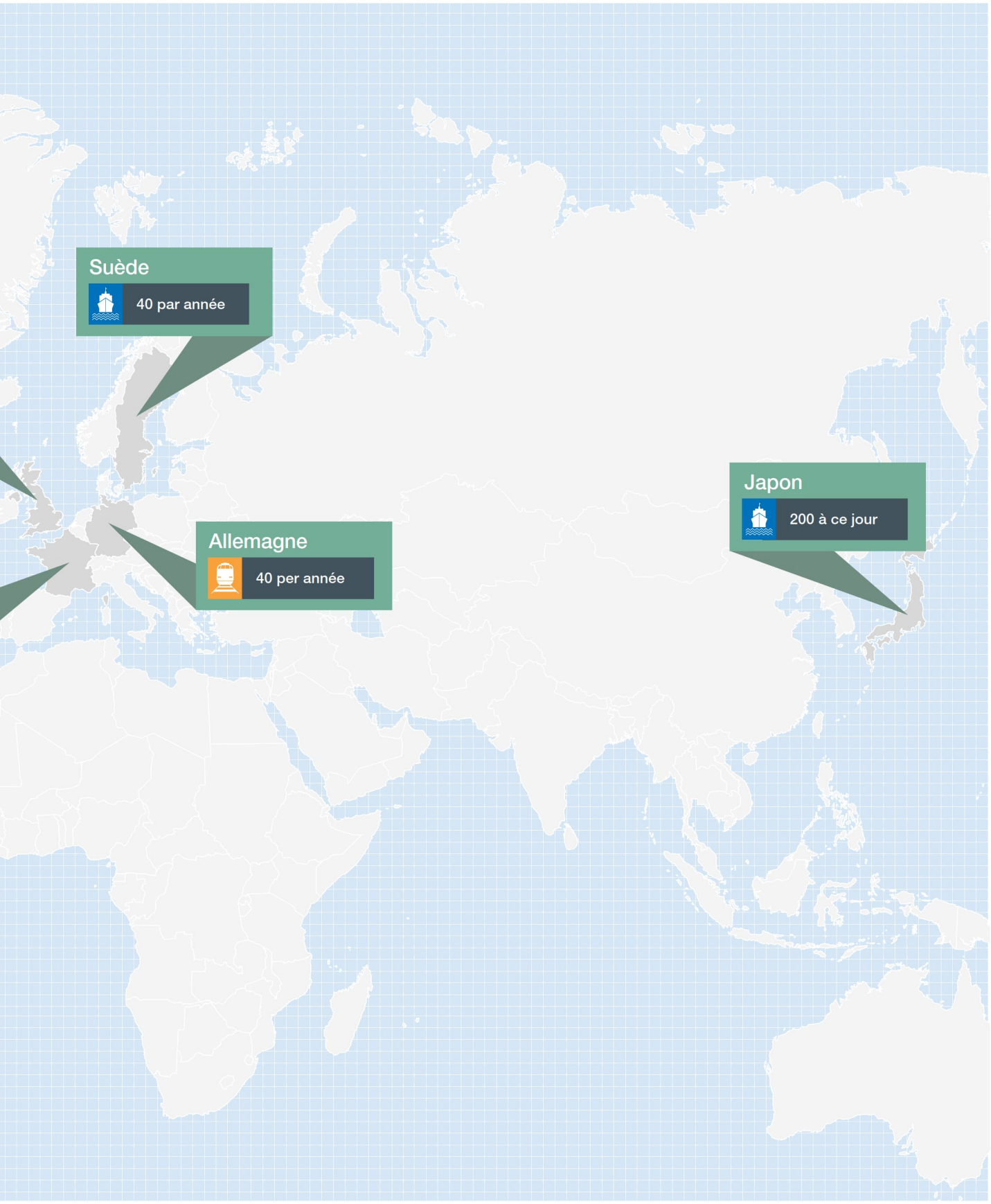




Courtoisie de World Nuclear Transport Institute



Un bilan canadien et international éloquent concernant la sûreté du transport de combustible nucléaire irradié


Suède
40 par année
Allemagne
40 per année
Japon
200 à ce jour

12 Ressources

Publications, sites Web et vidéos pertinents

Société de gestion des déchets nucléaires : www.nwmo.ca

- Transport du combustible nucléaire irradié canadien
- Mise en oeuvre de la Gestion adaptative progressive
- Point d'accès centralisé aux rapports annuels, vidéos, brochures et plus
- La gestion sûre du combustible nucléaire irradié au Canada
- Évaluation générique des doses reçues par le public
- Évaluation des doses reçues par les travailleurs
- Évaluations préliminaires de la Phase 1 de l'Étape 3 : Chapitre 6 – Évaluation préliminaire du transport

Commission canadienne de sûreté nucléaire : www.nuclearsafety.gc.ca

- Effets biologiques du rayonnement
- Réglementation de l'emballage et du transport des substances nucléaires au Canada
- Foire aux questions sur le transport du combustible nucléaire irradié
- Guide d'application de la réglementation sur les plans de sécurité pour le transport des matières nucléaires de catégorie I, II ou III (G-208)

Transports Canada : www.tc.gc.ca

- Préparation aux urgences

Agence internationale de l'énergie atomique : www.iaea.org

- Transport des matières radioactives

World Nuclear Transport Institute : www.wnti.co.uk

Pour en savoir plus, veuillez contacter la :

Société de gestion des déchets nucléaires (SGDN)

22, avenue St. Clair Est, 6e étage
Toronto (Ontario) M4T 2S3 Canada
Tél. : 416.934.9814
Courriel : contactus@nwmo.ca
Site Web : www.nwmo.ca



NUCLEAR WASTE MANAGEMENT ORGANIZATION

SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Deep Geological Repository
Conceptual Design Report
Crystalline / Sedimentary Rock

APM-REP-00440-0211-R000

September 2021

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Nuclear Waste Management Organization

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ABSTRACT

Title: **Deep Geological Repository Conceptual Design Report Crystalline / Sedimentary Rock**
Report No.: **APM-REP-00440-0211-R000**
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Abstract

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of used nuclear fuel. The APM approach encompasses centralized containment and isolation of the used fuel in a Deep Geological Repository (DGR) in a suitable rock formation, such as a crystalline rock or sedimentary rock geosphere, in an informed and willing host community.

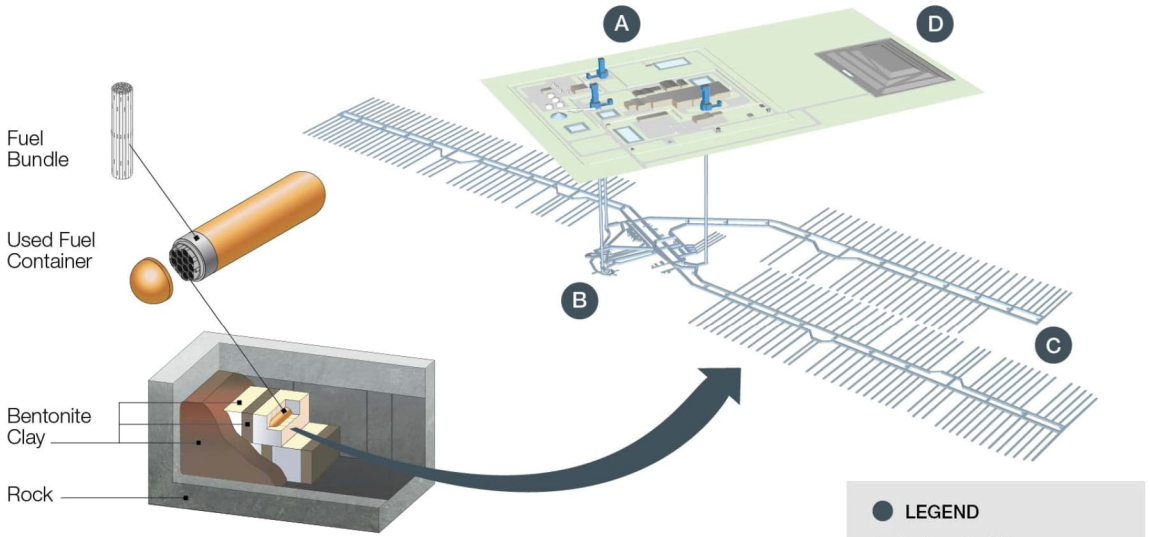
This report describes conceptual designs for a DGR facility in either crystalline or sedimentary rock. For costing purposes, it is assumed that the facility will receive 5.5 million used CANDU fuel bundles over a 46-year period. The report describes the required facilities and infrastructure needed to safely receive, package, and emplace the used nuclear fuel in the underground repository. At the end of emplacement activities and following a period of extended monitoring the DGR facility will be decommissioned and closed. All underground rooms, tunnels and the three shafts will be permanently sealed.

EXECUTIVE SUMMARY

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of used nuclear fuel. The APM approach encompasses centralized containment and isolation of the used fuel in a Deep Geological Repository (DGR) in a suitable rock geosphere, such as crystalline rock or sedimentary rock within an informed and willing host community.

In January 2020, the NWMO announced that the Ignace area in northwestern Ontario and South Bruce area in southern Ontario will undergo more detailed investigations to determine suitability for hosting the DGR. The Ignace Area has a crystalline rock geosphere while the South Bruce Area has a sedimentary rock geosphere. This report describes DGR facility concepts for these two locations. The concepts will continue to be updated to support future licensing submissions and as new information becomes available from on-going site investigations at these two locations.

As of June 2020, Canada has produced over 3.0 million used fuel bundles. If Canada's existing reactors operate to the end of their planned lives, including planned refurbishments, the inventory that will need to be managed in the DGR facility is estimated to be 5.5 million bundles. An inventory of 5.5 million used fuel bundles is also used in the life cycle cost reporting. The used fuel bundles inventory is reviewed annually by the NWMO.



Lateral Tunnel Approach

Deep Geological Repository (DGR)

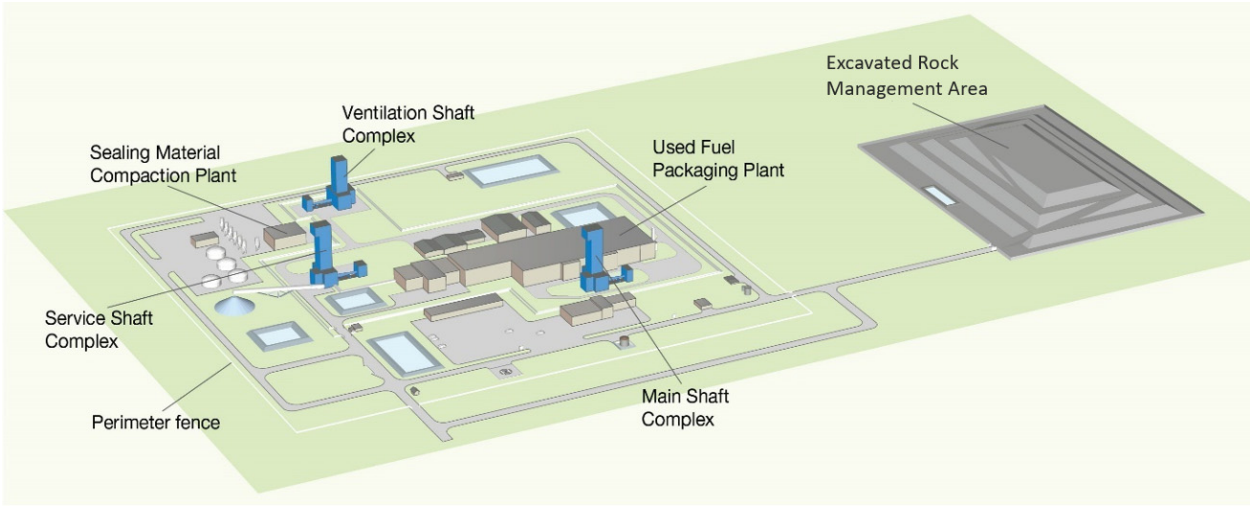
This report describes concepts for a DGR facility in crystalline and sedimentary rock. It describes the required facilities and infrastructure needed to safely receive, repackage, and emplace the used nuclear fuel into the DGR safely using a series of Engineered Barriers including the Used Fuel Container (UFC) and bentonite clay.

Surface Facilities

The DGR facility will be self-contained and will have facilities for operation, maintenance and long-term monitoring.

For security purposes, certain areas of the surface facilities will have restricted access and will be located inside the Protected Area. The Protected Area will include the Used Fuel Packaging Plant, Main Shaft Complex, Service Shaft Complex and Ventilation Shaft Complex. Security and double perimeter fencing will be required to prevent unauthorized access into the Protected Area.

Surface facilities located outside the Protected Area, but inside the outer perimeter fence, are considered the Balance of Site. The Balance of Site area will include the Administration Building, Sealing Material Compaction Plant and a Concrete Batch plant.



Deep Geological Repository (DGR) Main Surface Facilities

External facilities, located outside the DGR's perimeter fences, will be required to support the DGR facility. Such facilities include a Centre of Expertise and accommodation for construction personnel. An Excavated Rock Management Area (ERMA) from the underground repository and the associated stormwater management pond will also be required. The location and footprint will be determined as new information becomes available from on-going site investigations.

Used Fuel Packaging Plant (UFPP)

The used nuclear fuel will be received at the Used Fuel Packaging Plant (UFPP) from the interim storage sites located at the reactor sites. The used fuel will be transported in two certified road transportation packages; the Used Fuel Transport Package (UFTP) and Basket Transportation Packages (BTP). These transportation packages will be received at the UFPP where the contained used fuel bundles will be transferred to the Used Fuel Containers (UFC). The filled UFCs will then be sealed by welding, inspected and assembled into bentonite buffer boxes. The buffer boxes will be made of two blocks of Highly Compacted Bentonite (HCB) clay with a cavity machined in these blocks to hold the UFC. These buffer boxes, each containing a UFC, will then be dispatched for placement in the underground repository.

The UFPP will incorporate multiple processing systems for receiving and unloading used fuel from the transportation packages and for safely processing and handling the UFCs.

Sealing Materials Production Plant

Sealing Materials Compaction Plant (SMCP) and Concrete Batch Plant operations will be required to produce repository sealing materials needed for the underground Engineered Barrier Systems (EBS) (e.g., bentonite blocks, granular bentonite gap fill material, concrete bulkheads, etc.). Imported aggregate will be stockpiled and then used to support the material needs of the SMCP and concrete batch plant.

At the SMCP, Highly Compacted Bentonite (HCB) blocks for the buffer boxes will be manufactured and transferred to the UFPP. The SMCP will also produce HCB spacer blocks and granular bentonite Gap Fill Material (GFM) that will be placed inside each placement room. The plant will employ custom designed presses, moulds and shaping equipment for manufacturing the HCB blocks with specialized lifting devices in place to handle the formed materials. In addition, during decommissioning the SMCP will manufacture dense backfill (DBF), GFM and HCB in support of repository underground closure operations.

At the concrete batch plant, aggregate will be blended with binders and a water reducing admixture to produce Low Heat High Performance (LHHP) concrete. The LHHP concrete will be used for construction of bulkheads at entrances of the UFC-filled placement rooms in the repository underground. These concrete bulkheads will be part of the placement room seal.

Shafts, Headframes and Hoisting Systems

Three shaft complexes (shafts, headframes and hoisting systems) will support the underground repository. The Main Shaft Complex will serve as the exclusive conveyance structure for the surface-to-underground transfer of the buffer boxes (with UFCs). The hoisting system will be tower-mounted concrete headframe structure approximately 60m high. The friction hoisting system will have a payload capacity of about 60 tonnes. The hoisting system will raise/lower a cage inside a 7m inside diameter concrete lined shaft.

The Service Shaft Complex will be a multi-purpose hoisting facility with three hoisting systems for movement of personnel and materials into and out of the repository. The hoisting systems will be tower-mounted inside a concrete headframe structure approximately 50m high. The Service Shaft Complex will incorporate equipment for delivering excavated rock to ground surface (skips), a main service hoist for movement of personnel and materials to the underground repository, and an auxiliary hoist for personnel movement both during normal operations and emergencies. The hoisting systems will raise/lower the skips and the two cages inside a 7m inside diameter concrete lined shaft.

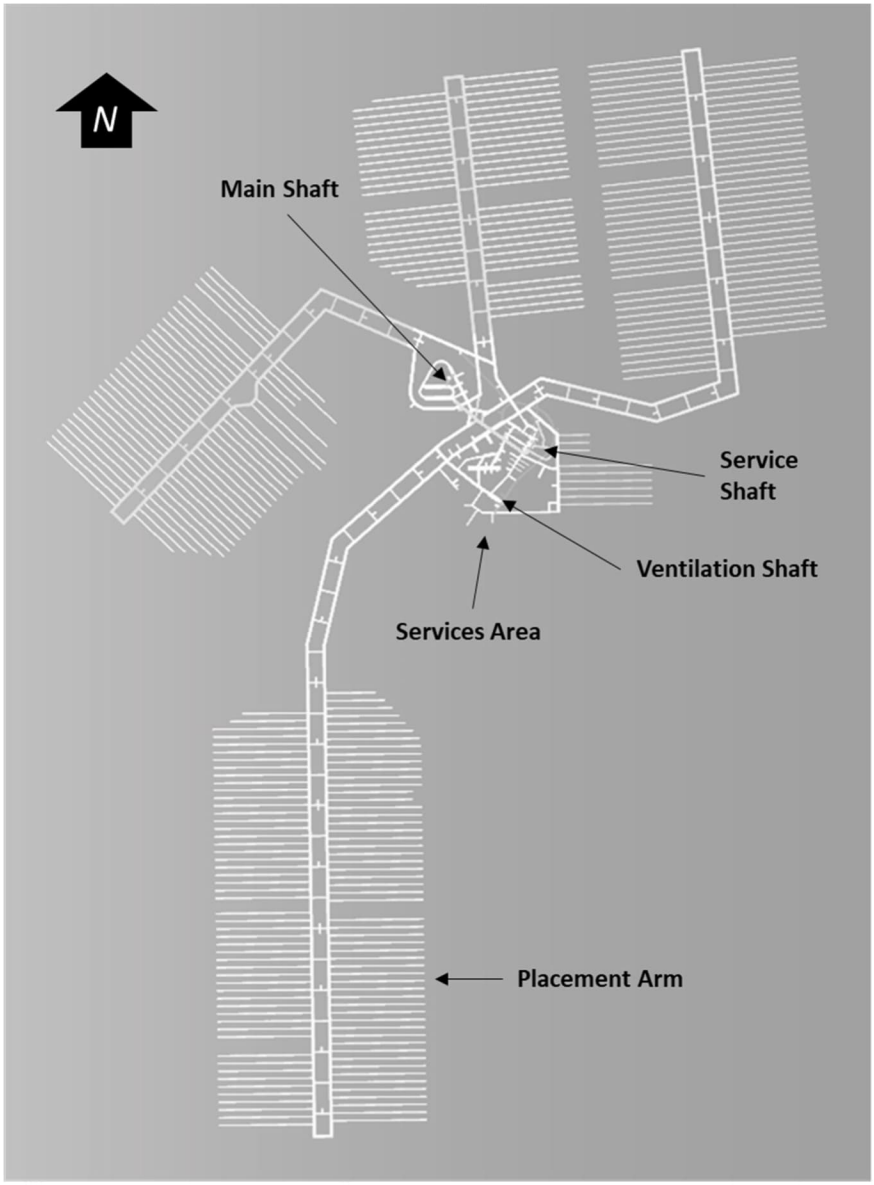
The Ventilation Shaft Complex will handle most of the repository exhaust air and will have an auxiliary hoist to provide a secondary means of egress for personnel in the event of an underground emergency. The hoisting system will be ground-mounted beside a steel headframe structure approximately 30m high. The headframe structure will be located above a 7m inside diameter concrete lined shaft through which ventilation air will be exhausted to surface and the auxiliary cage will operate.

Underground Facilities

The underground facilities will be comprised of the following two main areas: a) Services Area located at the base of the three shafts and b) Panels of rooms located in repository placement arms accessible by parallel access tunnels.

The following figure illustrates the layout of the underground repository (for the crystalline rock design concept).

The underground layout is designed to allow adaptability to site specific conditions. Specifically, the direction and location of the branching placement arms will change as site investigations proceed.



Underground Repository Layout Concept (Crystalline Rock Geosphere)

The Services Area will provide a range of facilities to support DGR operations:

- Underground Demonstration Facility;
- Refuge stations, offices, washrooms;
- Maintenance shop and warehouse;
- Battery charging station;
- Equipment / material storage areas;
- Explosives and detonators magazines;
- Main electrical substation; and
- Truck dump equipped with grizzly and rockbreaker.

The Underground Demonstration Facility (UDF) will be situated near the shafts and established soon after the repository level is reached. The UDF will support geoscientific verification, validation of construction methods, demonstration of excavation and placement techniques and long-term demonstration of the sealing systems. There is also a potential for using the UDF as a training area for future underground activities for DGR personnel.

The in-room placement of the buffer boxes containing the UFCs will involve a two-high stacking arrangement of the boxes. The rows of boxes will be separated by HCB spacer blocks. The buffer boxes will be placed in a retreating arrangement within the placement room with any remaining voids backfilled with granular bentonite Gap Fill Material (GFM).

The basic arrangement of the underground repository involves a series of parallel, dead-end placement rooms, organized into panels. All underground openings will be excavated by controlled drill and blast methods. The placement rooms will have a rectangular shape of nominal dimensions about 3.2 m wide by 2.4 m high.

Heat will be generated by the UFCs. Such heat and the resulting elevated thermal regime will be evaluated with respect to potentially induced thermal stresses, as well as the requirement that temperature on UFC surfaces must be below 100°C at all times. To meet this thermal requirement, the center-to-center spacing of the buffer boxes is set at approximately 1.3 m for crystalline rock and 1.7 m for sedimentary rock. In addition, the center-to-center spacing of placement rooms will be set at 25 m for both crystalline and sedimentary rock geospheres. These values are dependent on the site-specific geosphere; as a result, they will be updated as site investigations proceeds.

During the Construction Phase of the underground repository, the Services Area including the UDF, and all access tunnels that extend into the placement arms will be developed. Following the start of operations, excavation of placement rooms will proceed concurrently with placement activities. There will be separation of development (excavation) and UFC placement activities from a worker, ventilation and equipment perspective.

For both crystalline and sedimentary geospheres, and depending on geologic conditions encountered, the underground repository will likely cover an area of approximately 2 by 3 kilometers (about 1,500 acres or 600 hectares).

Underground Ventilation

Three primary airways will be used to ventilate the repository. The Service Shaft will constitute a dedicated fresh air passage. The primary exhaust air passage will be via the Exhaust Ventilation Shaft and relatively small amounts of air will exhaust via the Main Shaft. A series of surface fans and underground booster fans will be required to achieve the design air flow distribution in the underground repository. A surface-based fresh air heating plant will be used to heat air in winter

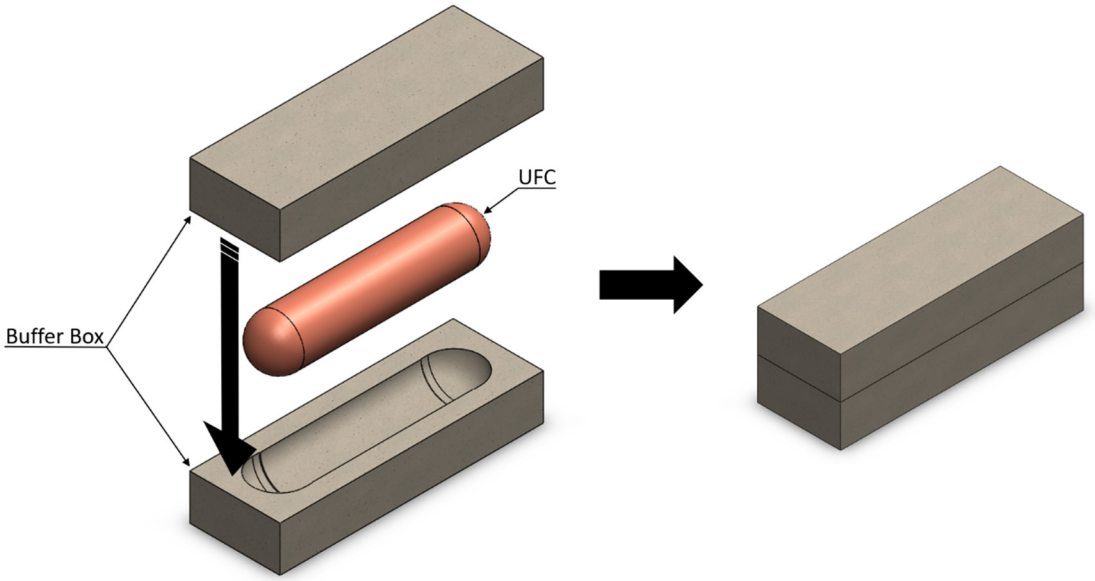
months. Auxiliary fans and ducting will be located in the underground tunnels and rooms, which will direct airflow into active placement rooms.

Used Fuel Container (UFC) Placement and Retrieval

The Used Fuel Container (UFC) consists of a carbon steel inner vessel with a copper coating fully bonded to the exterior surface. The steel vessel is designed to withstand the structural loads of the repository environment. The copper coating will function as a corrosion-resistant barrier to protect the steel vessel from corroding in the repository environment. The minimum thickness of the copper coating is 3 mm.

The UFC can hold 48 CANDU fuel bundles, distributed in four layers with 12 bundles per layer. The used fuel bundles are secured in place by an internal steel structure called an Insert.

Prior to underground transfer, the UFC will be pre-packaged into a rectangular shaped buffer box. The Buffer Box will be comprised of HCB formed into blocks with a machined cavity to house the UFC. The dimensions of the Buffer Box are approximately 1 m x 1 m x 2.9 m.



Used Fuel Container within Bentonite Buffer Box

Conceptual designs for the safe transfer and placement of the UFCs have been developed based on a review of proven nuclear industry material handling concepts, as well as related work by other national radioactive waste management organizations.

The transfer and placement technology will be refined and demonstrated in a mock-up of the placement room in a surfaced-based proof test facility and in the UDF prior to operations. The technology will also consider the potential retrieval of the UFCs from the repository placement rooms for subsequent return to the DGR's surface facilities. The intended retrieval approach may allow re-use of some of the container placement and mining equipment depending on time since placement.

Operational Safety and Radiation Protection

During the operational phase and the period of extended monitoring, there will be a numerous management systems and programs to ensure facility operational control and safety. These will include

- Worker occupational health and safety;
- Environmental monitoring at the surface and underground;
- Nuclear material safeguards;
- Radiation protection;
- Site security and emergency response planning; and
- Support systems including fire detection and suppression.

Radiological calculations have been carried out on selected aspects of the DGR's design elements to confirm that the potential whole-body dose for facility employees during normal operations at the DGR will be well below the limits established by the Canadian Nuclear Safety Commission (CNSC). The design includes sufficient shielding and use of remote operations to keep doses As Low As Reasonably Achievable (ALARA) in accordance with CNSC guidance (CNSC, 2021a) and the most recent recommendations of the International Commission on Radiological Protection (ICRP).

Extended Monitoring, Decommissioning and Closure

After used fuel placement activities are complete, there will be a period of extended monitoring. Following the receipt of regulatory approval, the DGR facility will be decommissioned, and the underground repository sealed. When sealing or closure of the repository is complete, the site will be available for surface use. These post-placement activities will take place in the following order, with assumed durations as shown:

- 70-year or more extended monitoring period;
- 10-year decommissioning period;
- 15-year closure period; and
- Post-closure period.

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DEFINITIONS AND ACRONYMS

AECL	Atomic Energy of Canada Limited.
AGV	Automated Guided Vehicle
ALARA	As Low As Reasonably Achievable
ANFO	High impact explosive made of a mixture of ammonium nitrate and fuel oil
AOO	Anticipated Operational Occurrences
APM	Adaptive Phased Management
Backfill	An engineered mixture (solid or loose) designed to infill a void
Basket	Cylindrical system holding used nuclear fuel in a vertical orientation
BB	Buffer Box
Bentonite	A swelling clay material used as a sealing material
BTP	Basket Transportation Package
Bulkhead	A concrete plug
Cage	Shaft conveyance used to move personnel and material underground
CANDU	CANada Deuterium Uranium
Cask	Mobile container for used fuel storage or transfer; typically shielded
CCA	Contamination Control Area
CCTV	Closed circuit television
CIP	Cold Isostatic Press
CNSC	Canadian Nuclear Safety Commission
Collar	The shaft opening at surface and the structure that supports the headframe
D&C	Decommissioning and closure
DBF	Dense backfill
DGR	Deep Geological Repository
Drill and Blast	Rock excavation by loading and detonating drill holes with explosive
EDZ	Excavation damage zone
ERMA	Excavated Rock Management Area
ERT	Emergency Response Team
FAR	Fresh Air Raise
Geosphere	The rock environment the DGR will be located within
GFM	Gap fill material
Grizzly	Heavy duty grate to stop oversize rock from falling into a muck pass
HCB	Highly compacted bentonite
HDPE	High-Density Polyethylene
Headframe	Tower structure that supports a hoisting operation, situated above the shaft
Heading	A tunnel that is being developed

HEPA	High efficiency particulate air (filter)
Hoek-Brown	Rock mass strength criteria
Hot Cell	An isolated and shielded room for contaminated (radioactive) material and equipment
HVAC	Heating, ventilation and air conditioning
IAEA	International Atomic Energy Agency
ILW	Intermediate level waste
Jumbo	A mechanized drilling machine
kg	Kilogram
kV	Kilovolts
L&ILW	Low and intermediate level waste
LAN	Local area network
LHD	Load / haul / dump unit (low-profile version of a surface front end loader)
LHHP	Low heat high performance (concrete)
LLW	Low-level waste
Loading Pocket	An underground assembly next to shaft to transfer excavated rock into skips
m / mm	Metre(s) / millimetre(s)
m^2 / m^3	Square metre(s) / cubic metre(s)
Mbgs	Metres below ground surface
Module	Rack system holding used fuel bundles within a rectangular framework
MPa	Megapascal (unit of pressure)
Muck	Broken rock
NDE	Non-Destructive Examination
NEW	Nuclear Energy Worker
NFC	National Fire Code
NFPA	National Fire Protection Association
NWMO	Nuclear Waste Management Organization
OPG	Ontario Power Generation
Permeability	The ability of a rock or soil mass to transmit water
PLC	Programmable logic controller
PPE	Personal protective equipment
QA/QC	Quality Assurance / Quality Control
Raise	Vertical excavation used for ventilation, or to move personnel via ladders
Rock Bolt	A long anchor bolt installed in a drilled hole for local ground support of excavated face.
RMSA	Radioactive Material Storage Area
Safety Bays	Cut-out in tunnel for personnel to stand when equipment is passing
Scissor lift	Working platform that can be raised and lowered

Shaft	Vertical excavation for the hoisting of personnel, materials and rock
Shotcrete	Concrete sprayed on tunnel surfaces for ground support
SKB	Svensk Kärnbränslehantering AB (Swedish Nuclear Waste Management Org.)
Skip	Shaft conveyance mainly used for hoisting excavated rock to surface
SMCP	Sealing materials compaction plant
TBD	To be determined
TC	Transfer cask (intra-site)
UDF	Underground Demonstration Facility
UFC	Used Fuel Container (holds the used fuel bundles in repository)
UFIC	Used Fuel Inspection and Classification
UFPP	Used Fuel Packaging Plant
UFTP	Used Fuel Transportation Package
Wi-Fi	Trademark for wireless wide local area network
Working Face	The front end of a tunnel that is being developed

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1. INTRODUCTION

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of its used nuclear fuel. The APM approach encompasses centralized containment and isolation of the used fuel in a Deep Geological Repository (DGR) located in a suitable rock formation to safely contain and isolate used fuel. In January 2020, the NWMO announced that the Ignace area in northwestern Ontario and South Bruce area in southern Ontario will undergo more detailed investigations to determine suitability for hosting the DGR. The Ignace area has a crystalline rock geosphere while the South Bruce area has a sedimentary rock geosphere. This report describes DGR facility concepts for these two rock types.

The NWMO has adopted a Used Fuel Container (UFC) design that provides containment for 48 CANDU used fuel bundles. Prior to transfer to the underground repository, the UFCs will be pre-packaged into rectangular shaped bentonite buffer boxes to facilitate placement inside the underground placement rooms. The repository is assumed to be located in either a crystalline or sedimentary rock geosphere at a nominal depth of 500 m.

This report describes the concept for the facilities and infrastructure needed to safely receive, repackage, and place the used nuclear fuel, as transported from reactor storage sites, in an underground repository.

The report is organized as follows:

- Section 2 lists the main design basis and battery limits that form the conceptual design.
- Section 3 addresses the proposed surface facilities including the Used Fuel Packaging Plant (UFPP), which will receive and process the incoming used fuel, and then package the used fuel inside the UFCs and Buffer Boxes.
- Section 4 describes the shafts and hoists that will service the underground repository.
- Section 5 provides an overview of the underground repository and supporting ventilation system.
- Section 6 describes the transfer of UFC/Buffer Box Transfer Casks to the underground repository and emplacement inside a placement room. This section also describes the process to seal the placement room.
- Section 7 addresses the potential retrieval of UFCs from the repository.
- Section 8 describes site security and safeguard features.
- Section 9 addresses operational safety and monitoring systems.
- Section 10 addresses the topics of decommissioning and closure of the surface and underground facilities.
- Key technical references are listed in the References section.
- Appendix A provides further information on the UFC/Buffer Box design.

2. DESIGN BASIS

The following sections identify regulations, the main assumptions and other design criteria that form the basis for the conceptual design work presented in this document. Battery limits (the scope of design work) are also discussed.

2.1 ACTS, REGULATIONS, CODES AND STANDARDS

The following are the key acts, regulations, codes and standards that are applicable to the design of the DGR facility:

- Nuclear Safety and Control Act, Canada Gazette Part III, Vol 139, 1997 and associated regulations;
- CNSC Radiation Protection Regulations (SOR/2000-203);
- Ontario Occupational Health and Safety Act, Regulations 854/90, Mines and Mining Plants;
- Ontario Occupational Health and Safety Act, Regulations 851/90, Industrial Establishments;
- National Fire Code of Canada (NFCC);
- National Building Code of Canada (NBCC);
- Ontario Electrical Safety Code (OESC);
- CSA N286-12 (R2017), Management system requirements for nuclear facilities;
- CSA N288.4 (R2019), Environmental Monitoring Programs at Nuclear Facilities and Uranium Mines and Mills;
- CSA N393-13 (R2018), Fire protection for facilities that process, handle, or store nuclear substances;
- CSA C22.1, Canadian Electrical Code (CEC), Part I;
- CSA N292 series, covering the principles for the management of radioactive waste and irradiated fuel;
- Nuclear Security Regulations;
- Class I Nuclear Facilities and Prescribed Equipment Regulations;

2.2 DESIGN ASSUMPTIONS AND CONSTRAINTS

The primary assumptions that formed the basis for the conceptual design described in this report are as follows:

2.2.1 Used Fuel Characteristics

- The used fuel inventory to be accommodated comprises 5.5 million CANDU fuel bundles (Gobien and Ion, 2020);
- All used fuel bundles are a minimum of 10 years out-of-reactor prior to shipment;
- The used fuel is in the form of CANDU fuel bundles (Figure 1).



Figure 1: CANDU Fuel Bundle

2.2.2 Modules and Basket Configurations and Transportation Packages

- Ontario Power Generation (OPG) owned used fuel is stored and will be transported in a rectangular racking system known as a module, shown in Figure 2. Each module holds 96 fuel bundles in a horizontal orientation. Used Fuel Transportation Packages (UFTP) are certified for road transport and can transport 2 modules for a total of 192 fuel bundles to the repository.

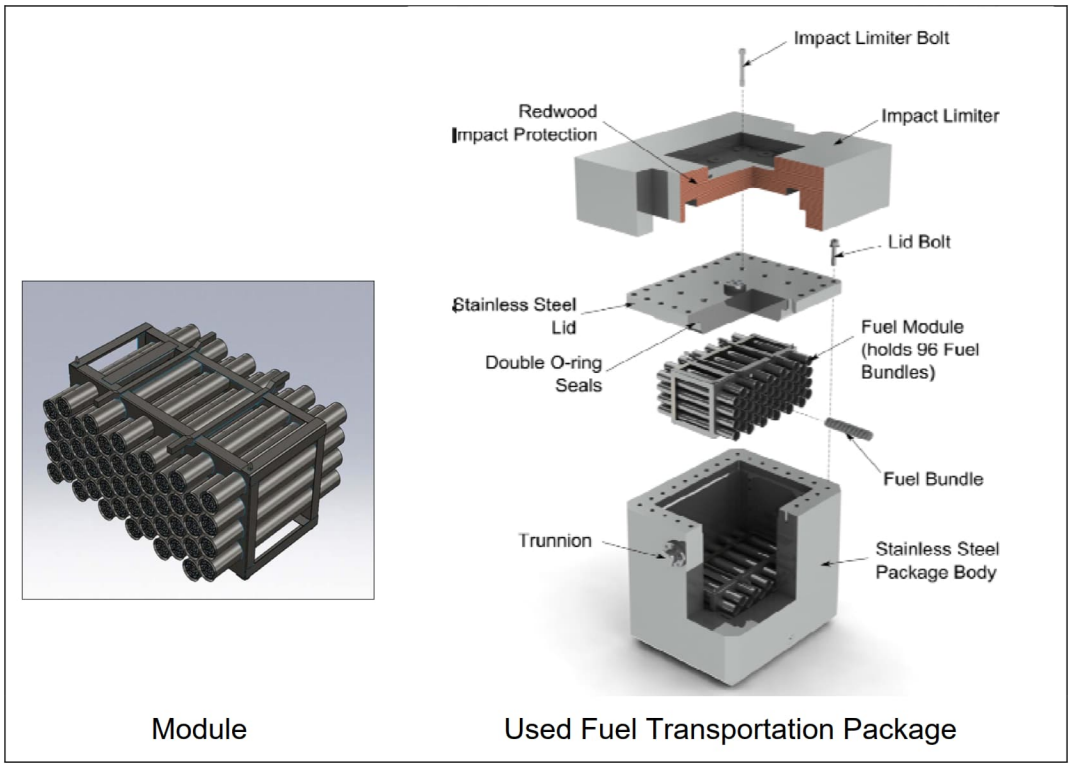
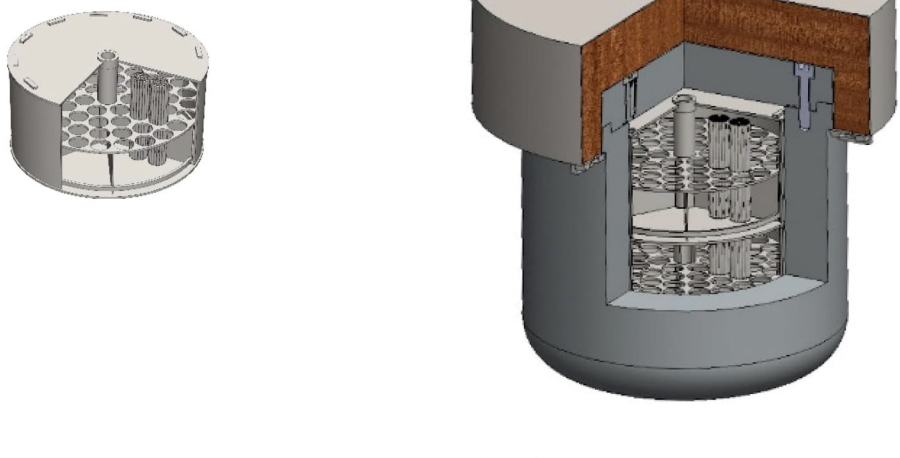


Figure 2: Module and Used Fuel Transportation Package

- Non-OPG owned used fuel is stored and will be transported in a cylindrical system known as a basket, shown in Figure 3. A typical basket holds 60 used fuel bundles in the vertical orientation. Basket Transportation Packages (BTP) are in the conceptual design stage and are assumed to be certified for road transport. It is assumed that the BTP can transport 2 baskets (for a maximum of 120 fuel bundles) by road to the repository.



Basket Basket Transportation Package

Figure 3: Basket and Basket Transportation Package

2.2.3 Used Fuel Handling, Packaging and Placement

- The used fuel will be repackaged at the Used Fuel Packaging Plant (UFPP) into Used Fuel Containers (UFC);
- The UFC will be a copper coated steel vessel with a steel insert that holds the fuel (see Appendix A);
- Prior to transfer underground, the UFC will be pre-packaged into a two-piece rectangular shaped buffer box made from highly compacted bentonite (HCB) blocks with a machined cavity to house the UFC. The Buffer Box dimensions will be approximately 1 m x 1 m x 2.9 m and each box will have an approximate loaded mass of about 8 tonnes;
- Design of operational systems and engineered barriers are based on an average thermal output of all the used fuel bundles in a used fuel container, which is equivalent to that of a 37 element CANDU fuel bundle with a burnup of 220 MWh/kgU and a storage time of 30 years from discharge.
- Empty storage modules and baskets (used in the delivery of used fuel bundles) will be processed in a dedicated area within or attached the UFPP and then sent off site for recycling, re-use, or long-term waste management;
- In the event that filled UFCs are returned from the underground repository (for example as part of a retrieval program), it shall be possible to modify the UFPP so that packaging process can be reversed in order to cut open and unload the UFCs;

- The UFPP will be designed with the principle that any abnormal anticipated operational occurrences (AOO) shall not lead to serious consequences for the environment, personnel or the plant itself;
- A rate of placement equivalent to 120,000 used fuel bundles per year will be accommodated. This is equivalent to 2,500 UFCs (in buffer boxes) placed per year (48 used fuel bundles per UFC);
- An average of 10 UFCs will be placed in the repository per day based on the assumption there are 250 working days each year;
- Each UFC/buffer box will be transferred inside a shielded transfer cask in a horizontal position on a trolley from the UFPP to the entrance of the placement room.

2.2.4 Underground Repository

- For the purposes of this conceptual design work, it is assumed that the repository will be located either within a high-quality sparsely fractured crystalline or within a sedimentary rock geosphere which has a thick homogenous and competent host rock formation;
- The underground repository will be constructed at a nominal depth of 500 m below ground surface subject to site specific conditions (shaft bottom allowances for sumps, etc. will be below this elevation);
- The repository's placement rooms, and access tunnels will have a pre-defined minimum stand-off distance from a major fracture and/or investigation borehole;
- To the extent practical and necessary, placement rooms will be oriented with respect to the in-situ stress fields so as to minimize stress concentration around openings to promote long-term stability and minimize rock support requirements;
- Placement room will be designed to minimize stress levels and excavation damage at the rock surface; and
- Flexibility and adaptability will be provided in the repository layout so that changes can be implemented if necessary (e.g., due to adverse rock conditions).

2.2.5 Used Fuel Placement and Retrieval

- An in-room horizontal placement method will be utilized in the underground repository;
- Buffer boxes containing the UFCs will be stacked between HCB spacer blocks and surrounded by granular GFM;
- The placement room cross-section will be sized to provide the required clearances for excavation, insertion of sealing materials and UFC placement. It will also contribute to excavation stability;
- The design includes a space allowance equal to about 10% of each room to account for possible groundwater seepage or unsuitable rock conditions (this assumption increases the total number of placement positions to be established);
- UFC placement configurations will ensure temperature on the UFC container surfaces does not exceed 100°C;
- Upon completion of each placement room, a placement room seal will be constructed at the room entrance to allow bentonite to develop swelling pressure and limit migration of radioactivity out of the room including migration via the excavation damage zone (EDZ); and
- The DGR design will allow the potential for retrieval of used fuel containers prior to closure of the repository.

2.2.6 Radiation Shielding

- In compliance with REGDOC-2.7.1 (CNSC, 2021a), shielding structures will be designed to ensure that doses are maintained to As Low As Reasonably Achievable (ALARA) during both normal operations and AOO. Shielding will be integrated into the design of structures, equipment and containers, with consideration of time and distance within the fuel handling procedures.
- Use of remote handling techniques will be considered;
- The shielding design will be optimized using annual effective dose constraints of 5 mSv for Nuclear Energy Workers (NEWs) and 0.1 mSv for workers that are not designated as NEWs;
- Shielding design of transfer casks (both UFC and UFC/Buffer Box Transfer Casks) assumes that 10-year-old used fuel with a burnup of 290 MWh/kgU is handled (Heckman & Edward, 2020). The external dose rates on the transfer casks are limited to 2000 μSv/h on contact and 100 μSv/h at 1m; and
- In order to simplify construction, maintenance and operations, shielding will be comprised of ordinary materials (e.g., steel, lead, concrete) wherever possible and be designed for easy decontamination of exposed surfaces.

2.2.7 Supporting Operations

- A hoisting speed of not more than 2.5 m/s will be used for movement of transfer casks with buffer boxes down to the underground repository;
- The shaft complexes will be designed to function during the construction phase and the operations phase including the period of extended monitoring;
- Service Shaft and Exhaust Ventilation Shaft auxiliary hoisting systems will employ Blair multi-rope hoists to eliminate the need for timber guides (required for single-rope drum hoisting systems) and thus reducing fire hazard inside shafts;
- Redundant services (i.e., duplicating services in the Service Shaft) will be located in the Exhaust Ventilation Shaft;
- Waste processing facilities will be capable of safely and efficiently handling, treating and packaging any generated low and intermediate level (non-fuel) waste prior to disposal in a suitable long-term waste management facility;
- Ventilation for the underground repository will provide effective dilution of contaminants and dissipation of heat to provide a comfortable working environment, and be kept under positive pressure;
- Raw material inventories will be adequate to compensate for any delivery delays due to adverse weather conditions; and
- Surface ponds with DGR surface facilities have been sized to accommodate a 1-in-500-year storm event.

2.2.8 Decommissioning and Closure

- After placement is complete, we have assumed a 70-year extended monitoring period during which underground access will be maintained and the placement rooms will be monitored;

- During this extended monitoring period, the capability to retrieve UFCs from placement rooms is maintained but will require increasing efforts as time advances; and
- To the degree that it is practical to do so, final decommissioning and closure of the DGR facility will return the site to natural conditions and there will be no provision for re-entry to underground repository after closure.

2.3 BATTERY LIMITS

The battery limits for the design work are essentially represented by the DGR's perimeter fence systems, which encompass practically all of the design elements outlined in this report with a few exceptions. These exceptions relate to the external off-site facilities (e.g., excavated rock management area) and transportation (Taylor, 2021).

3. SURFACE FACILITIES AND INFRASTRUCTURE

The DGR surface facility will include structures, systems, equipment and components for operation, maintenance, and long-term monitoring. Surface facilities are identified as either being in a Protected Area (i.e., a restricted area) or associated with the Balance of Site area. The differentiation being that all buildings or activities pertaining to the handling and storage of used nuclear fuel will be located in the Protected Area. The Protected Area will be located near the center of surface facilities site and will be surrounded by the Balance of Site area. The two areas will be separated for safety and security reasons (see Figure 4).

External facilities, located outside the DGR's perimeter fence, will also be required for support of repository construction and operation. Such facilities will include the Centre of Expertise and accommodation for construction personnel (if required), as well as, an Excavated Rock Management Area (ERMA).

The following section describes the primary surface facility components with the exception of the underground shafts, site security and safeguard features. The three Shaft Complexes (Main Shaft, Service Shaft and Exhaust Ventilation Shaft) are discussed in Section 4. Site security measures (fencing, security checkpoints, guardhouses, and monitoring rooms) and safeguard measures are described in Section 8.

3.1 GENERIC SITE LAYOUT

The generic DGR surface facility layout is shown in Figure 4 with component facilities identified in Table 1. The facility is laid out such that all buildings which handle, or store used nuclear fuel are located in the Protected Area. This area is separated from other surface facilities by a security fence, equipped with lighting and intruder detection systems. Personnel and vehicular access to the Protected Area will be strictly controlled by way of checkpoints and security gates provided with radiation monitors.

The layout of the buildings provides for the safe and efficient operation of the facility in terms of radiological zoning, material movement, traffic patterns and interaction between the services provided by the different buildings. The Service Shaft, Exhaust Ventilation Shaft, and the Main Shaft Complexes are the anchor points for the DGR's layout. The distance between the UFPP and the Main Shaft Complex, for example, has been kept to a minimum to accommodate the delivery of buffer boxes/UFCs.

The land required to accommodate the DGR surface facilities covers an area of approximately 625 m x 700 m as shown in Figure 4. A three-dimensional perspective of the surface facilities is provided as Figure 5.

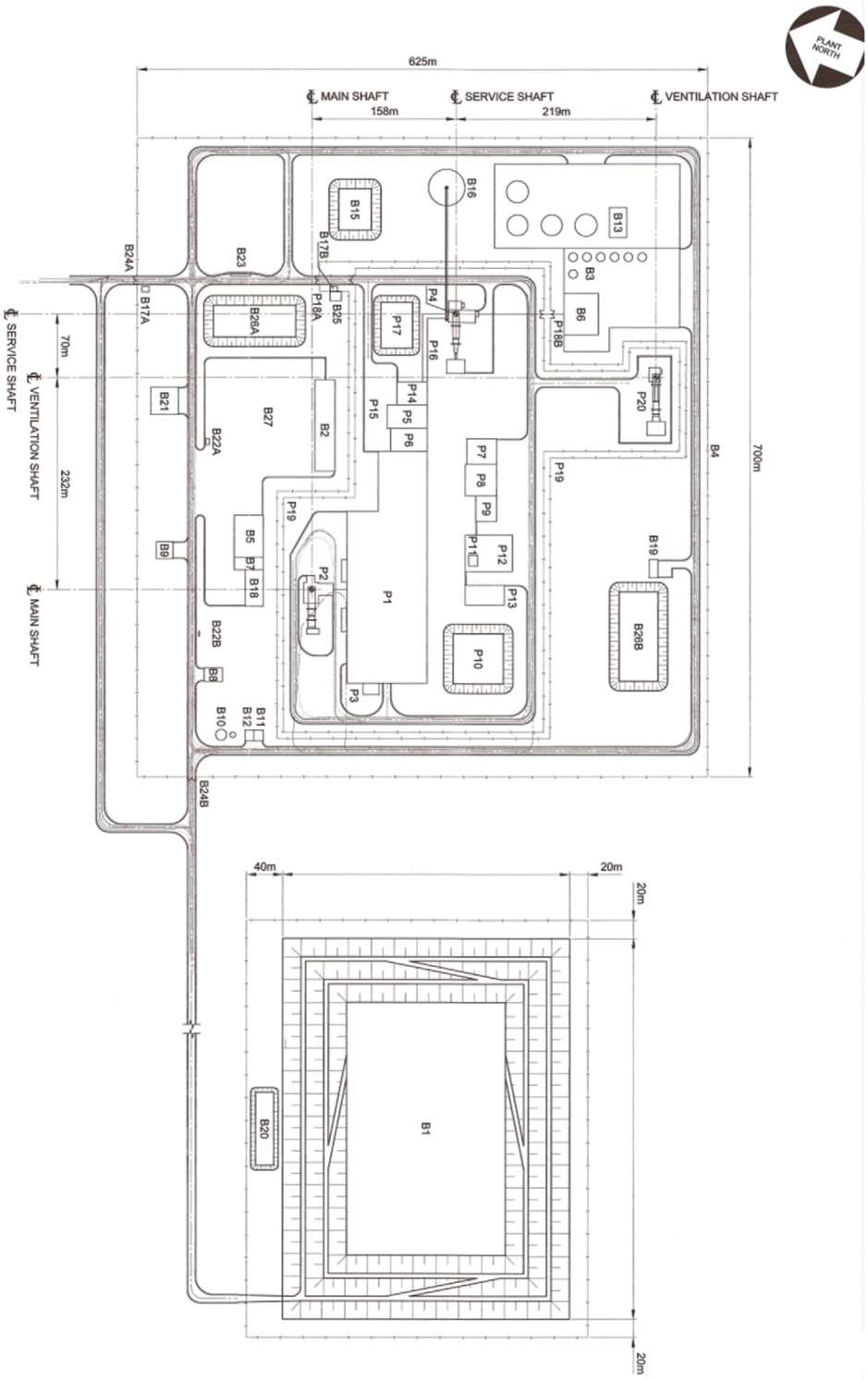


Figure 4: Surface Facilities (Generic) Site Layout

Table 1: Area Number and Description

Area	Protected Area	Area	Balance of Site
P1	Used Fuel Packaging Plant	B1	Excavated Rock Management Area (ERMA)
P2	Main Shaft Complex	B2	Administration Building including Firehall and Cafeteria
P3	Stack	B3	Sealing Material Storage Bins
P4	Service Shaft Complex	B4	Perimeter Fence
P5	Auxiliary Building	B5	Garage
P6	Active Solid Waste Handling Facility	B6	Sealing Material Compaction Plant
P7	Waste Management Area	B7	Warehouse and Hazardous Materials Storage Building
P8	Active Liquid Waste Treatment Building	B8	Air Compressor Building
P9	Low-Level Liquid Waste Storage Area	B9	Fuel Storage Tanks
P10	Stormwater Management Pond	B10	Water Storage Tanks
P11	Switchyard	B11	Water Treatment Plant
P12	Transformer Area	B12	Pump House
P13	Emergency Generators	B13	Concrete Batch Plant
P14	Quality Control Offices and Laboratory	B14	Not Used
P15	Parking	B15	Service Water Settling Pond
P16	Covered Corridor / Pedestrian Routes	B16	Excavated Rock Stockpile (Working)
P17	Mine De-watering Settling Pond	B17	Guardhouses (A, B)
P18	Security Checkpoints	B18	Storage Yard
P19	Double Security Fence	B19	Sewage Treatment Plant
P20	Ventilation Shaft Complex	B20	ERMA Stormwater Management Pond
		B21	Helicopter Pad
		B22	Bus Shelters (A, B)
		B23	Weigh Scale
		B24	Security Checkpoints
		B25	Security Monitoring Room
		B26	Stormwater Management Ponds (A, B)
		B27	Parking Area

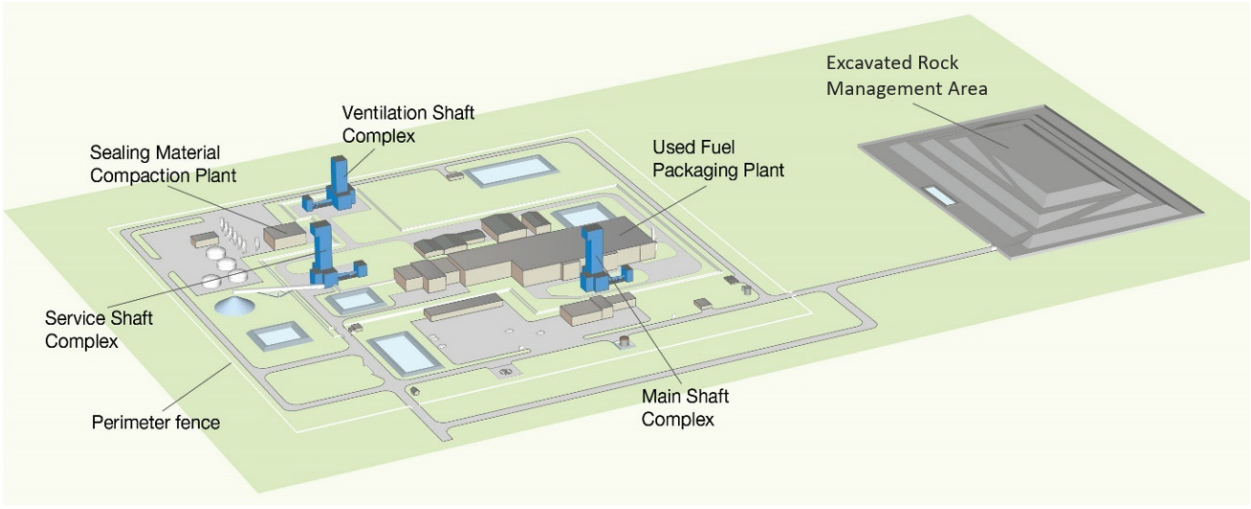


Figure 5: Deep Geological Repository Surface Facilities

3.2 USED FUEL PACKAGING PLANT (UFPP)

Area P1

The Used Fuel Packaging Plant (UFPP) is identified as Area P1 on the generic site layout shown in Figure 4. In the current conceptual design, the UFPP will be a single storey, reinforced concrete structure. The UFPP will contain the necessary provisions for receiving used nuclear fuel in certified road transportation packages (i.e., the Used Fuel Transportation Packages (UFTP) and Basket Transportation Packages (BTP)), transferring the fuel to UFCs, and assembling UFCs into Buffer Boxes for transfer underground to be emplaced in the DGR. The current UFPP layout is shown in Figure 6. The key process steps to achieve safe repackaging consist of:

- receiving and opening up the transportation packages in the UFTP/BTP Shipping and Receiving area;
- removing the used fuel and transferring them into the UFCs in the UFC Loading Cell;
- seal welding the loaded UFCs in the UFC Weld Cells;
- decontamination of the welded UFCs in the Decontamination cells;
- copper coating in the Copper Application cells;
- copper annealing in the Copper Annealing cells;
- assembling the UFC in the bentonite buffer box to be emplaced underground in the Buffer Box Storage, Handling and Dispatch area; and
- multiple inspection points, utilizing various non-destructive examination techniques, to verify that the packaging process achieves the specified safety and security requirements.

The UFPP will ensure that used fuel received from the reactor sites is properly packaged for emplacement in the DGR. This includes detection of damaged or defective used fuel and segregating these bundles for further processing, as required, prior to packaging and placement in the DGR.

All handling operations that involve used fuel will be completed within heavily shielded enclosures (cells). Fuel handling will use remote tooling. Transfers between the cells and will be completed

in shielded packages to minimize worker dose. All shielded cells will also be environmentally controlled by an active ventilation system to prevent the spread of airborne contamination.

The UFPP will also include the required auxiliary systems, like electrical power systems (regular, emergency and back-up), a central control room, waste management facility, and facilities for personnel and visitors. Maintenance on used fuel handling equipment will be performed within the confines of the UFPP. The provisions for the safe handling of any wastes generated as a result of packaging the used fuel or maintenance of the used fuel handling equipment will also be provided in the UFPP.

All areas of the UFPP will be classified, zoned, and controlled according to external dose rates and the potential for contamination. Ventilation systems will be according to the best engineering practice and latest standards for active ventilation systems. These standards specify negative pressure ranges for each area classification. Areas with the highest activity and contamination hazards will generally be kept at the most negative pressure.

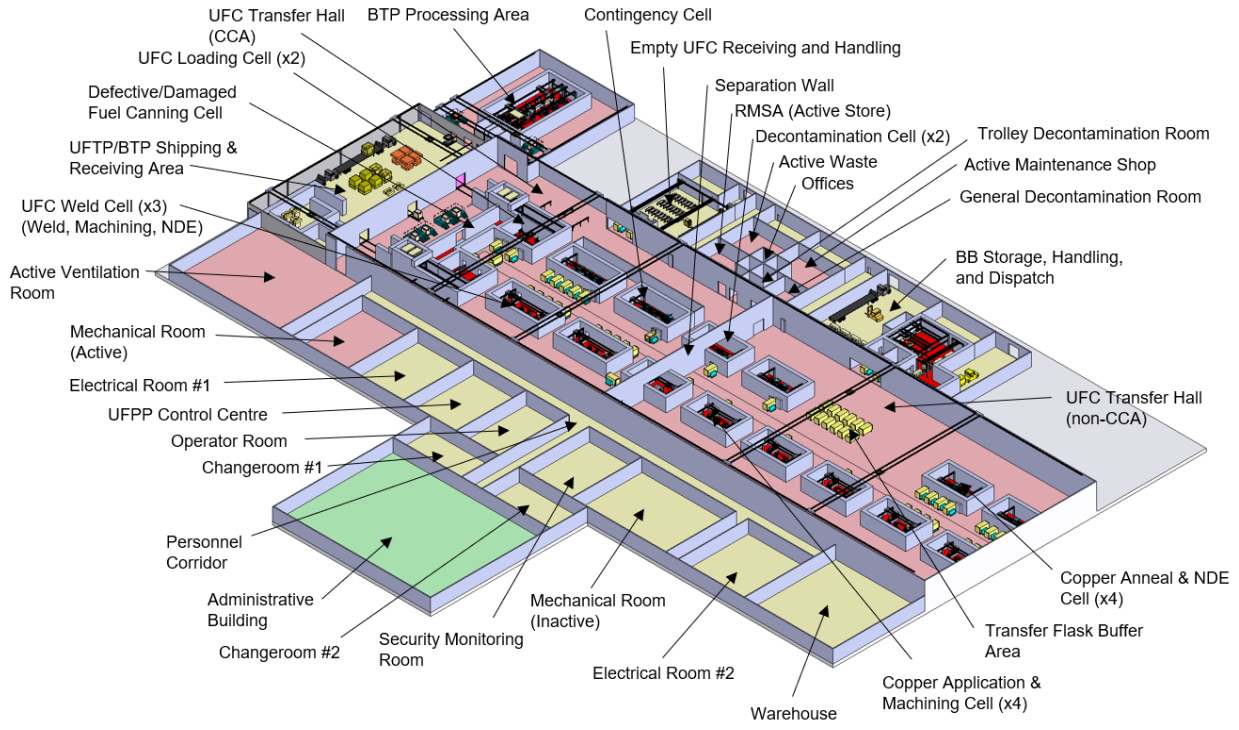


Figure 6: Layout of the Used Fuel Packaging Plant (UFPP)

3.2.1 Facility Throughput

The UFPP will have a lifetime throughput requirement of processing over 5.5 million used nuclear fuel bundles over the facility life of approximately 46 years. This will be accomplished by processing approximately 120,000 used nuclear fuel bundles into 2,500 UFCs on an annual basis. On average, 10 UFCs will be processed each workday.

The UFPP facility throughput is based on annual transportation shipping assumptions, as shown in Table 2. These annual shipping assumptions define the annual used fuel quantities to be transported from each interim storage facility and have been established for planning purposes which will be further refined closer to operations.

Table 2: Annual Transportation Shipping Assumptions

Interim Storage Facility	Transportation Package (1)	Total Used Fuel Transported (bundles)	Total Used Fuel Transported (shipments)	Start Year	Finish Year
Bruce	UFTP (2)	2,907,650	15,147	2050	2088
Pickering	UFTP	902,148	4,699	2043	2050
Darlington	UFTP	1,268,801	6,610	2050	2088
Point Lepreau	BTP (3)	258,820	2,157	2054	2066
Chalk River	BTP	7,187	90	2068	2068
Gentilly 1	BTP	3,213	43	2050	2050
Gentilly 2	BTP	129,925	1,083	2050	2054
Douglas Point	BTP	22,256	207	2067	2068
	Total:	**5,500,000**	**30,036**		

Note:
(1) One transport package (UFTP or BTP) per shipment.
(2) UFTP holds 2 modules (192 fuel bundles)
(3) BTP holds 2 baskets. For Point Lepreau and Gentilly-2, baskets hold 60 bundles per basket. For Chalk River, Gentilly-1 and Douglas Point baskets hold fewer used fuel bundles (i.e., 40, 38, and 54 used fuel bundles, respectively).
These shipping assumptions are conceptual and are subject to future refinement and change.

The expected maximum annual throughputs are shown in Table 3. The maximum number of UFTPs and BTPs received at the UFPP, in any given year will be 625 and 260, respectively. The UFPP will receive and process up to 3 UFTPs and 2 BTPs per day.

Table 3: Throughput processing parameters for the UFPP

Item	Bundles per Unit	Throughput		
		Base Case Total	Annual	Daily
Bundle	1	5,500,000	120,000	480
UFC	48	~115,000	2,500	10
Basket	60	~7,200	520	4
Module	96	~53,000	1,250	6
BTP	120	~3,600	260	2
UFTP	192	~26,500	625	3

* Based on assumption of 250 UFPP UFC processing days working days per year.
**: UFTP/BTP shipments fluctuate depending on year (i.e., the facilities actively shipping). The UFTP, BTP, Basket (typical), and Modules presented in the above represent maximum yearly throughputs.

3.2.2 UFPP Process Flow Overview

The UFPP concept adopts a modular manufacturing approach, utilizing multiple duplicate packaging systems, to ensure redundancy to achieve the required processing throughput. The key used fuel processing steps to achieve repackaging in the UFC and bentonite buffer box ready for placement in the DGR are shown in Figure 7.

3.2.3 UFPP Process Descriptions

3.2.3.1 Receipt of UFTP/BTP and used fuel module/basket unloading

Used fuel will be transported from the reactor sites via certified road transportation packages (i.e., UFTP and BTP). The trucks, trailers, and packages will arrive at the Transportation Package (UFTP/BTP) Shipping and Receiving area in the UFPP.

The Shipping and Receiving area, as shown in Figure 8 will contain a laydown area and short-term handling space directly adjacent to the transport trailer unloading area. This space will be used to handle short term storage needs of transportation packages. This includes space for unpacking transportation packages with consideration for weather covers, impact limiters and specialized handling tools. The UFPP will also have additional shielded space (laydown area) available to minimize worker dose consistent with ALARA principles. A large overhead crane will sit above the entire shipping and receiving area. The overhead crane will be the main system used to move UFTPs, BTPs and supporting equipment around this area of the UFPP.

After the UFTP or BTP are removed from the transport trailer, the packages will be placed on one of two work platforms. At the platforms, International Atomic Energy Agency (IAEA) safeguard seals will be inspected and removed.

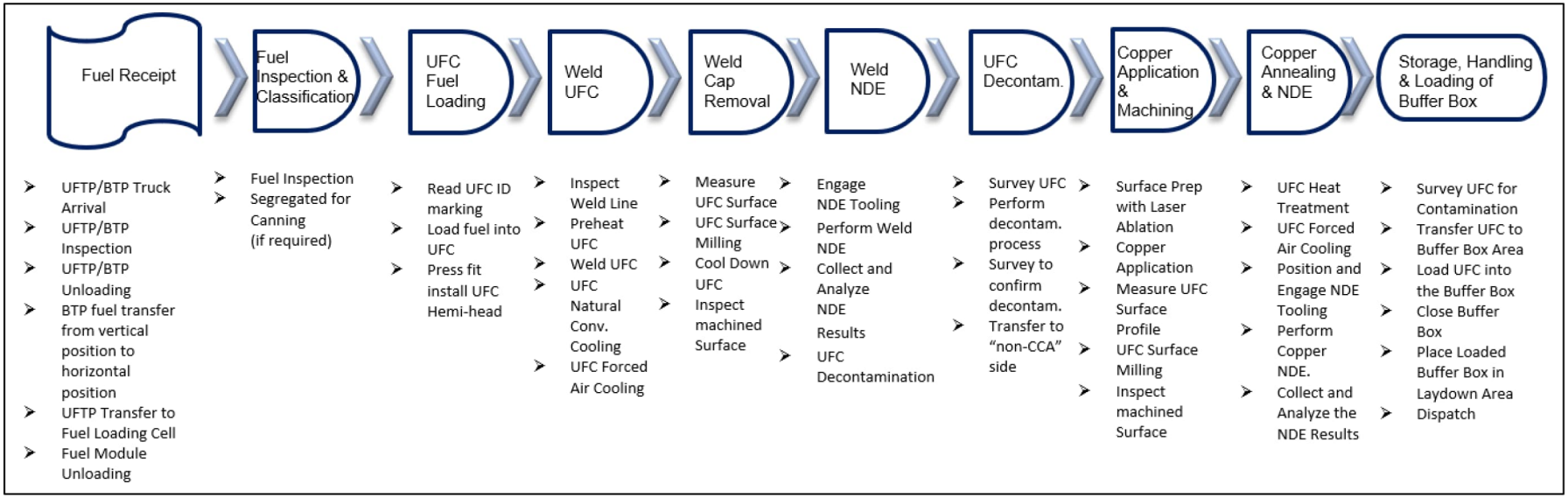


Figure 7: Used Fuel processing activities in the Used Fuel Packaging Plant (UFPP)

After IAEA seals are inspected and removed, the UFTP will be processed in the following manner:

- The impact limiter bolts, and impact limiter will be removed.
- The lid lift and vent port adaptors will then be installed.
- UFTPs will then be transferred by crane onto a trolley which will enter the UFC transfer hall for further processing.
- Within the UFTP unloading cell, specialized tools will unbolt the UFTP lid, lift the lid and transfer the modules from the UFTP cavity onto the module worktables in the UFC Loading Cells.
- The used fuel bundles will be unloaded from the modules
- The empty modules will then be transferred to the waste management facility for processing. The modules will be either sent off site for recycling/reuse or long-term waste management.

After IAEA seals are inspected and removed, used fuel in BTPs will undergo a separate process prior to unloading because the used fuel is contained inside a secondary seal-welded steel basket and housed in a vertical orientation. The BTPs will be processed in the following manner:

- The BTP will be transferred to a BTP processing area.
- BTP processing tools will cut open the baskets and reorient the fuel to a horizontal position in a module(s) to conform with the used fuel received in UFTPs.
- The reoriented fuel will then be transferred to the UFTP unloading cell where it will undergo the same process as UFTPs.
- The empty baskets will then be transferred to the waste management facility for processing. The baskets will be either sent off site for recycling/reuse or long-term waste management.
- The UFPP will have one BTP processing area and two independent UFTP unloading areas.

Empty UFTPs and BTPs will be returned to the Shipping and Receiving area after their lids are reseated, bolts tightened and decontaminated. Packages will be reloaded back onto the empty trailers (with impact limiters and weather covers) and returned to the reactor sites for reloading.

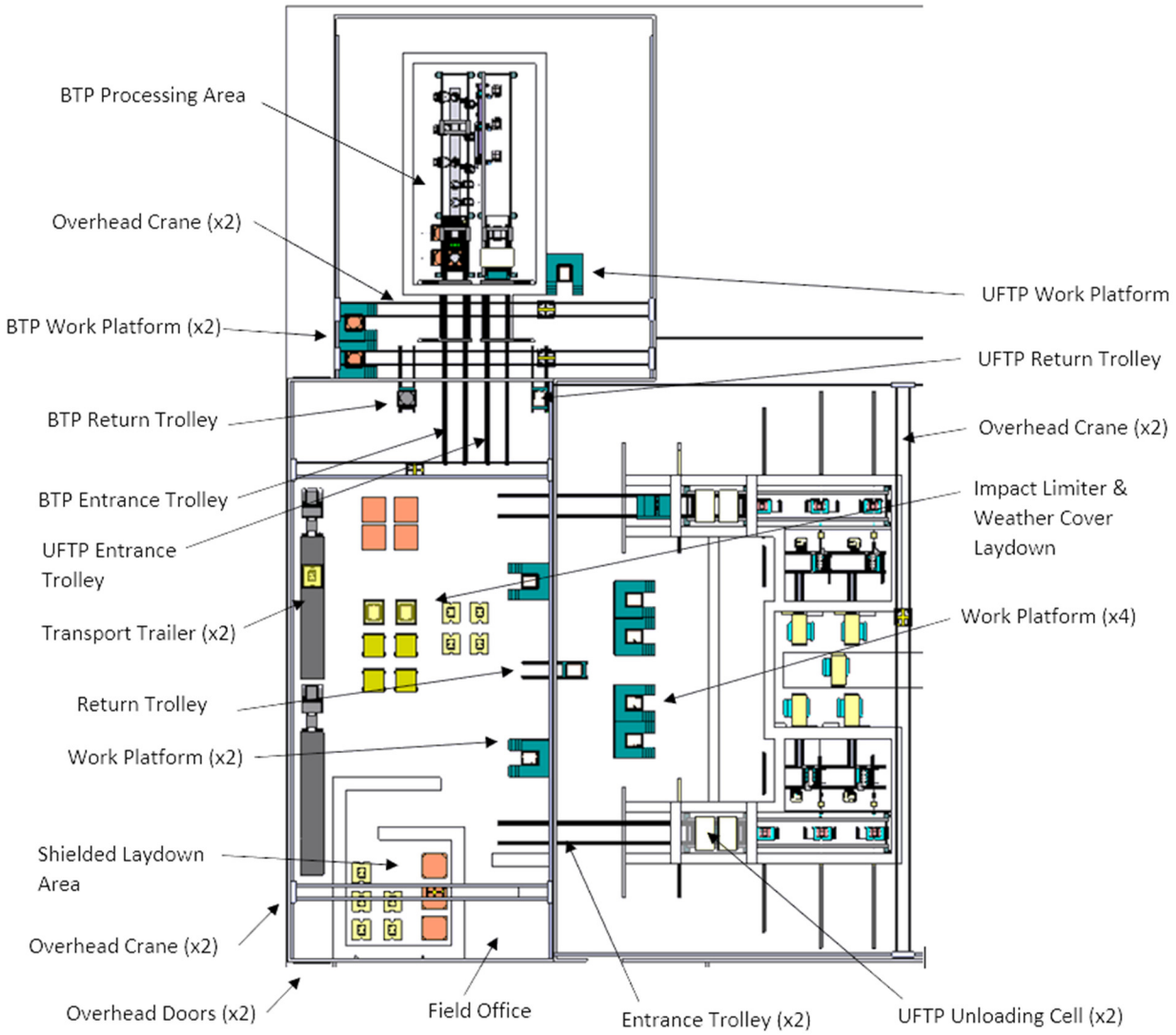


Figure 8: Transportation Package (UFTP/BTP) Shipping & Receiving Area

3.2.3.2 Used Fuel Inspection and UFC Loading

The UFPP will contain two UFC loading cells designed to transfer used fuel into UFCs, as shown in Figure 9, from one of the two UFTP unloading cells.

Each UFC loading cell will contain two Used Fuel Inspection and Classification (UFIC) systems integrated with two UFC loading system. The entire system will inspect and load approximately 10 UFCs per day (2.5 UFCs per UFIC and UFC loading system).

The Used Fuel Loading system will consist of two positioning tables, a push ram and stationary guide sleeve. The positioning tables and guide sleeves ensure alignment between the module and UFC insert.

The UFC Loading process will begin with the push ram pushing the used fuel bundles from the modules to the UFIC system. The UFIC system will then performs the following inspection on each the used fuel bundle:

a) bundle identification,
b) radioactivity measurement, and
c) examination for damage / defect.

If the bundle passes the inspection criteria, the used fuel will be loaded into the UFC insert. If the used fuel does not pass the inspection, the fuel will be segregated for further processing and returned to the fuel module.

Once fully loaded, the UFC will be temporarily closed by press-fitting the Hemi-Head cap onto the UFC Lower Assembly. The key components of the UFC are shown in Figure 10.

The assembled UFC will be loaded into a shielded UFC Transfer Cask and moved by an Automated Guided Vehicle (AGV) (also called the intra-plant transfer system) through the UFC Transfer Hall to an available UFC Weld Cell. If all weld cells are in use, then the transfer cask will be placed into a buffer position until a Weld Cell becomes available. The shielded UFC transfer cask will keep personnel working in the vicinity safe from radioactivity. The AGV will move the shielded transfer cask, containing the UFC, between the various work cells in the UFPP.

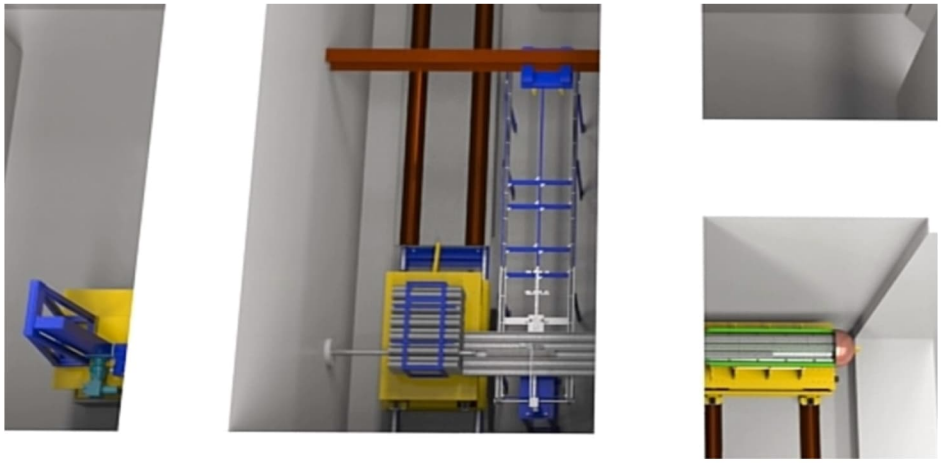


Figure 9: Fuel Transfer into Used Fuel Container

Description of Figure 9:

a) Room at left of figure houses the equipment to operate the push ram that penetrates the work cell shielding wall.

b) A used fuel module loaded with fuel bundles is located on a positioning table in the shielded work cell (center). There will be two (2) module positioning worktables per cell.

c) Bundles are pushed by the ram into the UFC located in the shielded work cell at right of figure. The UFC is shown in a cut-way view with top half of the UFC removed for the purpose of this illustration.

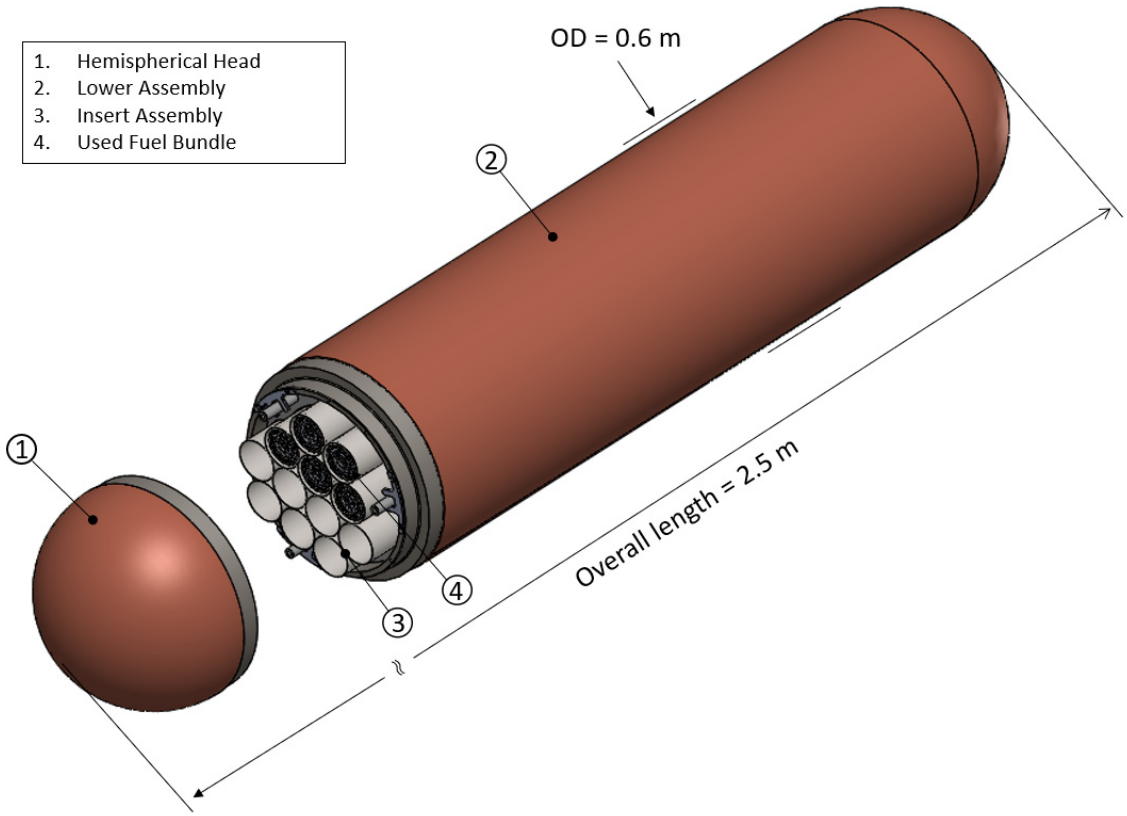


Figure 10: Used Fuel Container Components

3.2.3.3 UFC Weld Cell

After completion of the UFC fuel loading, the UFC will be transferred to one of three UFC Weld Cells using the intra-plant transfer system. Upon arriving at the UFC Weld Cell, the UFC will be extracted from the shielded cask into the shielded process cell and transferred onto a rotary positioner. The rotary positioner will transfer the UFC between the various workstations within the weld cell and will provide the rotary feed motion required for each process of applying the closure weld. The UFC Weld Cell and process steps are shown in Figure 11 and Figure 12.

The UFC on the rotary positioner and pre-heat worktable will align using a camera system to verify the joint line fit-up. Then the UFC is preheated using an induction coil while the UFC is rotated to ensure even heat distribution until the required temperature is reached.

The pre-heat coils will then be retracted while the weld arm is extended to the UFC. While the UFC continues its rotation, the welding system will weld along the joint line between the UFC hemi-head and UFC Lower Assembly. When welding is complete the UFC will be cooled prior to moving to the next operation.

The rotary positioner will then move the UFC to the weld machining worktable where a dry milling process will remove the weld cap to create a smooth profile at the UFC weld joint. The finished surface will allow for the weld to be inspected and, if acceptable, covered by copper coating.

A series of Non-Destructive Examination (NDE) inspection processes will verify the weld meets design requirements (i.e., adequate depth and have no defects that would compromise the integrity of the UFC). After weld NDE data is collected, the UFC will be placed back into the shielded transfer cask and moved to a waiting area while the NDE data is being processed and reviewed. The next UFC will then be allowed to be processed in the now empty weld cell.

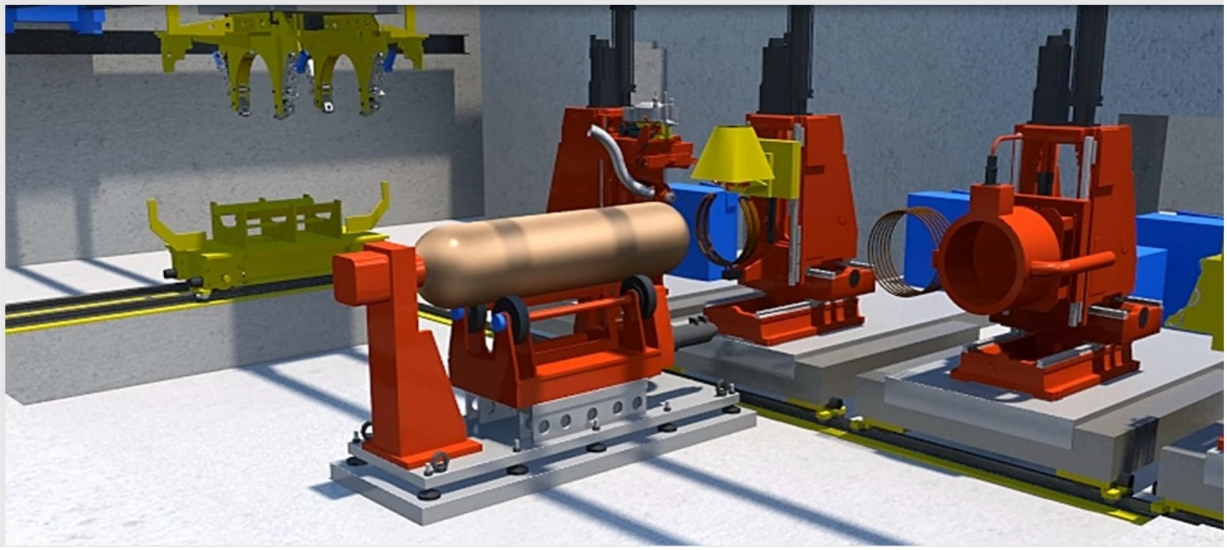


Figure 11: Used Fuel Container Well Cell arrangement with various process worktables

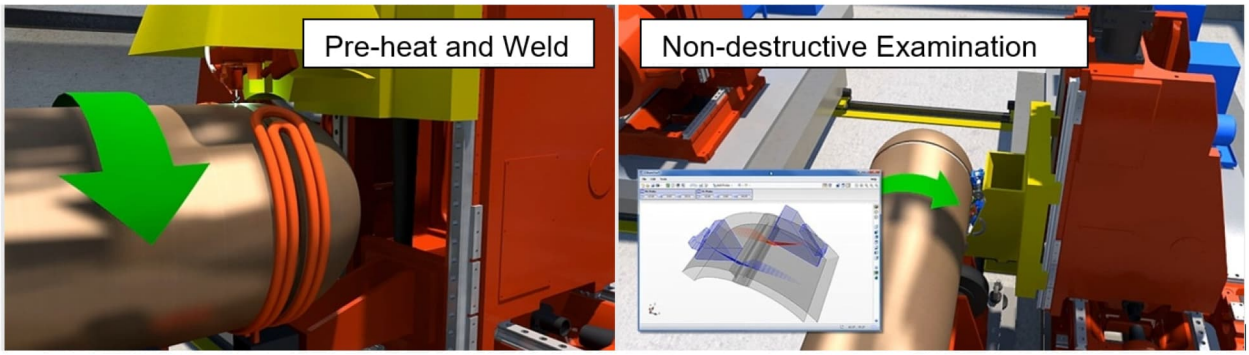


Figure 12: The Pre-heat & Weld Worktable and Weld NDE Worktable

3.2.3.4 UFC Decontamination Cell

The UFC Decontamination cell will remove radiological and non-radiological surface contaminants from the sealed UFC. This system will limit the risk of surface contamination entering subsequent processing cells and other systems within the UFPP.

The UFC Decontamination cell will be the separating barrier between the Contamination Control Area (CCA) side of the UFC Transfer Hall where the UFC will be loaded and welded from the non-CCA side. Decontamination of the UFC exterior will be accomplished within one of two independent UFC Decontamination cells as shown in Figure 13.

The UFC will be decontaminated using remote tooling and surveyed to confirm the UFC is free of contamination. A “clean side” lift will then transfer the UFC across a contamination barrier wall spanning the width of the UFC transfer hall and place the UFC into another shielded UFC transfer cask for movement throughout the “non-CCA” side of the facility, where the remainder of the processing steps will be completed. While the non-CCA side is expected to be free of radioactive contaminants, best practices will include regular monitoring through the UFPP.

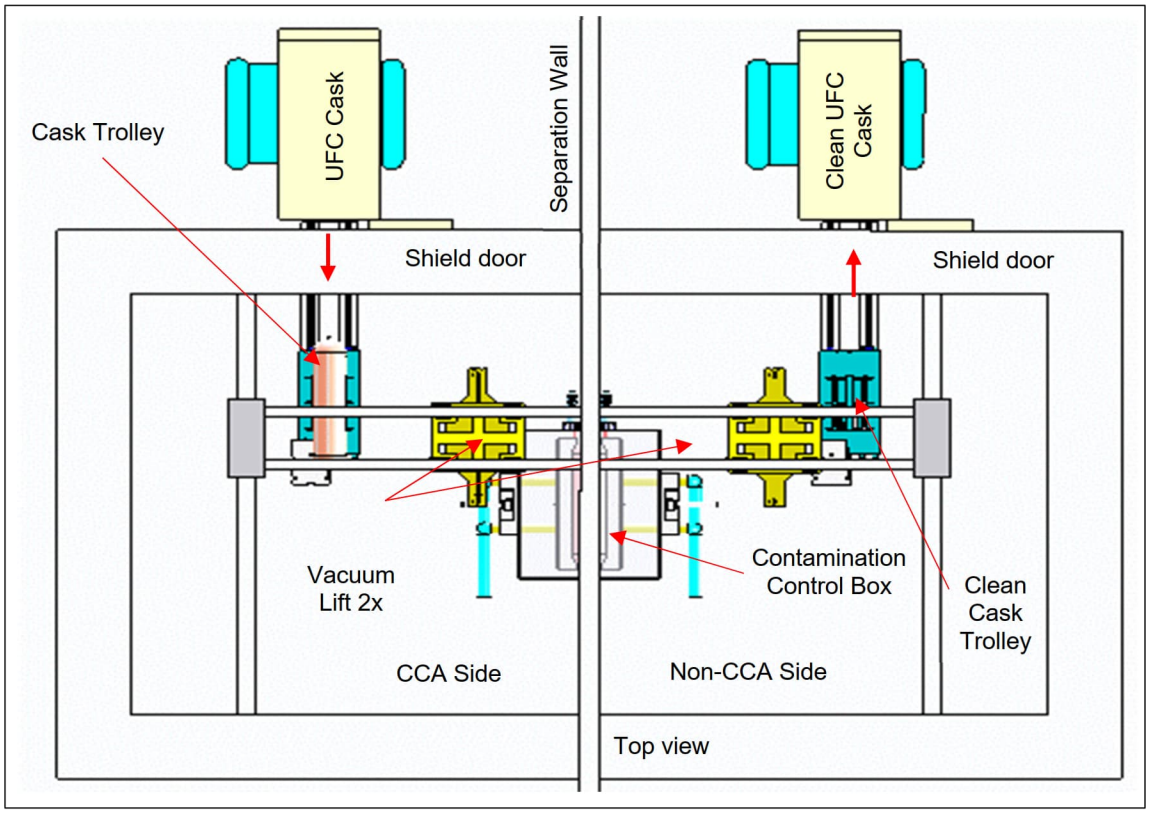


Figure 13: UFC Decontamination Cell

3.2.3.5 UFC Copper Application and Machining Cell

After the UFC is decontaminated, it will enter one of four UFC Copper Application and Machining shielded work cells to undergo the process of completing the corrosion-resistant copper barrier, as shown in Figure 14. The UFC will be placed onto a rotary positioner to be transferred between worktables within the cell.

The UFC’s machined weld area will be coated in copper using gas dynamic cold spray (cold spray) application process up to the required thickness. Following copper application, the UFC will be transferred to the machining worktable where the applied copper will be machined smooth to allow inspection.

After completion of the machining process, the UFC will be loaded back into a shielded transfer cask and moved to a UFC Copper Annealing / NDE work cell.

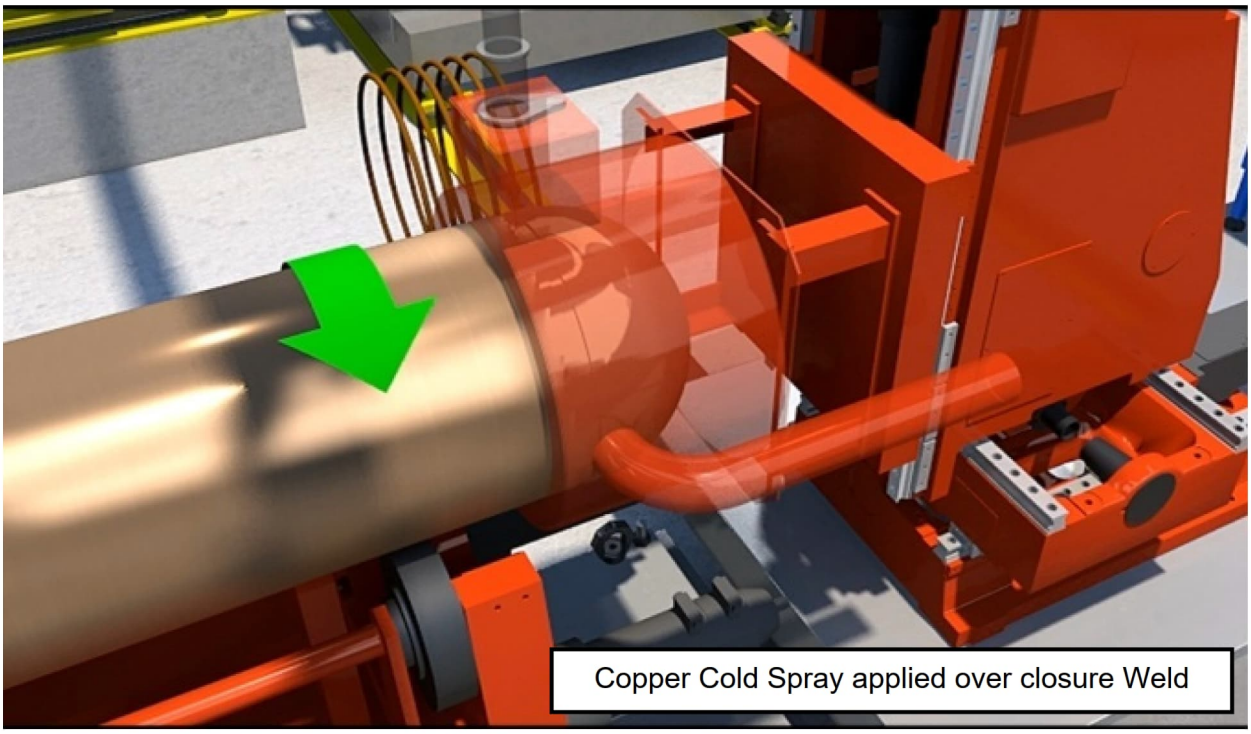


Figure 14: Copper Cold Spray Worktable

3.2.3.6 UFC Copper Annealing / Non-Destructive Examination Work Cell

When copper application and machining processes are complete, the UFC will enter one of four Copper Annealing / Non-Destructive Examination (NDE) work cells, where it will be transferred onto a rotary positioner.

Heat will be applied to the UFC at the copper annealing worktable, as shown in Figure 15, to soften the copper previously applied by cold spray to increase ductility.

Following copper annealing, the UFC will be transferred to the copper NDE worktable where the copper coating is inspected for defects using ultrasonic and eddy current NDE techniques.

When the copper NDE data is collected, the UFC will be placed back into a transfer cask and moved to the Transfer Cask Buffer area (i.e., waiting area) and held while the NDE data is reviewed and evaluated. The UFC assembly will be considered completed after confirming the copper coating meets the required acceptance criteria.

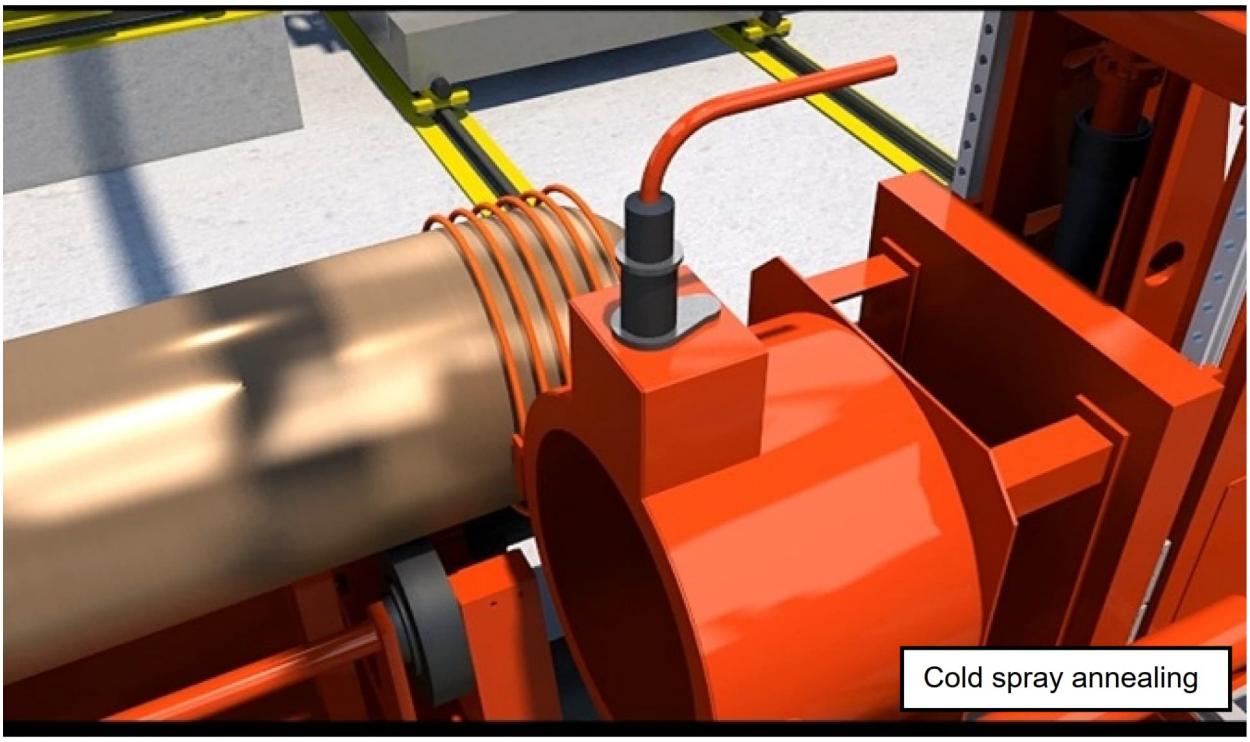


Figure 15: Copper Annealing Worktable

3.2.3.7 Buffer Box Storage, Handling & Dispatch Area

Upon positive confirmation of copper integrity by the NDE evaluation, the UFC will be transferred from the Transfer Cask Buffer area to the Buffer Box Storage, Handling & Dispatch Area, as shown in Figure 16. The main purpose here will be to assemble the Buffer Box, comprising two large Highly Compacted Bentonite (HCB) blocks with the UFC inside, as described in Appendix A. The area will also provide storage for unassembled HCB and fully assembled buffer boxes prior to dispatch to the underground. The storage will be environmentally controlled (humidity and temperature) to maintain the integrity of the bentonite clay prior to emplacement within the repository.

The Bentonite Buffer Box Storage, Handling & Dispatch area will receive the HCB blocks from the on-site Sealing Material Compaction Plant (SMCP). HCB blocks will be received on trucks and forklifted to a laydown area. Forklifts will then place the empty HCB blocks onto transfer trolleys that move them to the assembly area. The transfer trolley will enter the assembly area through an air control vestibule to be pre-staged for receipt of a completed UFC.

Completed UFCs will enter into one of two final survey cells where spot checks for contamination will be made. When it is confirmed that there is no surface contamination, the UFCs will be placed on trolleys and moved into the assembly area, where they will be placed into the lower HCB blocks. The top HCB block will then be set on top, and the fully assembled Buffer Box is then placed onto a conveyor system. They will be loaded into the UFC/Buffer Box Transfer Cask and transferred into the repository via the main shaft.

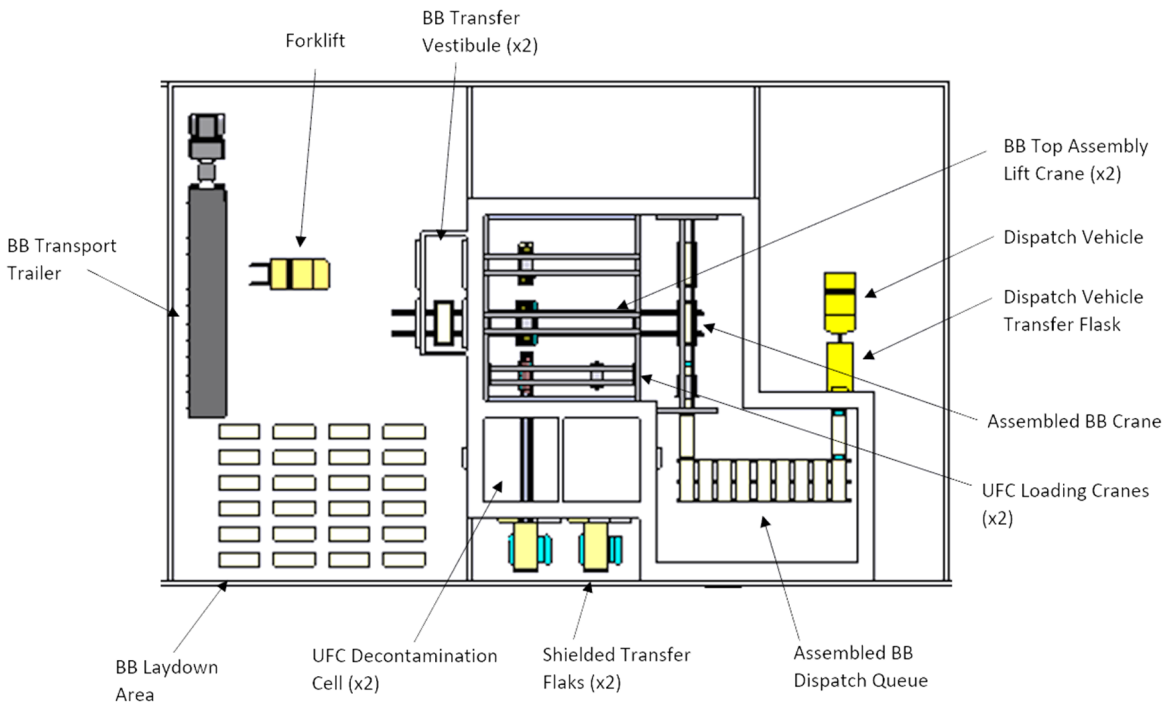


Figure 16: Bentonite Box Storage, Handling and Dispatch Area

3.2.4 Dispatch to Main Shaft

In the UFPP, the Buffer Box assembly will be inspected for loose contamination prior to its insertion into a UFC-buffer box transfer cask. The transfer cask will also be inspected for loose contamination prior to leaving the UFPP. If contamination is found, the equipment or buffer box assembly will be quarantined and decontaminated. The assessed buffer box transfer cask with UFC will travel through a dedicated travel route to the Main Shaft.

3.2.5 UFPP Contingency Cell

As part of the dedicated UFC processing systems, the UFPP will also be supported by several other auxiliary areas. These auxiliary areas will ensure safe operations at UFPP as well as safe emplacement underground in the DGR. One of these areas will be the Contingency Cell. The purpose of this cell will be to address UFC defects that have been discovered throughout the packaging process through the various visual and NDE inspections. These defects will be repaired independently from the regular processing line to minimize disruption to the main process. The contingency cell will house remote tooling that can make repairs above the capabilities of the main processing line, up to and including the ability to retrieve the used fuel from a UFC deemed unrepairable. The UFPP design will permit transfer of a non-conforming UFC to this cell from anywhere within the UFPP. If the UFC is located on the non-CCA side they will be transferred to the CCA through the Decontamination Cell. Within the contingency cell, the following operations will be performed on an as needed basis:

a) Weld defect removal;
b) Weld repair;
c) Removal of used fuel from UFCs that cannot be repaired; and
d) Re-packaging used fuel into new UFCs and hemi-head installation.

UFCs from the Contingency Cell will be returned to the main process after the corrective actions have been undertaken.

3.2.6 UFC Intra-Plant Transfer System

The UFC intra-plant transfer system will be comprised of an AGV and shielded casks housing a UFC trolley, as shown in Figure 17 and Figure 18. The intra-plant transfer system only operates within the UFC Transfer Hall and will be responsible for transferring both empty and loaded UFCs between the different work areas.

The UFC Transfer Hall will be divided into the CCA area (before the UFC is sealed) and the non-CCA area (after the UFC is seal). The areas will be separated by a barrier and can only be crossed through the UFC Decontamination Cells.

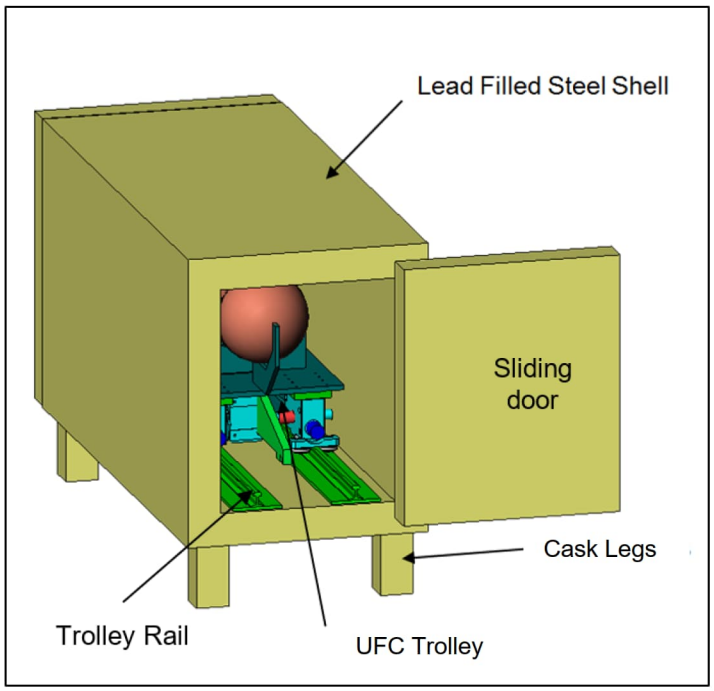


Figure 17: Shielded Used Fuel Container Transfer Cask concept

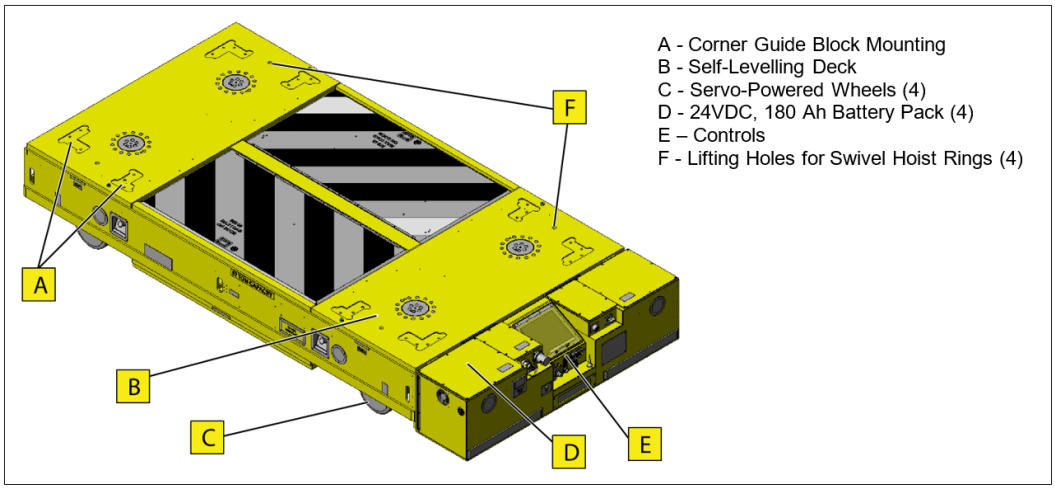


Figure 18: Automated Guided Vehicle (AGV) concept

3.2.7 UFPP Support Facilities

In addition to the main processing work cells, the UFPP will have several support systems necessary for facility operation. These include:

1. Operator Room, UFPP Control Centre – These are the main areas that will house the personnel responsible for plant operations and process monitoring inside the Transfer Hall.
2. Security Monitoring Room – This area will be used to house the main security monitoring systems and personnel.
3. Changeroom facilities and Washrooms – Changerooms will be for all personnel entering / exiting the UFPP from the Administrative Building. Washrooms will be provided within the changerooms and throughout the facility (based on radiological zoning).
4. UFC Shipping / Receiving area – Empty UFCs will be received from outside the UFPP, inspected and dispatched into the Transfer Hall from this area.
5. Active Waste – Active waste generated during operations will be collected, sorted, segregated, and repackaged in this area.
6. Radioactive Materials Storage Area (RMSA)/Active Store – This area will be allocated for the laydown and storage of potentially contaminated tools and equipment from the packaging process.
7. General and Trolley Decontamination Rooms – These areas will support decontamination of tooling / equipment and AGVs / trolleys to support operations.
8. Active Maintenance Shop – This space will be allocated for performing maintenance and repair activities to equipment, including potentially contaminated equipment.
9. Warehouse – The warehouse will be used for receipt and storage of PPE, process consumables, equipment spare parts, etc.
10. Mechanical, Electrical, and Active Ventilation rooms – Housing the equipment in support of all UFPP operations (pumps, sumps, chillers, air handlers, filtration, heat exchangers, electrical panels, etc.)

3.3 AUXILIARY BUILDING
Area P5

The Auxiliary Building will be situated adjacent to the border of the Protected Area and will provide facilities for surface operations staff who work primarily in the Protected Area. The building will be connected by covered walkways to the UFPP, the Service Shaft Complex, and the Administration Building.

The Auxiliary Building will be located as central as possible to the UFPP and Service Shaft to reduce the distance for personnel to walk, and to minimize the extent of needed covered walkways.

The Auxiliary Building will be a two-storey structure and will be equipped with full fire protection and radiation monitoring systems. The building will include the following facilities:

- Operational management areas consisting of offices and meeting rooms equipped with voice, video and data connections;
- A main control room from which staff will control and/or monitor the remote underground movements of the Buffer Box/UFCs;
- First Aid station;
- Change rooms, lockers, washrooms and shower facilities for staff and visitors accessing the Protected Area. Lockers will be in place to accommodate safety hats, boots, overalls and protective suits;
- Laundry facilities for all laundry needs exclusive to the Protected Area; and
- Protected Area cafeteria, which will be provided to minimize the movement of personnel into or out of the Protected Area during shifts. This cafeteria will be supported by the main cafeteria in the Administration Building, with foods being prepared and delivered on an as-required basis.

3.4 WASTE HANDLING FACILITIES
Areas P6, P7, P8 & P9

This section addresses low and intermediate level waste (L&ILW) management facilities as well as those designed for management of non-radiological hazardous wastes. The principal subject waste streams, generated in both solid and liquid form, will be as follows:

- Low Level Waste (LLW): radioactive waste in which the concentration or quantity of radionuclides is above the clearance levels established by the regulatory body (CNSC), and which contains limited amounts of long-lived activity;
- Intermediate Level Waste (ILW): radioactive non-fuel waste, containing significant quantities of long-lived radionuclides and
- Free Release Waste: comprises waste that in which radionuclides are below CNSC clearance levels. This would include non-radioactive hazardous and non-hazardous materials.

3.4.1 Active Solid Wastes

Figure 19 illustrates the expected primary solid L&ILW streams. The main sources of active solid wastes are anticipated to be from the UFPP, the Auxiliary Building, and from the active liquid waste treatment processes.

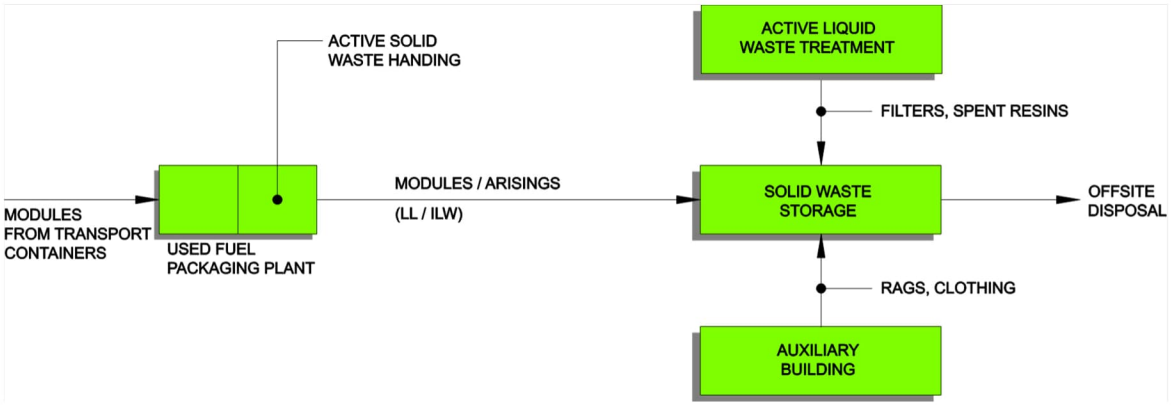


Figure 19: Active Solid Waste Flow Diagram

The modules and baskets from the incoming transportation packages (UFTPs and BTPs) will represent the most significant source of active solid waste. When a module/basket has been emptied of used fuel bundles, it will be processed including decontamination to achieve free-release limits to allow shipment to an offsite metals recycling facility. If decontamination to these levels is not achieved, it will be temporarily stored at an on-site interim storage building until sent off site for reuse at reactor facilities or for long term waste management.

Active waste streams will also include used HEPA filters from the active ventilation exhaust air units as well as spent filters and/or ion exchange media from the treatment of active liquid wastes.

Other active solid waste streams will include arisings (spent equipment/tools or components) from the maintenance of hot cell equipment. LLW streams will include waste generated from general decontamination activities and/or resulting from incidental contact with loose radioactive material such as cleaning materials and used personal protective equipment (PPE).

Table 4 identifies the quantities of solid L&ILW expected to be generated. After waste reduction, approximately 2,000 m^3 of such wastes are anticipated each year. These processed wastes will be sent to an on-site interim storage building.

Table 4: Inventory of Active Solid Wastes

Source	Description	Level	Annual Quantity
UFPP	Modules from UFTPs	L or ILW	up to 330 m^3
UFPP	Baskets from BTPs	L or ILW	up to 40 m^3
UFPP	Arisings from operations and maintenance	ILW	3 m^3
		LLW	100 m^3
UFPP	Bead IX resins	L or ILW	500 L
UFPP	Powder resins	L or ILW	120 kg
UFPP	HEPA & cartridge filters	L or ILW	285 filters
UFPP	Hot Cell vacuum filters	L or ILW	0.5 m^3
Active Ventilation Exhausts	Used HEPA filters	LLW	TBD
Aux. Building & other Facilities	Dry swabs, swipes and clothes, etc.	LLW	TBD
	PPE (clothing, gloves, etc.)	LLW	10,000 kg
Active Liquid Treatment	Spent filters and IX media	L or ILW	20 m^3
Various	Miscellaneous	L or ILW	10,000 kg

3.4.2 Active Liquid Wastes

Figure 20 identifies the expected liquid L&ILW streams. Similar to the active solid waste flows, the primary sources are anticipated to be from the UFPP and Auxiliary Building.

Active liquid waste flows from the UFPP will originate from the decontamination of used fuel modules, baskets, cell washdowns, and from the decontamination of transportation packages and containers. The other primary source of liquid waste flows will include some laundry wash and rinse waters (normally directed to sewage treatment system, only rerouted if indicated by monitoring).

Table 5 identifies all sources and the associated quantities of liquid L&ILW that is expected to be generated. In total, approximately 200 m^3 of containerized active liquids and 9,000 m^3 of piped active liquid wastes will be produced each year.

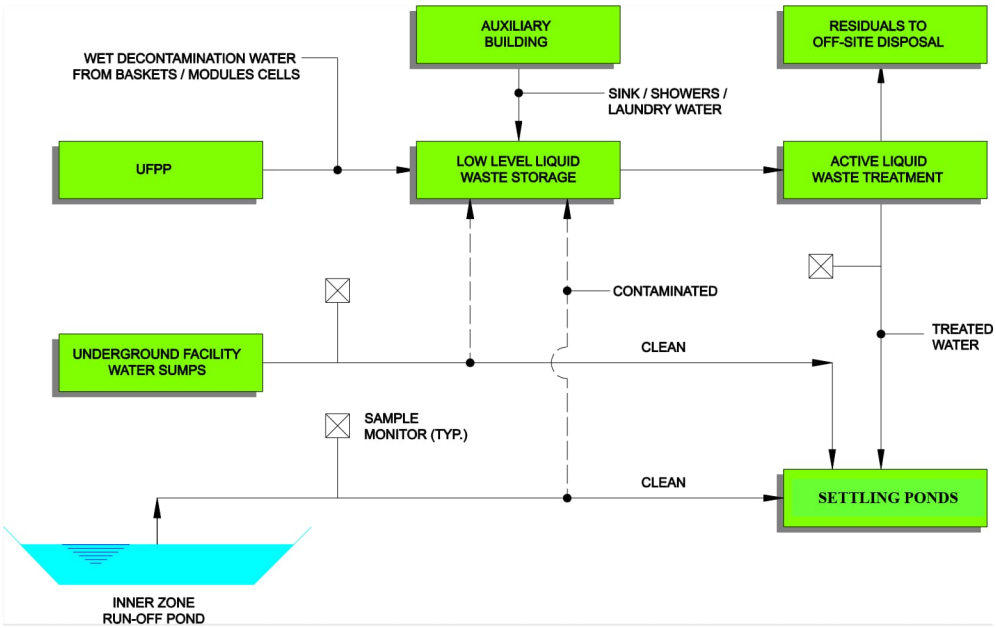


Figure 20: Active Liquid Waste Flow Diagram

The discharge water from the mine dewatering settling pond ("Underground Facility Water Sumps" in Figure 20 which is Area P17 in Figure 4) and the storm water management pond ("Inner Zone Run-off Pond" in Figure 20 which is Area P10 in Figure 4) are normally expected to have radioactivity concentrations well below limits that are acceptable for release to an off-site water body. However, in the remote event that the monitoring of pond discharge water finds radioactivity levels to be above acceptable limits, then the pond water would be routed to active liquid waste treatment building for treatment. The water could be taken to the treatment building by tanker truck or a pumping system (to be determined in the detailed design phase).

Table 5: Inventory of Active Liquid Wastes

Source	Description	Level	Annual Quantity
UFPP	Module / basket decontamination	ILW	1,250 m^3 (piped)
UFPP	Active cell wash downs	ILW	10 m^3
UFPP	Transportation package / container decontamination	ILW	1,600 m^3 (piped)
Lab. & Test Areas	Cleaning and samples	LLW	100 m^3
Auxiliary Building	Laundry, change rooms	LLW	max. 6,000 m^3 (piped)
Waste Management Area	Cleaning of package exteriors	LLW	25 m^3
Underground or Surface	Mine Dewatering Settling Pond (P17) & Storm Water Management Pond (P10)	LLW	normally clean and nil (piped)
Active Liquid Waste Treatment	Spent regenerates	LLW	30 m^3 - 60 m^3

3.4.3 Non-Radiological Hazardous Waste

Various non-radiological, hazardous solid and liquid wastes are also expected to be generated from the on-going operation and construction activities at the DGR site. These will include:

- Solvents used in decontamination and cleaning in non-radiological areas;
- Lubricants and greases;
- Petroleum based fuels; and
- Explosive residues.

To minimize the total amount of these waste materials, steps will be taken to limit activities that generate these wastes, find less-hazardous replacement materials, and ensure separation of incompatible materials such as organic solvents and inorganic acids. All conventional waste materials will be collected and sent to a disposal facility that is licensed to accept these types of waste materials. Spill containment and monitoring will be provided wherever hazardous liquid wastes are handled and stored.

3.4.4 Non-Radiological Non-hazardous Waste

There will be a number of conventional waste streams generated at the DGR (e.g., office and lunchroom waste, etc.). To the extent possible, the quantity of these wastes will be minimized and segregated by type for recycling and organic composting.

3.4.5 Waste Management Approaches

With respect to the waste facilities, four separate operations will be incorporated into the design and operation of the DGR. As discussed in the following sections, these will include:

- Active Solid Waste Handling Facility – meant to receive active solid wastes from the UFPP;
- Waste Management Area – which will manage active solid waste materials;
- Low-Level Liquid Waste Storage Area – which will receive low-level liquid waste materials prior to transfer to the treatment area; and
- Active Liquid Waste Treatment Area – a processing plant for active liquid waste materials.

Generally, non-hazardous and non-radiological refuse will be handled as in any other type of industrial setting. Such garbage will be directed to a local municipal landfill or other waste management facility. The approach to handling non-radiological hazardous waste is expected to be similar, with wastes being transported off-site to an appropriate hazardous waste management facility. The quantity of such materials will be reduced to the maximum extent possible, and any collected wastes will be shipped off-site for recycling or long-term management.

Active Solid Waste Management Systems (Areas P6 & P7)

L&ILW management activities will center on two on-site operations, the active solid waste handling facility, and the waste management area (Areas P6 and P7 in Figure 4, respectively).

The active solid waste handling facility will be associated with and attached to the UFPP and will serve as a staging area for solid wastes from that building. It will comprise an area for managing of modules/baskets and for processing of other solid wastes materials. Once processed and packaged, the containerized wastes will be directed to the waste management area.

The waste management area will incorporate a stand-alone storage building. The wastes will be stored in suitable containers to prevent damage and loss of containment. A compactor to consolidate collected material will be provided.

It is currently assumed that active solid wastes which are not, or cannot be, decontaminated to free-release limits will be placed into suitable transportation containers and shipped off-site to a licensed long-term management facility. As the quantity of waste which is combustible is expected to be limited, on-site incineration for volume reduction will not be pursued. However, further treatment at off-site facilities may be considered where appropriate.

Active Liquid Waste Management Systems (Areas P8 & P9)

Active liquid waste treatment will be managed through two facilities, a storage building located in the low-level liquid waste storage area (Area P9 in Figure 4), and the active liquid waste treatment building (Area P8 in Figure 4), where the latter is a processing plant for the liquid wastes.

The storage building, incorporating secondary containment for spills or leaks, will provide for the interim assembly of collected liquids prior to treatment. The building will house storage tanks to receive piped and containerized active liquids as well as an area where containerized liquids would be stored. One tank will be kept empty to provide space for unplanned receipts. Over normal operations, active liquids will be transferred into one of the storage tanks for blending or moved directly to the treatment building.

The active liquid waste treatment building will house the following equipment:

- Two feed / equalization tanks with feed pumps;
- Two treated water collection and monitoring tanks with transfer pumps;
- Treatment systems comprising filtration to remove particulate contaminants, ion exchange or membrane separation to extract dissolved contaminants and possibly post-treatment filters to allow for recycling of the treated water;
- Three tanks to supply regeneration / cleaning liquids and receive spent regenerant / wash water and concentrate from the membrane separation modules; and
- Pumps to serve the three tanks above.

The treatment of active liquid wastes using particulate filters and ion exchange columns is commonly used in the industry wide including nuclear power plant operation. The system will be comprised of three 50% capacity modules, two of which would be operating at any given time with the third unit on stand-by. Alternatives to this treatment approach include the use of membrane separation technologies such as ultra-filtration and reverse osmosis.

3.5 SWITCHYARD, TRANSFORMER AREA AND EMERGENCY GENERATOR BUILDING

Areas P11, P12 & P13

Regular electrical power and emergency electrical power will be supplied by the switchyard, transformer area and emergency generator building. For security, these facilities are all located in the Protected Area.

3.5.1 Switchyard

The switchyard (Area P11 in Figure 4) is designated to host all high voltage equipment for circuit-breaking interruption, circuit-making, isolating disconnects, switching, and for the protection of transformers, lines, cables, and capacitor banks. All designated equipment mechanisms will be fully enclosed and protected. Protection from high winds, rain, sleet and snow will be in place. The switchyard area will be surrounded by a dyke (or perimeter ditch and sump) to collect any accidentally spilled transformer oil. It will be lined, as required, and have a surface comprising a compacted granular sub-base.

3.5.2 Transformer Area

Two step-down transformers capable of handling the required electrical load will be located at the sub-station (transformer area) with all controls and switchgear housed in an adjacent building. These facilities are identified as Area P12 in Figure 4.

Table 6: Site Power Requirements

Equipment Description	Net M.V. Run Demand		Net L.V. Run Demand	
	(kW)	(kVA)	(kW)	(kVA)
Used Fuel Packing Plant			6,438	8,048
Sealing Materials Operations			7,910	9,224
3 Shafts Substations & Hoists	1,336	1,498	614	747
Ventilation Systems including Exhaust Vent Shaft Substation and Ventilation Shaft Complex	933	1,085	2,660	3,246
Waste Management Operations			355	444
Underground Operations			2,701	3,291
Other Underground Operations and Surface Facilities	1,193	1,476	1,981	2,410
Total	3,462	4,059	22,659	27,409
Total demand, M.V. + L.V. excluding contingencies (values rounded)			26,100 kW	
			31,500 kVA	
Allowance #1: * Defined load but not quantified Load: Load that exists but whose kW rating has not been defined (5% of total defined load).			1,306 kW and 1,573 kVA	
Allowance #2: Electrical Losses, kW (3% of total defined load)			784 kW and 944 kVA	
Allowance #3: Unknown Load/Miscellaneous Loads (2% of total defined load) (rounded)			522 kW and 629 kVA	
Total Site Power Demand Including 10% (allowances# 1, 2, and 3) Defined Load (values rounded)			28,700 kW	
			34,600 kVA	

Notes: M.V. (4,160 volts and 13,800 volts) and L.V. (600 volts) means medium and low voltage, respectively.
* For a Pre-feasibility Load List, an estimate of the electrical requirements for certain (typically small) loads are not completed individually. Instead, an allowance factor of 5% is applied to of the total known load.

The total electrical power demand for the facility is indicated in Table 6. The site's power supply will be received from a high voltage overhead line branching off from the regional power grid. This line is expected to be tower mounted, with towers generally spaced at approximately 200 m intervals (pending voltage system and tower design) for stability.

After being received at the two transformers, the electrical power will be conveyed via overhead medium voltage (13.8 kV) power lines to the facility distribution level. The power lines will run alongside access roads within the surface facilities to all buildings and terminate at step-down units. Step-down transformer units will provide the needed power for motors, buildings, compressors and other electric driven installation as per requirements. Use of underground lines with armoured cable will be considered where required depending on site conditions.

The transformer area will be situated within the previously described switchyard. Reinforced concrete platforms will be provided for the transformer units with mounted switches in steel box enclosures designed with suitable fire wall separation and fire protection measures.

3.5.3 Emergency Generators

The emergency generator building (Area P13 in Figure 4) will house the emergency power generators and related equipment. The location and design of the emergency generator building will take into account the flood hazards, as identified in NWMO (2016), to ensure continued operation under such conditions. Three diesel generators (one for standby) will be able to provide the emergency power needed at the DGR facility. In this respect, the primary loads that would be served by the emergency generators are for the underground ventilation system as well as for the Exhaust Ventilation Shaft hoist and the Service Shaft auxiliary hoist. As illustrated in Table 7, allowances have also been made to sustain critical services in the UFPP, and the various other surface and underground operations.

Table 7: Estimated Emergency Power Requirements

Applicable Emergency Services	Needed Power (kW)
UFPP Area	1,960
Shaft Complexes and Ventilation Systems	2,040
Surface Buildings & Security Control Systems	1,470
Miscellaneous Underground Requirements including Pumps	210
Miscellaneous Surface Requirements	430
Defined but not quantified load allowance (approximately 5%)	310
Unknown/Misc. Loads (approximately 2%)	120
Electrical Losses (approximately 3%)	180
Total:	6,720

The 4.16 kV diesel generators will be connected to 4.16 kV generator switchgear. The generator switchgear will be connected to the plant main 13.8 kV switchgear through 4.16/13.8kV step-up transformers. Plant main 13.8 kV switchgear will distribute power to different areas through 13.8 kV power line. Each area equipment would have 13.8/4.16 step-down transformer to feed 4.16 kV loads, and 4.16/0.6 kV power distribution transformer to feed 600V. That is, the switchgear will be compatible for either grid power or diesel generated power. All other controls and switches will be housed in the emergency generator building and be capable of switch-over from the main grid to the diesel generators. A separate storage room for diesel tanks (2 weeks supply) and oil will be provided in the building.

Most buildings at the DGR will have connections for emergency power to the key areas, corridors, washrooms and external security lighting, key offices, laboratories and essential services. In an emergency, all security lighting and facilities for monitoring and detection of intrusions will receive full power.

In addition to the emergency generators, uninterrupted power supplies (e.g., battery back-up) will be in place in various facilities to ensure the continued functioning of vital computer, instrumentation, and security equipment.

3.6 QUALITY CONTROL OFFICES AND LABORATORY
Area P14

The quality control office and laboratory facility (Area P14 in Figure 4) will provide space for resident quality control specialists and scientists. The staff will provide quality control, monitoring and testing for such items as groundwater, stormwater, air quality, and radiation-related issues.

The building, envisaged as a single storey structure, will be located in the Protected Area. It will house the quality control offices, laboratories and workstations for the facility's technicians, researchers, quality inspectors, scientists and managers. Work benches, experimental areas and refrigerators (for any chemicals or reagents requiring cool storage conditions) powered by emergency power will be in place. Meeting rooms will be provided.

In addition to the normal sprinkler system in the ceilings, firefighting equipment will be installed near most work areas and outside the laboratories.

3.7 ADMINISTRATION BUILDING INCLUDING FIREHALL AND CAFETERIA
Area B2

The Administration Building (Area B2 on Figure 4) will be the first building that visitors and most staff encounter when coming to the DGR facility. Equipped with full fire protection and monitoring systems, the building will be divided into three main areas: the administrative offices, a cafeteria and the firehall. It is estimated that up to 700 full-time staff will be working at the DGR facility and approximately 200 staff will have office space in this two-storey structure.

Employees will enter through the parking area adjacent to the building and proceed to their respective locker spaces or to the Auxiliary Building. Protective clothing (for those working inside the Protected Area) and civilian clothing will be stored in separate lockers. The lockers will be of sufficient size to accommodate safety hats, boots and overalls. Provision will be made for locker space for site visitors including inspectors and government officials. Showers will also be in place.

The cafeteria will provide sit-down areas with a serviced hot kitchen for continuous full meal services.

The firehall (supported by the security monitoring room) will be equipped with detection and monitoring equipment for any fire hazards or smoke from any of the DGR facility operations. Firefighters will be on duty each shift, with other fire team members on standby in the event of an emergency. Two large municipal fire trucks will be available with telescopic ladders, hoses, pumps and all other typical fire-fighting tools.

The main administrative area will have offices for senior management and key staff, boardrooms for meetings and training sessions, and cubicles for other supervisory or technical personnel. Offices will have full internal and external communications facilities, as required, including internet, telephone, two-way radio systems and wired networks. Additional facilities at the Administration Building will include:

- Transportation and logistics coordination centre equipped with display monitors for the real time tracking of used fuel transport trucks;
- Procurement area to serve as the central procurement department for all on-site equipment and consumables;
- IT and communication facilities;
- Health and safety training room and offices to be used for the training of employees and the orientation of visitors to the DGR; and
- Nursing station and first aid area with consultation rooms and a doctor's office. A full-time nurse practitioner will be on duty for all shifts.

3.8 SEALING MATERIALS PRODUCTION FACILITIES

Areas B3, B6 & B13

The sealing material receipt, storage and preparation facilities will be used to produce various concrete and clay-based sealing materials for the encapsulation of the UFCs / buffer boxes in the underground repository. The facilities will comprise of a concrete batch plant (Area B13 in Figure 4) and a Sealing Material Compaction Plant (SMCP) with associated material storage bins (Areas B6 and B3, respectively). Materials, quantities or processes related to the backfilling and closure of access tunnels, shafts or other openings would be addressed at the time of final facility decommissioning and closure.

From the concrete batch plant, a Low Heat High Performance (LHHP) concrete mix will be produced for constructing bulkheads at the entrance to each placement room. Concrete will be required for the access tunnel floors. During the operations phase, the SMCP will produce the following clay-based sealing material products:

- Highly compacted bentonite (HCB) blocks for use in the buffer boxes;
- HCB blocks for spacers between the buffer boxes, floor tablets, and for the room seals; and
- GFM for filling the space between the stack of buffer boxes and spacer blocks and the surrounding rock.

Aggregate products will be stockpiled and stored within the concrete batch plant area. Overhead field conveyors will be used to bring finished aggregate product to the concrete batch plant. In all, the aggregate, concrete batch and SMCP operations are seen as an interconnected network.

The sealing materials production facilities will be situated adjacent to the Protected Area, so as to be located as close as possible to the Service Shaft and UFPP. This location will minimize the distance materials will need to be conveyed, help to reduce the footprint of the site, and lessen the need for workers in the SMCP to enter the Protected Area. The products will be either brought to the UFPP for the buffer box assemblies or to the Service Shaft for delivery underground.

For day-to-day operations, the concrete batch plant will run on an as-needed basis. Conversely, the high demand for clay-based sealing materials will necessitate a three shift, daily operation for the SMCP. All required materials (modified granular A, different binders such as cement T50, silica fume and silica flour, as well as bentonite and other clays) will be sourced from external suppliers.

The main difference between the crystalline and sedimentary repository options is the spacing between adjacent buffer boxes. This means that there will be a difference in the HCB spacer block size, which will result in variances in the quantities of the fill materials that will be required.

The following sections initially describe the material requirements for the concrete batch plant and the SMCP. Detailed descriptions of each plant are provided thereafter.

3.8.1 Material Requirements for Concrete Batch and Sealing Materials Compaction Plant

Table 8 summarizes the approximate raw materials required at the concrete batch plant and SMCP on an annual basis. Where there is a difference, separate values are provided for the crystalline and sedimentary design cases.

Table 8: Materials Requirements for Concrete Batch and SMCP

Material	Concrete Batch Plant (tonnes/year)		SMCP (tonnes/year)	
	Crystalline	Sedimentary	Crystalline	Sedimentary
Concrete Stone	985	836	N/A	N/A
Concrete Sand	1132	930	N/A	N/A
Cement T50	502	382	N/A	N/A
Silica Fume	23	27	N/A	N/A
Silica Flour	47	54	N/A	N/A
Superplasticizer	32	25	N/A	N/A
Bentonite*	N/A	N/A	29,000	39,000
Water	222	174	N/A	N/A
Total	2,943	2,428	29,000	39,000

Note: *Bentonite mass reflective of final as-place condition, as bentonite trimmed during shaping will be recycled as GFM

3.8.2 Concrete Material Requirements

Low Heat High Performance (LHHP) concrete will be used for the construction of the floor smoothing layer and the placement room bulkheads immediately adjacent to room seals (Figure 51). As a result, the demand for LHHP concrete is relatively low on a week-to-week basis. However, the plant does need to operate year-round. The other mixes, such as shotcrete, grout or other concrete uses would also place a demand on plant operations. The LHHP concrete materials produced will be highly specialized, and the binders will require extensive on-site testing prior to use.

3.8.3 Clay-Based Sealing Material Requirements

Clay-based sealing material will be required for the buffer boxes as well as for preparing and filling the placement rooms. The material composition of each of these clay-based sealing materials is as follows:

- Highly Compacted Bentonite (HCB) – 100% bentonite
- Gap Fill Material (GFM) – 100% bentonite

On an average work week basis (and allowing for a 10% rejection rate), the following materials are expected to be produced:

- 125 HCB buffer blocks for buffer boxes and dummy blocks (approximately 1 m x 0.5 m x 2.9 m);
- 65 HCB spacer blocks; (approximately 1 m x 2.9 m x either 0.3 m or 0.7 m)
- HCB floor tablets (0.15 m thick) for underlying both spacer blocks and buffer boxes;
- HCB forklift hole bricks for the placement of the Spacer Blocks or Buffer Blocks (approximately 0.5 m x 0.14 m); and
- granular GFM for filling remaining voids (roughly 140 and 185 tonnes for the Ignace and South Bruce DGRs, respectively).

Figure 21 illustrates a cross-section view of the placement room for the crystalline DGR design concept and the arrangement of UFCs/buffer boxes, spacer blocks and gap fill. The spacer blocks in the placement room will be approximately 1 m in height and 2.9 m in length. The spacer block thicknesses are 0.3 m and 0.7 m for the crystalline and sedimentary DGR design concepts, respectively.

Storage silos will inventory approximately two weeks of raw product.

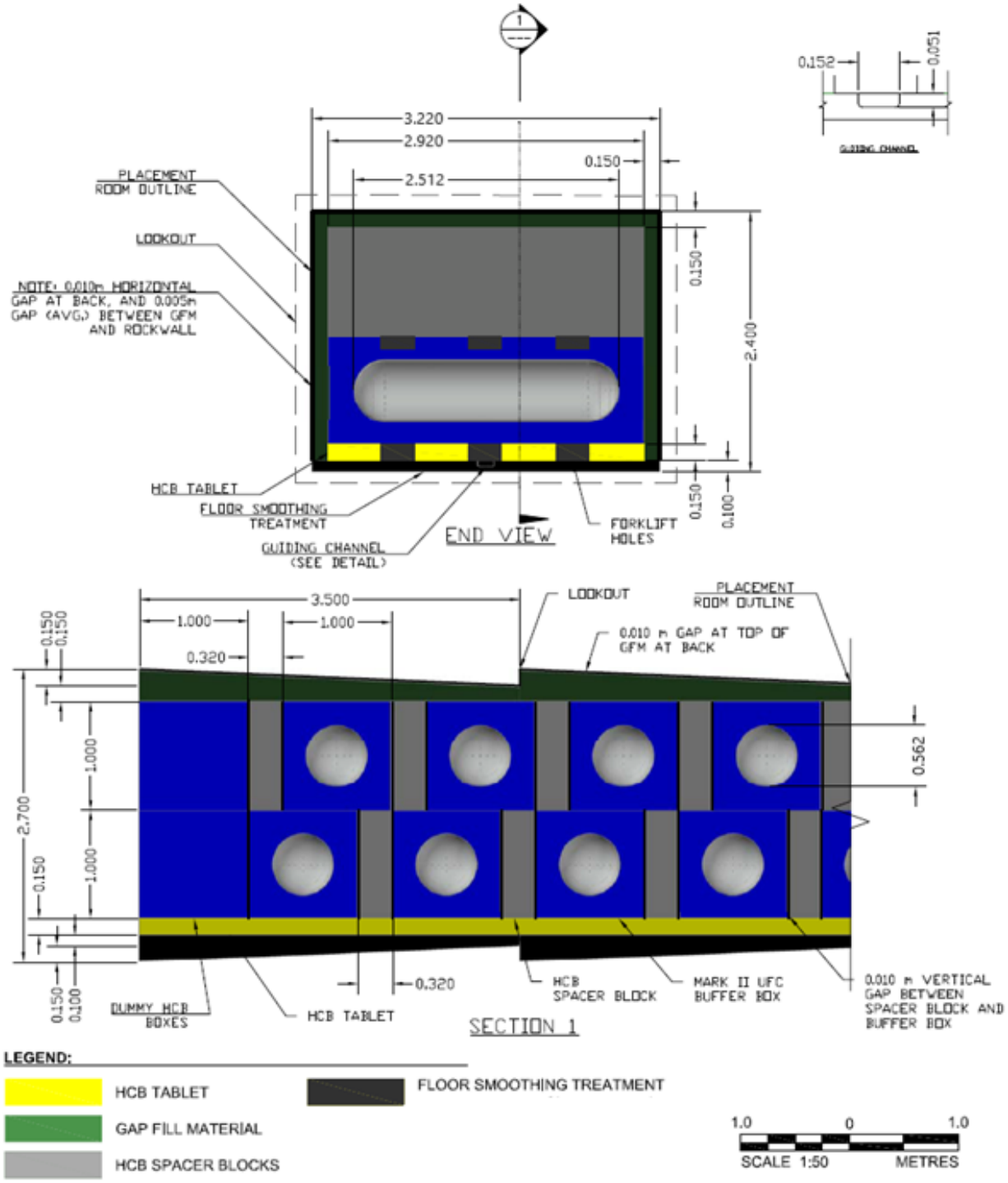


Figure 21: APM Sealing Material in Placement Room Section View (Crystalline Geosphere)

3.8.4 Aggregate Supply

The minimal requirement for aggregate does not support the establishment of an on-site aggregate plant. Instead, it is assumed that this material (associated with the production of LHHP concrete), will be purchased and delivered from an external source. In addition, an annual aggregate supply of Granular A of about 400 and 500 tonnes for the sedimentary and crystalline sites, respectively, and Granular B of about 800 and 1000 tonnes for the sedimentary and crystalline sites, respectively will also be required for the granular base underlying the concrete floor for the development of the tunnels.

3.8.5 Concrete Batch Plant Description

As shown in Figure 22, the concrete batch plant (designed to primarily produce LHHP concrete) will be fed by a loader bringing aggregate from storage to a twin (coarse/fine) feed bin. The aggregate will be delivered to a batcher where it will be weighed and dispensed into a ready-mix truck. The cement T50, silica fume and silica flour will be delivered from an external resource via tanker trucks directly to the plant (Area B13 in Figure 4).

Cement T50 and silica fume will be stored in 75-tonne silos, with silica flour kept in a 150-tonne silo. These storage capacities are considered to be sufficient to supply LHHP concrete for two successive bulkhead pouring campaigns. The binders will be subsequently dispensed into a cement batcher, where they are weighed and discharged into a ready-mix truck (along with water and admixture). At the ready-mix truck, a homogeneous product is formed which is then delivered to the Service Shaft where it would be delivered underground via a slickline and then by underground ready-mix trucks to the pour location. The concrete plant will be enclosed where necessary to allow for year-round operation (to minimize winter weather impacts).

The plant will produce material constantly during the LHHP concrete bulkhead pours with a required capacity of between 9 m^3/hr and 18 m^3/hr. A small, commercial concrete batch plant in the operating range of 20 to 25 m^3/hr is considered suitable for this application.

A crew that is dedicated to the concrete batch plant on a full-time basis would not be necessary because the plant would only be used periodically to produce concrete for the room bulkheads, placement room floors, and panel access tunnel floors. Operations to produce concrete material will consist of a trained team (likely a supervisor, loader operator, ready mix truck drivers and batch plant operator) gathered from other parts of the DGR facility operations team.

Each year, up to eight bulkheads pouring campaigns are anticipated. Each bulkhead pour will take about 50 m^3 of LHHP concrete. Two ready-mix trucks will provide enough surface delivery capacity. As binder and aggregate materials are confirmed to meet target specifications, they will be used in the concrete batch plant. Slump and air content will be measured for each load prior to placement.

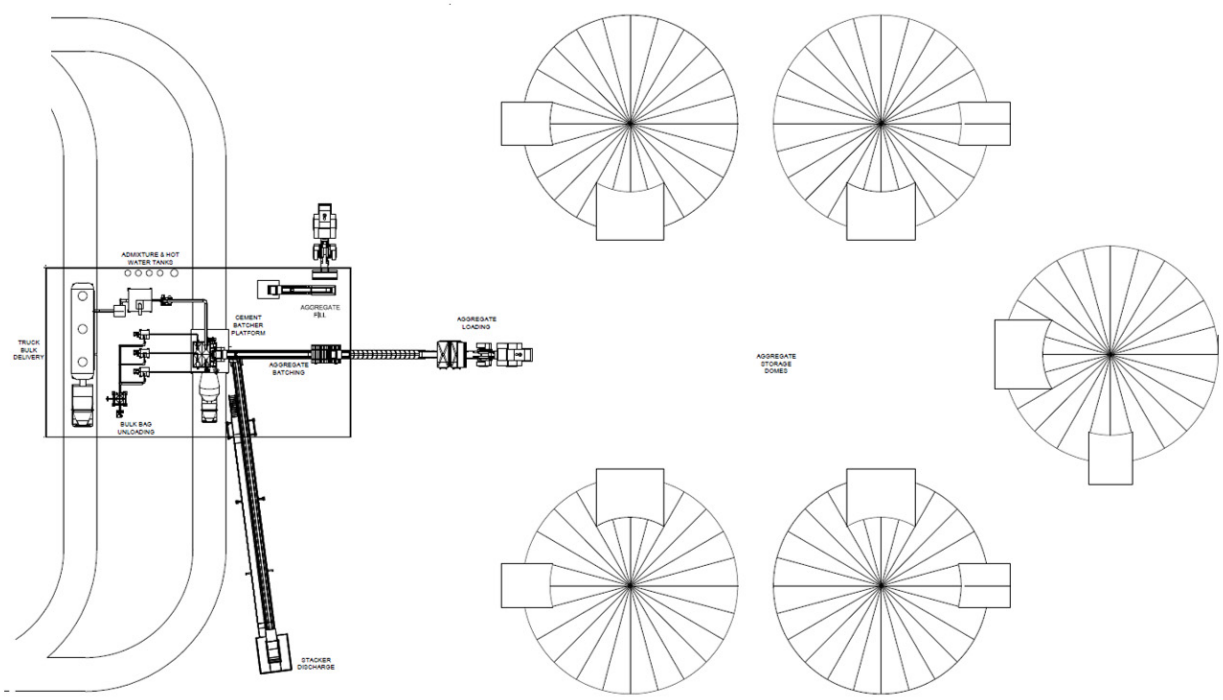


Figure 22: Conceptual Aggregate Storage and Concrete Batch Plant Layout

3.8.6 Sealing Material Compaction Plant (SMCP) Description

The SMCP will produce HCB spacer blocks, HCB floor tablets, HCB blocks for the buffer box, and Gap Fill Material (GFM) for filling void spaces between the buffer boxes and spacer blocks, floor tablets, and the surrounding rock. The spacer blocks, floor tablets and bentonite GFM will be delivered from the SMCP to the Service Shaft inside the protected area via security gate for transfer underground. The HCB components, used for the Buffer Box assembly, will be directed to the UFPP. The SMCP is divided into two primary sections:

- Raw materials storage, handling, and mixing; and
- HCB block, HCB spacer block, HCB floor tablets and GFM production.

Bentonite will be delivered via tanker trucks to the plant. Ten exterior silos, each of a 150-tonne capacity, will be in place to dispense bentonite using rotary valves, day bins and positive displacement blowers. Water will be subsequently added to the mixer to produce a homogenous material after blending for the HCB Blocks. The bentonite storage silos will accommodate the equivalent of approximately two weeks of material consumption.

Blended gap fill will be discharged from the batch mixers to a briquetting circuit operating under negative pressure to reduce the infiltration of dust to the surroundings. The material will be loaded into tanks on rubber-tired trolleys for transportation to the underground repository or storage.

The presses that will produce the buffer box, floor tablet, and spacer block materials will be specialized items designed to suit this purpose (Johanesson, 1999; Koskinen, 2012). They will be hydraulically driven units with custom fabricated moulds. A depiction of the type of press envisioned for the production of these clay-based blocks is shown in Figure 23.



Figure 23: Example of Closed-Die Compaction Press

Figure 24 shows an example of a small portable press that produces blocks through uniaxial, two-sided compression. This device has been demonstrated as being capable of producing small blocks of highly compacted bentonite at a very high rate.



Figure 24: Portable Uniaxial Highly Compacted Bentonite (HCB) Brick Maker

Based on initial estimates about 110 to 160 hours of compaction machine time will be required to produce HCB segments to fulfil 1 week demand. Additionally, spacer blocks would require an estimated 35 to 50 hours of pressing time per week, depending on the size of block ultimately produced. The target minimum dry density for the HCB blocks is 1.7 g/cm^3.

Cold Isostatic Press (CIP) technology that could produce the buffer and spacer block materials are also being considered (Ritola and Pyy, 2011). A depiction of the type of press envisioned to produce these clay-based blocks is shown in Figure 25.

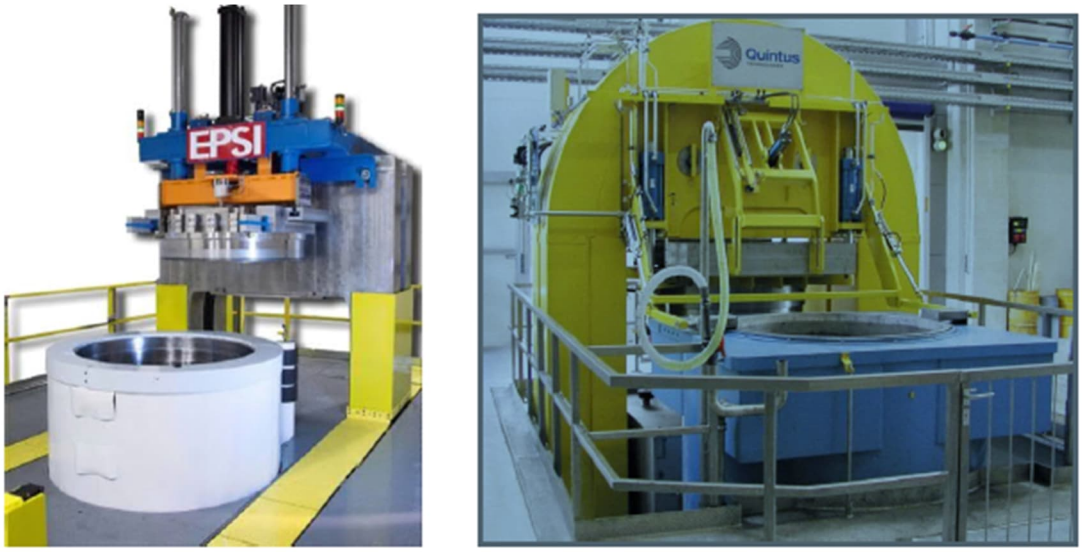


Figure 25: Examples of Commercially Available Cold Isostatic Press, Manufactured by EPSI (Left) and Quintus (Right)

Specially designed equipment will be used to lift the HCB products out of the moulds. A prototype vacuum lift system for handling HCB blocks is shown in Figure 26. This lifting technique is non-intrusive, safe, and effective way to handle these types of compacted materials.



Figure 26: Prototype Buffer Block Vacuum Lift

The SMCP will be a highly automated facility, operated by a small number of skilled workers on the plant floor. Such workers are likely to include a plant supervisor and foreman, control room and floor operators, and quality control technicians.

The SMCP and its compacted or granulated materials' storage areas will be enclosed to maintain climate and humidity control (to minimize moisture absorption and ensure the integrity of the finished products). The exterior silos or storage domes will also have heated concrete floors (as required) to protect stockpiles from freezing. The enclosed structures will further help to prevent wind erosion effects that can cause fugitive dust emissions. A multi-chamber dust collection baghouse will be in place to collect any dust generated by the sealing materials operations.

A quality control laboratory and geotechnical technicians will be housed in the SMCP. The laboratory will be responsible for materials testing of the imported aggregate and clay materials, as well as for testing of the products from the concrete batch plant and SMCP.

3.9 GARAGE / WAREHOUSE / HAZARDOUS MATERIALS STORAGE

Areas B5 & B7

The garage / warehouse / hazardous materials storage areas will be housed in a one-storey building and it will include maintenance shops, repair bays and a space allocated for hazardous materials storage.

The building will be a single structure with partition walls between the distinct areas, and a limited-access area for hazardous materials storage. The garage area and one portion of the storage warehouse will be heated while another section of the warehouse will be unheated. While separate entrances will be provided for the garage and warehouse areas, a wide opening sliding double-door will be provided for off-loading supplies in the main warehouse through the garage. Firefighting equipment will be available in all rooms. Additional details are as follows:

- Maintenance and repair bays – the garage area will have three vehicle maintenance bays as well as benches and extra space for machining, welding, etc. While major vehicle and equipment repairs will generally not be handled at the DGR (instead being carried out at designated and proximate authorized facilities), the maintenance and repair bays will be available to deal with emergency and routine requirements.

  The maintenance and repair area will be equipped with all the tools and small machinery needed including hydraulic jacks, ramps and lifts as well as an overhead crane. An air compressor will be supplied for pneumatic tools and equipment and stored lubricants will be available for routine maintenance;

- Truck wash bay – a single bay will be provided for washing buses, trucks and other equipment. Discharged water will collect in a holding pond where suspended particles will be allowed to settle out. A separator in the pond area will collect oils for containment and removal before the wastewater is re-used or discharged to the environment. The collected water will be topped up with fresh water as required; and

- Warehouse – a warehouse area, with forklifts, will be provided for the bulk storage of all equipment, parts and items required for the areas of the DGR facility without their own

storage. This warehouse will also be used as a staging area for distribution to other buildings. Warehouse space will be split as further described below:

- An unheated area for storing bulky items (not associated with used nuclear fuel waste) at the far end of the building;
- A heated storage area for mechanical and electrical equipment, spare parts, workshop items, benches, jacks and toolkits;
- A heated area for construction related items including cement, geotextile membranes, pipes, couplings, etc.; and
- A separate and limited-access (fenced-off) heated area for hazardous materials storage including any reagents for water or wastewater treatment, laboratories, etc.

3.10 WATER STORAGE, TREATMENT AND DISTRIBUTION

Areas B10, B11 & B12

Service (raw) water for the DGR facility will be sourced from a local river, water body, or well.

The required average water supply rate or water demand for the surface facilities during operations is expected to be approximately 97–134 m^3/day as summarized in Figure 9.

The required service water demand for the underground activities is highest during the construction phase when the services area, access tunnels, and initial placement rooms are being excavated; once in operations only additional placement rooms are excavated so water demand lowers. The required average underground service water demand estimates for the construction phase are 102 - 190 m^3/day and 33 - 51 m^3/day for the operations phase as summarized in Table 10.

The required potable water demand for the underground facilities is up to 4m^3/day during both the construction and operations phase.

The total average water demand for both the surface/underground facilities and activities during operations is approximately 134 -189 m^3/day (33.5 to 47.3 million litres per year, assuming 250 operating days).

The sourced raw water will be held in the water storage tanks (Area B10). These tanks will be located adjacent to the water treatment plant and pump house building (Areas B11 and B12, respectively). The pump house area will accommodate the potable, fresh and firewater distribution pumps in a single storey engineered structure.

Table 9: Surface Facilities Average Water Demand during Operations

Area	Facility	Process / Consumer	Daily Water Demand
P1	Used Fuel Packing Plant	Module/Basket Decontamination Active Cell Wash Down Cask / Transportation Package Decontamination Building Utilities	22.8 – 39.9 m^3
P5	Auxiliary Building	Laundry and Change Rooms Building Utilities Cafeteria	27.2 – 29.2 m^3
P7	Waste Management Area	Cleaning of Package Exteriors	0.1 m^3
P14	Quality Control Offices and Laboratory	Cleaning and Samples Building Utilities	1.2 – 1.6 m^3
B2	Administration Building	Building Utilities Cafeteria	13 – 22 m^3
B5	Garage	Building Utilities Truck Wash Bay	1.0 – 3.4 m^3
B6	Sealing Materials Compaction Plant	Bentonite Compaction Building Utilities	15.5 – 18.2 m^3
B13	Concrete Batch Plant	Concrete Production Building Utilities Truck Wash Bay	1.3 – 4.3 m^3
N/A	Site-Wide	Dust Control (Spray Truck)	15 m^3
		Estimated Total	**97 – 134 m^3 / day**

Table 10: Underground Activities Service Water Average Water Demand

	Daily Service Water Demand	
Activity Description	**Construction Phase**	**Operations Phase**
Probe/Pilot Hole Drilling	49.1 m^3	18.2 m^3
Lateral Development	29.3 – 117 m^3	6.0 - 23.9 m^3
Dust Control (Waste Rock Muck Pile)	11.3 m^3	1.3 m^3
Dust Control (Main Access Tunnel)	0 m^3	1.0 m^3
Mobile Equipment Shop Cleaning	1.1 m^3	1.1 m^3
Mobile Equipment Wash Bay	10.4 m^3	5.2 m^3
Concrete Equipment Cleaning	1.1 m^3	0 m^3
Estimated Total	**102 – 190 m^3/day**	**33 – 51 m^3/day**

Measures will be in-place to support a total fire water demand of about 1,360 m^3 with 100% redundancy based on the duration of 2 hours at 340 m^3/h as stipulated by NBC 2010 and CSA N393-2013. This volume will be stored at the site in a shared fresh/fire water tank. The fire water volume will be kept separate from the raw water by using different draw off points from the tank. Fire water pumps will be packaged as a set containing a diesel, electric and jockey pump.

The water will be distributed through pressure pipes (a dedicated fire main) feeding fire hydrants situated at visible and accessible locations within the vicinity of buildings and other facilities exposed to fire hazards conforming to applicable requirements of CAN/ULC-S520-07, “Standard for Fire Hydrants”, as well as those contained in AWWA C502, NFPA 24 and other applicable fire standards and specifications. The Fire Hydrants will generally be located at 60 m spacing to meet the minimum Fire Hydrant spacing requirement as listed in the NBCC.

Potable water will be produced on site at the water treatment plant using the fresh / fire water tank as a supply source. The water treatment plant will be capable of full treatment to provincial safe drinking water standards and a 24-hr supply of treated water will be stored in a potable water storage tank. The treatment plant will be complete with a filtration and sterilization system, filter backwashing equipment with air blowers, backwash pumps and inter-connecting pipework. The final water quality will be monitored for chlorine residual and turbidity.

A dedicated supply system will distribute potable water to all buildings. The system will be capable of providing a peak flow rate of four times the average daily flow rate. Two duty potable water distribution pumps and one standby pump will be installed. A central operations room in the pump house will permit remote control of these pumps.

3.11 SEWAGE TREATMENT PLANT

Area B19

Sewage collected from all serviced buildings will be piped to an on-site sewage treatment plant for treatment to provincial standards prior to recycling or discharge to a local water body. The plant (Area B19 in Figure 4) will be sized to handle 100% of the produced potable water plus a peaking factor of four for the shift changes. Sewage waste from below-ground operations will also be treated in this plant.

A packaged sewage treatment unit such as rotating biological contactor (RBC) or similar system will likely be utilized to handle the liquid waste. The RBC technology employs a fixed growth media process whereby bacteria are grown on a media surface that is rotated into and out of the wastewater. The RBC rotor is enclosed in a steel tank and the system also includes a primary clarifier, final clarifier, ultra-violet disinfection system, controls, switchgear and piping.

Such a modular sewage treatment system can accommodate variations in flow and is fully enclosed, eliminating any tanks and unsightly ponds. Organic loading fluctuations are dealt with easily without affecting the treatment process or effluent quality. Sludge accumulated in the plant would periodically be pumped to a mobile sludge tank and taken off-site for further treatment.

Treated effluent from the plant will be monitored for compliance before being discharged to a natural watercourse or for other uses (e.g., dust control). Laboratory tests will be conducted regularly to ensure that the effluent quality is maintained at the design levels.

3.12 SERVICE WATER AND STORMWATER CONTROL

Areas P10, P17, B15, B26A & B26B

Five ponds will be established on the DGR site, to manage service water, mine dewatering, or stormwater run-off. All the ponds will be lined, as required, over their base and embankments for

protection and to prevent water infiltration back into the ground. Collected flows will, in all cases, be quality monitored and potentially treated before being directed to any downstream uses (e.g., landscape irrigation) or discharged off the site. With regards to the latter, water quality will be analyzed for compliance with the applicable limits as set out in permit for the pond before the pond water is released to a natural watercourse.

The ponds will be designed to settle out suspended particles with any collected mud and silt deposits cleaned out on a periodic basis to maintain design retention volumes at all times. The ponds may be used for the temporary storage of snow and ice removed from the access roads and parking areas during winter months.

Storm Water Management Pond (Area P10)

A perimeter ditch around the Protected Area will direct falling precipitation to this stormwater management pond. The runoff collection ditches, conveyance pipes and culverts as well as the storage pond will be designed for the 1-in-500-year storm event with the pond discharge weir normally closed. The pond dimensions will be about 75 m by 75 m, and it will have a depth of approximately 5 m.

Mine Dewatering Settling Pond (Area P17)

Mine water pumped from the underground dewatering sumps will be piped to a dewatering settling pond. The pond will be designed to have a retention period of 5 days. An allowed freeboard and adjustable weirs on the outlet side of the pond will control the discharge rate and retain floating material such as oil residue collected in the underground sumps.

The mine water in the settling pond may contain sediment (rock dust), nitrogen compounds (arising from the explosives used to excavate rock), salt (due to saline ground water inflow into underground repository), possibly particular metallic elements (notably uranium), and hydrocarbons (oils from equipment). If the concentration of these potential contaminants are above acceptable levels, then the water will be treated before being reused as service water or discharged into a receiving water body.

During construction phase it has been conservatively estimated for design purposes that up to 350 m^3/day of water would be pumped to the ground surface. Whereas during the operations phase it is estimated that up to 180 m^3/day or less will be pumped to ground surface. These values include both the peak repository-wide underground water inflow and the maximum service water usages as noted in Section 3.10. Conservative maximum values are selected to ensure both the dewatering sump and settling pond designs can handle worst case (peak) operating conditions.

The underground water inflow amounts are generic, conservative crystalline geosphere estimates based on mining operational experience. It is anticipated that groundwater inflows into underground repository at both sites will be lower; particularly, at the South Bruce site with sedimentary rock geosphere. This information will be updated as site investigations advances.

Service Water Settling Pond (Area B15)

Service water high in suspended solids will be directed to this pond which will be designed for a 7-day retention time. Pond dimensions are expected to be about 45 m by 40 m, and it will have a depth of approximately 4 m.

Storm Water Management Ponds (Area B26A & B26B)

Two retention ponds located at opposite ends of the DGR site will receive stormwater run-off collected from the Balance of Site. Similar to the stormwater pond in the Protected Area (Area P10), the ponds will be sized for the 1-in-500-year storm event. The water will be routed to the ponds through a system of conveyance pipes, ditches and culverts, also designed for the aforementioned storm event. The ponds will have a bypass arrangement to directly discharge into the local watercourse if the storm event is continuous, to prevent damage to pond embankments. One pond will measure about 120 m by 50 m and the other pond will be about 90 m by 60 m. Both ponds will have approximately 5 m depth.

3.13 ROADS, PARKING AREAS, BUS SHELTERS AND COVERED PEDESTRIAN ROUTES

Areas B27, P15, B22, & P16

Access Roads

There will be a paved two-lane access road to the DGR site from the existing local highway. In addition, the site facility itself will require a total of approximately 5 km of road network within the Protected Area and the Balance of Site. Private vehicle traffic allowed into the controlled zones will be kept to a minimum with most DGR employees using the main/primary parking lot.

The main access road from the highway will be constructed with a compacted base course and asphaltic surfacing and be provided with shoulders and ditching on both sides. The main access road from the highway will be designed for frequent transfer of heavy loads. The roads and parking pads within the facility will be paved and will be complete with drainage ditches but without any shoulders. Collected on-site runoff from these roads and parking lots will be directed to the stormwater management ponds.

Parking (Areas B27 & P15)

Parking will be available in several locations at the DGR site with the primary parking lot (Area B27) situated adjacent to the Administration Building. This lot will be of sufficient size to accommodate cars, buses and trucks requiring parking services at the DGR facility. Unobstructed parking will further be ensured for all fire and security vehicles. An additional parking area (Area P15) will be provided in the Protected Area near the Auxiliary Building and the quality control offices and laboratory for deliveries as well as fire and security vehicles.

Bus Shelters (Areas B22)

Bus shelters (Areas B22-A & B22-B) will be located in the main parking area adjacent to the Administration Building as well as in the vicinity of the water treatment plant and air compressor building (Areas B11 and B8, respectively). All shelters will be complete with sliding doors, benches and heat to keep the occupants warm during winter.

The bus shelters in the main parking area are expected to be used by staff commuting to the DGR site.

Covered Corridor / Pedestrian Routes (Area P16)

Covered corridors or pedestrian routes will be established to facilitate personnel movement between the Administration Building, Auxiliary Building, UFPP and the Service Shaft Complex. The covered corridors will allow easy access and movement between buildings during winter and other harsh weather conditions.

Corridors will be located so as to allow vehicle traffic to circulate the facility in an efficient manner. Adequate space will be provided for pedestrians to share the passageways with handcarts. The corridors will be climate controlled (insulated and heated). Windows and doors will be installed as required for safety, and fire protection measures will be in place along the corridor lengths.

3.14 OTHER SURFACE FACILITIES

Areas B8, B9, B18, B21 & B23

Air Compressor Building (Area B8)

Air compressors will be required for supplying service air to the surface facilities and underground repository, and emergency breathing air to the UFPP, and underground refuge stations. Compressed will be delivered using 3 rotary screw compressors (with one standby). Service air will be delivered at a rate up to 0.12 m^3/s. Breathing air, required for underground in the refuge stations and on surface in the UFPP, will be delivered at a rate of 0.23 m^3/s by the same compressors that supply service air.

Fuel Storage Tanks (Area B9)

A fuel storage area will store diesel and gasoline fuel in accordance with applicable requirements listed in the NFPA 30, Flammable and Combustible Liquid Code. The tanks will be located within a concrete-lined containment area with sufficient capacity to hold the volume of the largest tank plus 10%.

Tanker fuel pumps or dedicated loading pumps will be used to fill the storage tanks and fuel will be dispensed through a metered fuel dispensing station. Card readers will be in place at the dispensing station.

Storage Yard (Area B18)

The storage yard will be an open area reserved for the laydown and temporary storage of new and decommissioned equipment and materials. It will have a granular surface and be fenced with lockable access gates.

Helicopter Pad (Area B21)

An area adjacent to the main parking lot will be dedicated for a helicopter landing pad. The helipad's clear area will be 30 m in diameter and will be capable of receiving a single helicopter while also allowing for parking on the pad. The landing pad will be designed with proper navigational aids and lighting requirements.

Weigh Scale (Area B23)

A weigh scale will be provided to properly monitor the receipt of bulk materials to the DGR facility as well as the shipping of excavated rock off-site. The scale will be sized to accommodate a fully loaded tractor and a double trailer for an overall length of 25 m. The scale will be supported by fully automatic controls, signal lights for traffic management and a motion detection system.

3.15 EXTERNAL FACILITIES AND OPERATIONS

This section describes facilities that will be located outside the security boundaries of the DGR facility and established to support the DGR facility development and operations. Such facilities will include an area for management of excavated rock, accommodation for construction personnel and a Centre of Expertise. A pumphouse will also be situated off-site for supply raw water to the DGR facility.

3.15.1 Excavated Rock Management Area Area B1

It is expected that most of the excavated rock will not be suitable or required for concreting, road works or backfill at the DGR facility. Excavated rock will not be used for production of LHHP concrete and various sealing material. It is also conservatively assumed that the excavated rock will not be released for commercial use (e.g., as a source of aggregate for road works or concrete). Therefore, a facility will be required for the long-term management of about 2.5 million cubic metres (broken volume) of excavated rock.

The Excavated Rock Management Area (ERMA) will be located outside the perimeter fence of the DGR surface facilities; the location will be selected to avoid streams and wetlands. It is assumed that the ERMA will be located within a 5 km distance of the DGR surface facilities and will occupy an area of approximately 25 Ha (~500m x 500m) depending on height of rock pile. The maximum height of the rock pile is expected to be between 15 to 20 m. The ERMA will be fenced.

The topography of the Ignace area location (crystalline) is undulating and forested. The ERMA will initially be prepared by clearing and grubbing any vegetation and then stripping and stockpiling topsoil. The low-lying depressions will then be filled with excavated rock to create a level working surface. Excavated rock will be delivered by haul truck from the Service Shaft Complex then be placed and compacted in layers on the prepared surface. Access routes and paths will be prepared on the rock pile for movement of trucks and grading equipment.

The topography at the South Bruce area location (sedimentary) is relatively flat in a farmland setting. The ERMA will be prepared by clearing and grubbing any vegetation and then stripping and stockpiling topsoil. Fill material will be placed and compacted to create a level working surface for the excavated rock. The excavated rock will be delivered by haul truck, and then placed and compacted in layers on the prepared surface.

The ERMA will have a perimeter ditch for collecting run-off from the rock pile and will direct run-off water to a stormwater management pond. The ditches will be hydroseeded and riprap lined

to prevent erosion. An external ditch system may be employed to prevent run-off from surrounding areas from entering the perimeter ditch around the ERMA.

A storm water management pond (Area B20) will be used to collect and monitor the run-off from the rock pile before being released to the environment. The pond will be used to control water discharge within design criteria for water quantity, water quality and total suspended solids. The pond will be designed to hold water for a sufficient amount of time to allow settling of suspended solids. The pond will create a single location to measure the quality of run-off from the rock pile. The potential contaminants of concern in the run-off will likely be various chemical constituents due to the dissolving of minerals in the excavated rock into the water and release of nitrogen compounds from residual explosives on the excavated rock.

Should future site investigations find the rock at site to be acid generating, then the ERMA will be designed to limit the amount of potentially contaminated water (leachate) that could seep into underlying soil and rock. This will be achieved by first creating a level working surface at the ERMA and then covering this surface with a composite or multiple-layer liner system. Excavated rock will be placed on this liner. The liner will be sloped towards the perimeter ditch water system that surrounds the ERMA. The perimeter ditch will also have a liner to ensure all potentially contaminated water is directed to a lined stormwater management pond where water would be treated as necessary before release.

The rock pile will be rehabilitated after excavated rock placement has ended. The pile will be restored by vegetating the surface with native plant species and in manner capable of supporting a self-sustaining ecosystem.

3.15.2 Accommodation for Construction Personnel

During the initial construction period, accommodation will be required for the construction personnel. These workers could be housed in the community and surrounding area, or there could be a need to develop a nearby temporary infrastructure to provide sleeping quarters, kitchen, dining, laundry, medical and recreational facilities.

NWMO will work with the community and surrounding areas to plan for and contribute to the development of community infrastructure required during construction and operation to house and integrate personnel into the community. It is assumed that accommodation is required for about 600 construction personnel.

If required, a temporary facility to provide construction accommodation will be developed in collaboration with the community. Typically, they will be two storey buildings with units whose internal layout will vary depending on the intended occupancy. Some units will feature rooms with larger sleeping quarters and private bathrooms to be intended for management and supervisory personnel. Other units will comprise of rooms with one or two beds and shared toilet facilities. Common areas will also be provided.

In addition to the residential structures, other required support facilities and systems will include the following:

- Security fencing including access gates around the facility as well as area and security lighting;
- Access roads and parking;
- Power generation and distribution systems (electrical power will initially be supplied by generators) and fuel supply;
- Water, stormwater, sanitary sewage and solid waste facilities as well as a telecommunications system;
- Fire detection and protection systems;
- Kitchen, dining, laundry and recreation facilities; and
- Medical centre (e.g., nursing station).

3.15.3 Community Infrastructure

The NWMO is transitioning to a site-specific project. The incremental addition to community infrastructure will be determined through discussions with the communities based on a mutual understanding of the existing capacity of the infrastructure and the anticipated demand that is expected to arise with the implementation of the project.

3.15.4 Centre of Expertise

A Centre of Expertise will be established in the community selected to support ongoing detailed site evaluation. The centre will be located in or near the community, as determined with people who live in the area. Its purpose will be to support the multi-year testing and assessment of the site on technical safety and community well-being related dimensions, which are key components of the site selection process. The Centre of Expertise will be home for an active technical and social research program and a technology demonstration program during this period, involving scientists and other experts in a wide variety of disciplines, including geoscience, engineering, environmental, socioeconomic and cultural impact assessment fields.

An engineering test facility will be located at the Centre of Expertise. Potential activities in the engineering test facility may include testing of prototype systems for the Used Fuel Packaging Plant (UFPP) (e.g., mock fuel handling, container welding, copper coating, etc.), as well as the development of container placement equipment for the underground repository. The engineering test facility may also house demonstration equipment to show key repository packaging and container placement processes.

The Centre of Expertise may be expanded to support construction and operation of the deep geological repository. The centre will become a hub for knowledge sharing across Canada and internationally. Artist renderings of what the Centre of Expertise could look like are shown in Figure 27.

Design details of the Centre of Expertise will be developed with the interested community, potentially affected First Nation and Métis communities and surrounding municipalities with their preferences in mind.





Figure 27: Centre of Expertise concepts

4. SHAFTS, HEADFRAMES, AND HOISTING SYSTEMS

This section describes the three Shaft Complexes (Main, Service, and Exhaust Ventilation Shafts) required to support the construction, operation, and extended monitoring of the DGR. The Main Shaft, Service Shaft and Exhaust Ventilation Shaft which are identified as Areas P2, P4 and P20, respectively, shown in Figure 4.

4.1 HEADFRAMES AND HOISTING SYSTEMS DESIGN

The shafts will be serviced by a total of five hoists that are housed in three headframes. The Main Shaft cage, Service Shaft cage and development skips, which will be raised/lowered by friction hoists. The remaining two hoists will be Blair-type hoists that will be used to raise/lower auxiliary cages for movement of personnel. The following sections describe the headframe structures and various hoisting systems to be used at the DGR facility.

4.1.1 Main Shaft Headframe and Hoist

The Main Shaft Complex will serve as the exclusive conveyance structure for the surface-to-underground transfer of the Buffer Boxes (with UFCs) for placement in the underground repository. Additionally, if there is a need in future, the Main Shaft will also accommodate the transfer of any retrieved UFCs from the repository level to the surface.

The Buffer Box weight and dimensions are described in Appendix A. The intended mode of buffer box transfer to the underground repository is via trolley. Each Buffer Box with a UFC will be loaded into a transfer cask and then placed onto a trolley.

The Main Shaft hoisting system will be tower-mounted within an approximately 60 m high slip-formed reinforced concrete headframe structure. The use of a concrete headframe will provide a sturdy and resilient structure, and a system that will afford a high level of protection against any potential meteorological or seismic-related impacts. The facility will be insulated wherever possible to maximize its energy efficiency. Immediately adjacent and joined to the head frame structure will be a collar house, which will house the facility for loading the transfer cask onto the cage. The head frame will have various floors, including one floor for the Koepe hoist, a deflection sheave floor, the collar floor, and a sub-collar floor, in descending order.

The Main Shaft will use a friction hoist which will have a payload capacity of approximately 60 tonnes. Such a hoisting system will have a nominal 100-year life, assuming the adoption of appropriate preventative maintenance practices and component upgrade schedules. The Main Shaft's friction hoist system, comprising one main cage with a counterweight in balance, will be configured as noted in Table 11.

Table 11: Main Shaft Hoisting Systems

Item	UFC Hoist
Configuration	Koepe Friction Hoist
Weights / Payloads	
➢ Approximate Tare with Attachments	50 tonnes
➢ Approximate Payload	60 tonnes
➢ Approximate Counterweight with Attachments	80 tonnes
Suspended Load	280 tonnes
Hoist Speed	2.5 m/s
Required Motor	1,000 kW

Note: Required payload capacity of Main Shaft may change as design of UFC, Buffer Box, transfer cask and trolley evolve.

4.1.2 Service Shaft Headframe and Hoisting Systems

The Service Shaft Complex will be a multi-purpose hoisting facility with three hoisting systems for movement of personnel and materials into and out of the repository. The hoisting systems will be tower-mounted inside an approximate 50 m high slip-formed reinforced concrete headframe structure. The headframe structure will be designed to maximize durability and weather-tightness to ensure a long service life. The head frame will have 7 floors, consisting of 3 hoist floors, one power floor, one dump floor, the collar floor and a sub-collar floor, in descending order. The Service Shaft Complex will also have a collar house and a bin house for handling excavated rock brought to surface. The headframe will be equipped with a rock dump and chute to direct the excavated rock into a temporary storage bin or onto the ground. From this location the excavated rock will be loaded onto haul trucks which will take the rock to the ERMA.

The following hoisting systems will raise/lower the equipment and cages inside a 7-m-inside diameter concrete lined shaft:

- Excavated rock friction hoist for raising/lowering two counterbalanced skips;
- Main service friction hoist for raising/lowering a cage for personnel movement and material handling; and
- Auxiliary Blair-type hoist for raising/lowering cage for personnel movement both during normal operations and emergencies.

A key reason for selecting the Blair-type hoist for raising/lowering the auxiliary cage in this shaft as well as the Exhaust Ventilation Shaft is that this hoisting system avoids the use of combustible materials in the shaft. Single-rope drum hoisting systems must use wooden guides to allow use of “safety dogs” for catching the cage in the event of rope failure. Whereas Blair-type hoisting system uses two ropes and in the event of a rope failure the second rope will safely support the

cage. Thus, in a Blair-type hoisting system steel guides can be used to control movement of the cage within the shaft.

The details of the Service Shaft hoist systems are presented in Table 12.

Excavated Rock Hoist

The Service Shaft Complex will incorporate the permanent excavated rock handling installation for the DGR. A friction hoist will raise and lower skips (large metal buckets for handing rock) with excavated rock that is generated by the development of the underground repository both during initial construction and operation phases. The two bottom-dump skips will be in a balanced arrangement on the friction hoist.

The skips will be loaded at the loading pocket near the base of the Service Shaft. Excavated rock or muck will first be delivered by haul trucks to a grizzly (heavy duty screen with approximately 250 mm openings) above a raise that feeds the loading pocket. The oversize material will be broken with the use of a hydraulic rock-breaker until it fits through the grizzly.

The loading pocket (as shown in Figure 28) will consist of conveyor and two bins or flasks that are weight controlled. Feed to the bin/flasks from the raise will be via a conveyor, to allow for fine control on the load levels in each skip. Each flask will be filled with a measured amount of excavated rock during the skip cycle. Upon the skip's arrival in the loading pocket the weighed rock will be transferred into the skip via a chute from the corresponding bin/flask. The loaded skip will be raised to surface where the rock will be dumped into the bin house.

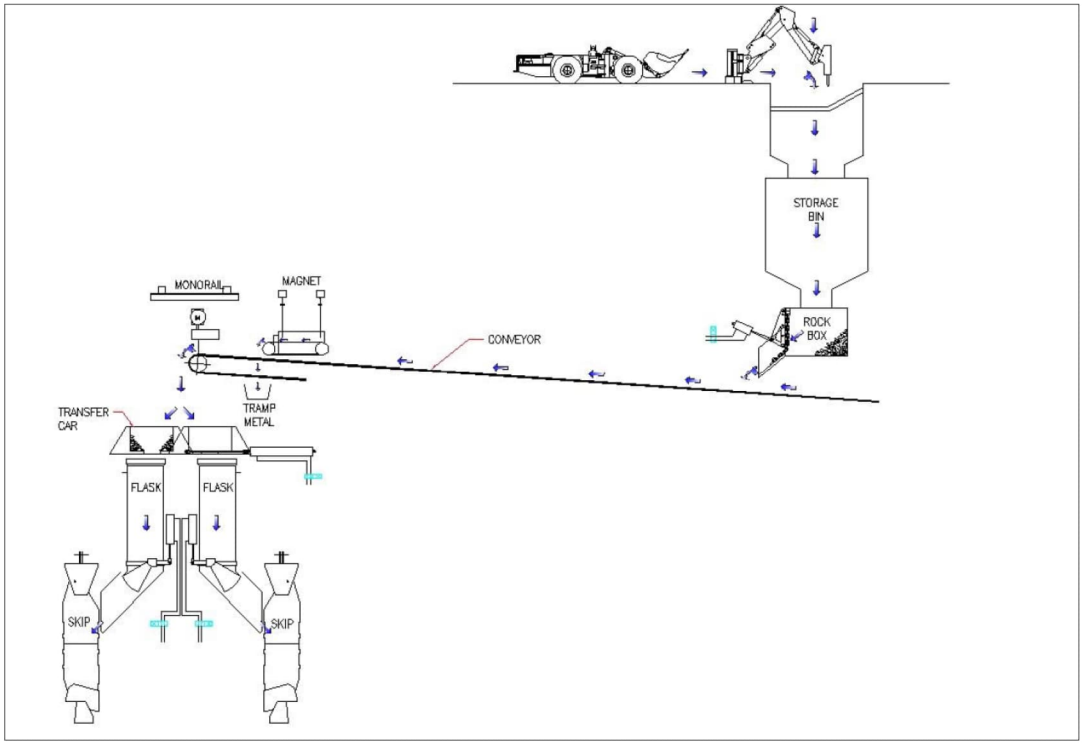


Figure 28: Typical Loading Pocket Arrangement

Service Hoist

The Service Shaft will be equipped with a friction hoist and cage (with a counterweight in balance). The service hoist will move personnel, consumables and equipment into and out of the underground repository. It will also be used to move sealing material components such as HCB blocks and bentonite gap fill materials (GFM) from the surface to the repository. It will be able to carry up to 50 personnel or handle loads up to 10 tonnes.

The Service Shaft, as an excavated rock handling shaft, will require additional maintenance relative to the other two shafts. Because there is a possibility that loose rock will fall down the shaft and into other shaft compartments, the muck handling compartments will be separated from other compartments over the full height of the shaft by brattice panels. Brattice panels are frames with cladding on the inside which act as a physical barrier between compartments and will prevent loose rocks from falling into the other hoisting compartments.

Auxiliary Hoist

The Service Shaft will be equipped with a Blair-type auxiliary hoist and cage. The auxiliary hoist will be available in the Service Shaft to move personnel into and out of the underground repository on an as needed basis without interrupting the movement of materials. This hoist will provide a second means of egress for personnel during an emergency event. In the event that main electrical power supply is lost, electrical power will be supplied to the auxiliary hoist by emergency power generators.

Table 12: Service Shaft Hoist Systems

Item	Hoist for Excavated Rock (Development Skips)	Service Hoist/Cage	Auxiliary Hoist/Cage
Configuration	Koepe Friction Hoist	Koepe Friction Hoist	Blair Multi-rope Hoist
Weights/Payloads			
➢ Tare with Attachments	10 tonnes	10 tonnes	2.3 tonnes
➢ Payload	6.5 tonnes	10 tonnes	1.8 tonnes
➢ Counterweight with Attachments		15 tonnes	
Suspended Load	40 tonnes	50 tonnes	7 tonnes
Hoist Speed	5 m/s	2.5 m/s	2.5 m/s
Required Motor	300 kW	300 kW	75 kW

4.1.3 Exhaust Ventilation Shaft Headframe and Hoisting System

The Ventilation Shaft Complex will handle most of the repository exhaust air and will have an auxiliary hoist to provide a secondary means of egress for personnel during an underground emergency event. The 30 m high steel headframe structure will have a single operating floor to support the deflection sheave, plus the collar floor and sub-collar. The collar house will be able to support mine rescue or evacuation efforts.

The Blair-type hoisting system will be ground-mounted beside the steel headframe structure. Like the Service Shaft auxiliary hoist, in an event that main electrical power supply is lost, electrical power will be supplied to the auxiliary hoist by emergency power generators. The details of the Exhaust Ventilation Shaft's hoist system are as shown in Table 13.

Table 13: Exhaust Ventilation Shaft Hoist System

Item	Auxiliary Hoist
Configuration	Blair Multi-rope Hoist
Weights/Payloads	
➢ Tare with Attachments	2.3 tonnes
➢ Payload	1.8 tonnes
Suspended Load	7 tonnes
Hoist Speed	2.5 m/s
Required Motor	100 kW

4.2 SHAFT DESIGNS

The primary design elements of the three shafts are dictated by hoisting requirements for personnel, materials and equipment, as well as emergency egress considerations and underground services needs. The Exhaust Ventilation Shaft diameter is set by ventilation requirements and, in particular, a requirement to maintain the up-cast air velocity in the shaft outside the range of 7 to 13 m/s to avoid suspension of water droplets.

Taking in account these various design considerations, the inside diameter of the three shafts have been set at 7 m. An advantage of standardizing inside diameters is standardization of shaft sinking operations which will lead to a more efficient shaft sinking program. The shaft liner designs will be finalized once a final DGR location has been selected and geologic conditions have been defined at each shaft location and the design parameters finalized. Future design considerations will include possible removal of reinforcing steel to facilitate liner at the time of decommissioning and, if required and depending on site conditions, design features to control water inflow through the liners into shafts.

The following sections describe the conceptual layouts for each of the shaft. These sections make reference to Figure 31 for the Main Shaft, Figure 32 and Figure 33 for the Service Shaft, and Figure 34 for the Exhaust Ventilation Shaft, respectively.

4.2.1 Main Shaft

During the Operations Phase, the Main Shaft Complex will serve as the exclusive conveyance structure for the surface-to-underground transfer of the UFC/BB Transfer Cask for placement in the underground repository. Additionally, based on future needs, the Main Shaft will also accommodate the transfer of any retrieved UFCs from the repository level to the surface.

A secondary function of the Main Shaft will be to act as a conduit for exhaust ventilation air from the underground temporary UFC/BB Transfer Cask storage/staging area located near the base of the Main Shaft. At the surface, the air will exhaust to the atmosphere via a plenum which leads to a 9-m-high ventilation stack that will be located close to the Main Shaft headframe. A plenum is an underground structure that directs air out of the shaft envelope to a location away from the headframe.

The Main Shaft will also provide access to an underground repository for some services. The shaft will have separate compartments for:

- Cage for transfer of the UFC/BB Transfer Casks;
- Counterweight; and
- Shaft-specific Communications Cable(s).

The Main Shaft (Figure 31) will have a finished internal diameter of 7 m with a 500 mm thick reinforced concrete liner. The Main Shaft hoisting system will be tower-mounted within an approximately 60 m high reinforced concrete headframe structure. The use of a concrete headframe will provide a sturdy and resilient structure and a system that will afford a high level of protection against any potential meteorological or seismic-related impacts. The facility will be insulated wherever possible to maximize its energy efficiency. Immediately adjacent and joined to the head frame structure will be a collar house, which will house the facility for loading the UFC/BB Transfer Cask onto the cage. The headframe will have multiple floors, including one floor for the Koepe hoist, a deflection sheave floor, the collar floor, and a sub-collar floor, in descending order. The hoisting system will be designed to operate with a hoisting speed of 2.5 m/s, alignment integrity and guide wear will not be an issue with respect to ongoing maintenance needs.

During the Construction Phase, the Main Shaft will be used to mobilize large heavy equipment underground, support general material handling logistics, and to support the underground demonstration facility (UDF) activities, for example, the movement of non-nuclear UFC/BB Transfer Casks for placement in the UDF area. The commissioning of the Main Shaft will be linked to the transition of the Exhaust Ventilation Shaft to full Operations mode ventilation versus supporting the initial underground development works.

4.2.2 Service Shaft

The Service Shaft (Figure 32 and Figure 33) will have a final finished internal diameter of 7 m with 500 mm-thick reinforced concrete liner. The primary functions of the Service Shaft will be delivery of personnel and materials to and out of the underground repository, to act as a conduit for delivery of fresh to underground repository, and to provide primary access to underground repository for services.

The Service Shaft will have separate compartments for:

- Equipment to deliver excavated rock to ground surface (skips);
- Cage to move personnel and materials to the underground repository and compartment for an associated counterweight;
- Auxiliary cage for personnel movement during normal operations and emergencies; and
- Services including service and potable water pipes, two high voltage power cables, communications cable, compressed air pipe and two concrete slicklines.

All conveyances will run on steel guides. There will be a ventilation plenum to connect the fresh air intake to the shaft. The plenum will allow the fresh air intake fans to be located away from headframe and thus reducing noise levels in the vicinity of the headframe.

At the bottom of the Service Shaft, the loading pocket will have some spillage during its operation. A ramp will be developed to the shaft bottom so that equipment can travel to the shaft bottom on a regular basis to remove broken rock.

4.2.3 Exhaust Ventilation Shaft

The Exhaust Ventilation Shaft (Figure 34) will have a finished internal diameter of 7 m with a 500 mm thick reinforced concrete liner. The primary functions of the Exhaust Ventilation Shaft will be to act as a conduit for exhaust ventilation air from the underground repository, to provide a secondary means of egress during an underground emergency event, and to provide access to underground repository.

The Exhaust Ventilation Shaft will have separate compartments for:

- Exhausting air from the underground repository;
- Auxiliary cage for personnel movement during emergencies; and
- Services including service and potable water pipes, dewatering pipe, two high voltage power cables, communications cable, and compressed air pipe.

The shaft diameter has been set at 7 m to ensure the ventilation air velocities will remain below or close to 7 m/s.

The main exhaust fans will be located underground at the DGR level and will push air up the exhaust ventilation shaft. At surface the air will exhaust via a plenum which leads to a 15-m-high ventilation stack that will be located close to Exhaust Ventilation Shaft headframe (see Figure 29).

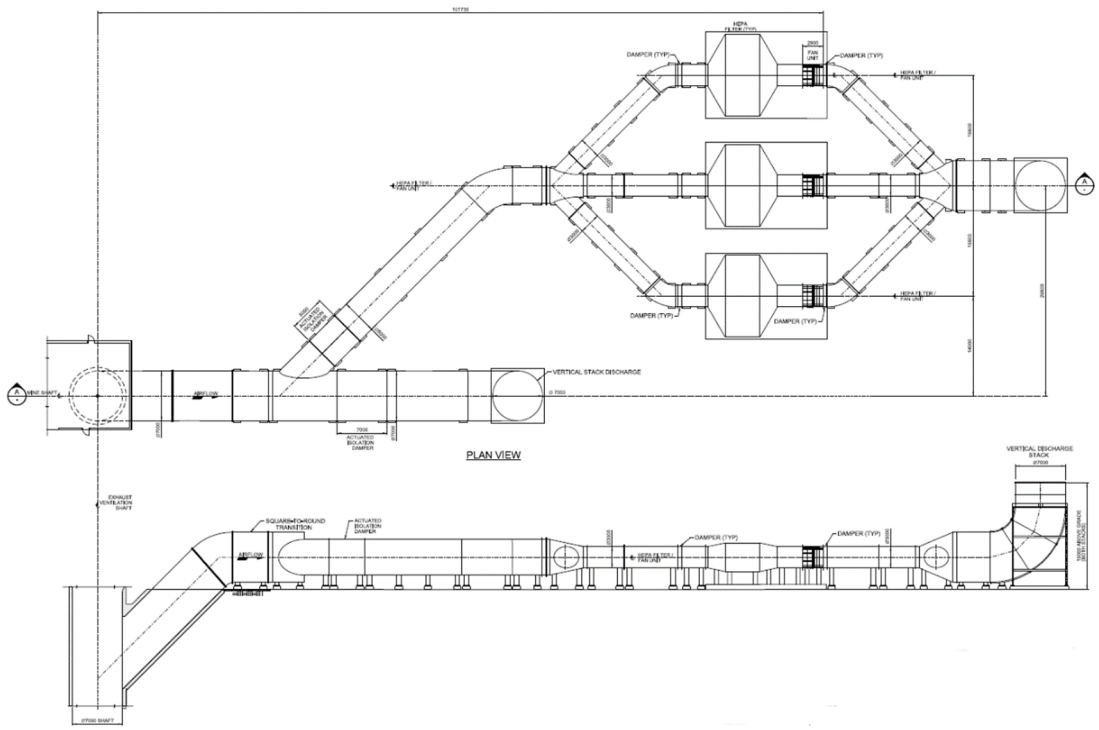


Figure 29: Conceptual Exhaust Ventilation Shaft Exhaust Stack & HEPA Filters Arrangement

4.3 SHAFT SINKING REQUIREMENTS

NWMO's current planning assumption is that the three shafts will be developed using a conventional controlled drill and blast sinking approach. It is envisaged that the Main Shaft and Service Shaft will be sunk using the permanent concrete headframes. Whereas the Exhaust Ventilation Shaft will be sunk utilizing temporary head frame in lieu of using the final headframe. As the site investigation and the construction plan advances, other shaft excavation techniques (e.g., Raise Bore Excavation) will be investigated.

The design of the shaft liner and grouting system (if grouting is required), will be completed after the location of the shaft (and site) is established. The shaft liner will serve two purposes; first it is a measure of ground support, preventing minor ground shifts or loose rock from falling into the shaft, and second it will act as a means to prevent seepage of water in the shaft. It is expected that the host geosphere for the underground repository will consist of a very good quality rock mass, one that is only moderately to sparsely fractured and with a low permeability. However, it is possible that the near surface rock will have permeable features where water could flow into the shaft excavation. These zones of higher inflow rates will be addressed through grouting and the liner design.

The shaft sinking process itself involves several steps, which will include:

- Collaring or starting the shaft;
- Setting up the equipment needed to sink the shaft;
- Sinking the shaft to its full depth including significant allowances for geoscience verification activities of each round and any notable geologic features;
- Dismantling the equipment used for sinking; and
- Installing the permanent equipment and its commissioning.

The Service Shaft and Exhaust Ventilation Shaft will be sunk concurrently. The sinking crew from the first shaft to be completed will then move the Main Shaft.

4.3.1 Shaft Collaring

Collaring the shaft requires the establishment of the shaft centerline via survey, and usually requires the drilling of a borehole to confirm rock type and quality. The borehole will be drilled within the finished diameter of the planned shaft to at least the planned depth of shaft bottom.

Once the location is confirmed, the shaft excavation will commence. This will involve use of controlled dill & blast techniques to establish the rough diameter of the shaft to an approximate 30 m depth. Removal of excavated rock or muck will be accomplished using a crane equipped with a bucket, and a small excavator, which will be lowered into the excavation to load the bucket. Once the desired depth is achieved, a set of forms will be installed close to the bottom, and the permanent concrete liner for the collar will be poured into place.

If the shaft is first excavated through overburden, then a similar process will take place, with the excavation through ground being carried out with a small excavator that is captive in the hole until the bedrock is reached. During excavations, temporary support of the walls will be provided using liner plates and ring beams, which will be bolted into place. Once bedrock is reached, a drill will be lowered into the hole and a 5 m cut will be sunk into the excavation's bottom to act as a water-proof socket for the shaft liner, preventing influx at the rock / overburden interface. With the cut completed, a set of shaft forms will be lowered into the hole, and the concrete collar will be poured from the bottom up.

At the sedimentary rock location, it is likely that the top 180 to 200 m of bedrock will require ground conditioning to limit the amount of groundwater inflow during shaft sinking. Ground conditioning would be achieved by either grouting or ground freezing. The upper 180 to 200 m of the concrete liner will be designed to limit ground water into the finished shaft.

4.3.2 Sinking Plant Set-up

Once the collar is established, the equipping of the sinking plant will commence. The sinking plant has four main elements as listed below:

- Sinking hoist;
- Sinking winches;
- Sinking headframe; and
- Galloway (or sinking stage, see Figure 30).

The sinking hoist will be a double drum hoist, equipped with two sinking buckets to both move personnel and material into the shaft excavation, and to remove excavated rock from it as it is excavated. The sinking winches (2 to 4 required) are smaller low speed hoists that will be used to raise and lower the Galloway as required during the sinking cycle.

The sinking headframes for the Main Shaft and Service Shaft will be the permanent slip-formed concrete headframe structures. The concrete headframes will be constructed in advance of shaft sinking and will be used to raise/lower shaft sinking equipment. Once shaft sinking has been completed, the temporary hoisting equipment that is housed in these headframes will be removed and the permanent hoist systems will be installed.

The sinking headframe for the Exhaust Ventilation Shaft will be a temporary steel structure that supports the ground-mount sinking hoists and winches. The temporary headframe will be approximately 40 m high to accommodate travel room for the hoisting plants, and to allow for the lowering of items like drill jumbos and mobile equipment into the shaft. A temporary enclosure attached to the headframe, called a collar house, will be in place to shelter workers from the elements and to temporarily house material and equipment.

Once the Exhaust Ventilation Shaft is sunk a temporary rock loading system will be installed at the DGR level. This system will be used to remove rock that is generated by the development of the underground repository during initial construction. This system will be used until the permanent skipping facilities are installed in the Service Shaft.

A shaft sinking stage or Galloway is a multi-decked structure that is supported by the sinking winches in the shaft (Figure 30). The stage is not attached to or supported by the shaft walls, and it hangs independently. It is an integrated development and excavation system, wherein all aspects of the shaft development effort are completed from the one structure including drilling, mucking, ground control and liner installation. It contains all working needs, including small tools, shaft sinking drills or jumbos, and shaft liner forms.

Each deck within the Galloway has a different function, and each Galloway is unique to the shaft under construction. Because the shafts in this case are the same diameter, it will be possible to use similar Galloway designs in each shaft.

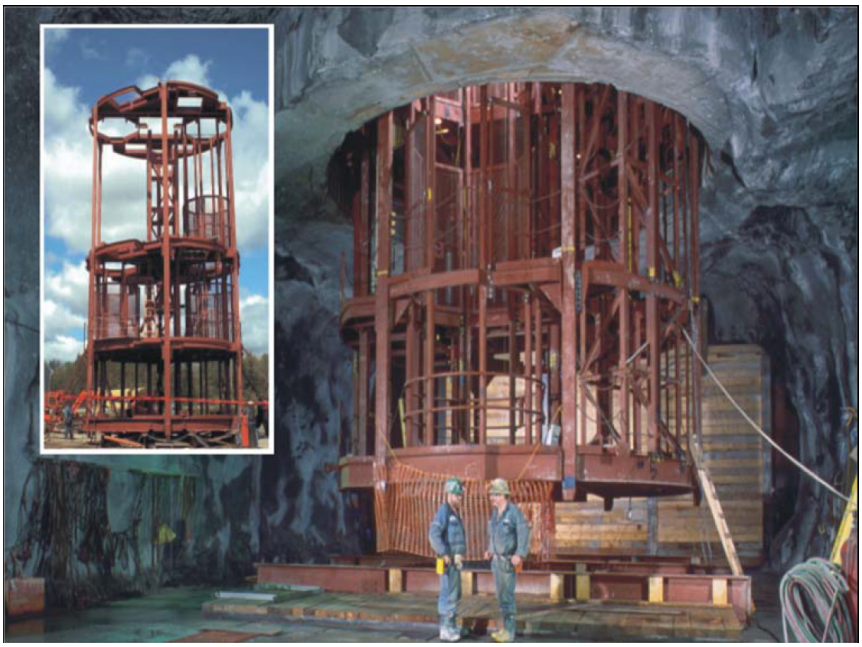


Figure 30: Typical Galloway Showing the Pre-Assembly on Surface

4.3.3 Shaft Sinking Operations

The basic process of sinking a shaft will be methodical and repetitive, as follows:

- The face (or exposed bottom) of the excavation will be cleaned and prepared for drilling;
- The shaft jumbo will be lowered to the face and the round is drilled;
- The jumbo is lifted clear, and the holes will be loaded with explosives;
- The workers will be brought to surface, the Galloway will be lifted clear to a safe distance and the round will be blasted;
- The shaft will be ventilated to clear blast gases prior to workers being allowed to re-enter;
- Workers will begin excavating the bottom of the shaft and installing ground control (i.e., rock bolts, screen) in the shaft walls. Geological inspections will be undertaken across the shaft walls and face during this time;
- The shaft liner will be formed and poured, extending it down closer to the face; and
- Once the face is cleared of excavated rock, the cycle will be repeated.

An average rate of advance for the shaft sinking will be between 2.5 m and 3.5 m per day. However, for planning purposes it is assumed that geoscience verification activities will occur for each round which will reduce the advance rate.

4.3.4 Dismantling the Sinking Gear

Once the shaft bottom is reached, the entire sinking system will be dismantled to allow for production equipping. This will require dismantling of the shaft sinking stage or Galloway and its hauling to the surface. The shaft sinking buckets will then be removed, the various ropes used will be re-wound and taken off the headframe. At the Exhaust Ventilation Shaft the temporary headframe will be removed and the permanent headframe will be constructed in its place.

4.4 SHAFT OPERATIONS AND MAINTENANCE

The three shafts have been designed to promote uniformity wherever possible, so that repeat maintenance events will be as similar as practical in terms of the sequence of events, equipment required, and manpower needs.

During normal operations, Ontario regulations stipulate a minimum number of shaft inspections per week. During the weekly inspections all shaft compartments will be examined with damage noted and with loose materials cleaned out. Maintenance will be scheduled as required.

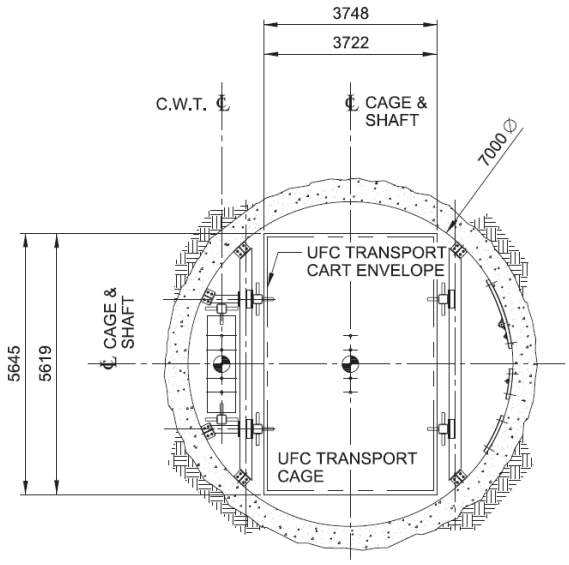
There will be regular testing of the hoisting and braking systems. The hoisting systems, including ropes, conveyances and hoisting equipment will also be inspected on a periodic basis to ensure that they are in proper condition and fit for continued use.

Hoist ropes will be periodically changed and will also be subject to regulatory requirements to have sections cut from the ends for destructive testing. This will require that conveyances be temporarily chaired (locked into position) or supported at the collars while head ropes are disconnected for inspection or change-out. Likewise, for the friction hoists, new tail ropes will need to be installed using small tuggers or winches to pull the ropes up the shaft during these operations.

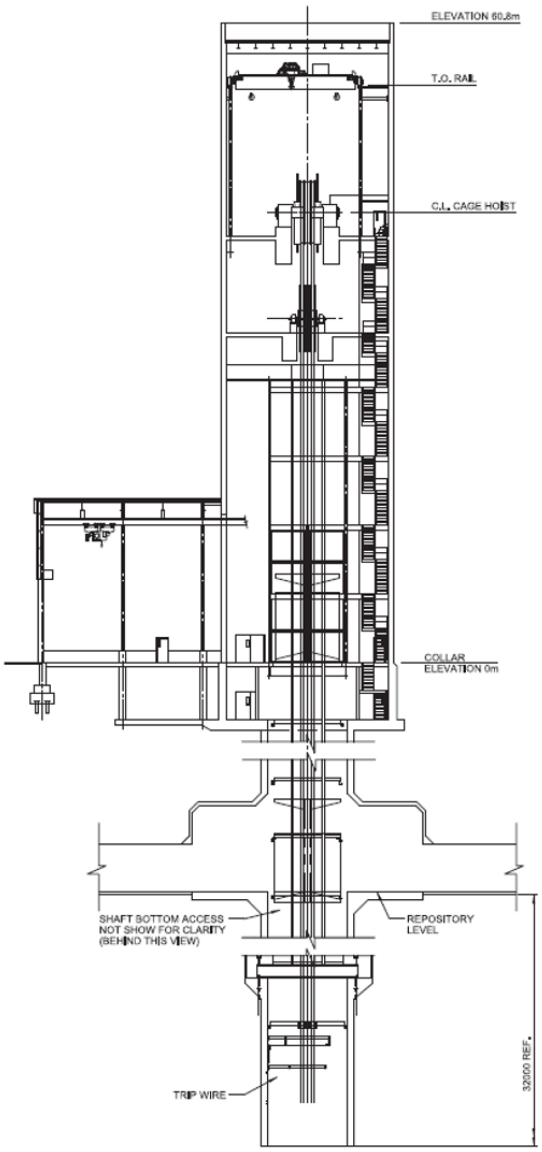
A general maintenance/replacement schedule is presented in Table 14. The Service Shaft, as an excavated-rock-handling facility, will require additional maintenance as compared to the other two installations.

Table 14: Shaft / Hoist General Maintenance and Replacement Schedule

Item	Replacement Frequency	Notes
Hoist Ropes	3 to 9 years	Depends on the findings of regulatory rope inspections. It should be assumed that all hoist ropes will be replaced every 3 years except for Exhaust Ventilation Shaft auxiliary hoist ropes. Due to low usage ropes in Exhaust Ventilation Shaft would be changed up to every 9 years.
Hoist Conveyances	5 years for skips 10 years for cages	Depends on inspections. If conveyance is not displaying fatigue or wear, it may be used longer.
Hoist Brake Liners	5 years	
Hoist Bearings	25 years	Depends on hoist alignment and balancing. Well balanced and lubricated machines will last longer.
Hoist Motors	25 years	Rule of thumb
Hoist Drives	25 years	Due to obsolescence and availability of spares, may need to replace components every 10 years.
Hoist Replacement	50 to 100 years	The oldest hoists in operation are 95 years old and there few hoists that have reached this age. Current assumption is to perform a full hoist replacement in 50 years.



7.0m∅ MAIN SHAFT PLAN



Shaft Plan **Shaft and Headframe Section**

Figure 31: Main Shaft

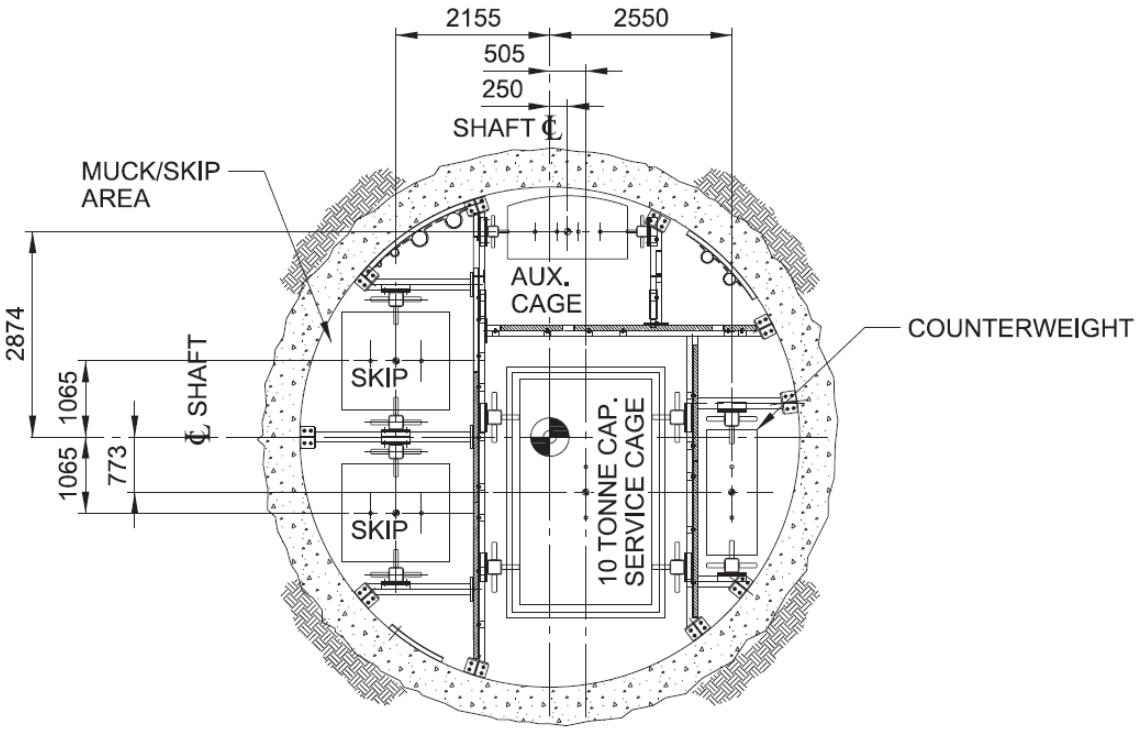


Figure 32: Service Shaft – Shaft Plan

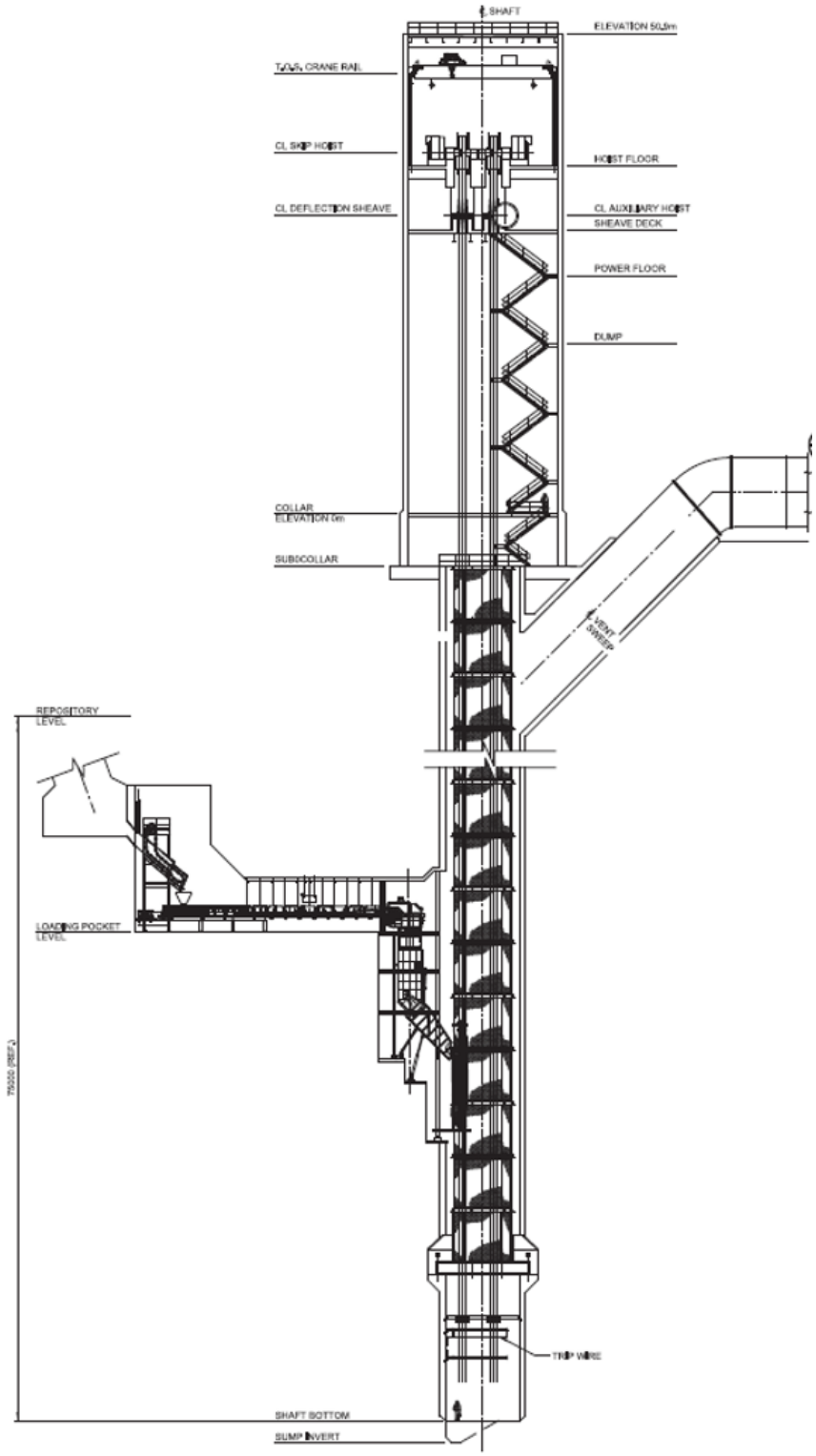
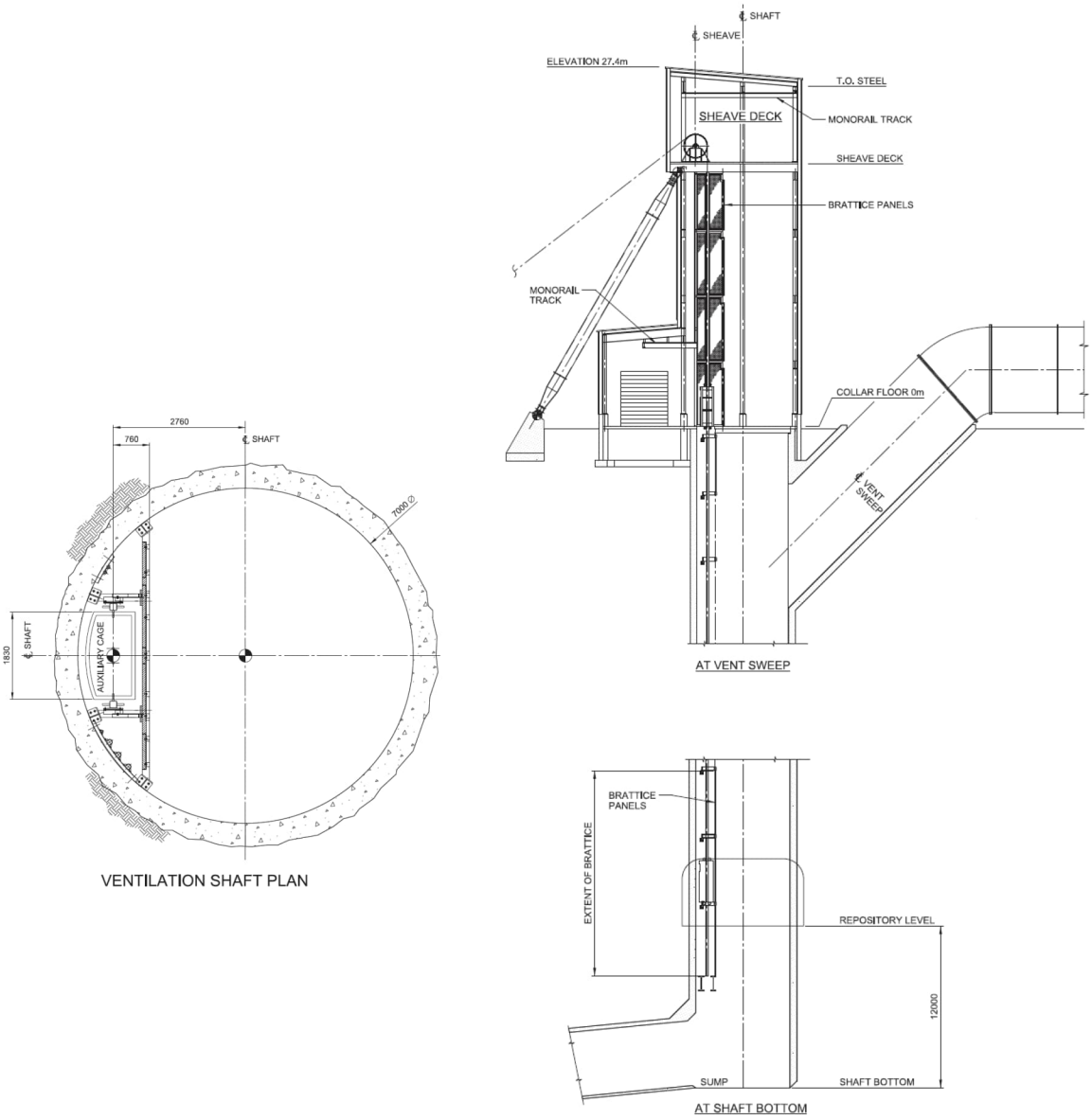


Figure 33: Service Shaft - Shaft and Headframe Section



Shaft Plan **Shaft and Headframe Section**

Figure 34: Exhaust Ventilation Shaft

5. UNDERGROUND FACILITIES

There will be two main components to the underground operations of the DGR: the Services Area and the main repository with placement rooms that will contain the buffer boxes (with UFCs). The Services Area will provide a range of facilities to support the DGR's operations including:

- Underground Demonstration Facility (UDF);
- Refuge station, offices, washrooms;
- Maintenance shop and warehouse;
- Battery charging station;
- Underground equipment / material storage areas;
- Explosives and detonators magazines;
- Main electrical substation; and
- Truck dump equipped with grizzly and rockbreaker.

Twin access tunnels will branch out from the Services Area into the placement area. Within the placement area the placement rooms will be divided into panels that will be located along the repository arms. The placement room length will range approximately between 305 m to 342 m for both the crystalline and sedimentary underground repository concepts.

During the construction period, the Services Area, including the UDF, twin access tunnels that extend into each repository arm and one panel of rooms would be developed. Following the start of operations, excavation of placement rooms would proceed concurrently with placement activities. Sequencing of the development (excavation) and UFC placement activities will provide for adequate separation of these two major activities from a manpower, ventilation and equipment perspective.

The placement rooms will be developed at a single horizon along with the various facilities, and infrastructure. The basic arrangement of the underground repository will involve a series of parallel, dead-end placement rooms, organized into panels. All underground openings will be excavated by drill and blast methods. The placement rooms will have a rectangular shape of nominal dimensions 3.2 m wide by 2.4 m high. There will be room-to-room spacing of 25 m, and an in-room container-to-container spacing of approximately 1.3 m and 1.7 m for the crystalline and sedimentary rock layouts, respectively.

The in-room placement of the Buffer Boxes will involve a two-high stacking arrangement of the boxes. The rows of boxes will be separated by spacer blocks. The buffer boxes will be placed in a retreating arrangement within the placement room with any remaining voids in the rooms backfilled with GFM.

Placement rooms will be arranged in a series of panels that will be located on either side of the twin access tunnels. The panels of placement rooms will be located along repository arms that will extend from the Services Area. Figure 35 and Figure 36 show hypothetical layouts for the underground repository at the crystalline and sedimentary locations, respectively, where both layouts are based on disposal of 5.5 million fuel bundles. The overall repository layouts are adaptive and will be updated as the site investigations work proceeds.

Depending on the geologic conditions encountered, the underground repository will likely cover an area of about 2 km by 3 km (1,500 acres, 600 hectares). The repository in sedimentary rock will have a slightly larger footprint area than the crystalline rock because the sedimentary rock has a lower thermal conductivity. In order to meet maximum thermal design criteria, the spacing between UFCs within each room will be slightly larger which will lead to a slightly larger underground repository footprint in a sedimentary geosphere.

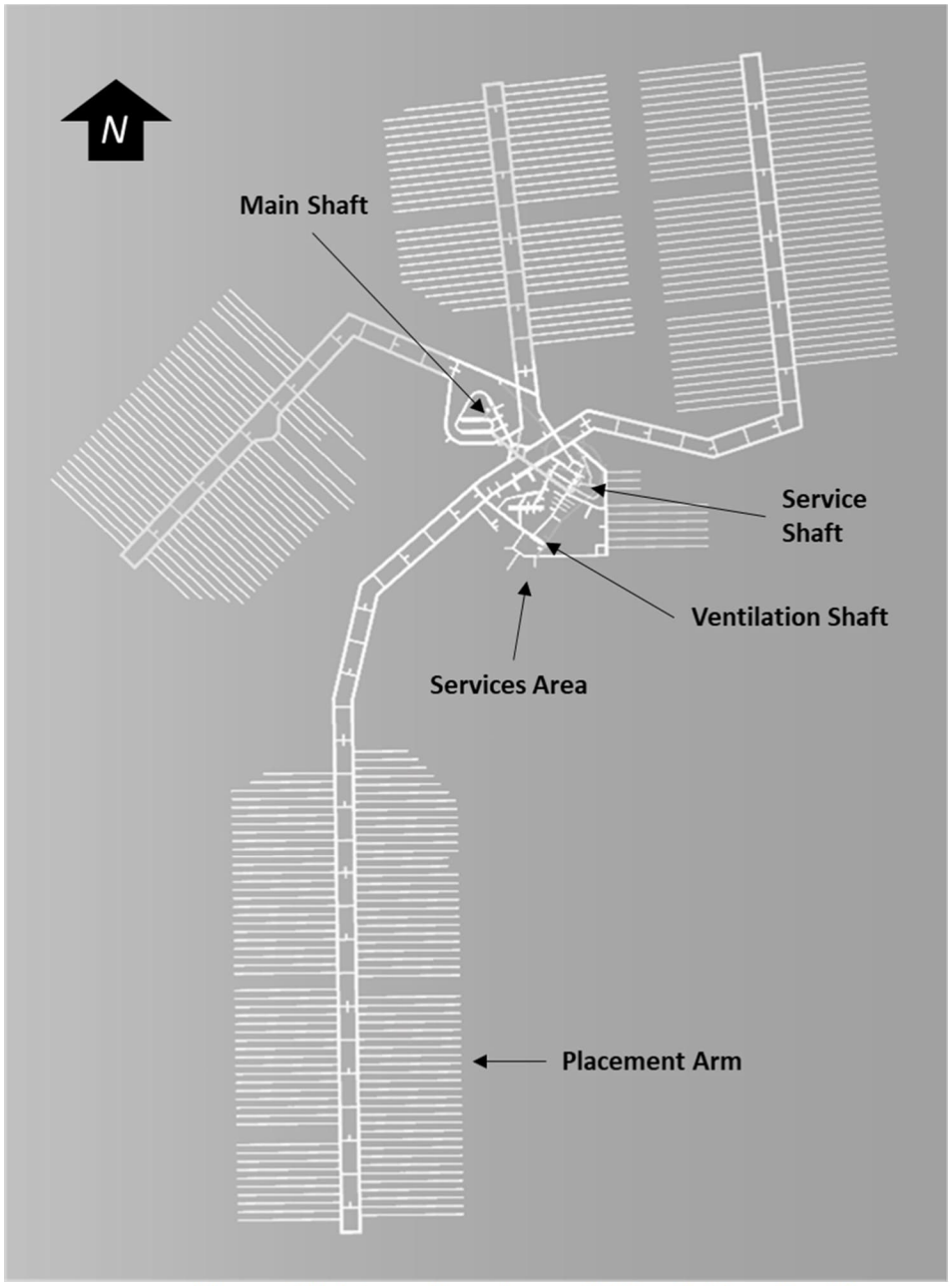


Figure 35: Repository Layout (Crystalline Rock)

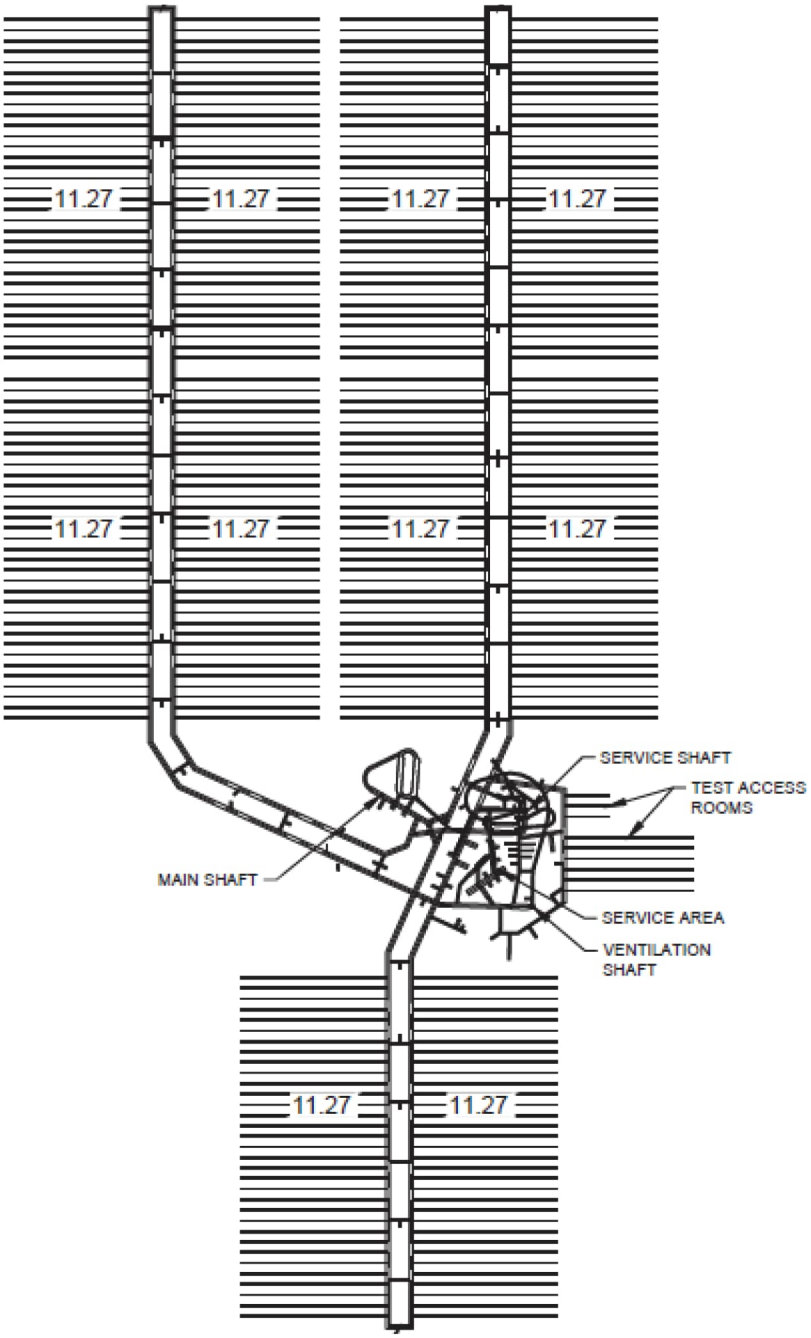


Figure 36: Repository Layout (Sedimentary Rock)

Three primary airways will be used to ventilate the repository. Service Shaft will constitute the dedicated fresh air passage and the Exhaust Ventilation Shaft and Main Shaft will constitute the exhaust air passages with the majority of air exhausting through the Exhaust Ventilation Shaft. A series of surface fans and underground booster fans will be required to achieve the design flow distribution in the underground repository. A surface-based fresh air heating plant will be used to heat air in winter months. Auxiliary fans and ducting will direct airflow into the placement rooms.

These aspects of the underground repository are described in the following sections, following a brief description of the expected geosphere conditions.

5.1 GEOSPHERE

The Ignace area in northwestern Ontario and the South Bruce area in southern Ontario are undergoing site investigations to determine suitability for hosting the DGR. The Ignace area is in a crystalline rock geosphere and the South Bruce area is in a sedimentary rock geosphere.

Site investigations have begun at the Ignace potential repository site and initial site-specific data as well as representative generic properties of crystalline rock are used to prepare a conceptual design for an underground repository at this site. Site investigations are just beginning at the potential repository site in South Bruce. At this stage, without site specific data, the conceptual design of the underground repository for this site is developed using data available from previous work done in the region.

5.1.1 Crystalline Rock Geosphere

Based on information available to date, the crystalline rock at the Ignace area location is expected to have favourable geoscientific characteristics for hosting a DGR. The geosphere is assumed to be an elastic, lithologically relatively homogeneous, and generally sparsely fractured rock. The rock at the depth range currently proposed for the planned repository, between 500 and approximately 800 m below ground surface, is assumed to be of a very good quality with mean permeability for the rock mass that is depth-dependent and ranges between $1x10^{-19}$ m^2 (at 500 m) and $3x10^{-20}$ m^2 (at 800 m), where the rock mass includes intact matrix and some amount of sparse fracturing.

The predominant rock encountered in the subsurface is a medium-grained igneous rock that varies compositionally between granodiorite and tonalite and with biotite as the characteristic mafic mineral, it is therefore identified as ‘biotite granodiorite tonalite’. Between 84 % and 97 % of the total length of recovered core in each of the three deep boreholes completed to date is identified as biotite granodiorite tonalite. The mean intact uniaxial compressive strength of biotite granodiorite tonalite at the Ignace location, based on testing results to date, is 225 MPa. For design purposes, it has been assumed that approximately 10% of the volume of the repository rooms excavated would not be useable for UFC placement due to geotechnical conditions.

Fractures and fracture zones will be present in the rock mass. Fracture zones that are at least 500 m in length are modelled deterministically and represent layout determining features that are used to guide the development of a conceptual layout for the underground repository. Fractures and fracture zones that are less than 500 m in length are modelled stochastically using a geostatistical fracture propagation procedure. These smaller fractures and fracture zones are not considered to be layout determining features.

Water-bearing fractures and/or fracture zones will be present in a crystalline geosphere. If intersected by a placement room, groundwater may flow into the room. The location of placement rooms will be designed with a prescribed off-set distance from the deterministic fracture zones. Detailed site characterization will be used to define the distribution of the stochastic fracture network at the repository scale. During underground construction, investigations will continue with the drilling of pilot holes and probe holes at the excavation face of underground openings to continually refine our understanding of the fracture network at the placement room scale. If water or adverse conditions are identified, this new information will provide an opportunity to redesign or to take mitigating action such are grouting or abandoning a section of the placement room. The assumed likelihood of encountering sub-500 m long water-bearing fractures is why 10% of the room length is allowed for abandonment in the calculations for overall capacity of the underground repository.

5.1.2 Sedimentary Rock Geosphere

The sedimentary rock formation in Southern Ontario is comprised of layers of various types of sedimentary rock. At the South Bruce area location, it is assumed that the repository will be excavated within the Cobourg Formation, an approximately 30 m thick layer of argillaceous limestone located near the top of an approximately 190 m thick layer of good quality, low permeability, limestone. This thick sequence of limestone is overlain by an approximately 200 m thick layer of low permeability shale. Based on existing information from the surrounding region, the argillaceous limestone of the Cobourg Formation is assumed to be elastic, slightly anisotropic, laterally homogeneous, and sparsely fractured. The limestone rock is assumed to be a very good quality rock with a permeability of 10^{-21} m^2 (hydraulic property of the intact rock parallel to layering).

It is assumed that the Cobourg Formation is laterally continuous and homogeneous such that its geological characteristics, e.g., sparsely fractured nature, are transferable over large distances. For design purposes, it has been assumed that approximately 10% of the volume of the repository rooms excavated would not be useable for UFC placement due to geotechnical conditions.

Based on available information, a reasonable value for the mean intact uniaxial compressive strength of the Cobourg Formation, normal to bedding, at the South Bruce location is expected to be about 113 MPa.

Due to the low permeability of the limestone and presence of a thick low permeability shale formation above the host limestone formation it is expected that there will be very little groundwater inflow into the underground repository rock openings. The rock formations closer to ground surface will likely be more permeable.

5.2 UNDERGROUND DEMONSTRATION FACILITY

An Underground Demonstration Facility (UDF) will be constructed at the DGR site during the construction phase. Studies that would be conducted as part of the UDF include verification of geological conditions, demonstration of excavation and construction methods, validation of placement procedures for used fuel containers and sealing materials, long-term studies of engineered barrier materials or processes, and/or monitoring of specially instrumented emplaced containers.

This approach provides site-specific underground information, similar for example to POSIVA's Onkalo facility built at the Finnish repository site at Olkiluoto. It will build on prior knowledge obtained from the AECL Underground Research Laboratory in Pinawa, Manitoba, and from NWMO's participation in other underground facilities around the world in both sedimentary and crystalline rocks (Dixon et al., 2009; Kuzyk and Martino, 2008; Nagra, 2009; SKB, 2013).

The Underground Demonstration Facility (UDF) will be constructed as soon as possible after the Service Shaft reaches the shaft station and rock handling system is installed. The full UDF requirements have been split into two areas: 1) early UDF located between the Service Shaft and the Exhaust Ventilation Shaft and 2) main UDF which will be located to east of the Service Shaft and Exhaust Ventilation Shafts. Work in the early UDF would start when it is safe for the testing and demonstration personnel to enter this area.

The UDF will be constructed:

- To carry-out geoscience verification activities;
- To initiate and perform long-term sub-surface testing, monitoring and demonstration experiments;
- To demonstrate placement and retrieval of empty buffer boxes;
- To demonstrate rock excavation methods; and
- To practice the required safety culture and quality needed for facility construction and operations.

Table 15: Potential Experiments, Monitoring, and Demonstration Activities to be Conducted for Short & Long-term Safety

Programs	Locations	Duration
Rock Mass Characterization		
➢ Geologic mapping of underground excavations ➢ Thermal property measurement ➢ In-situ stress state measurements ➢ Displacement monitoring (at underground openings) ➢ Seismic monitoring ➢ Geophysical monitoring	Shafts, test rooms, and perimeter tunnels	Throughout initial construction (some tests continuing during operations)
Rock Mechanical Experiments		
➢ 3D stress rotation experiment to support 3D modeling ➢ Large-scale rock strength tests ➢ Creep tests to determine the time and thermal dependent behaviour ➢ EDZ experiments around the underground spaces	Test rooms and perimeter tunnels	During tunnel excavations and throughout initial construction and operations

Programs	Locations	Duration
Hydrogeological Experiments		
➢ Straddle packer hydraulic testing of rock mass and fracture zones (if detected) ➢ Hydraulic interference and tracer transport experiments in detected fracture zones ➢ Monitoring of hydraulic pressures ➢ Characterization of EDZ from excavation and mining demonstration/optimization (see below)	Boreholes from test rooms and perimeter tunnels	Throughout initial construction and operation
Geochemistry Experiments		
➢ Long-term diffusion ➢ Radionuclide retention ➢ Microbial ➢ Monitoring of groundwater chemistry ➢ Matrix pore waters geochemistry	Boreholes from test rooms and perimeter tunnels	Several years throughout initial construction and operation
Excavation and Mining Engineering		
➢ Optimization of drill and blast techniques to minimize EDZ ➢ Optimal geometry / layout of placement rooms ➢ Long-term rock support performance ➢ Bulkhead Performance (including LHHP concrete interaction with bentonite bulkhead seal) ➢ Floor and wall smoothing experiments ➢ Grouting experiments	Test rooms	Emphasis during first years of initial construction
Demonstration of Placement and Retrieval Equipment		
➢ Radiation shielding and bentonite sealing systems ➢ UFC / buffer box placement trial ➢ UFC / buffer box retrieval demonstration	Test rooms	Throughout initial construction and operation
Long-term Partial and Full-Scale Demonstrations		
➢ Instrumentation and monitoring equipment ➢ Long-term degradation studies of sealing materials such as clays, clay mixtures, concretes and cements ➢ Long-term corrosion studies of container materials ➢ Performance of heated (empty) UFCs, bentonite sealing systems and near-field rock and groundwater ➢ Placement and long-term assessment of UFCs ➢ Retrieval of UFCs / buffer boxes with dedicated equipment ➢ Shaft, tunnel and room seals performance	Test rooms	Throughout initial construction and operation

A rigorous verification and demonstration program would be carried out with possible areas of investigation listed in Table 15. After an overview description of the UDF, there is a further elaboration of selected programs in the following sections.

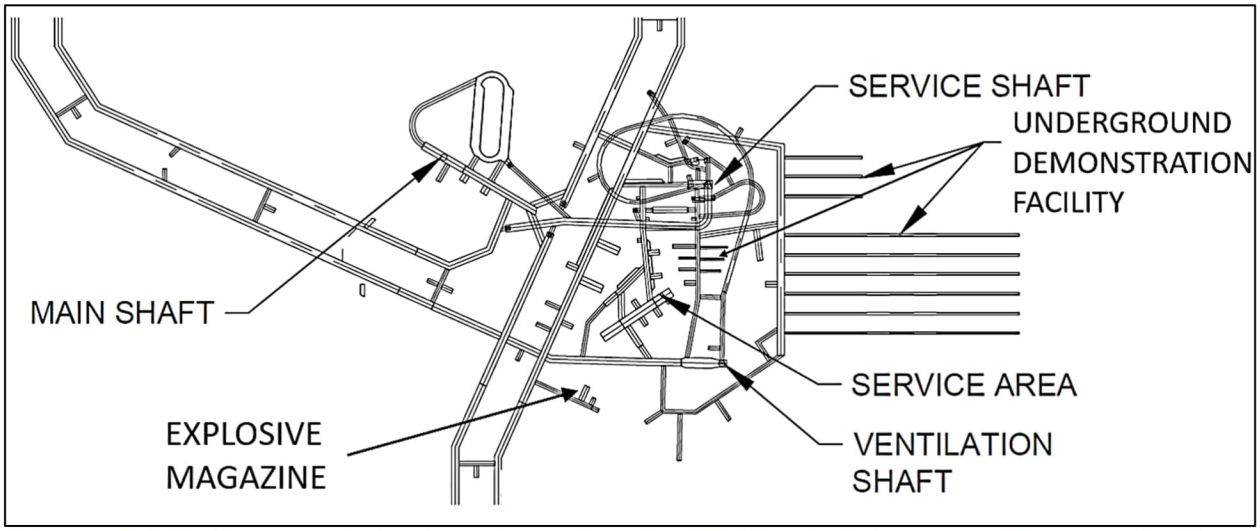


Figure 37: Underground Services Area showing Shaft and Underground Demonstration Facility locations

5.2.1 UDF Location and Configuration

The UDF will be designed to integrate with the overall underground repository but will be located to be separate from the repository placement rooms. This will ensure that facilities common to both the UDF and the repository are centrally located to both operations.

The UDF would be situated close to the Service Shaft and Ventilation Shaft Complexes as shown in Figure 37. The personnel offices and associated facilities will be located nearby. This area will be connected to the Shaft Complexes and other facilities through the access tunnels.

The proximity to the shafts will minimize the initial development required to place the UDF into operation. It will also minimize travel times and materials handling coordination during the initial room development. The technical staff involved in the experiments and demonstration work will have access to underground offices and specialized storage and repair facilities. These facilities will allow technical staff to undertake their support work close to where testing and demonstration work is being performed, thus reducing time in travel to and from the surface.

To simulate operating conditions as closely as possible, the test rooms would be designed and arranged so that their cross-sectional geometry and spacing are identical to that of the repository placement rooms.

The test room lengths would be designed to provide sufficient lateral area to allow setup of preliminary placement systems and their testing, and to accommodate any potential modifications as may be required while testing prototype equipment. In addition, the test room lengths are envisaged to incorporate sufficient space to allow for a production style operation of the finalized placement equipment configurations. This will ensure that the equipment systems can be successfully transferred from test to actual production conditions while also providing training to initial DGR crews in a near production mode environment.

5.2.2 UDF Life and Expandability

The UDF would be constructed during construction phase and would operate on a stand-alone basis for about 5 years prior to start of operations. The UDF would be developed to create a location to perform geotechnical and geoscience verification activities and to pre-test key aspects of the underground construction and operations. The UDF could continue to operate over the complete life of the repository, to demonstrate, monitor and confirm simulated UFC placement results and provide feedback on the effectiveness of the design approaches.

The underground repository's operational life is forecasted to be about 46 years, which translates into a 51-year life for the UDF. The additional 5 years, prior to start of operations, allows for test room development and the evaluation of various operational aspects of the underground works before UFC placement activities. It is possible that the UDF may operate longer than 51 years if it continues to operate in the extended monitoring period following the end of UFC placement activities.

5.2.3 Geoscience Verification Activities

Geoscience verification activities will be carried out in the UDF and at other locations in the underground repository for the purpose of verifying assumptions and geoscience data used in the safety case. In particular, data will be gathered to confirm that the host rock formation will be able to contain and isolate the used fuel. The results of these geoscience activities, among others, may be used in addressing any related licensing requirements during construction of the repository, and will be used to support the application for an operating licence.

Geoscience verification would also include investigations and monitoring activities to verify assumptions and geotechnical data used in the design of various underground openings. The data could be used to further optimize the design of various underground openings.

Geoscience verification activities at the repository level would begin upon completion of the Service Shaft and when a second egress is available. The characterization work will be performed in the area near the Main and Service Shafts and then progress into the UDF area. Characterization work would continue into the operations phase in various tunnels and placement rooms.

The data related to the baseline in-situ parameters such as rock strength, stress, temperature and permeability will require collection at an early stage of repository development to assess changes, if any, brought about by excavation activities. Measurement and the collection of representative samples for testing would, in part, be carried out through cored boreholes. Restriction on borehole location and orientation would be in place to mitigate the possibility of creating sub-surface pathways for groundwater and solute migration.

The excavation of the test rooms and the subsequent demonstration of placement and retrieval activities will impact the behaviour of the rock. Rock behaviour will be assessed by visual observation, physical measurement and geophysical techniques. For example, pre-installed stress cells, extensometers and inclinometers could be used to measure response of rock to excavation of test rooms. These same techniques could also be used to measure rock behaviour during access tunnel and placement room excavations and various other demonstration activities in the test rooms. Geophysical techniques such as seismic tomography and ground penetrating

radar could be employed to observe changes in properties inside the rock mass. Micro-seismic monitoring can also be used to assess the energy imparted by the various excavation techniques.

5.2.4 Long-term Testing, Monitoring and Demonstration Activities

Several long-term testing, monitoring and demonstration activities would be initiated during initial construction, and continue into the operations phase, with some monitoring expected to continue during the extended monitoring and closure phase.

Examples of long-term testing activities are, also identified in Table 15, are:

- Long-term diffusion experiments;
- Radionuclide retention experiments; and
- Seal materials compatibility tests.

Examples of long-term monitoring activities are listed below. These would include periodically checking of the physical conditions in the host rock and changes to those conditions, including:

- In-situ stress fields in the rock mass, and changes caused by excavation and heating;
- Groundwater pressure and chemistry, and changes caused by excavation and heating;
- Initiation, propagation and dilation of fractures, deformation or displacement of rock around openings, and changes in EDZ; and
- Rock temperature, and changes caused by excavation, ventilation and heating.

Examples of long-term demonstrations that could be conducted within the UDF or other niche areas:

- In-situ performance of heated (empty) UFCs and bentonite sealing systems;
- Placement and long-term assessment of active UFCs; and
- Performance of shaft and tunnel seals.

5.2.5 Demonstration of Placement and Retrieval of Used Fuel Containers

The UDF will provide an area prior to the start of operations for demonstration of various aspects of the eventual underground repository. The UDF will also be used for training operating personnel with mock-ups and actual equipment in a realistic environment. Some training areas could be employed to show visitors the operations of the underground works. Such interactions could be performed with little or no direct impact on the main repository's operation.

The UDF will also be used to test all aspects of the equipment and associated methodologies for UFC placement and retrieval. The evaluation work will be performed in a number of test rooms with each component of the placement or retrieval cycle undertaken in a location or room dedicated to that particular aspect of future activity.

The main aspects of placement room construction and operations to be tested, demonstrated, evaluated and refined would include:

- Placement room floor and wall leveling/smoothing, to reduce the need for fill materials;
- Buffer box and spacer block installations and stacking;
- Gap Fill Material (GFM) Backfill placements for room sealing;

- Use of remote-controlled equipment for various placement and backfilling operations;
- Construction of room seal and concrete bulkhead for room entrance sealing;
- Management of unsuitable volumes within a placement room and access tunnels due to fractures; and
- Retrieval demonstration.

Two rooms will be developed at the far end of the UDF for emplacement and monitoring tests. One room will have empty buffer boxes (without actual UFCs) to simulate buffer box installations. The second room will accommodate the placement of the buffer boxes with heaters that will simulate heat loading from used fuel inside UFCs (within buffer boxes). Data in the surrounding buffer and rock will be used to calibrate models that calculate the temperature, saturation and pressure conditions in the used fuel-filled underground repository. These two rooms will be isolated from the other test rooms to eliminate the possibility of any heating effect on local ground conditions and interfering with ongoing training or equipment testing being performed in the other rooms. Rooms will also be provided to demonstrate buffer installation in the placement rooms (HCB spacer blocks and GFM).

For these and other operational components, a demonstration room set-up will be established, and associated equipment installed. Following initial testing and monitoring in surface mock-ups settings, the operational components will be refined and improved with final testing carried out underground.

Testing will also focus on the potential automation and monitoring systems required for the underground operations. Test rooms will be provided with the same data, communication and automation support infrastructure that would be installed throughout the DGR facility.

Long-term performance demonstrations of UFC / buffer box, buffer, GFM backfill, sealing material(s) and geosphere over the period of operation of the DGR will be carried out. Tests will include dedicated demonstration rooms for monitoring the performance of both heated non-radioactive UFCs and UFCs containing fuel bundles. A component of this work will also examine the recovery of the buffer and backfill materials for geotechnical analysis, as well as the removal of the UFC / buffer box for corrosion assessments.

Placement methods for the UFC / buffer box will be assessed as well as the extraction/removal operations. UFC retrieval method will eventually be refined and perfected to encompass the removal of the concrete bulkhead, as well as the fully saturated sealing materials.

5.2.6 Demonstration of Excavation Methods

The test room excavation work will provide an opportunity to demonstrate and refine drilling and blasting techniques intended for the placement rooms. Grouting and other measures that are to be used to seal small local fractures will also be tested. In order to minimize potential pathways for groundwater movement after closure and to reduce the use of ground support in the placement rooms and tunnels, the blasting damage in the rock surrounding the created openings needs to be minimized and possible tolerances accordingly managed. This Excavation Damage Zone (EDZ) can be controlled through the use of careful excavation techniques. Detailed mapping of the rock after excavation, and correlation of the EDZ thickness to the blast-hole pattern and blasting techniques will ensure that the methods adopted meet all requirements. Excavation

methodologies for the various underground openings can, therefore, be optimized. Demonstration of quality requirements associated with excavation work will also be tested and optimized.

With respect to ground support, there are a number of options available depending on the rock conditions encountered. The UDF will allow testing of a variety of systems to optimize the approaches used for the different opening sizes and configurations. Where automated installation equipment (e.g., remote controlled rigs to install rock bolts) is deemed appropriate for quality control, such equipment would be tested and modified to meet the requirements of the DGR. If required, suitable experiments will be performed to demonstrate the process associated with removal of ground supports.

5.3 UNDERGROUND REPOSITORY LAYOUT

Conceptual layouts for the repository are illustrated in Figure 35 and Figure 36, for the crystalline and sedimentary rock geospheres, respectively. These layouts will change and be updated based on new information that is gathered from site investigations at the Ignace and South Bruce areas.

The operation of the DGR requires concurrent development, preparation, and placement of UFCs in the placement rooms. Separation of development (excavation) activities and Buffer Box / UFC placement activities will be achieved by ensuring that these activities occur in different repository arms. In the repository arm where UFC placement activities are occurring, non-nuclear equipment traffic and UFC delivery equipment traffic will follow dedicated and separate travel routes in twin access tunnels. In general, the excavation-related equipment and equipment carrying various non-nuclear materials (e.g., sealing materials and concrete) will travel in one access tunnel and the equipment carrying the UFCs will travel in the other access tunnel.

Placement room lengths are about 305 m in crystalline rock and 342 m in sedimentary rock geospheres which will reasonably accommodate development work by limiting ventilation ducting runs to practical lengths. These room lengths also allow the repository to be divided into a series of stand-alone panels with some flexibility in their location to avoid poor geosphere conditions, if encountered. As panel placement activities are completed, each placement room will be permanently sealed off with a room seal and concrete bulkhead.

The various components of the repository layout (access tunnels, services, placement rooms) are described in the following sections.

5.4 TUNNEL EXCAVATION PROFILES

The excavation profiles for the various tunnels and the ventilation raises have been based on equipment sizing and ventilation requirements.

Access Tunnels

Access tunnels will be developed with dimensions of 9 m wide by 4 m high (Figure 38). The width is determined to allow for the placement room entrance canopy and the forklift turning and positioning at the shield canopy.

As the access tunnels are developed, the main services will be installed including compressed air lines, waterlines, drain lines, power cables and ventilation ducting. After tunnel development has been completed the concrete floor will be established. The concrete floor will provide a smooth driving surface for buffer box handling equipment and will simplify any clean-up operations required. Lighting will be provided for the full length of operating access tunnels to improve visibility and safety.

These tunnels will also accommodate foot traffic without requiring safety bays for people. However, personnel on foot could stand in placement room entrances along the panel access tunnels to avoid passing mining equipment traffic during development, if necessary.

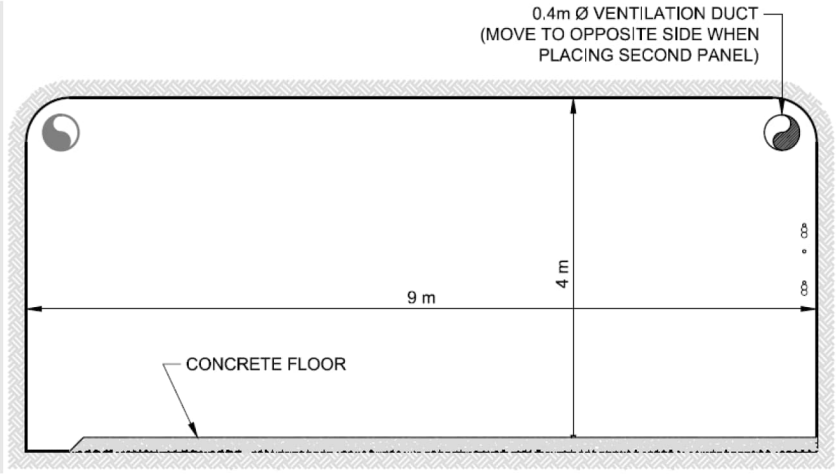


Figure 38: Access Tunnel Cross-Section

Ramps and Crosscuts

Ramps will be required in the Services Area to access the Fresh Air Transfer Level, and the Service and Exhaust Ventilation Shaft bottoms. Crosscuts will be excavated between the twin panel access tunnels about every 125 m. The crosscuts will be required to establish ventilation circuits in each placement room arm and to avoid the use of ducting to deliver ventilation air. The crosscuts will facilitate the separation of nuclear and non-nuclear traffic flow by allowing equipment to move between access tunnels. Crosscuts will allow personnel to move between access tunnels and to select the safest exit route during an emergency event. The crosscuts will be used to house electrical substations, refugee stations and drainage collection sumps.

The access ramps and crosscuts will be 5 m wide by 5 m high and are sized to fit the selected development equipment (Figure 39).



Figure 39: Ramps and Crosscuts Cross-Section

Fresh Air Transfer Level

The Fresh Air Transfer Level will be developed for distributing the intake air to each of the ventilation circuits without the need for ducting and airflow crossovers. The size of the tunnel is based on the planned airflow velocity at maximum rates (i.e., 6 m/s) to reduce the resistance factors and to ensure minimal entrainment of dust in the air. The fresh air delivery tunnels will be 9.0 m wide by 4.0 m high.

Ventilation Fresh and Return Air Raises

The fresh and return air raise sizes are based on the airflow velocity with the size for all based on the largest circular size of approximately 4.0 m diameter to allow common use of the excavation equipment. Raise boring could be the excavation methodology selected for these raises.

5.5 SUPPORT SERVICES AND INSTALLATIONS

Services and installations to support development of the underground repository, UDF and operations will be installed in their permanent configuration during the initial construction of the underground repository.

5.5.1 Support Services

The main support (utility) services to be provided for the underground operations are discussed below.

Electrical Distribution

Plant main 13.8 kV switchgear will supply power to underground infrastructure. One pair of 13.8 kV cables will be routed in the service shaft and another pair will be routed in the exhaust ventilation shaft. These two sets of 13.8 kV cables will distribute power to underground electrical

substations. The complete load can be carried by one pair of cables, providing 100% redundancy in capacity and alternate location. Electrical substations will step-down 13.8 kV to required 4.16 kV and 600V to feed relevant loads. The 600/208-120 V distribution transformers will provide power to miscellaneous loads including lighting and auxiliary power requirements.

Facility main 13.8 kV switchgear will supply power to different surface areas through a 13.8 kV power line. Each area equipped with 13.8/4.16 step-down transformer to feed 4.16 kV loads, 4.16/0.6 kV power distribution transformer to feed 600V loads, and 600/208-120 V distribution transformers to feed miscellaneous loads including lighting and auxiliary power requirement.

Compressed Air

Compressed air will be supplied by 3 compressors located on surface. One compressor will always be on standby while the other(s) are operating. This main supply line will be located in the Service Shaft and will connect to the underground distribution system piping. A back-up line will be in the Exhaust Ventilation Shaft.

Service and Potable Water

Underground service water will be required during both the construction and operation phases for mining equipment, dust suppression and various other services. Total annual underground service water requirements will be up to 47.3 million litres as noted in Section 3.10 during operations.

Underground potable water demand may be as high as 4 m^3/day during both the construction and operation phases.

Service water will be sent underground in a pipe with a nominal diameter in the range of 80 to 200 mm pipe depending on quantity of service water to be delivered. The pipe will be located in the Service Shaft along with an equivalent redundant line in the Ventilation Shaft. These pipes will feed the distribution lines underground. Potable water will be sourced at the surface-based water treatment plant and delivered underground via pipe. Potable water will be supplied to all lunchrooms/refuge stations and washrooms via a separate underground potable water distribution system. Bottled water may also be used for the supply of drinking water.

Used service water will be collected in sumps and pumped to surface settling ponds as noted below.

Mine Dewatering

Used service water and potable water, as well as, any underground water inflows will be collected and ultimately be sent to the main sump where the water will be pumped to surface. All water pumped to surface will be cleaned of particulate matter in the surface-based mine dewatering settling pond before discharge to a receiving water body.

The main sump will be located in the Service Area and additional sumps will be located as needed in the main repository footprint. Pumps placed in the sumps and dewatering lines will direct water to the main sump, for settling, recirculation and/or discharge from the mine. All sumps would be periodically cleaned to remove settled sediments.

Mine Communications and Controls System

A communications and data network will provide voice communications, Programmable Logic Control (PLC) monitoring and control, data collection and dissemination via an underground computer LAN and video. A fibre optic cable backbone and wireless data and voice system will provide all applications required to operate the mine and undertake data handling and transmission to the surface.

5.5.2 Primary Support Facilities

The key primary facilities that will be needed to support development and operation of the underground repository are discussed below. Additional support facilities not discussed below will also be in place (e.g., Buffer Box / UFC temporary storage area, parking areas, etc.).

Mobile Equipment Shop

A shop will be in place to perform all maintenance on the mobile equipment such as mining equipment, service vehicles and personnel carriers. This shop will be located relatively close to the Exhaust Ventilation Shaft and will have a main shop area for working on larger equipment and satellite bays to service smaller equipment. It will also incorporate a wash bay, welding shop, parts storage warehouse, electrical room, lunchroom and a supervisors' office. All workstations will be connected to the communication system. Details of the proposed maintenance shop arrangement are presented in Figure 40.

The main shop area will be approximately 50 m long, 12 m wide and 10 m high. Overhead bridge cranes and an overhead monorail crane will be in place to support the maintenance activities.

Lube Bay

A lube bay will be constructed near the mobile equipment shop. It will be provided with a fire-resistant roll-up door at the open end to separate the lube bay from other working areas in an event of a fire. The lube bay will house three high-density polyethylene (HDPE) lube tanks.

Charging Stations

Space has been allocated for parking and battery charging along the mobile equipment shop access tunnel and in the Services Area associated with unit parking. In addition, there is provision of a parking and charging station in the Main Shaft Station for the UFC/Buffer Box transfer cask tow vehicle. The battery-powered emplacement vehicles to be used in the placement rooms will have their batteries recharged at the placement room entrance area.

It is assumed that all equipment will be battery-powered both during construction and operations phases. Thus, there would not be a need for an underground diesel fueling station. Should a future decision be made to operate some diesel-powered equipment the diesel fuel would be supplied at a station located near the mobile equipment shop.

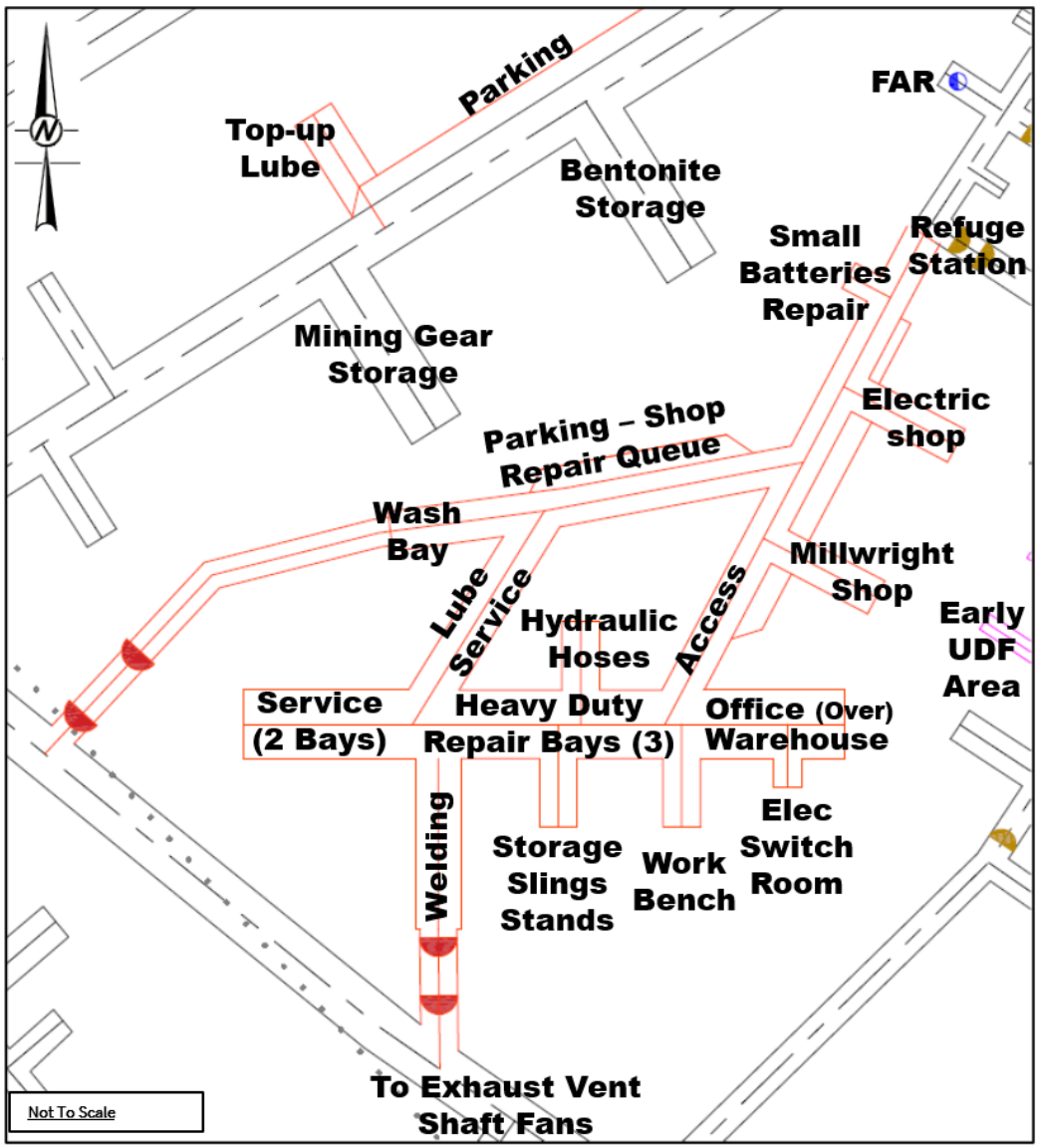


Figure 40: Maintenance Shop

Explosives Magazine

An explosives magazine will be located away from the Services Area and the panels of placement rooms, as shown in Figure 37, following best practice. However, it will be readily accessible for mobile explosives loading trucks. The magazine will be fitted with shelving for bulk explosives bags and stick powder and equipped with a wall mounted jib crane.

Detonator Magazine

The detonator magazine will be located nearby to the explosives magazine but separated by a distance of at least 8 m. It will be equipped with shelving for the stacking of detonator boxes.

Materials Handling and Storage Areas

A storage area for mining consumables including pipes and fittings, ground support materials, ventilation supplies, etc. will be developed along the Services Area east access tunnel. With a 20 m length, 7 m width and 5 m height, the area will include shelving and racking to safely store mining consumables.

A storage area will be developed along the Services Area east access tunnel for bentonite materials. Rubber-tired vehicles will transport bulk shipments from the Service Shaft to this temporary storage area.

Rock Dump and Rock Breaker

Excavated rock will be delivered to the rock dump by haul trucks. Prior to delivery this rock will be sent down to the loading pocket near the base of the Service Shaft, where it will be reduced in size, as required, by the rock breaker. Broken rock will be loaded into a skip at the loading pocket for delivery to surface and, ultimately, to the excavated rock management area.

5.5.3 Ancillary Support Facilities

The Services Area will include ancillary facilities for technical staff. Such facilities will include offices, specialized equipment repair areas, washrooms and combination refuge stations or lunchrooms (where, in the event of a fire or other emergency, personnel would gather for safety). A tunnel near the Main Shaft will provide access to most of these facilities.

Offices/Lunchroom

The offices, with lunchroom area, is a dedicated facility for this purpose. Offices will be provided with a computer network connection to the DGR-facility-wide data and control network.

Refuge Station

A large permanent refuge station will be established in the Services Area and will only be used as safe refuge for workers and visitors in the event of an emergency (i.e., will not used as a lunchroom or for office space). The station will be located between two access tunnels which will allow access at either end of the station. The station will have 2 concrete walls with steel doors in the wall at each entrance to the refuge station. They will include a main area for personnel, and an operations supervisor's office at the back end of the station. The refuge station will be equipped with safety and rescue equipment such as a fire extinguisher, eyewash station, first aid kit, emergency food and drink rations and stretchers. The refuge station will provide a location that can be sealed and will be supplied with fresh air via the compressed air system. The piping network supplying breathing air to the refuge station will be designed to be in pressurized state (always ready to use) although breathing air will only be required during emergencies. All breathing air supplied to a refuge station will pass through an air purifier unit, which will be located underground inside the refuge station.

Portable Refuge Stations

A portable refuge station will be placed underground in each arm of the repository within crosscuts that connect the twin access tunnels in each arm. These portable refuge stations will provide

refuge to workers and visitors during an abnormal event when safe passage to the permanent refuge station in Services Area is not possible. Each of the portable refuge stations will contain bottled compressed air for emergency breathing air. Alternatively, the portable refuge stations could use a Refuge One Air Centre (e.g., oxygen generator) to supply breathing air. The portable refuge station will also have a stock of bottled drinking water for the occupants.

Washrooms

Underground toilets (portable mining toilets) will be provided near the offices and refuge station. Wastewater from the washrooms will initially be held in local holding tanks. These tanks would be pumped out on an as-required basis to a larger transport tank for transmission to the surface for treatment. During the subsequent development of the underground repository, additional portable toilets will be provided, as needed, near working areas.

Instrumentation Shop

An underground instrumentation shop will be provided across from the offices to store and repair specialized equipment used in testing activities. The shop will be approximately 30 m long by 5 m wide and 4 m high. It will be equipped with work benches, shelving and repair and calibration tools. Other storage areas for specialized tools and parts used in the UDF testing rooms will be developed near the aforementioned rooms.

Special Equipment Storage

The special equipment storage area will be used for the storage of special equipment to be used for either testing or monitoring in the UDF or elsewhere in the underground repository. The area would have climate control to protect the equipment while in storage.

Temporary UFC/Buffer Box Transfer Cask Storage

There are two rooms that will be used for the temporary storage of transfer casks. If a placement room is not ready to receive a transfer cask with buffer box, then the cask could be taken to these areas for temporary storage. Similarly, empty transfer casks could be stored in one of these rooms while awaiting delivery back to surface via the Main Shaft.

5.6 PLACEMENT ROOMS

Each placement room will be dead ended. A nominal rectangular room section geometry has been adopted with a vertical height of approximately 2.4 m and a room width of 3.2 m. This is illustrated on Figure 41 and Figure 42 which shows a placed buffer box (with UFC) as well as the clay-based sealing components in crystalline and sedimentary geospheres respectively.

5.6.1 Placement Room Arrangements

Within the placement rooms, the buffer boxes will be stacked two high, separated by HCB spacer blocks (the approximate thickness of 0.3 m for crystalline and 0.7 m for sedimentary). GFM would be used to fill any remaining voids after placement. Following the completion of buffer box

placement within a particular room, it will be sealed with additional bentonite and a concrete bulkhead (plug).

The placement density of the buffer boxes (with UFCs) is designed to minimize the areal extent of the DGR, while satisfying established design parameters including heat dissipation and structural integrity. The actual configuration will be a function of the characteristics of the rock mass, and particularly the accommodation of any structural discontinuities or other geological features that may be encountered during development.

Placement room lengths will be based on the assumption that 10% of the buffer box positions will be rejected. Rejection will be due to unacceptable groundwater seepage ingress or other unsuitable rock conditions encountered in the placement room. As approximately 10 buffer boxes will be placed per day, at least 3 placement rooms will be required to be available for placement activities.

Prior to the buffer box placements, the full length of the placement room will be prepared by first placing a smooth levelling layer consisting of granular material that will be topped with a thin layer of concrete. 150-mm-thick bentonite floor tablets will then be placed on the levelling layer on which the Buffer Boxes will be stacked.

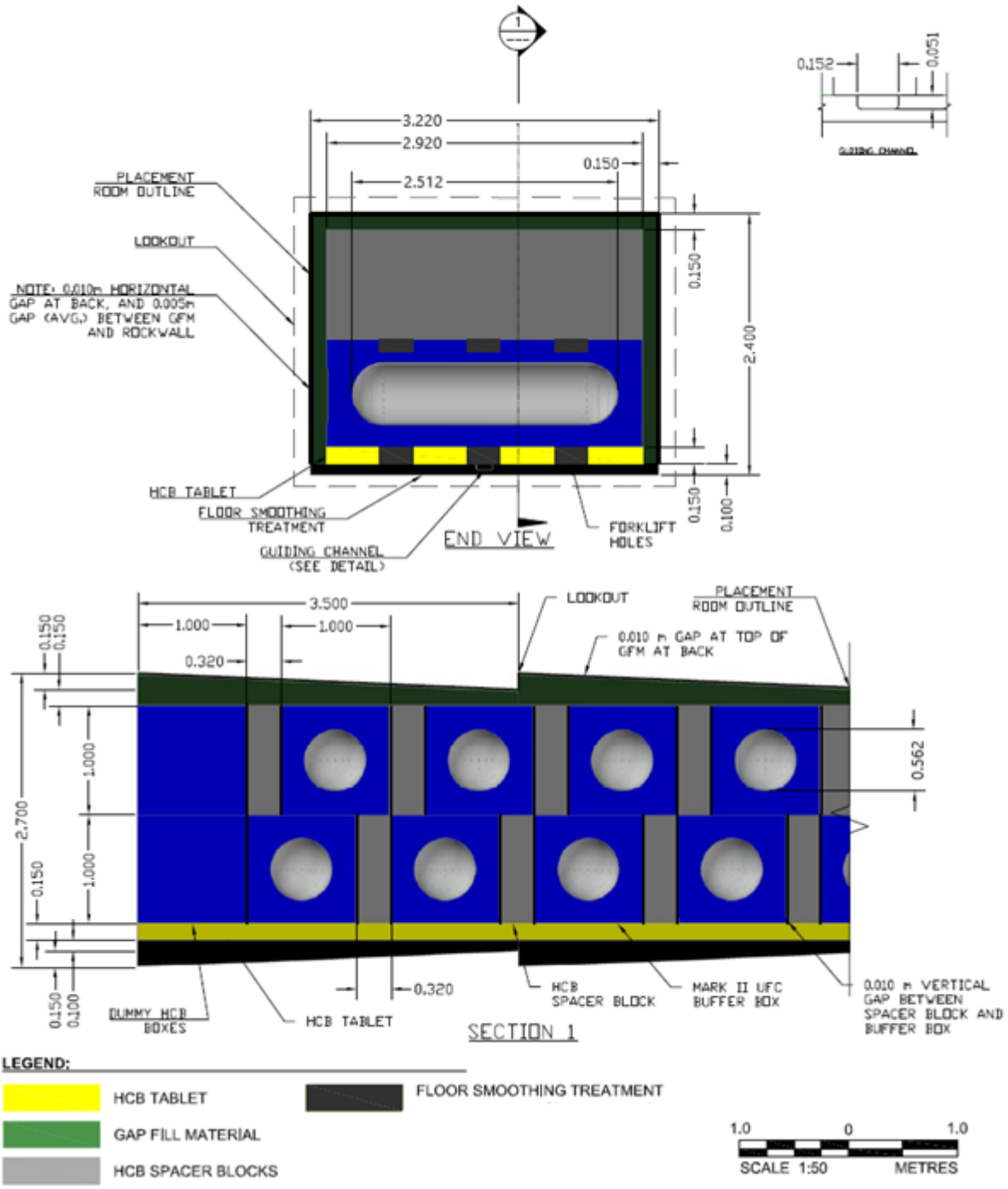


Figure 41: APM Placement Room Cross-Section View (Crystalline Geosphere)

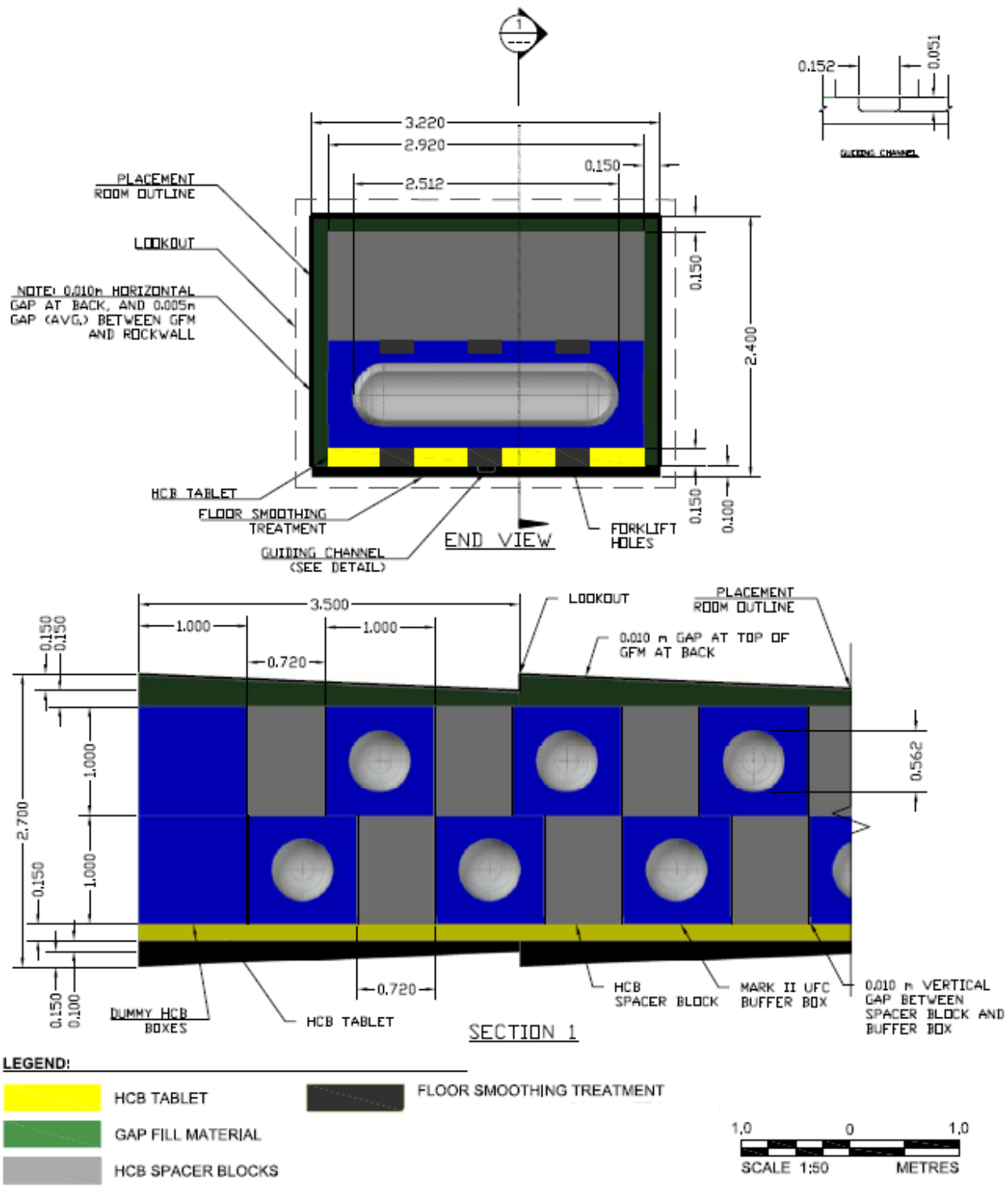


Figure 42: APM Placement Room Cross-Section View (Sedimentary Geosphere)

5.6.2 Placement Room Geometry

A nominally rectangular room cross-section will be adopted to minimize the amount of bentonite GFM required to fill the void space surrounding the stack of buffer boxes. A room cross-sectional dimension of 3.2 m wide by 2.4 m high was chosen which will allow buffer boxes to be stacked two high (see Figure 41 and Figure 42). This room geometry will be sufficiently large to permit access for the mining equipment and the buffer box placement equipment.

The repository host geosphere is expected to comprise a good quality rock with high strength and moderate in-situ stresses. The axis of the placement room will be oriented parallel, as far as practical, to the major principal stress orientation. This configuration will minimize stress concentrations about the perimeter of the placement room.

When designing the placement room geometry and the general arrangement of the placement rooms, possible rock loadings due to glaciation and/or a large earthquake event will be considered.

5.6.3 Buffer Box and Placement Room Spacing

Heat will be generated by the UFCs. Such heat and the resulting elevated thermal regime must be evaluated with respect to the requirement that temperature on UFC surfaces must below 100°C at all times. The surface temperature of the used fuel container must be maintained below 100°C to ensure that the properties of the surrounding bentonite and the copper are not adversely affected. At elevated temperatures (~140°C), the bentonite begins to convert to illite, a non-swelling clay. These physical changes are irreversible and leads to uncertainty for the long-term performance of the placement room. At temperatures above 125°C the electrochemical behaviour of the copper changes and more rapid corrosion may be possible.

To ensure temperature will not exceed 100°C on surface of UFCs, the center-to-center spacing of the buffer boxes will be set at approximately 1.3 m for crystalline rock or 1.7 m for sedimentary rock. In addition, the center-to-center spacing of placement rooms will be set at 25 m for both crystalline and sedimentary rock geospheres.

5.6.4 Above Ground Emplacement Demonstration

An above ground demonstration in a simulated emplacement room (mock-up) will be performed in 2022 to demonstrate specific unique technologies associated with the in-room emplacement. The mock-up full-scale emplacement room structure is metal framed with faux rock panels to simulate the drill and blast profile that could be expected in the underground, as shown in Figure 44.

The demonstration trial will integrate all the bentonite technology development into one complete demonstration. The first-of-a-kind technologies that will be demonstrated during this trial include:

- HCB consolidation from bentonite powder;
- Gap fill production from bentonite powder;
- Highly compacted bentonite block shaping;
- Temporary storage of the bentonite block after shaping;
- Assembly of the Buffer Boxes with completed HCB blocks using vacuum lifts;

- Emplacement of Buffer Box with semi-autonomous emplacement equipment (Figure 43);
- Gap fill emplacement with Auger system; and
- 3D scanning of the emplacement room before and after emplacement to confirm placed density.

Upon completion of the trial, the mock-up emplacement room will be inspected to quantitatively and qualitatively assess the achieved result. The demonstration trial will be an operational demonstration to gain confidence in the prototype technology development.



Figure 43: Prototype Buffer Box Emplacement Equipment



Figure 44: Prototype Emplacement Equipment entering the Mock-up Full-scale Emplacement Room

5.7 DEVELOPMENT OF UNDERGROUND REPOSITORY

5.7.1 Drill and Blast Excavation

Drill and blast method will be selected for excavating underground openings because this method can easily be adapted to a range of rock conditions and customized tunnel shapes. The blasting designs can be readily accommodated to meet particular requirements. Further, the technology is mature and efficient. All drill and blast underground excavations will be undertaken using rubber-tired mining equipment.

Blasting operations will include drilling holes in a converging pattern, placing an explosive and detonator in each hole, detonating the charge, and removing or excavating the excavated rock. The blasthole patterns will be selected to minimize the quantity of explosive detonated per volume of rock broken. Blastholes will be typically detonated in sequence from the center of the excavation outwards with each detonation creating an open face for the next volume of rock to break towards.

Between the blasting cycles, fumes will be vented, scaling will be undertaken to remove loose rock, ground support will be installed as required, and the next round of blasting will be surveyed. Typical standard drill and blast practices result in a rate of advance in the range of 5 m to 15 m per day based on one crew working multiple headings.

All underground excavations will be excavated by using controlled drilling and blasting techniques. Conventional drilling and blasting in normal mining environments inherently create a damaged zone in proximity to the opening. A controlled drill and blast method will be used to minimize the EDZ and thus, the zone of potentially enhanced permeability at the perimeter of the underground openings. Under a controlled drill and blast approach, a closely spaced series of perimeter holes will be established around all sides of the opening. Computer-assisted drill jumbos will be used to ensure accuracy of perimeter drill hole locations. The perimeter drill holes will be loaded with decoupled low impact explosives and these holes will be blasted last. The blasting of these holes will also be timed to ensure that ground movement is minimized in the walls and that minimum energy transfers from the main development round and perimeter hole blasting to the surrounding wall. Electronic blast initiators can also be utilized to provide maximum accuracy in blasthole initiation.

5.7.2 Rock Support Requirements

It is assumed that there will be good quality rock in both the crystalline and sedimentary rock geospheres. Thus, it is expected that no rock support will be required in small rock openings (i.e., spans less than 5 m). However, to meet health and safety requirements, an appropriate rock support system will be installed in the Services Area openings and access tunnels, as these are permanent working areas. In zones of poorer rock conditions, additional rock support will be applied as required.

After the broken rock will be removed from the various openings in the Service Area and the various tunnels, a scissor-bolter-screener unit would be used to install ground support. The roof and walls will be first secured with rock bolts and later with fibre-reinforced shotcrete. For the access tunnels with a 9 m span, it is assumed systematic bolting will be installed on a pattern of 2.5 m x 2.5 m spacing. Patterned bolting will also be required at the intersections of all tunnels.

Due to expected good quality rock of the host geosphere (crystalline or sedimentary), it is likely that no ground support will be needed from a geotechnical standpoint within the tunnels with a span of less then 5 m and in the 3.2 m-wide placement rooms. However, prior to underground construction and development, appropriate ground support requirements will be developed through more detailed geotechnical investigation and health and safety requirements.

Where the development and placement rooms cross zones of poorer ground, additional support will be applied as required. It has been assumed that 10% of the tunnel lengths will require additional support based on encountered conditions.

Due to the long life of the repository, a monitoring program will be implemented to assess the long-term performance of the established ground support features. Maintenance or installation of additional support will be carried out as required.

Note: The above support recommendations are preliminary and illustrative only. Rock support systems will need to be revisited after geotechnical characterization is performed at the preferred location.

5.7.3 Development Schedule

Construction Phase

Once the sinking and equipping of the shafts is completed, they will be utilized to develop the Service Area including the UDF. The sumps and main electrical substation will be completed first to support on-going development. Development of the other support facilities in the Service Area (e.g., mobile equipment shop, charging station, explosives magazines, etc.) will follow. With the underground infrastructure in place, the UDF and all twin access tunnels will be developed into the placement area from the Services Area.

Placement rooms will be excavated at the boundaries of each panel (called panel boundary rooms). The two rooms will be excavated to confirm the suitability of rock for hosting placement rooms. The one full panel of placement rooms would be established during construction phase and before the DGR facility is commissioned.

Services (compressed air, water, electrical, etc.) will be extended along twin access tunnels as appropriate to support activities along repository arms. A preliminary underground layout for the crystalline geosphere at the end of the Construction Phase is shown in Figure 45.

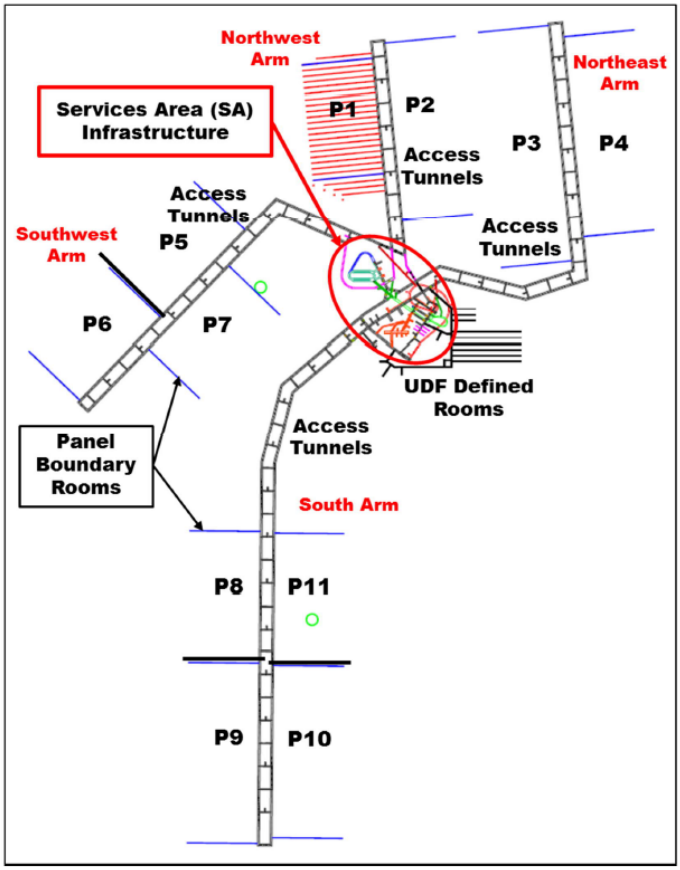


Figure 45: Underground Development during the Construction Phase (Crystalline Geosphere)

Operations Phase

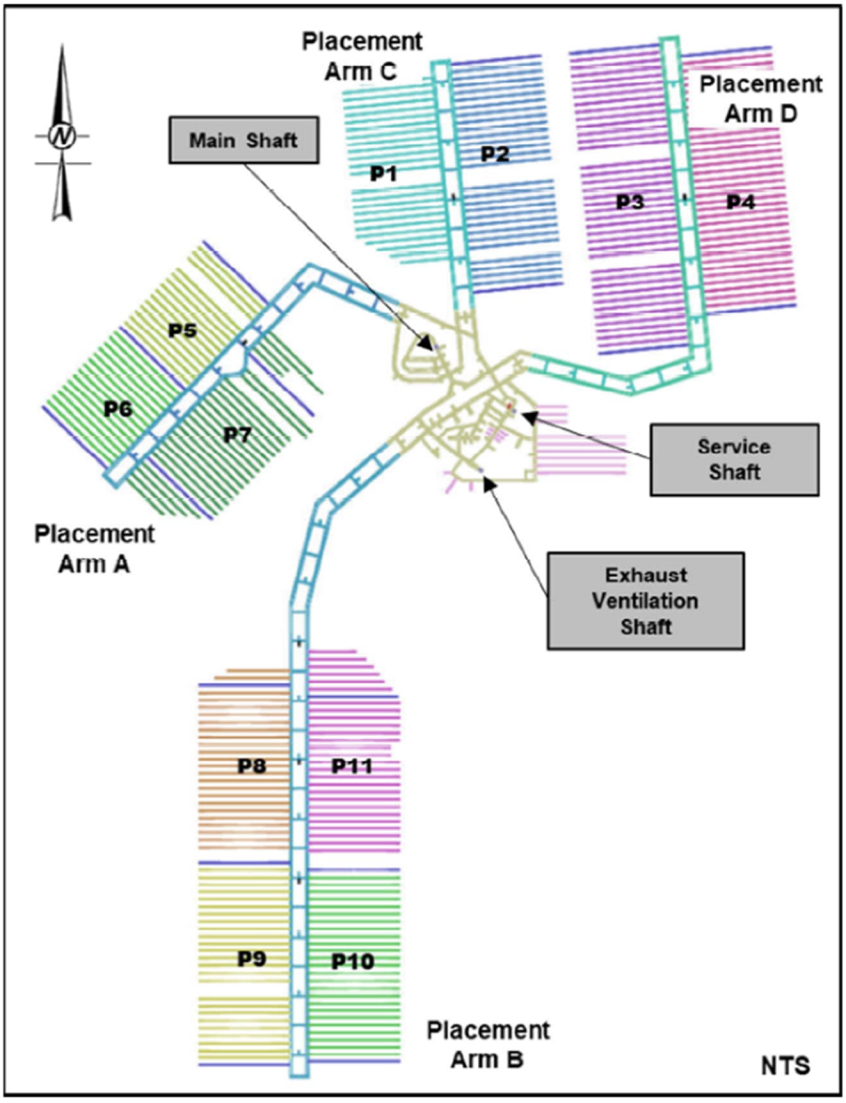
During the operations phase, there will be concurrent construction and placement activities. That is, buffer boxes will be placed in placement rooms at the same time as additional placement rooms are being excavated. However, excavation and placement activities will be isolated from one another so that excavation and placement equipment do not operate in the same repository panel simultaneously.

Each placement panel will be completed in its entirety before commencing to the next panel so that panel development will be completed prior to placement operations and to ensure that excavation and placement activities will be isolated from one another. When possible, excavation activities will be concentrated in one repository arm while placement activities will be performed in another repository arm. This will ensure that secondary vibration of already developed placement rooms, where placement activities are taking place, will be minimized until the finished rooms are backfilled and sealed.

The sequence outlined in Figure 46 also illustrates the separation of activities for the crystalline geosphere. Each placement panel in the DGR would require approximately 3 to 5 years for development. Buffer box UFC placement activities within the panel of rooms would require 3 to 6 years. Because of the requirement to have one panel completed before placement activities start, the development activities that occur during operations will end about ten years earlier than the placement activities.

Traffic Flow

The Service Shaft and associated underground shaft station area will generally only receive mining and construction equipment traffic or equipment handling sealing materials and other non-nuclear materials. Main Shaft and associated underground shaft station area will generally only receive Buffer box UFC handling equipment (i.e., will be “controlled areas”). Mining and construction equipment as well as non-nuclear material handing equipment traffic will travel along routes that are separate from routes used by the Buffer Box UFC handling equipment.



	Development		Placement	
Panel #	**Start Date**	**Finish Date**	**Start Date**	**Finish Date**
Panel 1	Feb-40	Nov-42	Jul-43	Mar-47
Panel 2	Jun-57	Jul-60	Jun-61	Feb-66
Panel 3	Jul-43	Apr-47	Apr-47	Jun-53
Panel 4	May-61	Nov-64	Jan-66	Nov-71
Panel 5	Sep-71	Sep-74	Jan-76	Sep-78
Panel 6	Apr-79	Apr-82	Oct-83	Apr-86
Panel 7	Apr-53	Feb-56	Jul-57	Jul-61
Panel 8	Sep-83	May-86	May-86	May-90
Panel 9	Dec-75	Apr-79	May-79	Nov-83
Panel 10	Dec-65	Sep-70	Oct-71	Feb-76
Panel 11	Apr-47	Apr-52	May-53	Aug-57

Figure 46: Example Sequencing of Development and UFC Placement Activities (Crystalline Geosphere)

5.7.4 Material Handling

Rock Handling

Broken rock will be loaded into the underground haul trucks at the placement room entrances. Loaded trucks will travel along the access tunnels to the truck dump near the Service Shaft. The trucks will unload their broken rock load onto a grizzly at the dump. A hydraulic rockbreaker would break any oversize rock left on the grizzly. The rockbreaker will be automated to allow remote operation by the skip tender or by a central control room operator. Material from the dump will flow to the loading pocket level for skipping to surface in the Service Shaft.

Materials Handling

Materials for development (e.g., explosives, rock bolts, pipe, etc.) will be transported on rubber-tired service vehicles in the Service Shaft and moved to the main storage area. The vehicles will be off-loaded, and materials placed in the main storage area. Similar service vehicles will carry materials from the main storage area to working places throughout the underground development.

5.7.5 Equipment Requirements

The underground repository will be developed by utilizing rubber-tired battery-powered equipment.

Buffer boxes will be transferred to the underground repository using the Main Shaft. All personnel, equipment and development muck will be transported using the Service Shaft (see Section 4). Placement equipment consists of a customized vehicle to handle the buffer boxes in the placement rooms and a tow vehicle and trolley to move the transfer casks (loaded with buffer boxes) from the shaft to the placement rooms.

A preliminary list of mining equipment and quantities for both the initial construction of the underground repository and for on-going development during the subsequent operations phase is presented in Table 16.

Table 16: Generic Underground Mobile Equipment List

Equipment Types	
Load-Haul-Dump (LHD) Loaders	Grader
32 tonne Trucks	Service & Crew Trucks
Development Jumbos	Boom Truck
Scissor Bolter	Bucket forklifts
Scissor Lift	Utility Vehicles
ANFO Loader	Miller Carts
Shotcrete Truck	Service Trade Vehicles
Concrete Truck	

In all, the following concepts for underground equipment will be applied:

- All underground excavations will be carried out by rubber-tired equipment (jumbo's, Load Haul Dump (LHD) machinery and trucks);
- Rubber-tired equipment will be propelled by battery-powered motors. Semi-stationary equipment such as drill jumbos will be powered by electricity;
- Haulage of development rock to the shaft will be by battery-powered trucks;
- Transfer of buffer boxes (with UFCs) on trolleys to entrances of placement rooms and trolleys will be moved by rubber-tired tow vehicles;
- Activities inside placement rooms receiving buffer boxes will be carried out by battery-powered machinery; and
- The routing and scheduling of panel development and buffer box placement activities will be separated, with dedicated routes for each.

5.8 SUBSURFACE VENTILATION

Three primary airways will be used to ventilate the repository. The Service Shaft will constitute a dedicated fresh air passage. The primary exhaust air passage will be via the Exhaust Ventilation Shaft and a relatively small amount of air will exhaust via the Main Shaft. A series of surface fans and underground booster fans will be required to achieve the design air flow distribution in the underground repository. A surface-based fresh air heating plant will be used to heat air in winter months. Auxiliary fans and ducting that are located in the underground tunnels and rooms will direct airflow into active placement rooms.

Network modelling techniques (e.g., Ventsim software) were used to create a three-dimensional representation of the ventilation system, and to conduct ventilation simulations for the excavation and placement activities. Based on the results of modeling the primary surface fans, underground booster fans and the associated distribution ducting were sized.

Independent ventilation circuits will be established for the placement and excavation areas of the underground repository. To the degree possible, the system will be set up to ensure that underground work would be performed in a fresh air supply stream with the exhaust being directed through unoccupied areas (low contamination areas to higher contamination areas). Ventilation requirements are based on providing dilution of excavation contaminants and dissipation of heat to provide a comfortable working environment.

5.8.1 General Description of Ventilation System

The system will use three vertical shafts and a combination of parallel airways to intake and exhaust the air from surface through the underground facility and back to surface (see Figure 47). The system will make use of underground booster fans, auxiliary fans, ventilation doors, and regulators to control airflow distribution and ensure a 'one-pass' ventilation system.

The main repository ventilation system conduits (panel access tunnels) will provide relatively large airways. The overall circuit, including the shafts, can be described as a system with relatively low airflow resistance characteristics.

The primary ventilation network consists of a push-pull type system. At the Service Shaft, the two surface fans (three fans including an installed spare) will force fresh air through the surface plenum and into the shaft area (a small amount will be upcast in winter months through the shaft

headgear to prevent freezing). Underground booster fans are then envisaged to take-over within the shaft system and pressurize the underground operation to allow for a positive pressure distribution in the repository. Ventilation control doors, booster fans, auxiliary fans and regulators will be used to direct and control the quantity of fresh air.

Fresh air will be routed into the Service Area to ventilate the mobile equipment shop, main electrical sub-station, main sump, storage areas, offices and shops before being discharged into the Exhaust Ventilation Shaft (see Figure 48). Exhaust air from the Service Area will be routed to the Exhaust Ventilation Shaft by two underground booster fans. The return air will then be exhausted to surface via a plenum which leads to 15 m-high ventilation stack that is located close to Exhaust Ventilation Shaft headframe. A small quantity air will be exhausted from the underground cask storage area up the Main Shaft. At surface the air will exhaust to surface via a plenum which leads to 9 m-high ventilation stack that is located close to Main Shaft headframe.

Air will be distributed throughout the underground repository through the use of ventilation doors, regulators and fans. Within a given repository arm, fresh air will be supplied via one of the twin access tunnels and exhausted through the other access tunnel. Fresh air will be delivered into individual placement rooms through auxiliary fans and duct systems. Exhaust air from repository arms would be routed to the Exhaust Ventilation Shaft by two underground exhaust booster fans and then directed to surface via the Exhaust Ventilation Shaft Complex.

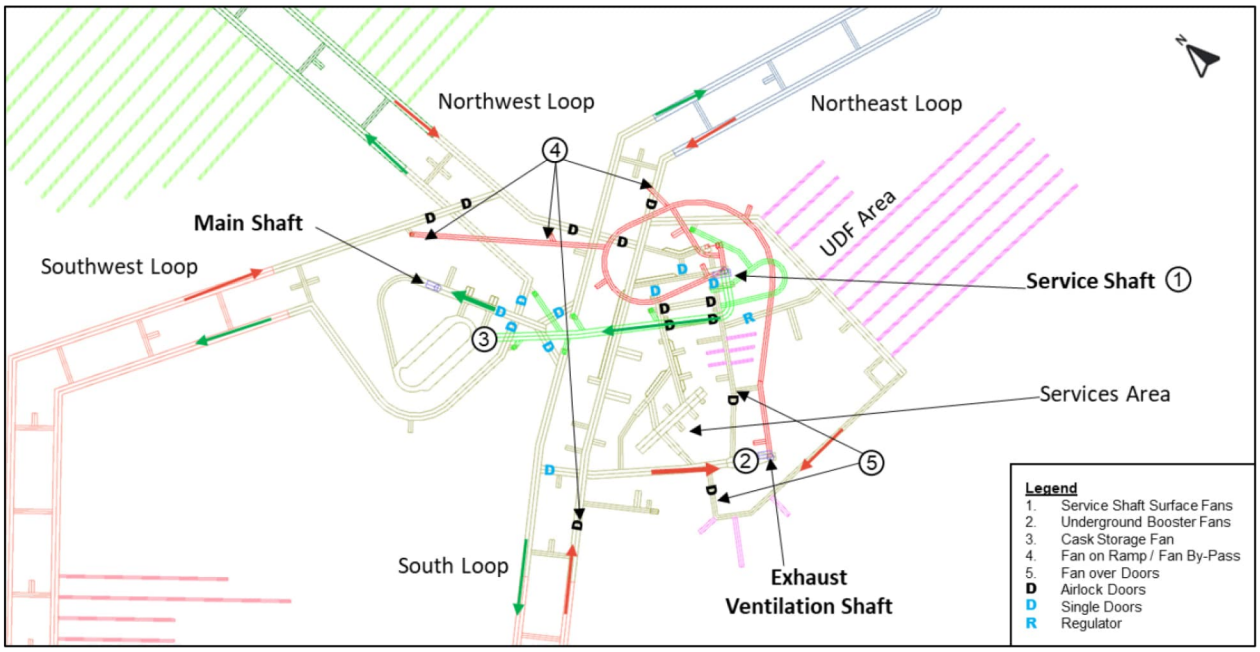


Figure 47: Ventilation Infrastructure for the Crystalline Repository

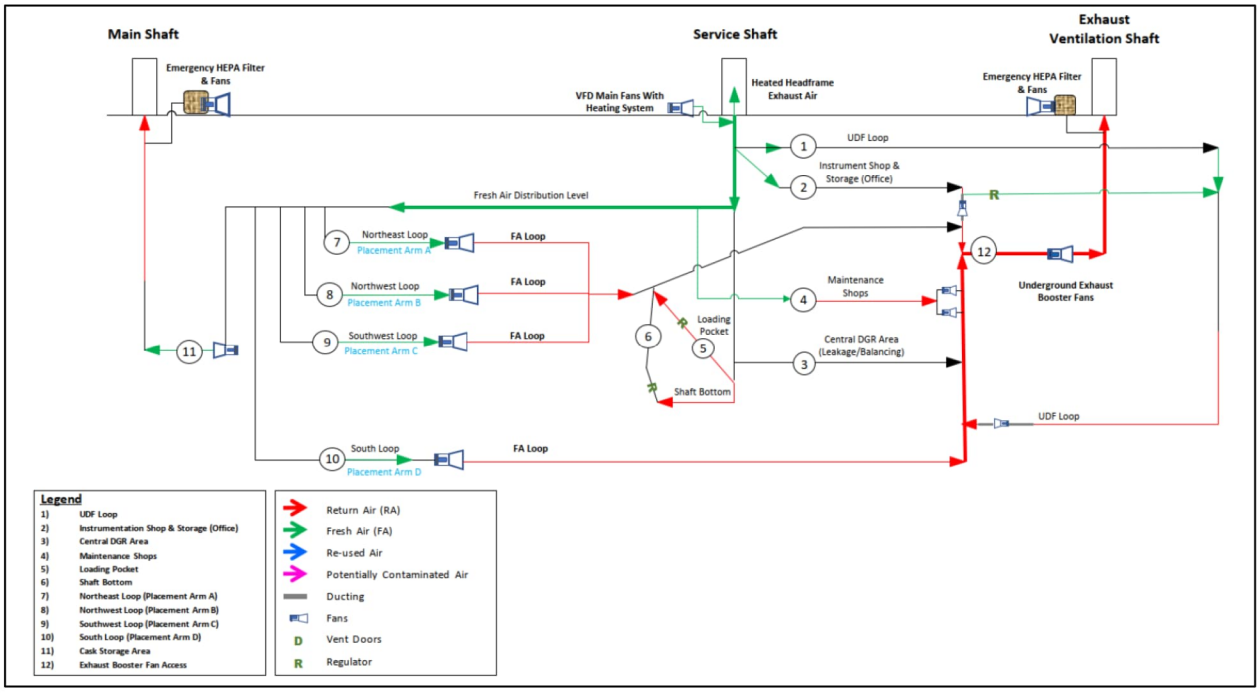


Figure 48: Ventilation Overview for the Crystalline Geosphere

5.8.2 Estimation of Air Flow Requirements

In assessing airflow requirements, the DGR will be subdivided into two areas: the Services Area and the repository arms in the placement area. These areas will be essentially ventilated independently. In both cases, airflow rates will be sufficient to allow a suitable working environment for personnel. In the case of the placement area, airflows will be based on the sum of that needed for repository development/excavation and for actual buffer box placement activities, since the two operations will be performed concurrently.

Unless otherwise specified, the minimum airflow velocity in all access tunnels and occupied placement rooms will be 0.5 m/s as a general mining best practices consideration for areas with no diesel equipment or other controlling factors. During buffer box placement, the minimum air velocity will be reduced to 0.25 m/s in the placement rooms. Use of battery powered emplacement vehicles and requirement of no personnel to be allowed in placement rooms during actual placement allow this lower air velocity.

The ventilation system will be capable of delivering air at a velocity of 3.5 m/s to prevent fire rollback. Fire rollback can cause hot combustion products (smoke and gas) to move along the roof of tunnels in the opposite direction to primary ventilation flow, potentially circulating combustion products into areas upstream from the fire source. Fire rollback can be a dangerous threat to workers and firefighters in an underground repository. By preventing fire rollback, the chances for safe worker evacuation and effective firefighting can be improved. In the remote event there is a fire in an access tunnel, airflow velocity of at least 3.5 m/s will prevent fire rollback.

The maximum allowable airflow velocity in any underground opening is 6 m/s. At airflow velocities above 6 m/s dust and other particles become entrained in the air which can cause uncomfortable

working conditions. High airflow velocities are also uncomfortable for workers and hinder communications.

During development of the placement rooms, the airflow needed at the working face area will be approximately 4 m^3/s. Two 55 kW fans in series operation will deliver the air quantity required. During buffer box placement, the airflow quantities needed at the working face area were determined to be about 2 m^3/s. As indicated below in Table 17, the airflow intake through the Service Shaft for the DGR will be 378 m^3/s during operations phase. The summarized exhaust airflows do not account for exfiltration and losses through the service shaft headframe.

Table 17: Shaft Airflow Requirements

Air Way Type	Shaft	Airflow Requirements (m^3/s)
Intake	Service Shaft	378
Exhaust	Exhaust Ventilation Shaft	311
	Main Shaft	40

5.8.3 Fan Systems

The surface fans at the Service Shaft will be designed to deliver fresh air to the shaft-plenum intersection where a small volume of air will travel up to the headframe and the balance of the airflow will go underground. From within the shaft, air will be drawn under the influence of the underground booster fans. Table 18 shows the data for the proposed fans including their calculated motor powers.

Fan system sizing will be influenced by repository depth and length of access tunnels/repository arms (i.e., distance from Service Shaft). At this time, the hypothetical crystalline rock geosphere layout has longer access tunnels; as result, it will require larger fan systems than the sedimentary. The ventilation systems of both the crystalline and sedimentary geospheres will change in future to reflect the actual underground conditions derived from the information received from the site investigation work.

A 10% allowance will be included in the fan motor requirements for events that may require additional power during operations. This can be due to friction factor changes due to mining systems or the movement of equipment in shafts and station areas. Further, all primary fans will be installed with a variable frequency drive, to have the flexibility of operating at different flow ranges depending on the required system conditions.

Table 18: Fans and Related Specifications

Crystalline Geosphere

		Total Flow (m^3/s)		Fan Total Pressure (Pa)		Power Consumption per Fan (kW)		
	Number of Installed Fans	Nominal	Design	Nominal	Design	At Nominal Flow/Pressure	At Design Flow/Pressure	Motor Size (hp)
Service Shaft Surface Fans	2	477	525	1245	1657	467	621	960
U/G Booster Fans	2	407	448	2202	2815	676	900	1350
Cask Storage Area Fans	2	42	46	1706	2214	55	73	120
Service Fans	2	36	40	120	146	3	4	7.5
UDF Loop	2	32	35	135	163	3	4	7.5
E-UDF Loop	2	12	13	104	126	1	1	5.5
North East Arm Return Fans	2	163	179	2099	2691	259	345	550
North West Arm Return Fans	2	142	156	1663	2163	181	241	380
South West Arm Return Fans	2	152	167	2007	2579	232	308	500
South Arm Return Fans	2	186	205	4506	5603	615	819	1350

Sedimentary Geosphere

		Total Flow (m^3/s)		Fan Total Pressure (Pa)		Power Consumption per Fan (kW)		
	Number of Installed Fans	Nominal	Design	Nominal	Design	At Nominal Flow/Pressure	At Design Flow/Pressure	Motor Size (hp)
Service Shaft Surface Fans	2	418	460	945	1294	319	425	675
U/G Booster Fans	2	351	386	1767	2289	474	631	960
Cask Storage Area Fans	2	41	45	1377	1817	44	59	100
Service Fans	2	36	40	79	96	2	3	5.5
UDF Loop	2	32	35	118	142	3	4	7.5
North Arm Return Fans	2	152	167	1331	1761	158	210	340
West Arm Return Fans	2	164	180	2288	2919	283	376	600
South Arm Return Fans	2	137	151	2367	3014	244	325	500

Main Shaft: The Main Shaft will be supplied with fresh air from a single Fresh Air Raise (FAR) connected to the fresh air distribution level. Air will be introduced to this area through a fan at the Cask Storage area elevation. The flow will be distributed through the cask storage area using an auxiliary fan and duct system for even distribution. Air will be discharged to the Main Shaft under its own pressure and under normal operating conditions, this will be released directly to atmosphere at 9 m above grade.

Under relevant emergency scenarios, the air will instead be drafted through a dedicated HEPA filter and fan installed at surface. During normal operating conditions, the air velocity in the Main is 0.9 m/s. This means that should a release event occur at the DGR level, the air containing the release will be expected to reach surface in approximately 10 minutes. Considering currently available fan and damper designs, the HEPA system can be activated within that time. It should be noted that location and type of sensors to detect a release will be determined in future when the ventilation system is progressed to detailed design stage.

Service Shaft: The fans at the Service Shaft “push” air into the DGR with sufficient pressure to reach marginally negative pressures in the ventilation level. This air will be distributed across the repository through the fresh air distribution level, which is approximately 25 m above the DGR level. Fresh Air Raises (FARs) connect these levels. Flow will be distributed using booster fans installed at the DGR level.

Exhaust Ventilation Shaft: The Exhaust Ventilation Shaft will act as the primary exhaust route for the repository. Large underground booster fans discharge the majority of the air from the repository to atmosphere at 15 m above grade.

During an emergency scenario, air will be drafted through a dedicated set of HEPA filters, similar to the Main Shaft. The Exhaust Ventilation Shaft has a variable velocity contingent on the operating condition of the repository. At a maximum, the intended shaft velocity will be 7 m/s to avoid water droplet suspension with the exception of the fire rollback situation. During normal operating conditions, should a release event occur at the closest placement room to the shaft, it will take approximately 3 minutes for the air to reach surface. Considering currently available fan and damper designs, the HEPA system can be activated within that time. It should be noted that location and type of sensors to detect a release will be determined in future when the ventilation system is progressed to detailed design stage.

All exhaust ventilation system fans will be linked to provide reliable operation during an emergency. If one fan fails or electrical problems occur, the system of surface and underground fans will react to this change by either increasing or reducing airflows. The system would be automated for this purpose.

For the fan systems, the plenum will be one of the most important components as poorly designed plenums can reduce the pressure capacity of a primary fan by as much as 50%. The primary contributors to pressure losses in a plenum are shock losses and the airway cross-sectional area. The plenums will be thus sized to primarily reduce the air velocity head and hence, shock losses. The headframes will also be critical to fan performance, since a leaky headframe will lower the system pressure capacity.

5.8.4 Fresh Air Heating System

The underground ventilation system will be designed to ensure reasonable underground temperature conditions. This will allow personnel to work, at all times of year, in normal indoor work wear (coveralls, work boots, etc.) as in a surface factory setting. A direct-fired heating plant in the ventilation network will be used to maintain working temperatures during winter months. Support offices and ancillary facilities will also be kept at temperatures where work can be performed in every day indoor work wear, without the need for heavy clothing.

The size of a heating plant is a function of the required temperature change. Considering a change in temperature from -30°C (surface outside) to +10°C (shaft), and after accounting for anticipated system inefficiencies, an estimated 21 MW heating plant will be required. The heating plant will use burners placed directly into the airstream. Common in the northern hemisphere, such systems have proven reliable and extremely safe. A draw-through system, in which the fan will be located downstream of the line burner is proposed. Direct propane or natural gas fired heaters will consist of an intake section, burner section and air plenum. Integral blower burners will be mounted directly in the airstream. The control system for the heater and fan systems will include local controls and connection to the central control infrastructure.

During winter months, the shaft headframes will need to be heated to prevent freezing. As previously described, a push-pull arrangement will be established for the DGR's ventilation system using a force fan system on surface and exhaust booster fans located underground. All three shafts will have a headgear located on the top of the shafts. Therefore, to prevent freezing

problems during winter months, small portions of the heated air streams would be directed into the shaft infrastructure.

Airflow Rate in Exhaust Ventilation Shaft

When ventilation air flows up the Exhaust Ventilation Shaft it is subjected to the effect of “auto-decompression”. The air will decrease in temperature by 10 degrees Celsius for every 1000 metres of rise in elevation. If the air is not at 100% relative humidity when it enters the shaft it may reach 100% relative humidity as it cools. Once at 100% relative humidity, water may start condensing on the shaft walls if the walls are cooler than the air. As the air reaches 100% relative humidity, fog will be generated, the fog droplets will start combining to form water droplets. If the air speed is high enough the water will be carried out by the air stream up the shaft. If the air speed is low, then the water droplets will fall down the shaft.

Air speeds between critical range of 7 to 13 m/s can suspend water droplets in the shaft. Water blanketing may occur in this range of velocities. The resulting variations in shaft resistance will cause an oscillating load on main exhaust fans which may affect fan performance and/or lead to fan damage. Water blanketing can produce large intermittent cascades of water falling to the shaft bottom.

The Exhaust Ventilation Shaft inside diameter will be set at 7 m to maintain target airspeed below or close to 7 m/s. Selecting to stay below the critical range will be due to variable operating airflow rates over life of the DGR. Low airflow rates will also reduce resistance to airflow and thus leads to lower operating costs for the long life of the DGR.

5.8.5 Exhaust Air Filtration

High-efficiency particulate air (HEPA) filtration systems will be established (as shown in Figure 29) where underground air exhausts to surface at the Exhaust Ventilation Shaft and Main Shaft locations. These systems will be activated in the remote events of radioactivity being detected in the underground ventilation air at above-background concentration levels and/or an underground fire. They will be installed on surface in the exhaust ducting systems. For the Exhaust Ventilation Shaft, the HEPA filters will be bypassed during normal operations. In the remote event of underground radioactive release or a fire, a damper would be activated by triggering of an underground sensor resulting in redirection of the contaminated ventilation air in the exhaust circuits with HEPA filters. The HEPA filters and exhaust fans will be enclosed in a structure(s) for protection from the elements. The system will be routinely tested. A similar but smaller HEPA filter system will be installed at the Main Shaft.

HEPA filters will also be installed on auxiliary ventilation ducts for the placement rooms and will be available for use during UFC placement activities. A portable HEPA filter will be provided on the exhaust duct from active placement rooms and each duct will be equipped with a radiation monitor and bypass damper. In the remote event that radioactive contaminants are detected, the damper will be activated, and the air exhaust will be routed through the HEPA filters. At same time an alarm will be sounded for the evacuation of underground workers to a refuge station. A future risk assessment will be performed to determine if this portable HEPA filter system is required.

6. USED FUEL CONTAINER HANDLING AND PLACEMENT

The UFCs will be assembled into buffer boxes inside the Used Fuel Packaging Plant (UFPP) (see Figure 10). Fully assembled buffer boxes will be staged in this area while awaiting transfer to the Main Shaft. After final inspection, each buffer box will be placed loaded into a shielded transfer cask and then loaded onto a trolley. Using a tow vehicle, the trolley with transfer cask will be moved to the Main Shaft Hoist and then secured within the cage. Upon arrival at the repository level, the trolley with transfer cask is removed from the cage by another tow vehicle and then taken to the entrance of a placement room.

The following sections and associated story boards describes conceptual processes and equipment to be used in the handing and placement buffer boxes in the underground repository as well as associated room backfilling and room sealing activities. The handling and placement strategies are under development. The placement sequence described below will be optimized in the future after the surface-based mock-up tests are completed.

6.1 UFC PLACEMENT IN REPOSITORY

The buffer box placement process is outlined below. It should be noted that all activities in the placement rooms will be remotely controlled once the first buffer box has been received at the room entrance.

- The transfer cask (with buffer box) will be received from the UFPP via the Main Shaft cage on a trolley;
- Once underground, the transfer cask will be transported to a shielding canopy located at the entrance to a placement room. An ejection ram will allow the buffer box to be pushed out of the transfer cask;
- Floor plates (with integrated ventilation ducts) will then have been laid on top of the compacted GFM floor (reference floor smoothing treatment) up to the current placement location;
- Through the access window in the shielding canopy, the buffer box will be transferred to the placement vehicle waiting inside the shielding canopy;
- The placement vehicle will travel the length of the placement room to the final placement location;
- The placement vehicle will deposit the HCB floor tablet followed by buffer box. The Buffer box center-to-center spacing would be approximately 1.3 m and 1.7 m for the Crystalline and Sedimentary design cases, respectively. Vertically, the buffer boxes are stacked 2 high in a staggered pattern;
- After the placement of two buffer boxes, small HCB bricks for filling larger buffer box forklift or floor holes followed by an HCB floor tablet and two HCB spacer blocks would be placed in a similar fashion to the buffer box placement;
- The placement vehicle will exit the placement room through the shielding canopy;
- The GFM placement system will enter the placement room through the rear door of the shielding canopy and perform the placement operation by augering granular bentonite GFM in the annular spaces around the buffer boxes. It will then exit the placement room;
- The placement vehicle with the magnetic floor plate removal system will enter the placement room through the rear door of the shielding canopy, remove a floor plate segment and then exit.

Graphical storyboards of the key steps in the conceptual transfer and placement of the UFCs/buffer boxes are provided as Figure 52, Figure 53, Figure 54, and Figure 55. The first of these illustrations provides a summary of the required placement equipment.

Three placement operations are expected to be performed in parallel to achieve the required annual 2,500 buffer box through put.

6.1.1 Placement Equipment

Various pieces of equipment will be developed specifically for this facility due to the unique nature of the work. The placement equipment to be used are illustrated in the legend located at the beginning of Figure 52.

Shielding Canopy: The buffer box placement concept relies on shielded operations for all activities that occur after the buffer box is received at the placement room entrance (See Figure 49). This mobile canopy will permit shielded activities to take place inside, while also allowing use of the panel access tunnel by passing vehicles and personnel. Where required, the small annular space around the canopy perimeter can be covered by manually placed lead shielding packs to ensure no radioactive shine escapes around the edges.

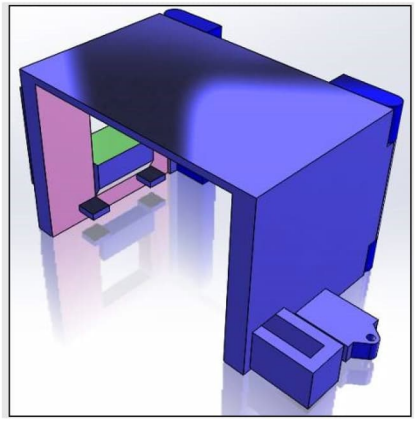


Figure 49: Shielding Canopy

The canopy design features include shielded hinged access doors for vehicle access and for buffer box insertion. A shielded access window is also included to allow buffer boxes and HCB spacer blocks to be passed through.

Floor Plates with Ventilation Ducts: The use of temporary metal plates with integrated ventilation ducts will facilitate equipment access to the work face (See Figure 50). Fresh air will be delivered into the placement room via room cross-section. The air will then be exhausted ("sucked") from the room via the ventilation duct which will remove heat and dust from the room.

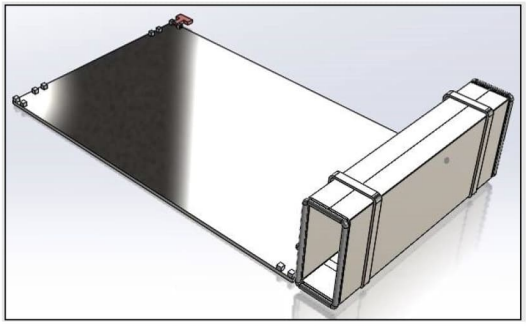


Figure 50: Floor Plate with Built-in Ventilation Duct

The floor plates would be installed before start of buffer box and floor tablet placement activities. As placement activities progress towards the room entrance, segments of floor plate will be removed. A magnetic attachment on the placement vehicle would be used to pick up the plate segments and bring them out of the placement room.

Buffer Box Placement Vehicle: This remotely controlled underground vehicle will be based on a highly customized commercial electric forklift with various enhancements including built-in remote operation sensing, lighting, and camera equipment as well as a customized lifting attachment to accommodate the bentonite floor tablets, buffer boxes and HCB spacer blocks. It

will also have an attachment for placing the floor plates. At least five placement vehicles are expected to be needed, assuming up to three active placement rooms are working in parallel and two vehicles are held as spares for maintenance rotations.

Bentonite Gap Fill Material (GFM) Placement System: For every two buffer boxes and two HCB spacer blocks that are placed, all annular spaces around the boxes will be filled with GFM. Using a piece of equipment similar to the placement vehicle, the bentonite placement system will rely on augured insertion of the granular bentonite using nozzles that can access all annular spaces around the buffer boxes.

6.2 BACKFILLING AND SEALING OF PLACEMENT ROOMS

Once the placement room has been filled with UFC / buffer boxes, a stack of HCB spacer blocks will be assembled after the last buffer box. The length of placement room between the last placed buffer box and the start of the room seal will be about 5 m. Two stacked rows of four 1 m thick HCB blocks will be required for both crystalline and sedimentary geospheres. The annular space around the blocks will be filled with GFM similar to the process used during buffer box placement.

The HCB spacer block placement process will require several pieces of equipment:

- Placement vehicle for spacer blocks;
- Shielding canopy and trolley;
- Bentonite GFM placement system;
- Floor plate handling system;
- HCB spacer block trolley; and
- Tow vehicle.

Once the room has been successfully backfilled, a room seal would be installed. The arrangement of the generic room seal is illustrated in Figure 51. The annular space around the blocks will be filled with GFM in parallel with the block placement process. The placement room seals in the crystalline and sedimentary geospheres will be similar.

Equipment required for the room seal construction process will generally be consistent with that needed for placing the HCB spacer blocks except vehicle for the spacer blocks and the shielding canopy, which will not be required. Once complete, the placed spacer blocks are expected to provide adequate shielding from the buffer boxes to allow the room seal and concrete bulkhead construction operations to be completed without shielding.

Once the room seal is complete the concrete bulkhead can be installed. The completed concrete bulkhead will be recessed approximately 10 m from the entry to the placement room.

A simplified graphical storyboard of the key steps involved in the backfilling and room seal construction process is depicted in Figure 56. Immediately preceding the storyboard, a summary of the required equipment is provided in the legend.

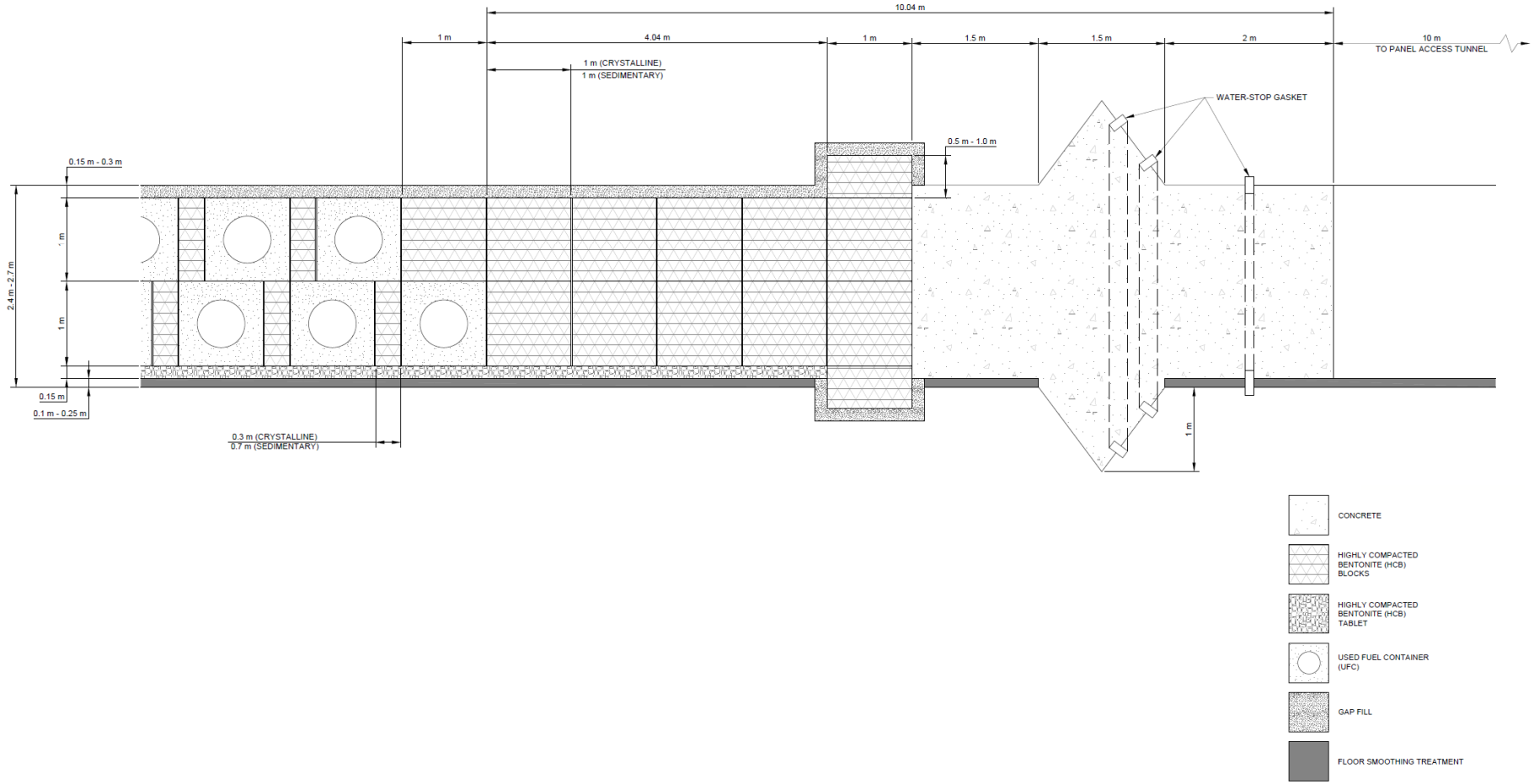


Figure 51: Generic Placement Room Seal

Legend for Generic Container Placement Equipment

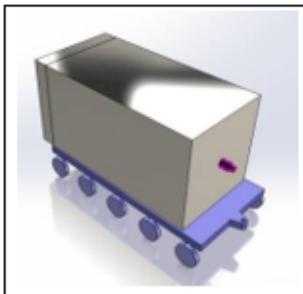
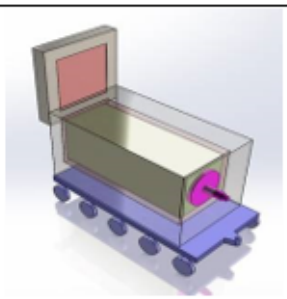
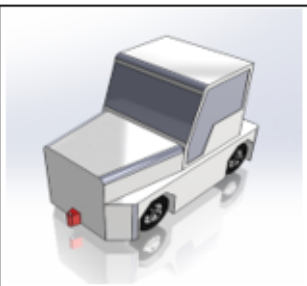
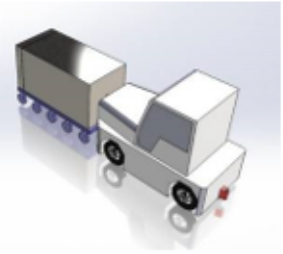
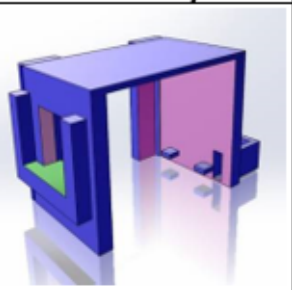
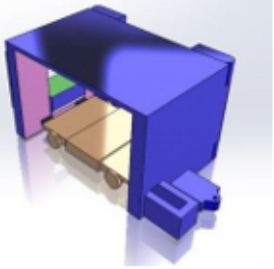
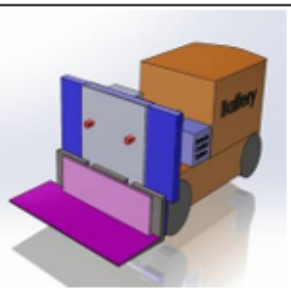
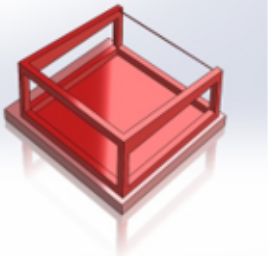
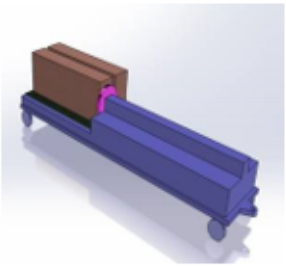
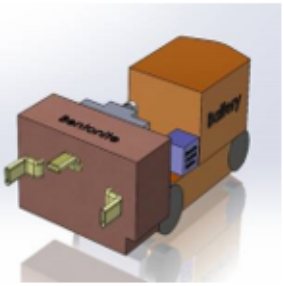
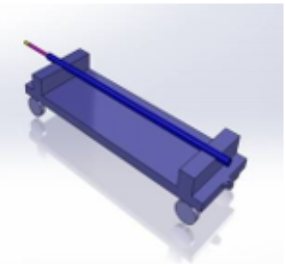
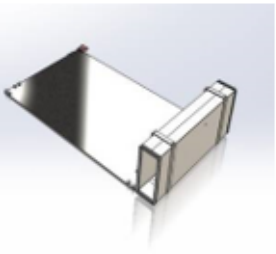
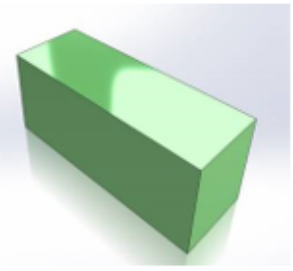
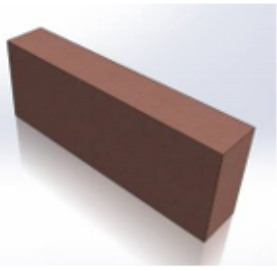
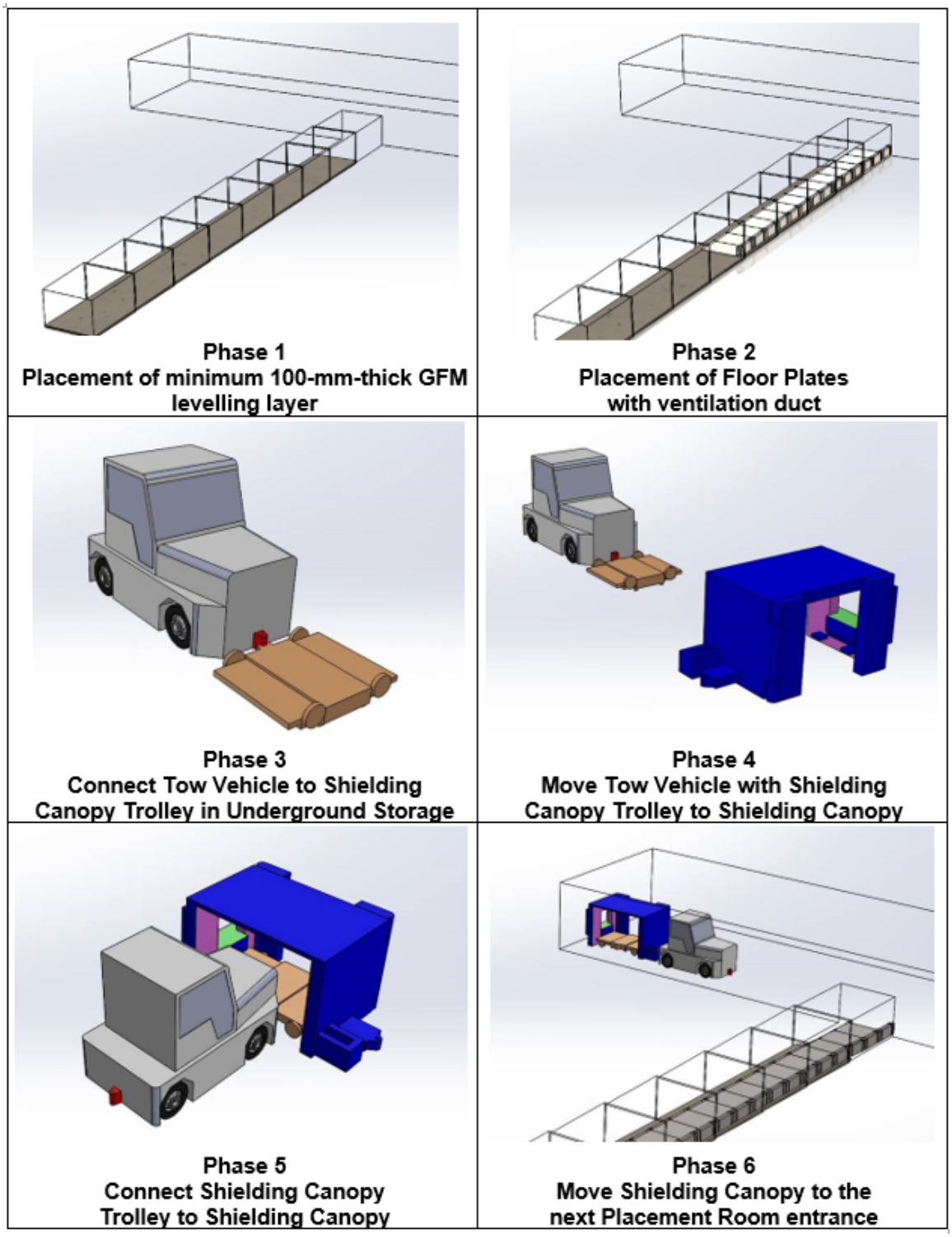
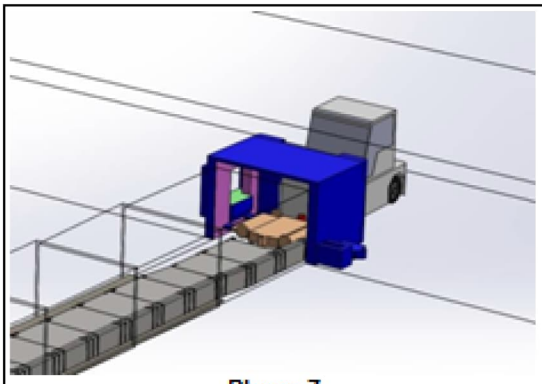
 UFC Transfer Cask & Trolley	 UFC Transfer Cask Door Open with UFC	 Tow Vehicle	 Tow Vehicle with UFC Transfer Cask
 Shielding Canopy	 Shielding Canopy with Trolley	 Placement Machine	 Floor Plate Handling System
 Trolley for Bentonite Blocks	 Bentonite Gap Fill Placement System	 Hydraulic Cylinder Cart	 25-mm-thick Floor Plate with Ventilation Duct
 Buffer Box	 HCB Spacer Block	 UFC	

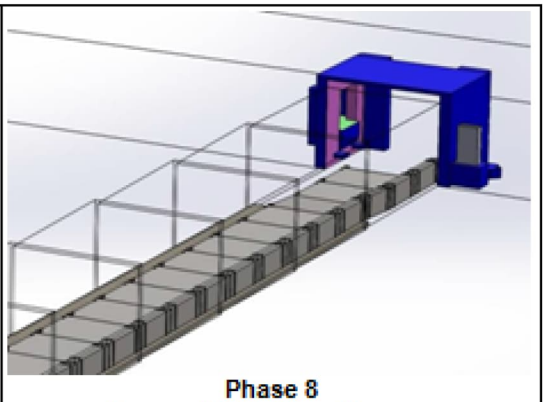
Figure 52: Generic Preparation of Placement Room & Shielding Canopy - Sequence of Operations



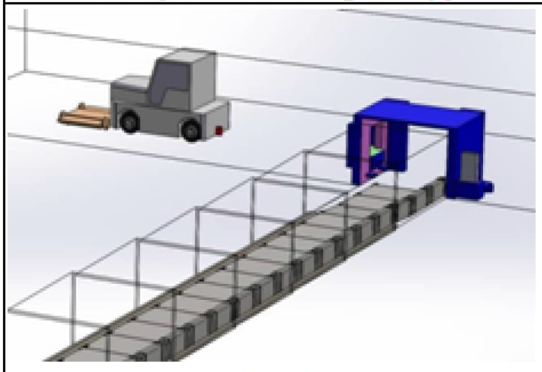
Generic Preparation of Placement Room & Shielding Canopy - Sequence of Operations (continued)



Phase 7
Disconnect Shielding Canopy
Trolley from Shielding Canopy

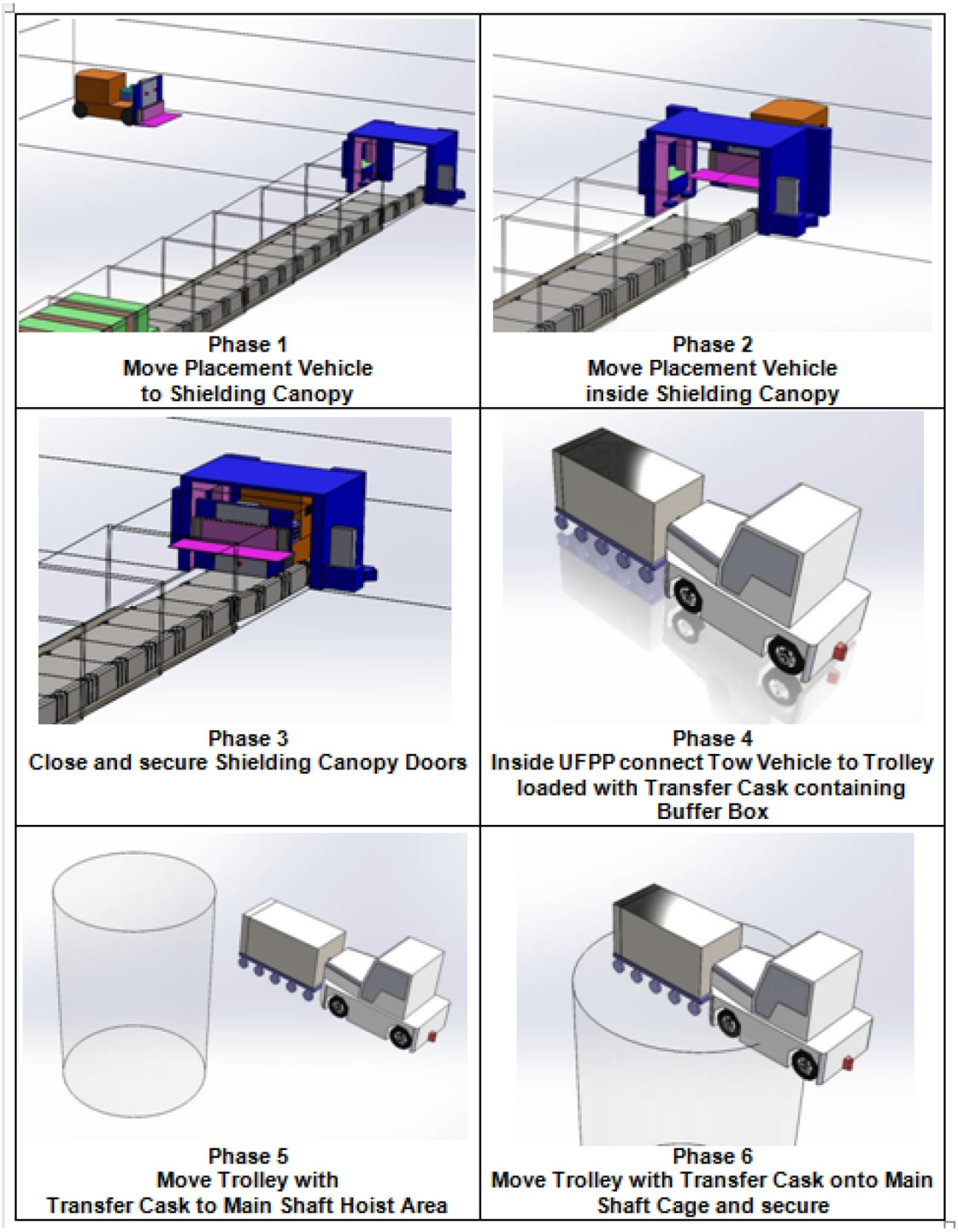


Phase 8
Connect Shielding Canopy
to ventilation and services

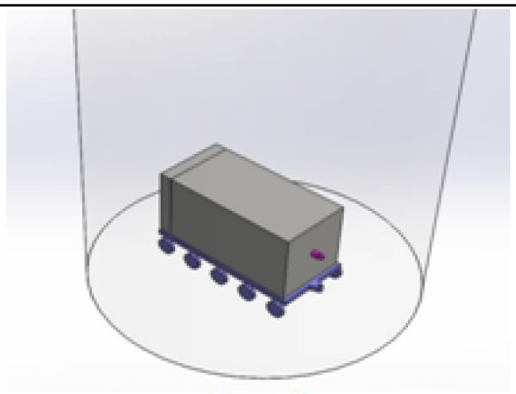


Phase 9
Move Tow Vehicle with Shielding Canopy
Trolley to Underground Storage

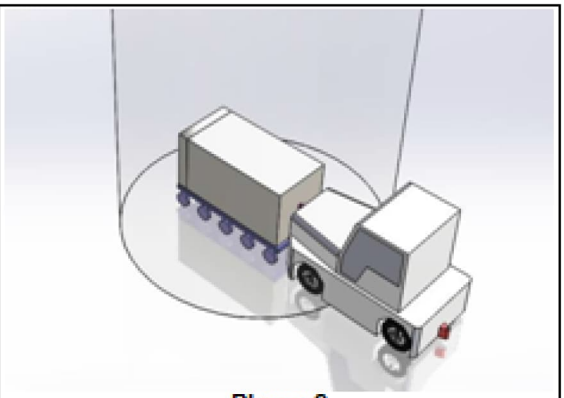
Figure 53: Generic Container / Buffer Box Placement - Sequence of Operations



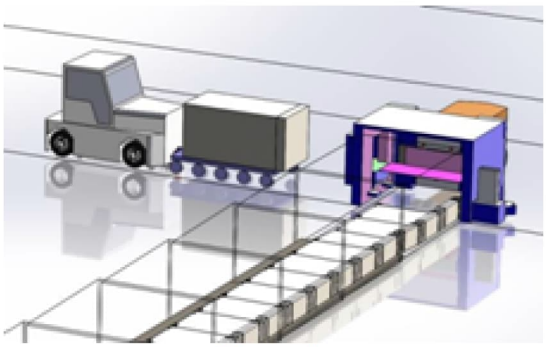
Generic Container / Buffer Box Placement - Sequence of Operations (continued)



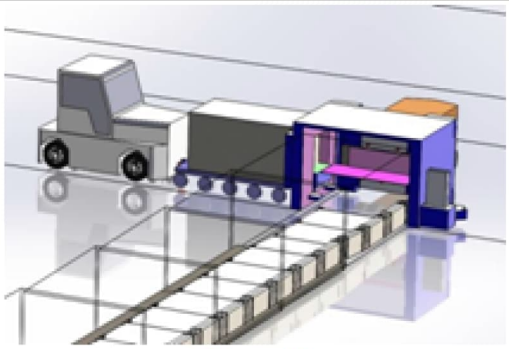
Phase 7
Trolley with Transfer Cask descend to Underground repository level



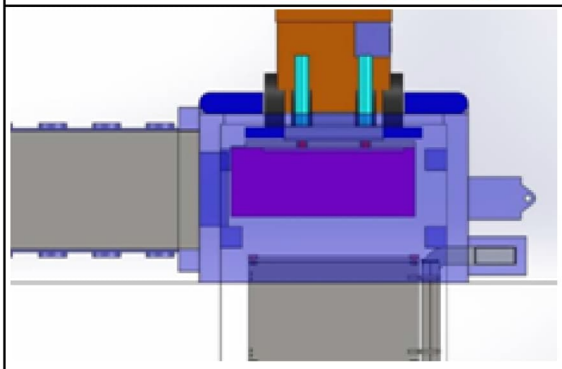
Phase 8
Unsecure and move Trolley with Transfer Cask off Shaft Hoist



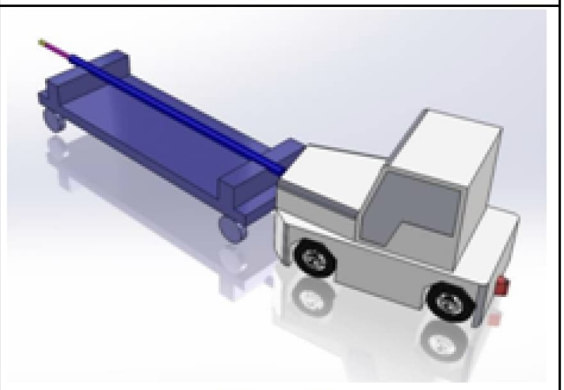
Phase 9
Move Trolley with Transfer Cask to Shielding Canopy



Phase 10
Secure UFC Transfer Cask to Shielding Canopy Transfer Window

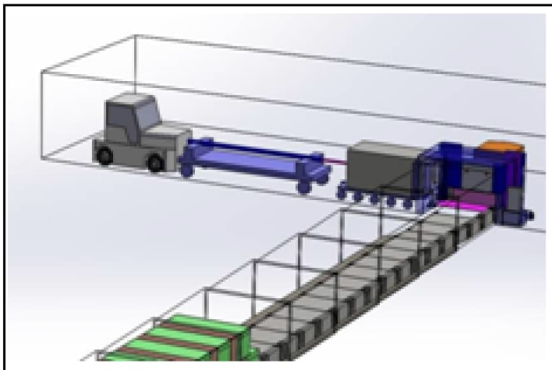


Phase 11
Verify alignment of Placement Vehicle Wedge Tray & UFC Transfer Cask

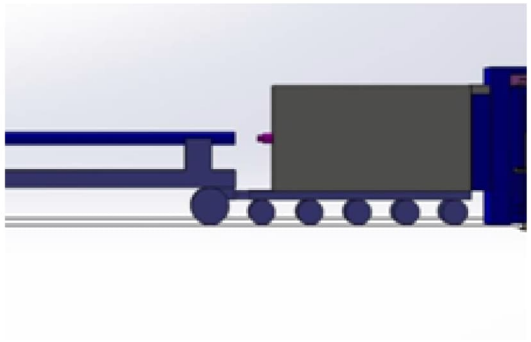


Phase 12
Connect Tow Vehicle to Hydraulic Cylinder Cart in Underground Storage

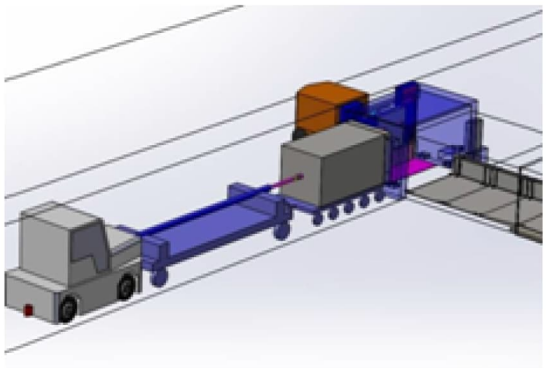
Generic Container / Buffer Box Placement - Sequence of Operations (continued)



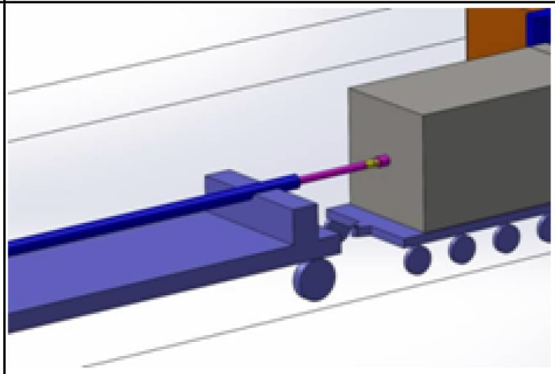
Phase 13
Move Hydraulic Cylinder Cart to Transfer Cask at Shielding Canopy



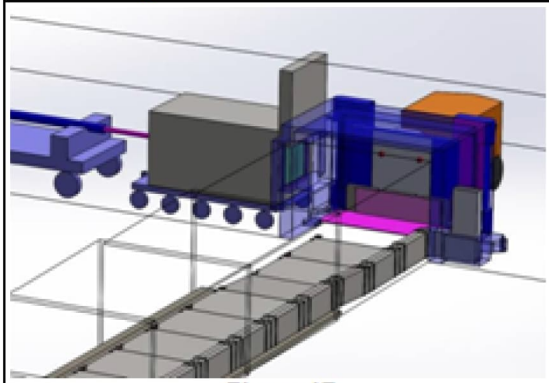
Phase 14
Connect Hydraulic Cylinder Cart to Transfer Cask Trolley



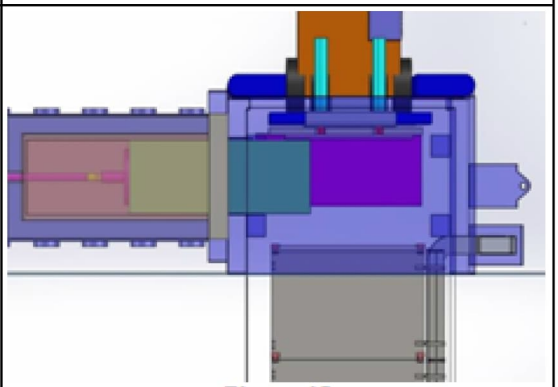
Phase 15
Connect Hydraulic Cylinder Cart to Services



Phase 16
Install Coupling between Cylinder and Ram on Transfer Cask

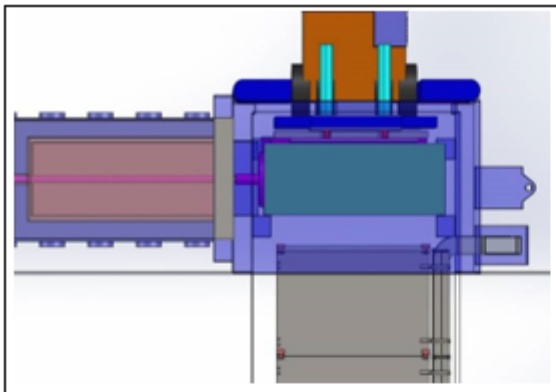


Phase 17
Open Transfer Cask Shielding Door

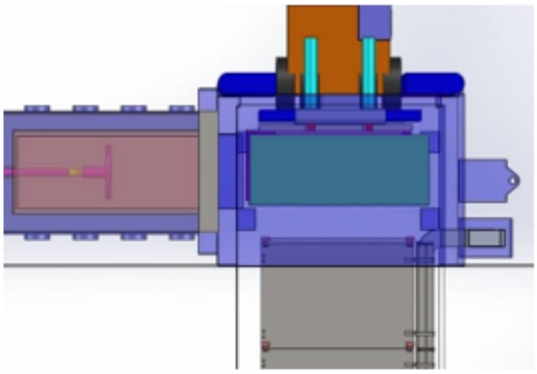


Phase 18
Push Buffer Box from Transfer Cask on low friction liner and window opening support

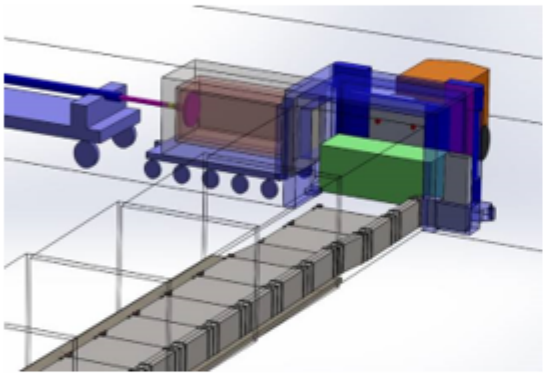
Generic Container / Buffer Box Placement - Sequence of Operations (continued)



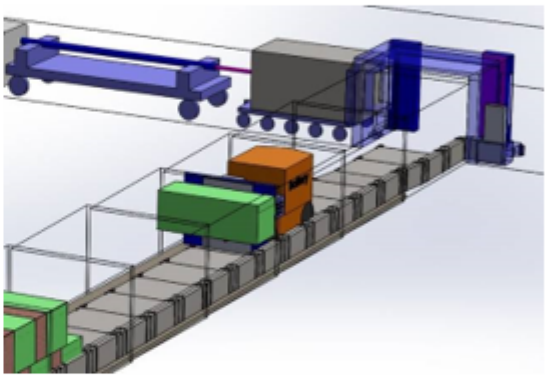
Phase 19
Verify position of Buffer Box on the Placement Vehicle Wedge Tray



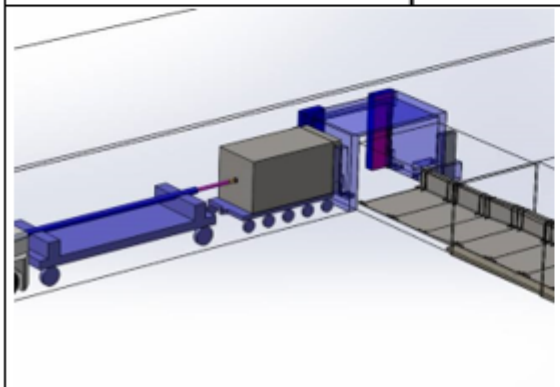
Phase 20
Retract Cylinder



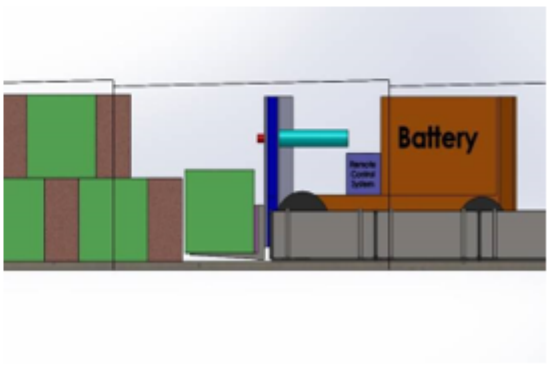
Phase 21
Close Transfer Cask Shielding Door and lift Buffer Box to travel position



Phase 22
Move Placement Vehicle remotely to placement position

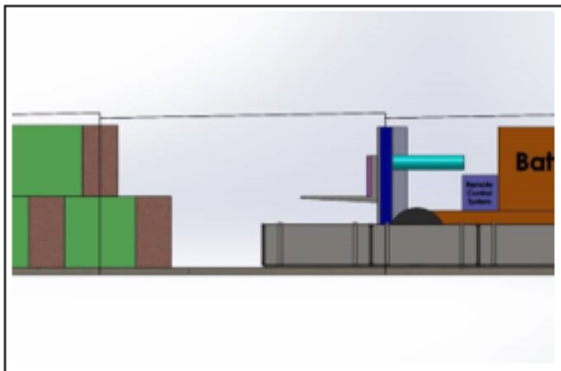


Phase 23
Disconnect Hydraulic Cylinder Cart from Services

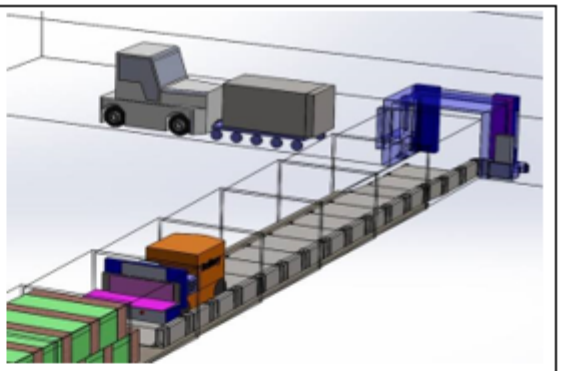


Phase 24
Place HCB Floor Tablets, position Placement Vehicle, and place Buffer Box on HCB Floor Tablets

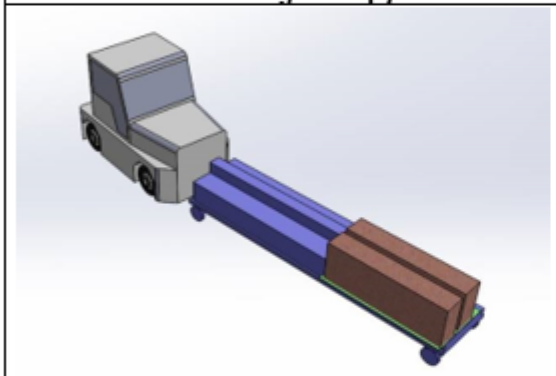
Generic Container / Buffer Box Placement - Sequence of Operations (continued)



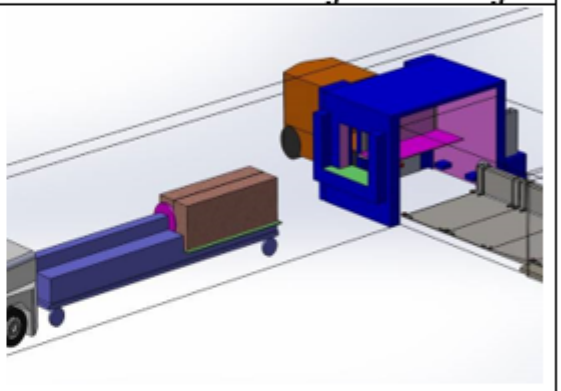
Phase 25
Move Placement Vehicle remotely back to Shielding Canopy



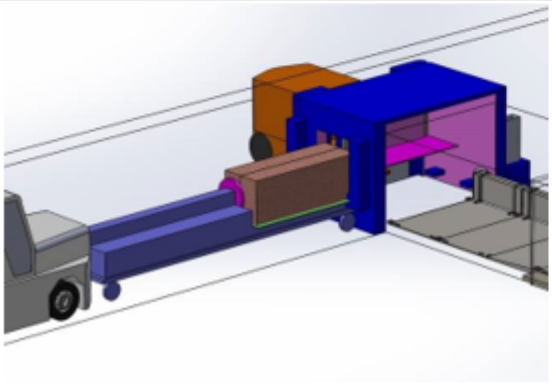
Phase 26
Move Trolley with empty UFC Transfer Cask to Underground Storage



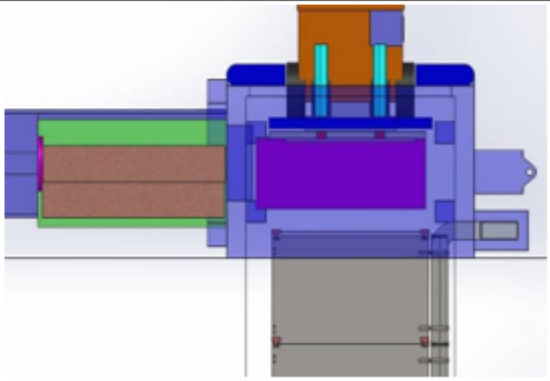
Phase 27
Connect Tow Vehicle to Trolley with HCB Spacer Blocks in Underground Storage



Phase 28
Move Trolley with HCB Spacer Blocks to Shielding Barrier

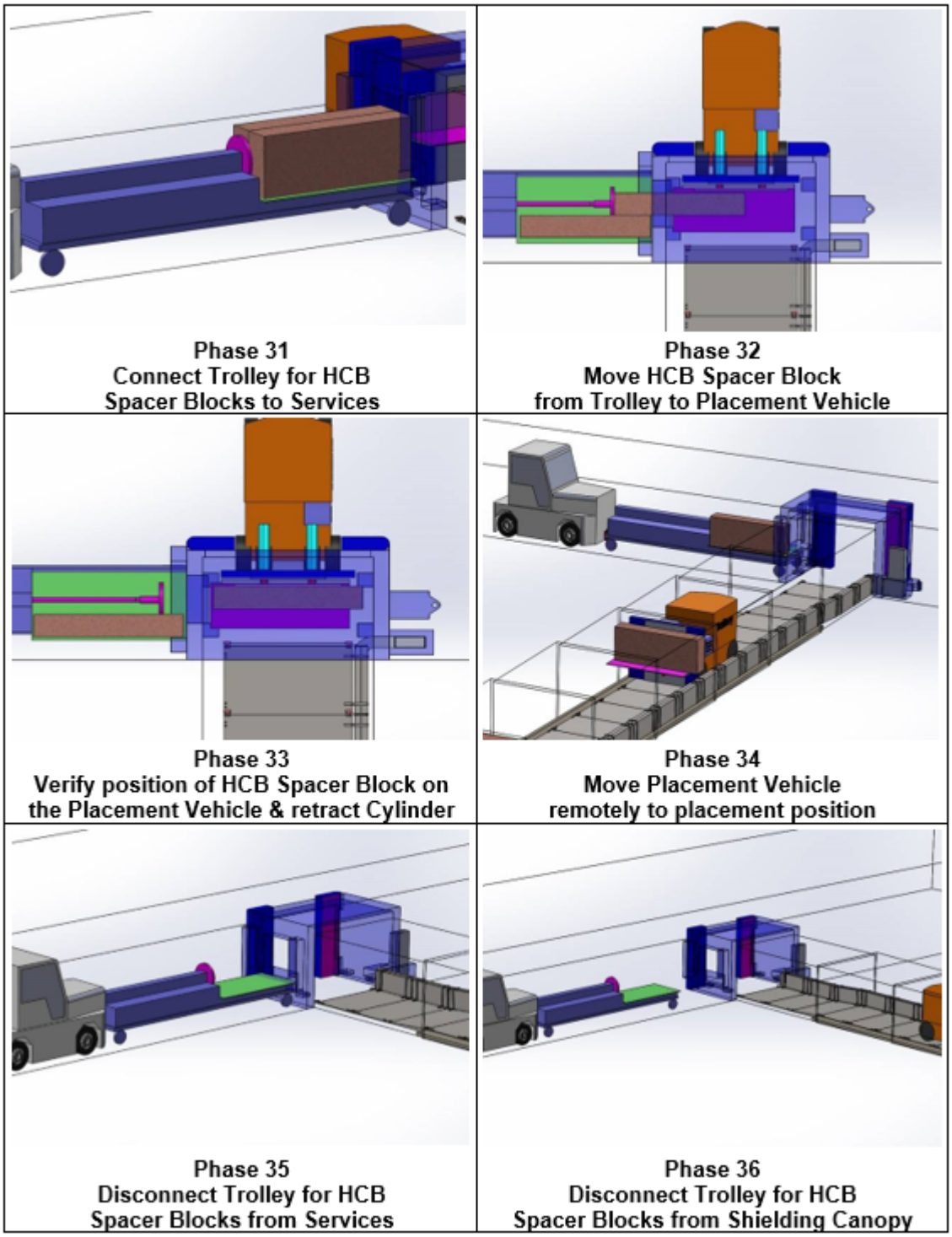


Phase 29
Secure Trolley with HCB Spacer Blocks to Shielding Canopy Transfer Window



Phase 30
Verify alignment of Placement Vehicle and HCB Spacer Block

Generic Container / Buffer Box Placement - Sequence of Operations (continued)



Phase 31
Connect Trolley for HCB
Spacer Blocks to Services

Phase 32
Move HCB Spacer Block
from Trolley to Placement Vehicle

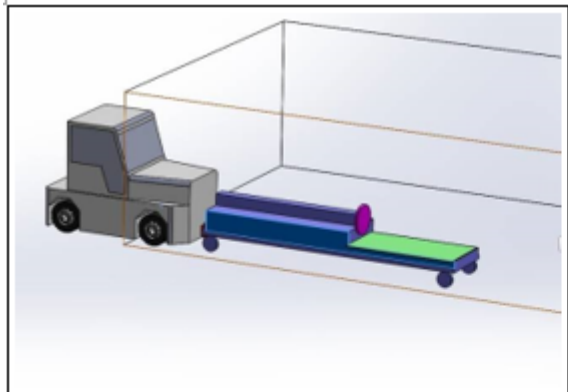
Phase 33
Verify position of HCB Spacer Block on
the Placement Vehicle & retract Cylinder

Phase 34
Move Placement Vehicle
remotely to placement position

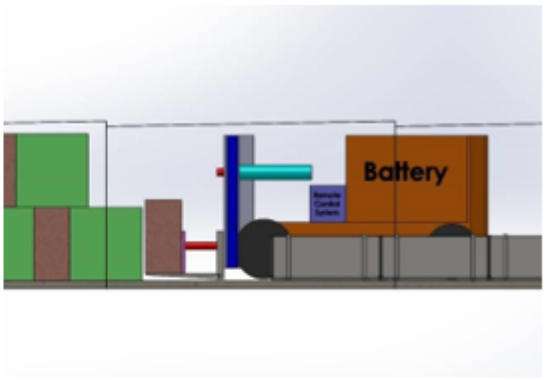
Phase 35
Disconnect Trolley for HCB
Spacer Blocks from Services

Phase 36
Disconnect Trolley for HCB
Spacer Blocks from Shielding Canopy

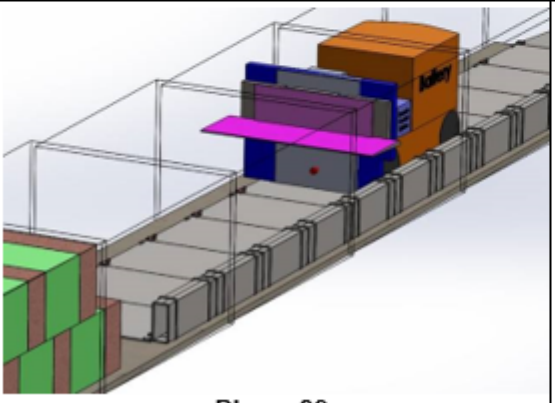
Generic Container / Buffer Box Placement - Sequence of Operations (continued)



Phase 37
Move Trolley for HCB Spacer Blocks to Underground Storage



Phase 38
Position Placement Vehicle and place HCB Spacer Block



Phase 39
Move Placement Vehicle remotely back to Shielding Canopy

Figure 54: Generic Bentonite GFM Placement - Sequence of Operations

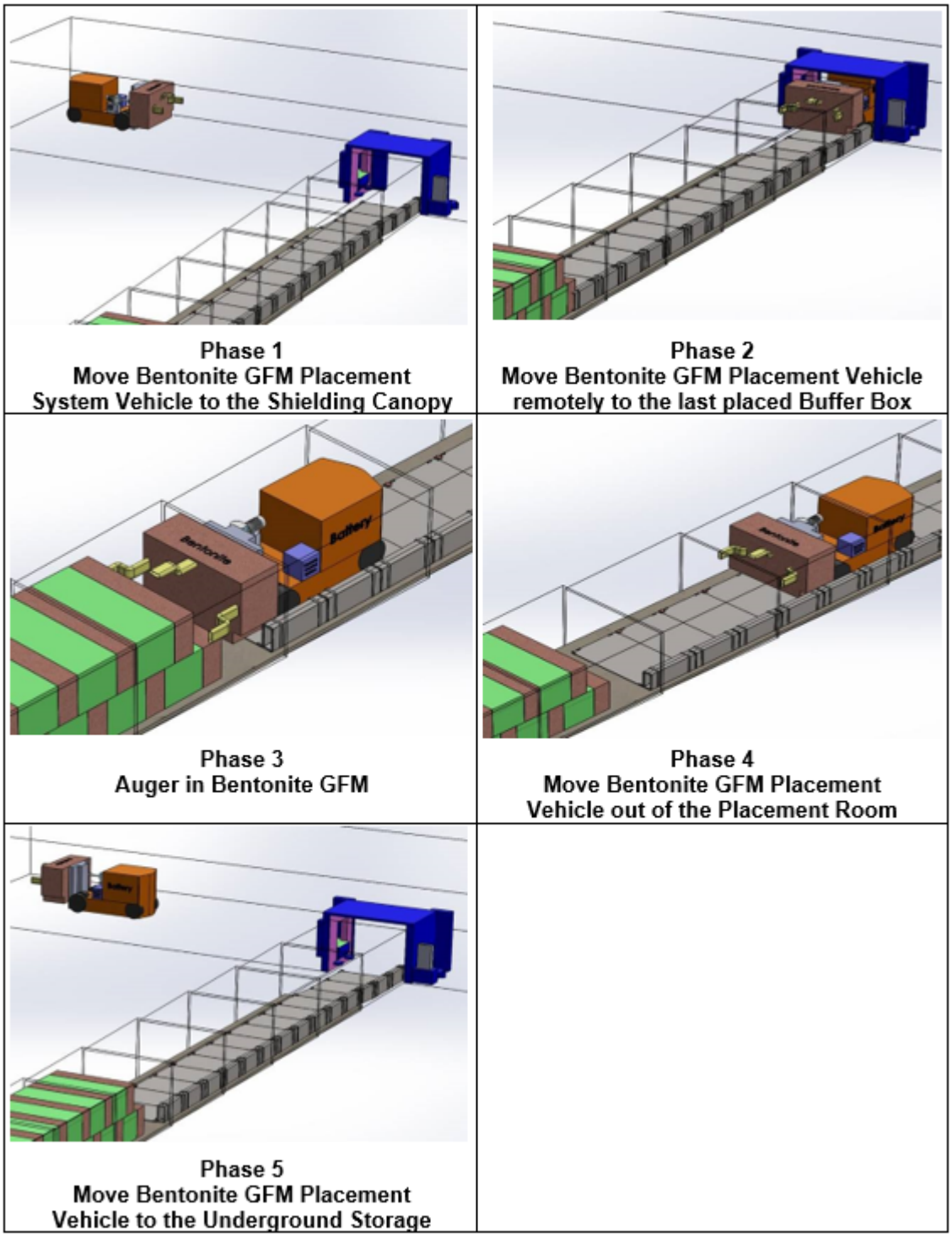
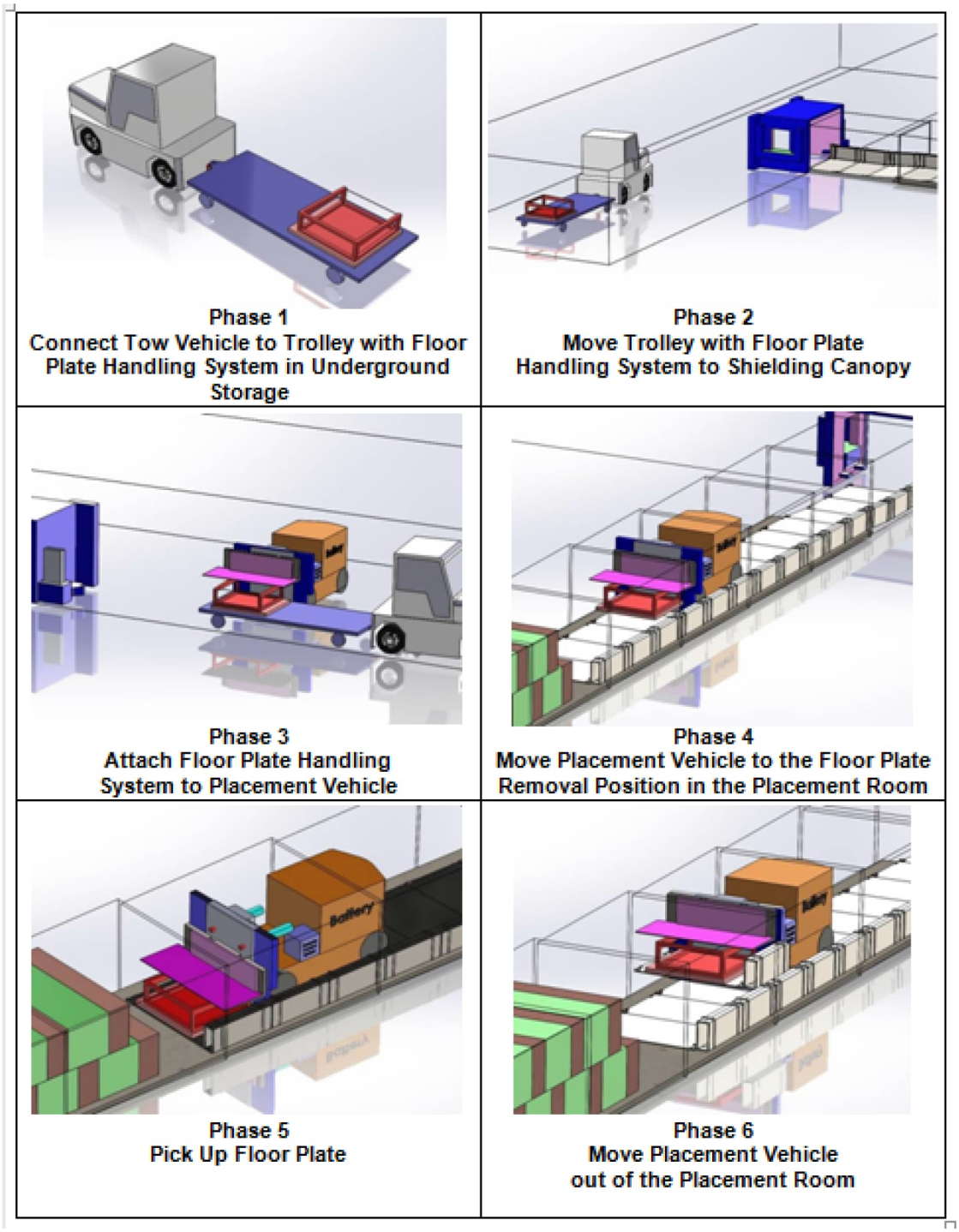
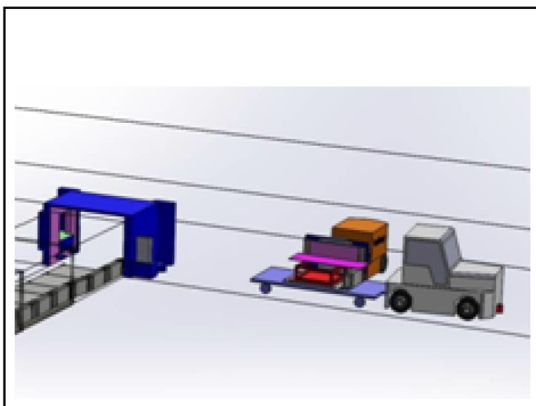


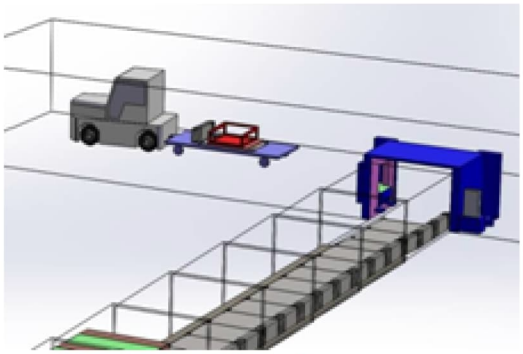
Figure 55: Generic Floor Plate / Ventilation Duct Removal - Sequence of Operations



Generic Floor Plate / Ventilation Duct Removal Operation (continued)



Phase 7
Detach Floor Plate Handling System
and Floor Plate from Placement Vehicle



Phase 8
Return Floor Plate System with
Floor Plate to Underground Storage

Legend for Placement Room Generic Sealing Equipment

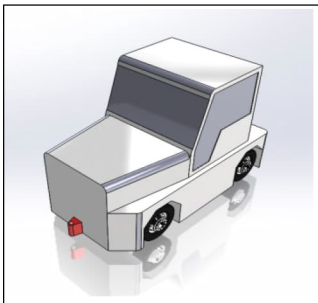
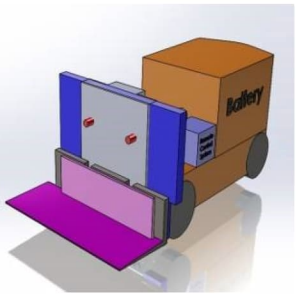
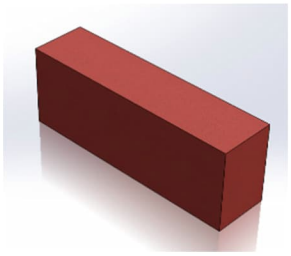
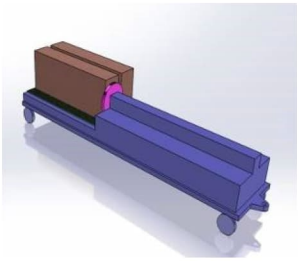
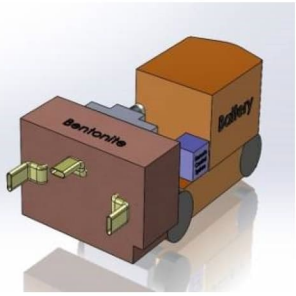
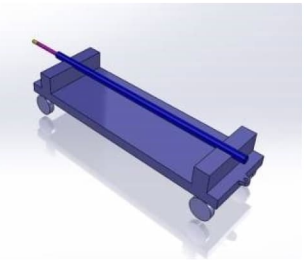
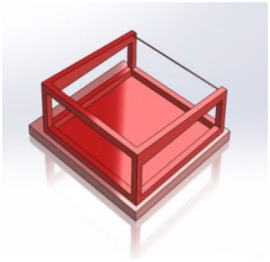
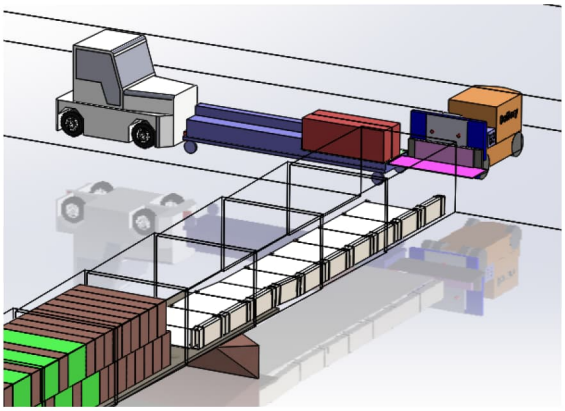
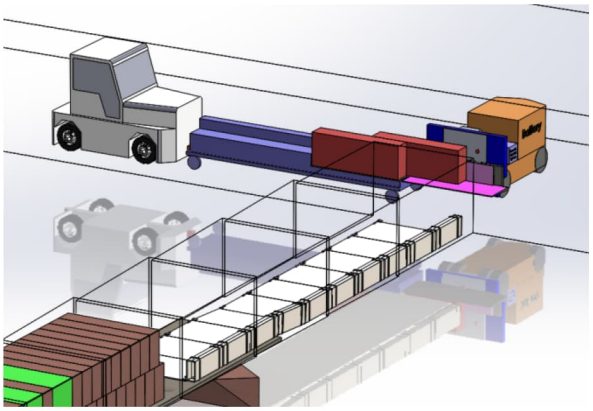
 **Tow Vehicle**	 **Placement Vehicle**	 **Spacer Block**	 **HCB Bricks and Tablets**
 **Trolley for HCB Blocks and Bricks**	 **Bentonite GFM Placement System**	 **Hydraulic Cylinder Cart**	 **Floor Plate Handling System**

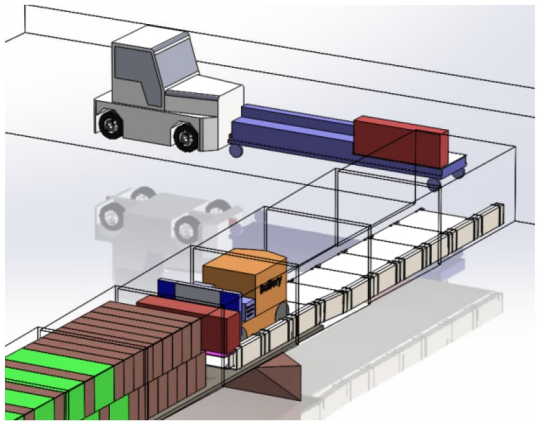
Figure 56: Generic Sealing of Placement Room – Sequence of Operations



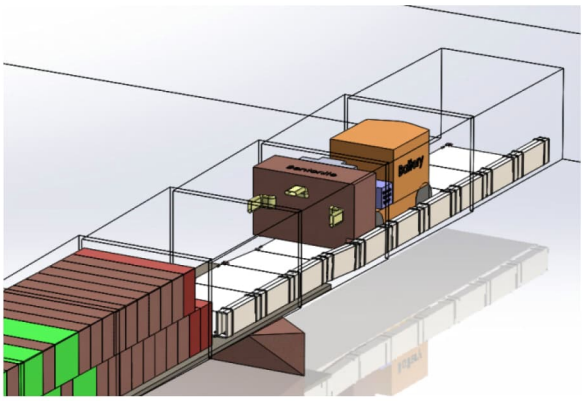
Phase 1
Align and connect Trolley with Placement Vehicle



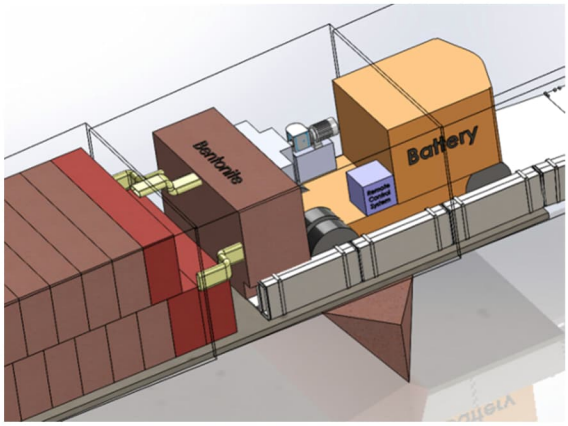
Phase 2
Move HCB Block from Trolley to Placement Vehicle



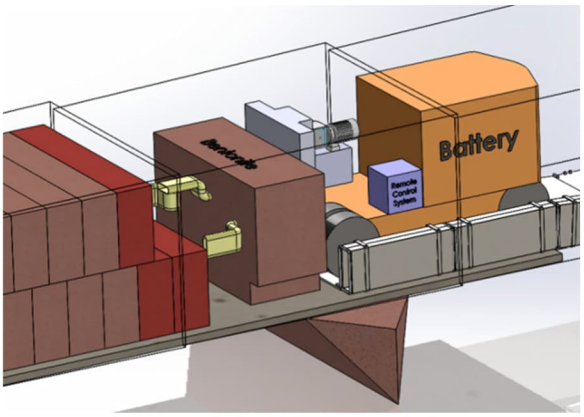
Phase 3
Position Placement Vehicle and eject HCB Block



Phase 4
Move Bentonite GFM Vehicle to the HCB Block wall

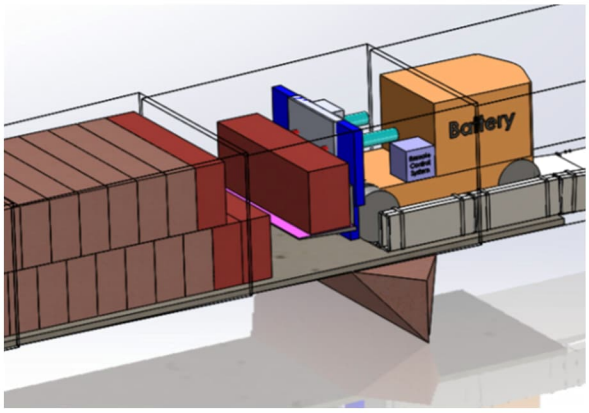


Phase 5
Fill gaps around HCB Block with Bentonite GFM

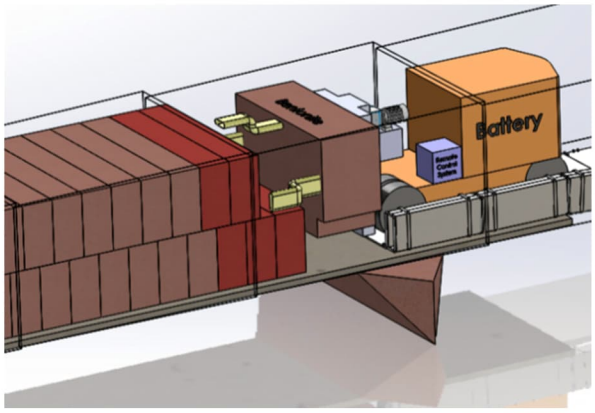


Phase 6
Level Bentonite GFM in front of HCB Blocks

Sealing of Placement Room – Generic Sequence of Operations (continued)



Phase 7
Position Placement Vehicle Wedge Tray and eject HCB Block



Phase 8
Install Bentonite GFM in gaps and construct Concrete Bulkhead

7. CONTAINER RETRIEVAL

The following section describes the approach for a buffer box/container retrieval system to safely extract a UFC (inside a buffer box) from its location in the repository for subsequent transfer to the DGR surface facilities. There are two major stages in the retrieval operation: providing access to the target buffer box with its UFC and retrieving the buffer box.

7.1 GAINING ACCESS TO TARGET UFC

Activities related to providing access to the target buffer box (with its UFC) will be significantly impacted by the location of the buffer box within a particular placement room as well as the length of time that has passed after its placement.

The immediate retrieval of a buffer box (and UFC) when the placement room is still open will not have to contend with the backfill used to seal the placement room. Secondly, and depending upon the extent that the placement room's development has been completed, the room's concrete bulkhead may or may not be in place.

The primary backfill materials in the placement rooms will be in the form of HCB floor tablets, spacer blocks and GFM. Of particular importance to the buffer box retrieval process are the characteristics of these materials, some of which may have been in place for an extended period of time. Over time, the placed backfill materials may evolve from an unsaturated to a saturated condition. Alternatively, the heat produced from the UFCs may also cause some of this fill to become dry.

The amount of water saturation that the surrounding bentonite will experience is also important for buffer box retrieval. Bentonite swells with moisture becoming a significant barrier to water movement but, more importantly, the swelling will introduce a gripping pressure on the buffer box. The net effect of this pressure is that a simple mechanical means of pulling the buffer box from a placement room cannot be performed by extraction equipment until the gripping pressure has been relieved.

The immediate impediments to buffer box retrieval (removal of the concrete bulkhead, the room seal bentonite materials, etc.) are discussed below. As noted, in order to minimize mechanical disturbance to the placed UFCs from transmitted lateral forces, the reuse of drill & blast techniques previously employed for the development of the repository was not considered to be appropriate (material hauling vehicles, the LHDs and haul trucks, may still be used).

7.1.1 Concrete Bulkhead Removal

To remove the concrete bulkhead without mechanically disturbing any placed UFCs, a non-explosive expansion agent will be used. Under such an approach, boreholes would be drilled into the concrete bulkhead and loaded with an expansion agent. Commonly available as powder-based materials that are mixed with water for activation, such agents can generate a high expansive stress without the ground vibration that is associated with drill & blast methods. The agent expands as it cures over a period of hours or days generating sufficient pressure to break the concrete (the bulkhead may require some cutting to allow room for expansion). The resulting concrete fragments are then removed through traditional mining material removal techniques.

7.1.2 Room Seal Removal

The room seal is comprised of a number of HCB blocks and bricks placed in a stacking arrangement to fill the cross section of the placement room. Its removal process must result in a flat, structurally stable travel surface over this area for retrieval operations to be performed. The floor notch itself would be excavated and refilled with gravel or a suitable structure for vehicle travel. The removal work will need to either take into account protection for any manual processes or it must be accomplished in a completely remote fashion. As the room seal is removed, there will be progressively less radiation protection from the UFCs (inside buffer boxes) behind it.

7.1.3 Removal of HCB Spacer Blocks and Gap Fill Material

The backfill in the placement room will be composed of a series of HCB spacer blocks as well as gap fill material. To effectively carry out the removal of this material without mechanically disturbing the placed UFCs, a hydrodynamic method will be employed. The basic premise is to wash away the backfill materials with a saline water solution. While potentially time consuming, the reasons for proposing a hydrodynamic technological approach are:

- The approach has been demonstrated in other applications as an effective means to eliminate gripping pressures prior to attempting container retrieval;
- Simultaneous chemical and mechanical action on the buffer erodes the compacted bentonite in any state (ranging from dry and hard to fully saturated);
- The method can be applied in a continuous process with little risk of damage to the UFC; and
- No bulky load bearing or positioning structural parts are needed (compared with equipment that uses some type of mechanical freeing technology).

The method essentially consists of two stages: slurrying of the backfill materials and dewatering of the generated slurry (which will contain a large volume of water).

Technology is currently available to deal with slurries (a common requirement in many mining applications) and a multi-stage separation process may be employed. The key component technology, however, will be based on the mechanical dehydration of sludge using a common decanter centrifuge process. Figure 57 shows a typical decanter centrifuge for bentonite slurries.

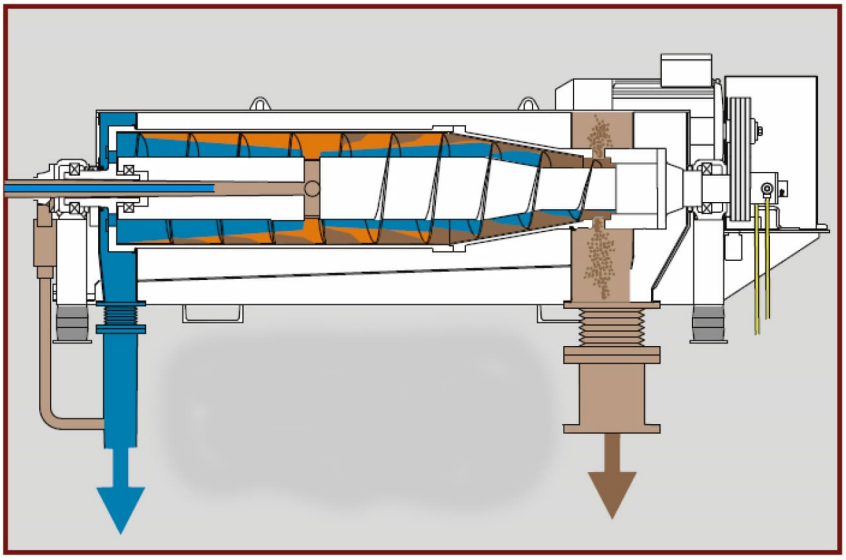


Figure 57: Typical Bentonite Decanting Equipment

The bentonite decanting system could be located outside the placement room in the access tunnel with hoses attached to the retrieval vehicle. Alternatively, the decanting system could be mounted on a unique piece of equipment similar to the placement vehicle. This would allow for a remotely controlled closed-loop bentonite collection and decanting system, integrated into an existing vehicle's power and control infrastructure.

While highly unlikely, it is possible that the slurry removed from the placement room may be classified as very low-level waste (VLLW) or possibly low-level waste (LLW) and would have to be managed accordingly.

7.2 UFC EXTRACTION AND RETRIEVAL

Once the backfill has been removed, the actual UFC retrieval process can be started. The envisaged process has primarily been influenced by the need to ensure a safe retrieval with continuous radiation shielding to allow unrestricted movement of personnel outside of the placement room as well as the effective re-use of placement equipment. The retrieval methodology has been based, to the extent possible, on the reversal of placement operations.

Some of the placement equipment can be re-used for retrieval like the buffer box transfer cask, the shielding canopy and the associated trolleys. The shielding canopy and trolley, for example, would be outfitted with an ejection ram to allow the UFC to be pushed off the retrieval vehicle into the transfer cask. New equipment required for the retrieval operations will include a lift for the UFC, hydraulic cylinder carts and tow vehicles. Retrieval vehicles would be equipped with retractable spray nozzles for high pressure water, lifting forks with individual spray nozzles and, suction tubes for retrieving slurry. Further, equipment for recovery of solids from slurry (hydrodynamic removal and decanting systems) will need to be developed in future.

8. SITE SECURITY AND SAFEGUARDS

The DGR facility will employ security measures for physical protection of nuclear material and the nuclear facilities in order to prevent unauthorized removal and sabotage of nuclear material in use and in storage at the facility. The DGR facility will have safeguards measures which will provide credible assurance of non-diversion and the absence of undeclared safeguards relevant activities.

8.1 SITE SECURITY

The interior section of the surface facilities as well as that area around the Ventilation Shaft Complex will be considered Protected Areas per current Nuclear Security Regulations (SOR/2000-209). The Protected Area boundaries will consist of a physical protection system, with controlled personnel and vehicle access points. Furthermore, the entire surface facility will be surrounded by a fence in order to provide controlled access to vehicles and persons and to prevent intrusion of wildlife.

The Protected Areas physical protection systems will incorporate a perimeter barrier with unobstructed land of minimum 5 m clear distance on both sides of the barrier. In addition, a system of protective elements will be in place to provide multiple layers of delay, detection and assessment that are controlled through a central command post or security monitoring room. The assessment component will enable security personnel to evaluate detected threats and provide the appropriate response. All of these component layers will further be connected to a back-up uninterrupted power supply, located within the Protected Area.

Nuclear Security Regulation (SOR/2000-209) stipulates that the detection and assessment components must each feature two independent systems. The delay component must have additional capabilities to deny intruders using large vehicles from forcing entry. Consistent with these requirements, the systems established to secure the Protected Areas will include:

- A physical barrier to delay intruders for a sufficient period of time to enable effective interception by response personnel and provide sufficient time delay at all points around the perimeter of the facility;

- A detection system to identify intruders immediately and alert security and response personnel; and

- An assessment system, with a dedicated lighting network, to allow security personnel to clearly identify and quantify any possible intrusion.

The various aspects of the site security infrastructure, including those for the Protected Areas, are discussed in this section. For illustrative purposes, their locations in the DGR facility have been shown in the following Figure 58.

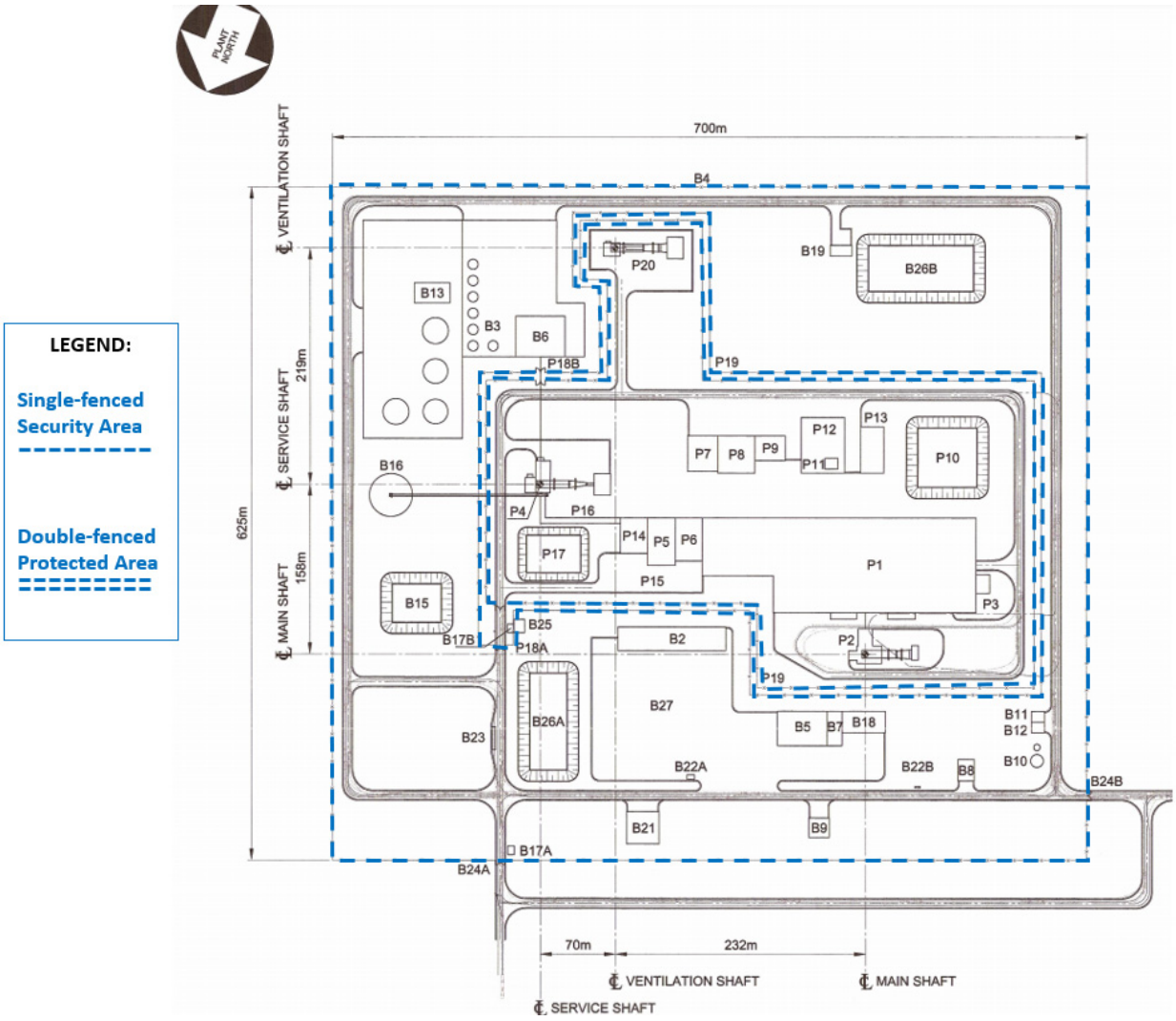


Figure 58: Site Security Components

8.1.1 Security Monitoring Room Area B25

The main security monitoring room will house monitoring equipment including cameras and closed-circuit TV monitors and will serve as the central command point for security surveillance serving both the Protected Areas and the Balance of Site. The security room (Area B25 in Figure 58), located adjacent to the Administration Building, will accommodate four on-duty personnel per shift. Remaining security team members will be on standby in the event of an emergency.

8.1.2 Physical Barrier Systems

There will be two security fence systems in place at the DGR facility. While a double fence (Area P19 in Figure 58) will surround the Protected Areas, a separate perimeter fence (Area B4 in Figure

58) will act to contain essentially all of the DGR's surface facilities, excluding the separately enclosed Ventilation Shaft Complex (Area P20 in Figure 58).

8.1.2.1 Protected Area Security Fence Area P19

A physical barrier system will be constructed to restrict unauthorized access by employees and visitors to the facilities in the Protected Areas. As illustrated on Figure 59, there will be two fences; one inner and one outer barrier each 3 m high above grade. The fences will be set 3 m apart with coils of barbed wire placed in between over a gravel surface. Lighting and monitoring will be in place as discussed below. The ground will be cleared to provide an unencumbered setback of 5 m on either side of the fence to permit visibility and provide moving room for patrol vehicles. Posted signs will identify the restricted access.

In addition, supplementary capabilities will be established to deny intruders using large vehicles access to the main Protected Area. While jersey barriers may typically be used for such purposes, a structure similar to that illustrated on Figure 60 will be installed at the vehicle access point. Two pairs of these movable gates will be established, separated by a space (sally port[1]) sufficiently large to accommodate any vehicle entering the Protected Area.

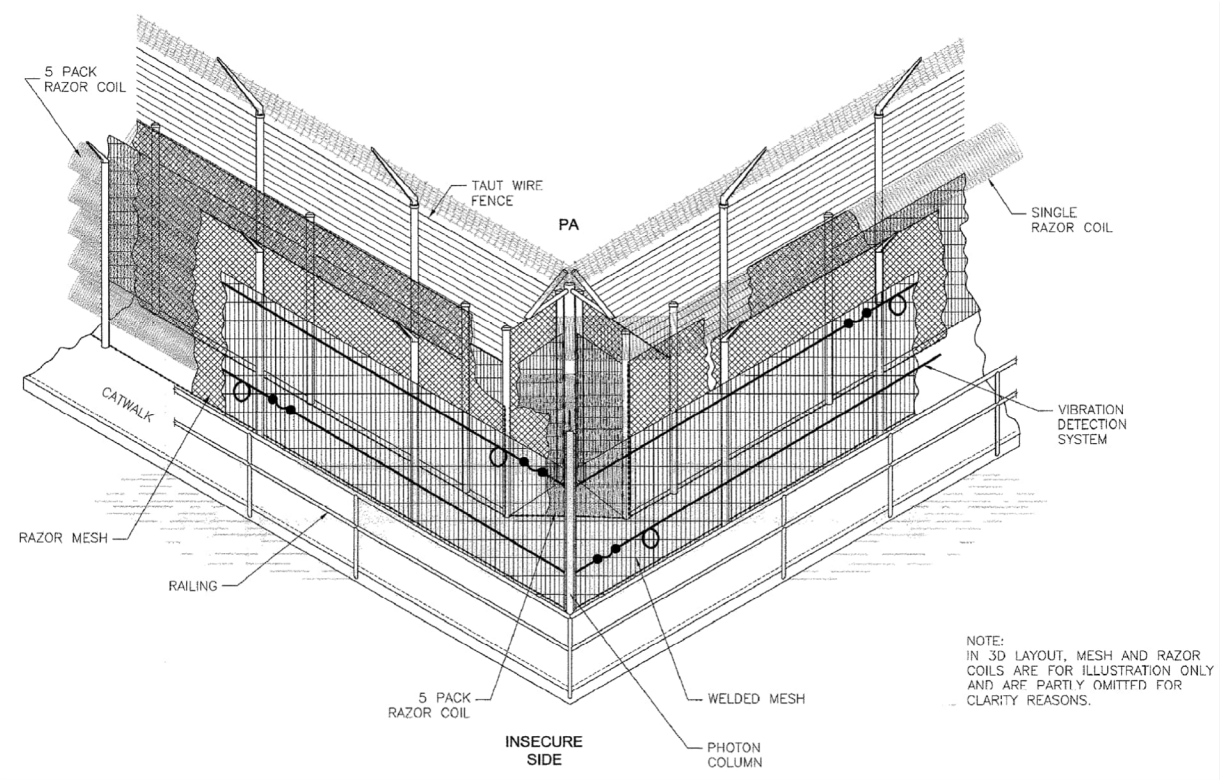


Figure 59: Protected Area Security Fence

[1] A sally port is an intermediate holding area for incoming vehicles. The vehicles are contained by two sets of gates for inspection and clearance.



Figure 60: Vehicle Entry Point

Protected Area Detection System

To detect intruders attempting to gain access into the Protected Areas the following sensor systems will be established:

- Photon sensors installed immediately outside the outer fence to detect and alert security personnel that an intruder is attempting to climb the fence;
- Shaker sensors installed on the outer fence to detect and alert personnel that an intruder is attempting to climb the fence; and
- A taut wire fence 3 m high and located 4 m away from the main fencing including a guy wire and detectors to alert security that an intruder is attempting to gain access.

Protected Area Assessment System

To assess alarm signals sent by the Protected Areas detection system sensors, the following will be in place:

- Each sector of the assessment system will have one dedicated CCTV camera installed on a pole. Every two sectors will have a camera with pan, tilt and zoom capabilities;
- Every two sectors will have one dedicated infrared camera to assist security personnel during poor weather and visibility conditions; and
- An auxiliary remote wireless surveillance camera mounted on the highest point of the facility will compensate for any deficiencies of the preceding equipment.

The installed cameras will be supported by lighting systems situated inside of the Protected Areas' boundaries that are capable of providing the required illumination levels. Additionally, secure mobile phones and satellite phones will permit secure lines of communication between security personnel.

The coordination of these security functions will be carried out through the security monitoring room.

Protected Area Entry Control System

Personnel access to the facility's Protected Area will also be controlled by several integrated security features. These could include entry turnstiles controlled by hand geometry identifiers and exiting turnstiles controlled by a radiation portal monitor. Explosive detectors as well as metal detection devices for personnel and personal articles will additionally be installed. Figure 61 provides an illustrative example of such a system.



Figure 61: Example of Entry Control System

8.1.2.2 Balance of Site Perimeter Fence Area B4

An additional fence will act as a site demarcation (perimeter) feature for the DGR facility while also providing a barrier / deterrent to intruders, including large animals. Entry through the fence will be by the facility access road from the incoming highway. While free access will be provided through this point, 'cattle grates' may also be incorporated to deter large animal entry. The ground will be cleared (minimum 5 m distance) to provide an unencumbered setback on either side of the fence to allow for unrestricted visibility and as a route for future maintenance. Signs will be posted on the fence indicating the purpose of the facility, and its restricted access.

The fence will consist of a 3 m tall, galvanized chain link wire, of heavy gauge construction. Access gates will be of the automatic sliding metal chain link type, with a secondary lift-up barrier. Gates will be controlled by security personnel at the guardhouses and be monitored by the main security monitoring room.

8.1.3 Security Checkpoints and Guardhouses

Several access control points and guardhouses will be established at the DGR facility, as illustrated on Figure 58. These are discussed below.

8.1.3.1 Security Checkpoints Areas P18A, P18B, B24A & B24B

Access to the Protected Areas will be strictly controlled, as discussed above. Regular staff will enter through controlled systems and all visitors, after registering with security staff, will be accompanied by authorized staff members when in the Protected Areas. The adopted system will be capable of tracking personnel into and out of the Protected Areas and maintaining an electronic list of on-site personnel and their locations.

Two Protected Area access control points are to be established; one will allow for vehicular traffic and personnel and the other serves as materials access identified as Areas P18A and P18B respectively on Figure 58. The access control points are described below:

- Checkpoint P18A – will serve as the main vehicular and personnel access point to the Protected Area, and the gate through which the incoming used fuel shipments will pass. This checkpoint will utilize a manned security booth for traffic control and inspections and will provide barriers to deny intruder entry using large vehicles; and also, will provide access to the Auxiliary Building (Area P5). This checkpoint will utilize a manned security station, turnstiles and biometric identification systems for personnel control, with an auxiliary access gate for equipment;

- Checkpoint P18B – will allow access for materials from the Sealing Materials Compaction Plant (Area B6). A manned security booth will be in operation during active hours for the transport of materials to the Service Shaft Complex (Area P4). Personnel access will not generally be through this checkpoint.

Access control points for the Balance of Site will be provided for general security concerns only, such as theft, vandalism, animal intrusion, and general liability (safety). Personnel and vehicular access to the Balance of Site will be controlled through access gates. Two control points will allow for vehicular traffic. Located as indicated on Figure 58, they include:

- Checkpoint B24A – will act as the main access point to the DGR facility. All facility traffic will pass through this point. While the gate will be able to be locked, its status will be controlled by the adjacent guardhouse (Area B17A); and

- Checkpoint B24B – will act as a secondary or contingency access point if needed. Traffic through this area is expected to be minimal, therefore a manned security booth will not be required. Access will be by key and lock.

8.1.3.2 Guardhouses
Areas B17A and B17B

In addition to the checkpoints described above, two guardhouses will be provided for security personnel for the control, verification and authorization of vehicle and staff movements into and out of the DGR facilities.

The first guardhouse will be located at the main entrance to the Balance of Site (Area B17A on Figure 58). A second station will be situated at the entry control point for the Protected Area (Area B17B). Both guardhouses will accommodate a control room and security desk. A secure staging area for vehicles (a sally port) will be provided adjacent to the Area B17B station.

8.2 SAFEGUARDS

The purpose of safeguards measures is to provide credible assurance of non-diversion and the absence of undeclared safeguards relevant activities as prescribed by the IAEA. In the DGR facility, this would be accomplished through nuclear material accounting techniques (to maintain knowledge of the contents of each package) and a containment and surveillance system (to verify the continued integrity and movements of the spent fuel packages to maintain the continuity of knowledge on them). An important aspect of the safeguard system is the security measures. The security measures will provide physical protection of nuclear material and nuclear facilities in order to prevent unauthorized removal and sabotage of nuclear material in storage. Security measures will include technical means and procedures of access control, detection of unauthorized intrusion and response to unauthorized intrusion.

9. OPERATIONAL SAFETY AND MONITORING

The following section addresses operational safety and monitoring initiatives that will be enacted at the DGR facility. The described initiatives have been identified both from a best practice perspective, as well as to meet the objectives set out in domestic and international regulatory and guidance documents (e.g., Canadian Nuclear Safety Commission, International Atomic Energy Agency, etc.).

Conceptual-level design details are provided herein for radiation detection and monitoring systems, fire detection and suppression, facility environmental and performance monitoring, and emergency response procedures.

9.1 OPERATIONAL SAFETY

An occupational health and safety program will be in place and implemented for all periods in the evolution of the DGR when there are workers actively involved. As the project's components involve underground construction and operation as well as the handling of used nuclear fuel, there are significant industrial and radiological components to the program.

9.1.1 Radiological Protection

An important component of the occupational health and safety program will be the radiation protection program. The radiation protection program will comply with the requirements and regulations of the Canadian Nuclear Safety Commission (CNSC). It will describe a set of standards, procedures and reports to ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA), taking into account social and economic factors (CNSC, 2019). The facilities will contain the systems, infrastructure and equipment required to support the radiation protection program and ensure effective application of the ALARA principle. Shielding design criteria are discussed in Section 2.2.6.

All protected areas within the APM DGR facilities' fence will be zoned according to their potential for exposure to external sources, airborne hazards, and loose contamination on surfaces. Four radiation hazard zones have been assigned to various areas of the facility, as noted below.

9.1.1.1 ZONE 1

Zone 1 will be a normally occupied area that is accessible to all staff. As there will be no potential for contamination, Zone 1 areas are considered to be "clean" areas. The dose received by an individual from external radiation sources during continuous occupancy of a Zone 1 area is not to exceed the recommended annual limit to the public in one year. Apart from natural background levels of radioactivity, no other radioactive contamination will be present in this zone.

Zone 1 space will typically include offices, access corridors, lunch / coffee rooms, site lands and roadways. In terms of the DGR facility, the identified 'Balance of Site' (that is, all locations outside of the Protected Areas) will be considered Zone 1.

9.1.1.2 ZONE 2

Zone 2 will normally be free from contamination, except for infrequent cross-contamination from the movement of personnel, materials and equipment from contaminated zones. Chronic recurrences of contamination in Zone 2 will not be tolerated. Continued occupancy of Zone 2 operations will be restricted to Nuclear Energy Workers (NEW), as specified in the Radiation Protection Regulations (SOR/2000-203), with controlled access to those not designated as NEWs.

Generally, all areas with operations with sealed UFTPs and UFC/Buffer Box Transfer Casks within the surface Protected Areas and all underground repository areas, except the placement rooms, will be Zone 2 areas. The underground repository is currently considered to be Zone 2 because the integrity of the UFCs and associated administrative controls will prevent the release of radioactivity.

9.1.1.3 ZONE 3

Zone 3 areas will be normally unoccupied by NEWs. These areas have the potential for contamination because they contain systems and equipment that may be sources of contamination. Controlled access is required for entry by NEWs into Zone 3 areas, along with planned exposure control measures (e.g., protective clothing, respiratory protection, work planning, etc.).

Depending upon the final design details, the only Zone 3 areas associated with the DGR facility will be within the UFPP.

9.1.1.4 ZONE 4

Zone 4 areas will be for hot cells. They are normally inaccessible to NEWs and contain unsealed sources or high radiation fields. All hot cells within the DGR facility will be located in the UFPP and will be designated as such if they have unshielded used fuel sources (e.g., UFTP unloading cells, UFC loading cells, UFC processing cells, etc.).

Surveys and monitoring of the facility will be used to control the spread of contamination and to ensure that radiological conditions at the facility are safe. Routine surveys will be performed to ensure that facility conditions remain constant, that all hazards are identified, and that signage and postage are up to date. In addition, task-specific monitoring and surveys will be performed if deemed necessary during work-planning.

In support of the survey and monitoring requirements, the facility will be equipped with surveying and monitoring instrumentation with alarm settings as required. The system will incorporate the following features:

- Hand and foot monitors, whole-body monitors, small article monitors or portable radiation detection instruments to monitor the movement of personnel and materials across the boundary of radiological control areas into an area of decreased potential for contamination (e.g., from Zone 3 to Zone 2);

- Fixed area gamma monitors located throughout the facility to gauge local dose rates at places routinely occupied by operating personnel;
- Air radiation monitors located throughout the facility, including the exhausts for ventilation systems;
- Radiation vehicle monitors (portable and fixed) at entry or unloading areas; and
- An uninterrupted power supply will be provided for all devices required by the detection and assessment systems (in addition to any associated alarm annunciations).

Doses of radiation will be ascertained and recorded as part of the Radiation Protection Program. A licensed dosimetry service will be used to measure and monitor the doses of personnel who have a reasonable probability of receiving a dose greater than 5 mSv in a one-year dosimetry period. Exposure to naturally occurring radioactive substances (i.e., radon) that result from NWMO activities will also be included in the assessment of doses.

In support of the dosimetry program, the facility will be equipped with the following:

- The use of dosimeters (i.e., thermo-luminescent dosimeters) and direct-reading devices (i.e., electronic personal dosimeters) as appropriate by staff, contractors and visitors; and
- Whole-body counters for annual or quarterly use.

A system will be established to detect, monitor and record any airborne or waterborne releases of radioactivity leaving the site. Before the start of operations, environmental programs will establish baseline conditions at the site for naturally occurring radioactivity (e.g., for naturally occurring radon and uranium) to help differentiate the radiological impact caused by the facility. Further details are provided on the Environmental Monitoring Program in Section 9.2.

9.1.2 Monitoring for Radioactive Releases

A system will be established to detect, monitor and record any airborne or waterborne releases of radioactivity leaving the site. The system will be implemented with the goal to align with the ALARA principle. Prior to start of operations, environmental programs will establish baseline conditions at the site for naturally occurring radioactivity (e.g., for naturally occurring radon and uranium) to help differentiate the radiological impact caused by the facility. Monitoring of releases and of environmental contamination will continue through operations. See Section 9.2 for further details on the Environmental Monitoring Program.

A licensed dosimetry service will be used to measure the radiation dose to all employees who have a reasonable probability of receiving a recordable effective dose due to work at the facility. This exceeds the requirements of the Radiation Protection Requirements, which require the use of a licensed dosimetry service to measure the doses to all employees who have a reasonable probability of receiving an effective dose of 5 mSv or greater in a year.

9.1.3 Fire Detection and Suppression

The following discussion focuses on the underground systems to be put in place as related to fire detection and fire safety. An optimum suppression concept that balances worker and nuclear safety will be established.

The underground portion of the DGR facility will have the following fire protection features:

- Suitable fixed fire suppression systems and portable fire extinguishing equipment in any fire hazard area;
- Fire extinguishing equipment in the mine entrance and at shaft stations; and
- Permanent and portable refuge stations with safety apparatus like breathing equipment, emergency air systems and communication devices to be used by underground workers during emergencies.

In addition, fire detection systems incorporating heat, smoke and carbon monoxide detectors at key points in the facility will also be set up. Key locations for fire detection equipment will include all underground infrastructure rooms, the exhaust ventilation air ducts exiting each placement room, the intake duct for the Main Shaft, and at the main exhaust ducts of the upcast Exhaust Ventilation Shaft. Audible and visual alarms will be activated on detection by any instruments required to do so. A stench gas system will also be used to notify underground workers in the event of an emergency.

All underground vehicles will also be fitted with fire detection and suppression equipment. In total, fire suppression will be achieved through the use of a number of systems both for the equipment and the underground environment. Systems will include the following:

- Hand-held foam-based fire extinguishers mounted throughout the facility;
- Automatic, foam-based fire suppression systems mounted on all heavy equipment;
- An inert gas generator and a portable foam generator for extinguishing any fires that develop in the placement rooms;
- Normal sprinkler and/or fire hose systems for areas where appropriate;
- A water spray deluge system for hazardous environments where fires may spread very quickly or where valuable materials need to be cooled; and
- A water mist system for areas where appropriate.

Breathing air requirements as prescribed by regulatory guidelines and worker health and safety protocols (as applied to firefighting, non-nuclear air contamination, etc.) will be followed.

9.1.4 Emergency Response and Mine Rescue

Procedures for emergency response planning, the notification of releases and incident reporting will meet CNSC requirements and include the utilization of incident command systems to meet the needs of any kind or complexity of situation. For severe incident management (e.g., extreme or violent weather, chemical spills, etc.), various emergency related resources will be available. These will include:

- Pre-planned response procedures (including shutdown protocols);
- Pre-established post-emergency procedures including those for resuming operations;
- Off-site and on-site communications and management protocols, including regulatory notifications and public interaction;
- The services of an Emergency Response Team (ERT) or Mine Rescue Team (MRT); and
- Pre-trained staff that have undergone regular training on emergency response issues.

The primary personnel involved in handling any emergency will reside within an ERT/MRT. These resources would also be supported by on and off-site firemen and first aid attendants as well as

the DGR's various superintendents and shift managers. Communications staff will be available to coordinate and assist in the required incident communications activities.

Emergency response requirements have been incorporated in the design of the facility (e.g., fire protection and suppression, egress and refuge, secondary repository egress, etc.) as well as identification of services to support response (e.g., mine rescue, fire rescue) for the various phases of the DGR.

9.2 ENVIRONMENTAL MONITORING PROGRAMS

Prior to the start of construction, the environmental monitoring program will collect data to establish baseline conditions. Thereafter, the program will monitor for any changes that may be imposed on the environment due to construction activities and ultimately the operation of the DGR facility. Monitoring requirements for the postclosure period will need to be re-examined as part of the final plan for decommissioning and closing the site.

The environmental monitoring program will be comprised of the following components:

- Radiological monitoring;
- Groundwater quality and levels monitoring;
- Monitoring of surface water and stormwater;
- Air quality monitoring; and
- Meteorological monitoring.

The following sections address each of the program components. The final elements will be developed as part of the formal licensing process for the DGR. The expectation is that the program will provide reliable, accurate and timely data in a fashion that is easily audited.

9.2.1 Radiological Monitoring

As a nuclear facility, radiological environmental monitoring will be established around the site as required to support compliance with the licensing conditions, which may include the Canadian Standards Association (CSA) Standard N288.4, Environmental Monitoring Programs at Class 1 Nuclear Facilities and Uranium Mines and Mills.

9.2.2 Groundwater Monitoring

Baseline hydrogeological studies will establish a conceptual groundwater system model that will describe site-specific properties, hydrostratigraphy and system behaviour. From the groundwater system model, features will be identified that should be monitored during the construction and operation of the DGR facility. Such features will encompass the groundwater regime at the DGR site, as well as any nearby community or individual water supply wells.

Potential groundwater impacts arising from operation of the DGR could include localized influence on near-surface groundwater flow patterns and/or the potential for non-radiologic contamination from, for example, chemical or fuel oil spills. Monitoring well locations will include those installed to characterize and establish baseline site conditions and those installed during the construction phase. In total, the monitoring well network is anticipated to be up to 100 wells. The wells will be

positioned within key sub-surface pathways both up- and down-gradient of potential on-site contaminant source areas (e.g., the excavated rock storage areas and on-site ponds) to allow reliable monitoring and detection of potential groundwater impacts, if any.

Representative water supply wells for any proximate community, as well as strategically positioned points between these and the DGR site, will also be included in the program.

Groundwater parameters monitored will include those related to groundwater flow (i.e., hydraulic head) and quality (i.e., non-radiologic; radiologic). Groundwater samples will be collected and analyzed on a quarterly basis. Assessment of groundwater quality impacts would be performed annually with 5-year reviews conducted to assess monitoring program adequacy and effectiveness.

9.2.3 Stormwater / Surface Water Monitoring

Stormwater runoff from the developed site (roads, parking areas and rooftops) can lead to increased flows and downstream erosion. Stormwater management ponds are designed to attenuate the variations in flow conditions while also being designed to detain and settle out sediments associated with runoff. They will also provide retention to allow sampling to confirm effluent limits are met prior to discharge and accommodate some emergency storage in the event effluent limits are exceeded and discharge is not allowed.

The monitoring program will be focused on the measurement of flows and water quality at the pond discharge points to confirm that water quality meet limits set in permits for the ponds. In the remote event that pond discharge water quality is found to exceed the limits then corrective actions will be taken to ensure the maintenance of regulatory compliance.

Pond water samples will be analyzed for a full suite of conventional parameters including anions and cations, metals, oil and grease and nutrient compounds. Sediment samples will additionally be collected from each pond and analyzed for trace metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, total organic carbon, nutrients, and oil and grease.

Grab samples from the inlet and outlet of each pond will be examined for the identified parameters on a regular basis and as required by the permit for these facilities. Sediment samples will be assessed on an annual basis.

The monitoring program will also encompass surface watercourses and bodies outside the DGR site footprint and at nearby communities. Sampling locations will be selected to characterize water quality and flows both upstream and downstream of the DGR site in the local watersheds. Gauging locations will further be established to measure surface water elevations and flows. Water quality and hydrologic conditions will be monitored using both automatic and manual sampling techniques.

9.2.4 Conventional Air Quality Monitoring

For the above-ground environment, ambient air quality monitoring locations will be established both in the predominant downwind direction of the facility (including one at the nearest community)

as well as upwind of the site. The underground ventilation system will be exhausting into the atmosphere and thus it will be necessary to monitor potential discharge impacts on the local air shed.

The air quality in the underground repository will be monitored, the underground air monitoring equipment will include hand-held instruments (see Figure 62) as well as in-situ continuous emission monitoring devices.



Figure 62: Manual Air Quality Monitoring

9.2.5 Meteorological Monitoring

A weather monitoring station will be installed and operated at the DGR site. Using tower-mounted instrumentation, the station will provide site-specific and continuous meteorological data to assist in the ongoing operations of the facility. Real-time measured parameters will include:

- Ambient temperature;
- Relative humidity;
- Dew point;
- Barometric pressure;
- Wind speed;
- Wind direction;
- Rainfall; and
- Solar conditions.

9.3 SEISMIC AND VIBRATION MONITORING

Earthquake ground motions could occur during the operating life of the DGR facility. To provide adequate protection for workers, the public and the environment, the DGR facility will be designed to withstand the effects of a potential strong earthquake ground shaking at the site.

A regional seismic monitoring network will be established prior to start of construction to collect seismic data. These data combined with historic seismic data will be used to assess the seismic hazard at the proposed DGR site and will provide data for the seismic design of the DGR facility. The seismic monitoring will continue to operate during the operating life of the DGR facility for the purpose of confirming that risk of unacceptable earthquake ground shaking event is still low.

Ground vibration or movement is a commonly examined characteristic at underground mines. Ground vibration may occur due to blasting or due to failure within rock mass as result of stress redistribution around rock excavations. Significant ground vibration events are not anticipated at the DGR site because site selection criteria are favouring sites that have large masses of

competent rock. In any event, a series of geophones will be installed to create an underground vibration monitoring system. This system will be used to confirm any vibrations that are sensed are well below acceptable levels at key underground locations (e.g., placement rooms receiving UFCs). A series of geophones will be grouted into short boreholes drilled into the roof and floor of the underground openings at repository level and into the shaft sidewalls at various elevations. A typical geophone is shown in Figure 63.



Figure 63: Geophone

9.4 GEOTECHNICAL MONITORING

Geotechnical monitoring will be performed during the construction of the underground repository openings to measure and confirm in-situ rock behaviour. Rock movement and changes in rock stress will be monitored at selected locations as follows:

- **Rock Movement Monitors**: extensometers will be installed within short boreholes in the shaft walls and the roofs of underground rock openings to monitor for rock movement; and

- **Stress Cells**: stress cells will be installed within the concrete shaft liner and at the rock / concrete shaft liner interface. Stress cells will be installed in the roofs of underground rock openings to measure any changes in rock stress as a result of excavation work and/or heating of rock due to heat loading by the UFCs.

9.5 QUALITY ASSURANCE / QUALITY CONTROL FOR MONITORING

Quality assurance / quality control procedures will be implemented throughout the monitoring programs to ensure thoroughness and accuracy of the data. In this regard, the programs will include the following measures (among others) to ensure a high degree of confidence in the collected information:

- Strict adherence to standard protocols for the collection, preservation, storage, handling and shipping of samples and for in-situ sampling;
- A field quality control program, including the submission of travel and field blanks and duplicate samples;
- Implementation of a quality control program for the laboratory analyses; and
- Timely review of analytical results to identify areas of concern (including potential impacts).

Annual and quarterly status reports will be prepared to summarize the activities as related to the environmental monitoring program. The results of the ongoing QA/QC activities will be incorporated in these reports.

9.6 CENTRAL TAGGING SYSTEM

A central tagging system will be put in place at the DGR facility to monitor the movements and quickly locate all facility personnel, equipment and tools (including radiation-impacted objects). The system will be coordinated out of a central control area which will receive wireless signals from transmitting / receiving devices assigned to on-duty personnel and installed on each facility vehicle or asset. Conceptually, the tagging system will operate as follows:

- A wireless tag will be provided to a person and/or attached to a piece of equipment when entering the DGR facility check-in point;
- As the person / equipment moves through the DGR facility, the associated tag is read by other multiple wireless readers positioned in various locations in the facility;
- In terms of hard assets, once the item reaches its destination, a tag reader will allow a cross-check to be made to confirm that it is supposed to be at that location;
- Items incorrectly received will be flagged for removal and re-routed; and
- When an item or person leaves the facility, the associated wireless tags are read at the exit point.

This tracking system will assist operational personnel and increase worker safety. It will also allow for the remote management of all assets by identifying their exact location.

In the underground environment, the collected data will be transmitted using a leaky co-axial and fibre optic system, which will relay information from the source instrument or electronic device to the surface control room. As illustrated on Figure 64, such a system consists of cables running along the tunnels and in shafts which emit and receive digital transmissions. The digital information is transmitted by fibre optic cable.

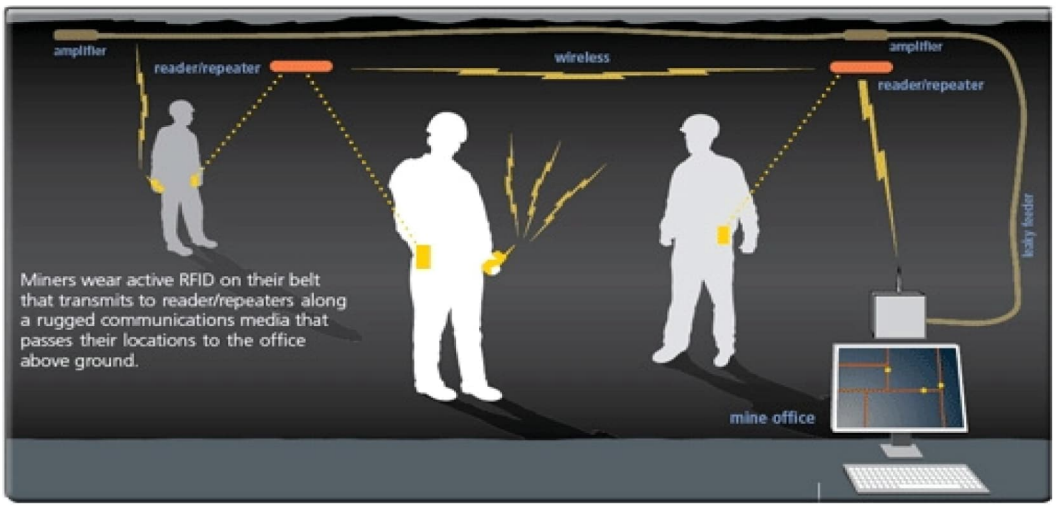


Figure 64: Typical Wireless System for Underground Mining Operation

10. DECOMMISSIONING AND CLOSURE

Subsequent to the cessation of used fuel placement activities and the 70-year extended monitoring period, the following series of actions will take place:

- 10-year decommissioning period;
- 15-year closure period; and
- Postclosure period.

These activities are the subject of this section, following a brief discussion of certain key issues that will impact upon the decommissioning and closure (D&C) work and the staged, progressive development of D&C planning. Actions undertaken during the D&C period will be designed to return the selected site and related facilities to the desired end-state. As discussed below, such planning will commence with the preparation of a Preliminary Decommissioning Plan structured to meet the requirements of REGDOC-2.11.2 (CSNC, 2021b), Decommissioning, and CSA Standard N294-09 (R2014), Decommissioning of Facilities Containing Nuclear Substances**.**

10.1 KEY ISSUES

Several issues have the potential for a material impact to D&C planning and implementation. Such issues include the final site selection, the status of container retrieval initiatives, the potential for advancements in associated technologies, and the direction received from regulatory bodies. These factors are outlined below.

10.1.1 Container Retrieval

The possibility for future container retrieval has a potential major impact on the implementation and staging of D&C activities. For example, a decision following completion of placement activities to forego the possible retrieval of buffer boxes (with UFCs) would allow a number of surface facilities to be decommissioned near the start of the extended monitoring period. On the other hand, under the approach that the potential for retrieval must remain open during the 70-year extended monitoring period, many surface and underground facilities will need to be inspected and maintained over the full 70-year period (or until a decision has been taken that the ability to retrieve buffer boxes is no longer required).

10.1.2 Advancements in Associated Technologies

The described initiatives within this section have been identified from, in part, a current best-of-practice perspective and feasibility perspective. Decommissioning and closure activities will occur in the future (in excess of 100 years from now) and it is likely that new technical solutions will be available at that time. These new solutions would be considered and, if appropriate, used to decommission and close the DGR facility.

10.2 PLANNING FOR DECOMMISSIONING AND CLOSURE

Major decommissioning and closure activities include the following:

- Initial preparation of the Preliminary Decommissioning Plan near the start of preliminary design at the preferred site. Progressive updates over the course of the preliminary and detailed design stages of work, as well as for the period of used fuel placement. The maintained and updated plan will support periodic licence renewals throughout the DGR operations based on current codes, regulations and standards and incorporate relevant advances in technology. The plan will evolve throughout this period to continually represent the current as-built status of the facility, and operational and maintenance experience gained during placement;

- Following operations and at the commencement of the 70-year extended monitoring period, a material revision to the Preliminary Decommissioning Plan will be made. The plan will be subject to a special detailed review in order to finalize requirements for the extended monitoring period. As a significant portion of the effort spent during the extended monitoring will be focused on the design of facilities needed to support decommissioning and closure, this review will assist in providing directions and recommendations for this work. Several key parameters that may be monitored for an extended period are rock temperature, rock stress / displacement (response to thermal loading), water ingress, emplacement room seal performance, ground water quality, ground water radioactivity, humidity and acoustic emissions. This revision will be progressively updated over the course of the extended monitoring phase. Any updates would consider experience gained, as well as regulatory or technology updates. The evolving D&C plans will also provide updated directions and recommendations for facility maintenance or even early removal and disposal of component operations, where appropriate;

- Another material revision to the plan will be made prior to the commencement of the 10-year decommissioning period, using information collected during extended monitoring phase. The resulting Detailed Decommissioning Plan will support the application for regulatory approval to start decommissioning and closure work. The plan will be based on a fully defined methodology and procedures for implementation. It will form the basis for contracting and managing the implementation activities. Progress reports would be published over the course of the decommissioning stage;

- Assembly of the final material revision to the plan will be made at the start of the 15-year closure period, based on information collected to that point in time and documenting the results of the decommissioning work. Progress reports would also be produced during the closure period; and

- Preparation of a postclosure report documenting the results of decommissioning and closure activities.

Regular maintenance of the evolving D&C plans will help ensure that the site programs and designs remain consistent with up-to-date and relevant internal / external decommissioning experience. It will also act to ensure that licensing and other regulatory requirements are continually met with regards to site safety, security and access control needs.

The D&C plans will all be designed, prepared and maintained to achieve the return of the site and related facilities to the desired end-state.

10.3 DECOMMISSIONING AND CLOSURE OF UNDERGROUND FACILITIES

Following the receipt of regulatory approval and the licence to decommission and close the DGR facility, underground facilities are expected to be removed first, in parallel with those surface facilities not required to support the remaining underground decommissioning and closure activities.

Decommissioning of underground facilities will involve the removal of operational systems and furnishings, the interim installation of temporary services and furnishings, and the repair and preparation of exposed rock surfaces for sealing. As currently envisaged, the decommissioning and closure activities will be carried out in several stages and will include activities related to removal of ground support (if feasible) and material handling systems, the sealing of underground horizontal openings, and the sealing of shafts and boreholes.

10.3.1 Sealing of Underground Horizontal Openings

The sealing of underground horizontal openings will consist of closing off access tunnels and ancillary facilities. Such activities would commence with the removal of instruments from boreholes (and sealing the boreholes) followed by the preparation of exposed rock surfaces and removal of loose rock before backfilling and sealing. The central access tunnels would then be backfilled, with sealing bulkheads installed at strategic locations where conditions dictate.

The key functional requirements for various components of sealing system will be as follows:

- Fill the entire excavated volume of each area being sealed;
- Resist physical and chemical deterioration by the local environment, which includes the preclosure and postclosure geochemical conditions;
- Limit the rate of groundwater flow to and from the sealed placement rooms; and
- Limit rate of potential radionuclide migration from placement room and, if released from rooms, radionuclide migration along various underground tunnels and within the shafts.

Sealing of the underground openings will be achieved by using materials and methodologies similar to that used within the placement rooms. The clay-based fill material would occupy most of the underground tunnel space. At strategic locations seals comprised of HCB blocks would be constructed which would be complemented by a concrete bulkhead. These bentonite seals and concrete bulkheads would likely be installed near access tunnel intersections and also near intersections with significant zones (as appropriate).

The key functional requirements for the concrete bulkheads will be to provide mechanical restraint against the forces exerted by swelling clays or pressures from other repository sealing systems, the surrounding rock mass or other sources. The bulkheads will further act to keep the sealing

materials isolated in their intended locations and protected from any adverse conditions that may exist in adjacent unsealed excavations.

The sealing of the access tunnels will be carried out ensuring that the required tunnels are maintained open to provide ventilation to working areas. Therefore, the sequence for tunnel closures will consist of sealing all tunnels in a retreating manner from the Exhaust Ventilation Shaft to the Service Shaft. Local ventilation systems using portable exhaust fans and duct tubing will be exhausted into the flow-through ventilation system. Periodic crossovers between the tunnels will be used to provide flow through ventilation and to draw air from the work areas.

10.3.2 Sealing of Shafts

Sealing of the shafts is the last step in the closure of the DGR. This activity starts when the sealing of underground openings and ancillary areas is complete. At that time, the following activities are envisioned:

- Removal of shaft services including compressed air lines, water lines, power supply and lighting cables, and communication cables;
- Removal of instruments from any impacted boreholes and sealing of each borehole;
- Removal of furnishings including all of the shaft guides and sets, steel support brackets, brattice and lower crash beam assemblies from bottom to top while backfilling; and
- Reaming of the shafts (as required) to remove the concrete linings and any highly damaged wall rock.

Thereafter, each shaft will be re-equipped with services and staging, and backfilling will commence with sealing bulkheads installed at strategic locations.

A generic shaft seal design is presented in Table 19 and shows a shaft seal for the nominal 500 m repository depth. The design assumes removal of 500 mm-thick annulus of highly damaged rock before sealing materials are placed and the concrete bulkhead is keyed into the rock in a conical shape to a depth of 0.5 times the radius of the shaft. The repository depth will be between 500 - 800 m and the shaft sealing design will be updated in each region to suit site specific geologic conditions as site investigations continues.

Table 19: Generic Shaft Seal Design

Component Depth	Shaft Seal Component
0 - 20 m	LHHPC – concrete cap at surface
20 - 150 m	70/30 bentonite-sand shaft seal compacted in-situ
150 – 170 m	LHHPC for concrete bulkhead keyed into rock to a depth of 0.5 times the original radius of the shaft
170 – 330 m	70/30 bentonite-sand shaft seal
330 – 380 m	Asphalt seal
380 – 480 m	70/30 bentonite / sand shaft seal compacted in-situ
480 – 500 m	Concrete monolith - LHHPC

The shaft sealing system is based on the assumption that all shafts will intersect low permeability rock over the full depth of the shafts. However, it is possible that the DGR shafts will intersect relatively permeable rock near ground surface. If so, then engineered fill material based on rock excavated during shaft sinking or some other suitable material will be used in the upper portion of each shaft. This engineered fill would likely be placed from surface to a depth where low permeability rock is first encountered.

The shaft seal design concept has focused on the use of simple, relatively well understood and durable materials, and use of proven methodologies for placement. Concrete, bentonite/sand mixture and asphalt will be the sealing materials used in each shaft. Additional information about each major component of the shaft seal system is presented below.

Concrete monolith will be placed at the base of the seal system. Concrete will provide a stable foundation for the overlying seal materials. The monolith will be constructed in stages beneath each shaft. Each monolith will form a contiguous mass concrete structure with no structural reinforcement within the concrete. All services and utilities will be stripped out of the excavations to be filled by the monolith.

Bentonite/Sand Seal: The column of sealing materials in each shaft is largely composed of a compacted bentonite/sand mixture. Once saturated, the compacted bentonite / sand materials will act as a low permeability barrier to retard the movement of radionuclides out of the repository and minimize the potential for groundwater flow down into the repository. Compacted clays or clay/sand mixtures are the most commonly proposed sealing materials for nuclear waste repositories. Sand will be added to the bentonite to act as a filler without compromising the hydraulic conductivity and swelling potential of the bentonite dominant material. The use of sand will improve workability during placement, ease compaction and dust control. As the compacted bentonite/sand materials saturate with groundwater from the surrounding rock, they will generate swelling pressures, which will aid in the development of a tight seal against the shaft wall and provide a confining pressure to the rock surface.

Asphalt Seal: An asphalt column will be placed above the lowermost bentonite / sand column. Asphalt has been selected because it has the ability to flow and make good contact with host rock. Immediately upon emplacement, the asphalt will create an effective barrier to water flow. Furthermore, the use of another low permeability sealing material provides an additional level of redundancy to the sealing system against upward or downward fluid flow.

Concrete Bulkhead: The primary function of the concrete bulkhead will be to provide structural support in the column of sealing materials. In the short-term the concrete will act as an additional seal and over the long-term the ability to act as a seal will diminish as concrete degrades. As with the monolith, concrete for the bulkhead will be placed in mass and with no reinforcing steel and using measures to control heat build-up. Contact/seal grouting will be applied around the bulkheads to minimize the potential impacts of shrinkage at the interface with the host rock formation. Concrete will be poured directly onto the bentonite / sand columns located below each bulkhead.

Concrete Cap: A surficial concrete cap will be installed on each shaft to minimize risk of human intrusion into the underground repository via shafts. The cap will be constructed using concrete. Air entrainment within the concrete is required to minimize adverse effects of freeze/thaw action on the concrete cap.

10.3.3 Sealing of Boreholes

The purpose of sealing a borehole (e.g., monitoring boreholes) is to inhibit groundwater movement and contaminant transport along the borehole and in the near-field rock parallel to the borehole axis. Cement-based sealing materials will be installed where required to isolate fractured and highly permeable zones because of their low hydraulic conductivities and their groundwater resistance. Clay-based materials with low permeability and a high swelling potential will be installed in adjacent zones.

Sealing of boreholes is commonly practiced in the construction and resource industries to decommission water and monitoring wells. As the geological features intercepted by each borehole will not be identical, a thorough review will be conducted on all available core and borehole logs and down-hole test results to ascertain the preferred sealing approach for each location.

Investigation boreholes will generally be located outside the footprint area occupied by the underground repository. Exceptions would be investigation boreholes at each shaft locations.

10.4 DECOMMISSIONING OF SURFACE FACILITIES

During the 10-year decommissioning period, some supporting surface facilities will be dismantled and removed from the site. The surface facilities and related services will be evaluated and classified in the D&C planning to identify if they are required to support underground decommissioning and closure activities. The sequencing described in this section and suggested in Table 20, is based on an initial evaluation in this respect which resulted in the placement of each component or service in a comparative position on the decommissioning time queue.

In general, the majority of surface facilities will not be decommissioned until the underground operations have been dismantled and removed, with the access tunnels and shafts sealed as planned. These activities will be the primary focus for concrete and special sealing materials which require an operating surface facility and an underground hoisting operation.

Table 20: Surface Facility Classification for Decommissioning

Area	Protected Area	Primary Function	Comments
P1	Used Fuel Packaging Plant (UFPP)	UFC processing	Decommissioned with underground (U/G) facilities. Once no UFC retrieval is contemplated the UFPP can be demolished.
P2	Main Shaft Complex	Provide U/G access	Can be decommissioned as last step of U/G D&C.
P3	Stack	Related to UFPP	Will be decommissioned with the UFPP.
P4	Service Shaft Complex	Provide U/G access	Can be decommissioned as last step of U/G D&C.
P5	Auxiliary Building	Related to U/G access	Can be decommissioned as last step of U/G D&C.
P6	Active Solid Waste Handling Facility	Related to operation and decontamination	Will be decommissioned as part of Protected Area facilities.
P7	Waste Management Area	Related to operation and decontamination	Will be decommissioned as part of Protected Area facilities.
P8	Active Liquid Waste Treatment Building	Related to operation and decontamination	Will be decommissioned as part of Protected Area facilities.
P9	Low-Level Liquid Waste Storage	Related to operation and decontamination	Will be decommissioned as part of Protected Area facilities.
P10	Stormwater Management Pond	Related to total project	Will be part of closure activity.
P11	Switchyard	Related to total project	Will be part of closure activity.
P12	Transformer Area	Related to total project	Will be part of closure activity.
P13	Emergency Generators	Related to total project	Will be part of closure activity.
P14	QC Offices and Laboratory	Related to total project	Will be part of closure activity.
P15	Parking Area	Related to total project	Will be part of closure activity.
P16	Covered Corridor / Pedestrian Routes	Related to total project	Will be decommissioned consistent with connected structures.
P17	Mine Dewatering Settling Pond	Related to decommissioning of U/G	Cannot be decommissioned until U/G decommissioning is complete.
P18	Security Checkpoints	Related to total project	Will be part of closure activity.
P19	Double Security Fence	Related to decommissioning of U/G	Cannot be decommissioned until U/G decommissioning is complete.
P20	Ventilation Shaft Complex	Related to U/G access	Can be decommissioned as last step of U/G D&C.

Area	Balance of Site	Primary Function	Comments
B1	Excavated Rock Management Area	Related to total project	Will be part of closure activity.
B2	Admin. Building, Firehall, Cafeteria	Related to total project	Will be reconfigured as part of closure activity.
B3	Sealing Material Storage Bins	Related to decommissioning of U/G	Cannot be decommissioned until U/G decommissioning is complete.
B4	Perimeter Fence	Related to total project	Will be part of closure activity, possibly reconfigured.
B5	Garage	Related to total project	Will be part of closure activity.
B6	Sealing Materials Compaction Plant	Related to decommissioning of U/G	Cannot be decommissioned until shaft sealing is complete.
B7	Warehouse and Hazardous Mat'ls	Related to operation and decontamination	Will be decommissioned with Protected Area facilities.
B8	Air Compressor Building	Related to total project	Will be part of closure activity.
B9	Fuel Storage Tanks	Related to total project	Will be part of closure activity.
B10	Water Tanks	Related to total project	Will be part of closure activity.
B11	Water Treatment Plant	Related to total project	Will be part of closure activity.
B12	Pump House	Related to total project	Will be part of closure activity.
B13	Concrete Batch Plant	Related to decommissioning of U/G	Cannot be decommissioned until shaft sealing is complete.
B15	Service Water Settling Pond	Related to decommissioning of U/G	Cannot be decommissioned until shaft sealing is complete.
B16	Excavated Rock Stockpile (working)	Related to total project	Will be part of closure activity.
B17	Guard Houses	Related to total project	Will be part of closure activity.
B18	Storage Yard	Related to total project	Will be part of closure activity.
B19	Sewage Treatment Plant	Related to total project	Will be part of closure activity.
B20	ERMA Storm Pond	Related to total project	Will be part of closure activity.
B21	Helicopter Pad	Related to total project	Will be decommissioned at end of decommissioning period.
B22	Bus Shelters	Related to operation until start of D&C	Will be decommissioned at end of decommissioning period.
B23	Weigh Scale	Related to total project	Will be decommissioned at end of decommissioning period.
B24	Security Checkpoints	Related to total project	Will be part of closure activity.
B25	Security Monitoring	Related to total project	Will be part of closure activity.
B26	Stormwater Management Ponds	Related to total project	Will be part of closure activity.
B27	Parking Area	Related to total project	Will be part of closure activity.

Once the shafts have been sealed, the surface facility decommissioning will proceed generally in the following sequence:

- The UFPP, hoisting systems, and all other facilities in the (formerly) Protected Areas will be dismantled, removed, and sent off-site for disposal or recycling;

- Approval will be obtained to remove the Protected Areas' fencing and security systems, and they will also be subject to disposal or recycling;

- All surface facilities not required for the maintenance of site administration and staff-related purposes (the administration-focused systems) will be dismantled and removed (e.g., service water settling pond, hazardous material storage, etc.);

- At this point the site status will be an Administration Building supported by electrical utilities, water and sewage treatment, parking, and the perimeter fence; and

- Reconfiguration of the remaining administration facilities and utility services into a suitable package to support the postclosure period. The balance of site will be rehabilitated to greenfield conditions.

10.4.1 Decontamination

The issue of decontamination during decommissioning is expected to be of potential significance solely from the perspective of radiological matters. After placement operations are complete, operations staff will decontaminate the UFPP and other surface facilities except for fixed contamination in the concrete surfaces or equipment which will be addressed during decommissioning. It is expected that proper practices during the DGR's operational period will have effectively eliminated any residual concerns with other forms of hazardous materials.

The strategy adopted for decontamination, therefore, is based on the facility being free of loose surface contamination, with design elements intended to minimize the amount of fixed or exposure-based radioactive waste.

Although the radiological facilities will have been surveyed and loose contamination removed following the end of operations, the first step will be to re-survey and confirm the loose contamination-free status and the current exposure rate levels where fixed contamination or material sources exist. Following the removal, packaging and disposal of any contaminated material or removable equipment found (including any additional wastes generated in addressing concrete surfaces), the initial radiation survey would be repeated to confirm the absence of contamination.

The survey and clean-up activities will be carried out for all appropriate facilities including the underground facilities (if needed).

10.5 CLOSURE AND POSTCLOSURE

A minimized administration area will be maintained during the closure period in order to support the post-decommissioning monitoring systems. If at that time it is felt that permanent facilities are

no longer required, the monitoring systems could be supported by small enclosures for the electrical equipment, and all other remaining facilities would be removed, and the site essentially fully returned to its intended end-state.

The facility's environmental monitoring carried out during the operational and extended monitoring periods, as well as throughout the decommissioning stage will further be continued into the closure and postclosure periods. While the level of monitoring will be reduced, it is expected that the program will still address (at a minimum) groundwater and surface water quality issues, to ensure compliance with regulatory requirements.

In addition, safeguards containment / surveillance monitoring (e.g., an acoustic emissions or micro-seismic network) will be considered on the surface in the rock above and around the DGR to detect any noise that might be associated with an attempt to excavate into the repository. In all respects, inspections and containment / surveillance measures will continue for as long as necessary to ensure the full safeguarding of the sealed DGR.

As the closure period nears its end, the final approval to release the site for public surface use (with underground access excluded) will establish any final postclosure long-term monitoring needs. At that point, the monitoring would be finally configured, fenced and signed as required, and the site released in accordance with the obtained approvals.

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APPENDIX A: USED FUEL CONTAINER AND BUFFER BOX DESIGN

The used fuel container (UFC) and the bentonite buffer are the key components of the engineered barriers.

The role of the used fuel container (UFC) is to provide containment for used CANDU (CANada Deuterium Uranium) fuel and any other fuel deemed acceptable for the repository in accordance with the Nuclear Fuel Waste Act (S.C. 2002, c.23) and NWMO's waste acceptance criteria.

The role of the buffer is to:

- Inhibit microbiologically influenced corrosion;
- Fill the excavated volumes and support the surrounding rock;
- Inhibit flow and act as a sorption agent;
- Support the container; and
- Transfer heat to the surrounding rock.

The UFC uses standard available materials and can be packaged into Buffer Box bentonite assembly to:

- Facilitate construction and operations of the facility;
- Provide greater certainty of container placement state;
- Efficiently use raw materials (e.g., copper); and
- Improve system performance during the post closure evolution of the repository.

The UFC is designed to use readily available, pre-qualified ASTM/ASME pipe and plate (to form the hemi-spherical head) for the steel core. The corrosion barrier is a copper coating that is bonded directly to the external surface of the steel core. Copper coating eliminates creep performance concerns, avoids the need for micro-alloying, and requires significantly less copper than having a separate outer copper shell.

The relatively smaller and light-weighted used fuel container provides an opportunity to pre-pack the highly compacted bentonite around the UFC at surface. This eliminates the need to perform tight tolerance work in a radiological environment underground. Once packaged, used fuel container placement is completed by using specialized vehicles with modified handling attachments to place the container underground.

A.1 Design Requirements

Although there are many requirements, below are the primary design requirements that must be met. These apply to the container and the bentonite buffer.

A.1.1 Used Fuel Container

1. Material – The steel vessel materials shall meet the minimum strength and impact toughness requirements of the ASME Boiler and Pressure Vessel Code for the service conditions intended by the design. The materials shall be resistant to radiation-induced and hydrogen-induced embrittlement.

2. Container design – Container shall be designed to withstand the normal and accident loads during operation and handling and the loads in the repository. The pre-closure performance and post-closure performance of the container shall support the performance targets in the safety case.

   Loads during operation and handling:
   a. Normal operation load – mechanical loads introduced during the normal operation and handling.
   b. Seismic loads – shaking load and the dynamic load associated with rock falls caused by earthquakes.
   c. Impact load – dynamic impact load associated with normal operations and handling accidents.
   d. Fire load – thermal load associated with a fire accident.

   Loads in the repository include:
   a. Interglacial hydrostatic load – hydrostatic load that would be associated with a water column from repository depth to the surface of the repository site;
   b. Glacial hydrostatic load – hydrostatic load that would be associated with a water column from repository depth to the surface of an icesheet of three kilometers in thickness covering the repository site;
   c. Buffer swelling load – mechanical load exerted on the UFC by the expansion of the buffer material in the form of contact pressure. The magnitude and distribution of this load depends on the saturation level of the buffer material;
   d. Seismic shaking load – dynamic load induced by earthquake in the repository;
   e. Internal pressure – pressure caused by the gas trapped inside the UFC; and
   f. Shear load – displacement load exerted on the UFC due to the relative movement of the surrounding rock along fracture lines. Such a load can be applied in a short duration, such as rock movement during an earthquake; it can also be slowly applied, such as rock movement due to long term geological evolution.

3. Leakage tightness – the container shall be leak-tight to maintain its function as containment.

4. Corrosion resistance – the materials, especially the corrosion barrier material, shall be resistant to corrosion in the DGR environment with a predictable corrosion rate. The following corrosion allowance shall be considered:

    a. an allowance for corrosion attributable to all of the oxygen trapped in the repository;
    b. an allowance for all of the chloride that may be present or flow through the repository;
    c. an allowance for sulphide that might be present in the buffer and any sulphide produced by sulphate reducing bacteria;
    d. an allowance for sulphide that might be present or produced in the rock that is capable of migrating to the container;
    e. an allowance for microbially induced corrosion and/or corrosion events that combine trapped oxygen, water and radiation to damage the inside of the container; and
    f. an allowance for flaw size detection limit.

A.1.2 Bentonite Buffer

1. Dry density – The dry density of the emplaced buffer shall be adequate to:
    a. Suppress microbial growth – Microbes are suppressed at Water Activity < 0.96 which is achieved with the dry densities above; and
    b. Provide interface contact pressure – The dry densities specified above generate a minimum of 100 kPa of interface contact pressure to ensure voids are filled in the room and to provide support to the container and excavated damage zone.

2. Heat Transfer – Bentonite geometry and container spacing shall be selected to sufficiently transfer heat to keep the container surface temperature below 100°C.

A.2 Used Fuel Container (UFC)

A.2.1 Used Fuel Container Description

The UFC is the main containment barrier in the engineered barrier system. Its primary safety function is to confine the radioactive material over a time frame in the order of 1 million years. This safety function would be fulfilled by:

1. Maintaining the UFC configuration and integrity against internal and external loads; and

2. Controlling the corrosion rate of the UFC materials so that containment can be maintained within the time frame of interest.

The UFC configuration and integrity will be maintained by a structural vessel designed to withstand loads. The corrosion rate will be controlled by applying a corrosion barrier outside the structural vessel.

The current reference UFC design, as shown in Figure A-1, includes a steel structural vessel made of mild carbon steel and a corrosion-resistant copper coating bonded to the exterior of the steel vessel. An internal steel structure referred as the Insert is designed to hold 48 used CANDU fuel bundles (i.e., configured in 4 layers with 12 bundles per layer). The UFC has an overall length of about 2.5 meters and a diameter of about 0.6 meter. The weight of a UFC loaded with used fuel bundles is about 3 metric tonnes.

The selection of the 48-bundle vessel is based on the results of the used fuel container sizing study which identified this design as an optimal mid-sized container in terms of vessel manufacturability and operation. This design permits the use of readily available standard materials to fabricate the structural vessel instead of a custom forged product. The size and weight of the container are manageable using commercially available equipment, and also better facilitate automated operations for fuel packaging, buffer assembly, handling and placement.

The reference UFC incorporate two hemi-spherical heads coupled with a standard steel pipe (referred as the “shell”) through welding. The hemi-spherical heads are designed for optimal stress distribution under external pressure. The weld is designed to provide sufficient strength while reducing the welding and inspection operations in the radioactive (hot cell) environment. The fully bonded copper coating is designed to achieve enhanced corrosion barrier strength and saving of material.

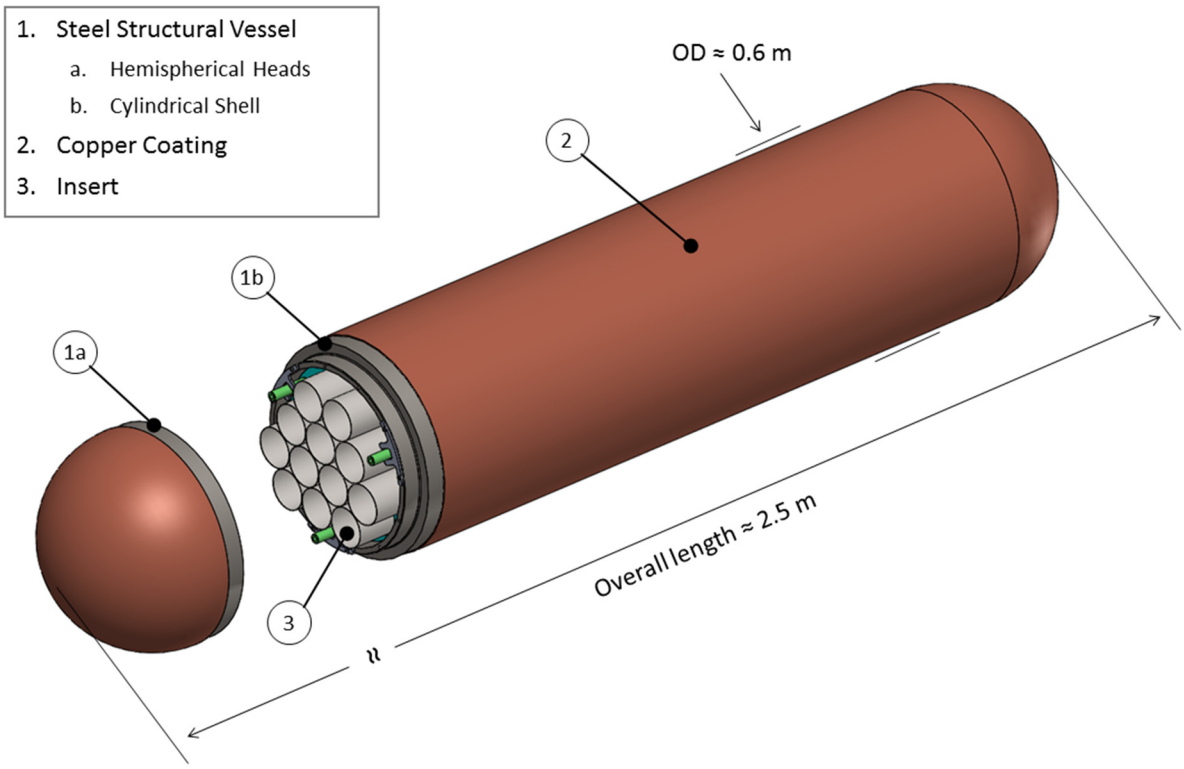


Figure A-1: The reference UFC design with a capacity of 48 bundles

A.2.2 Used Fuel Container Closure Weld

The used fuel container is sealed with a closure weld with a special weld joint design. In this design, a single path partial penetration weld of 8 mm to 10 mm in thickness is applied to the interface between the hemi-spherical head and the shell. An integral backing ring is designed to

hold the hemi-spherical head in place. This weld design is optimized for the compressive stress caused by the external pressure as the primary load in the repository.

NWMO has conducted feasibility evaluations of several welding technologies including Hybrid Laser Arc Weld process (HLAW) and Laser Preheated Gas Metal Arc Weld (LP-GMAW) processes, which can achieve high quality single path penetration for the UFC materials. The closure welding process is designed aiming fully automated operation or remotely controlled operation in a radioactive environment.

A.2.3 Copper Coating

Copper coating is selected as the design for the corrosion barrier of the UFC.

Copper is an excellent corrosion-resistant material, especially in an anoxic environment. Large scale research has been conducted on copper as a corrosion barrier material for nuclear waste disposal. It has been shown through accelerated experiments and conservative analyses that 1.3 mm of oxygen free pure copper would last more than 1 million years. The UFC copper coating is designed to be 3 mm as the minimum thickness.

The copper coating is applied in two product forms. The majority of the UFC surface that is away from the closure weld will be coated using an electrodeposition process prior to delivery to the Used Fuel Packaging Plant (UFPP). The closure zone (i.e., the narrow band adjacent to the closure weld location) will be coated using the cold spray process after the fuel is loaded and the hemi-spherical head is welded the shell in the UFPP.

For optimal corrosion performance, scratching, marking or attachment to the surface of the copper coating will be avoided to the maximum extent.

A.3 Buffer Box

Prior to transfer to the repository, the used fuel container is pre-packaged into a rectangular shaped buffer box. The Buffer Box (Figure A-2) is a 2-piece assembly made from highly compacted bentonite blocks with a machined cavity to house the used fuel container. The dimensions of the Buffer Box are approximately 1 m x 1 m x 2.9 m, and the loaded mass is approximately 8 tonnes.

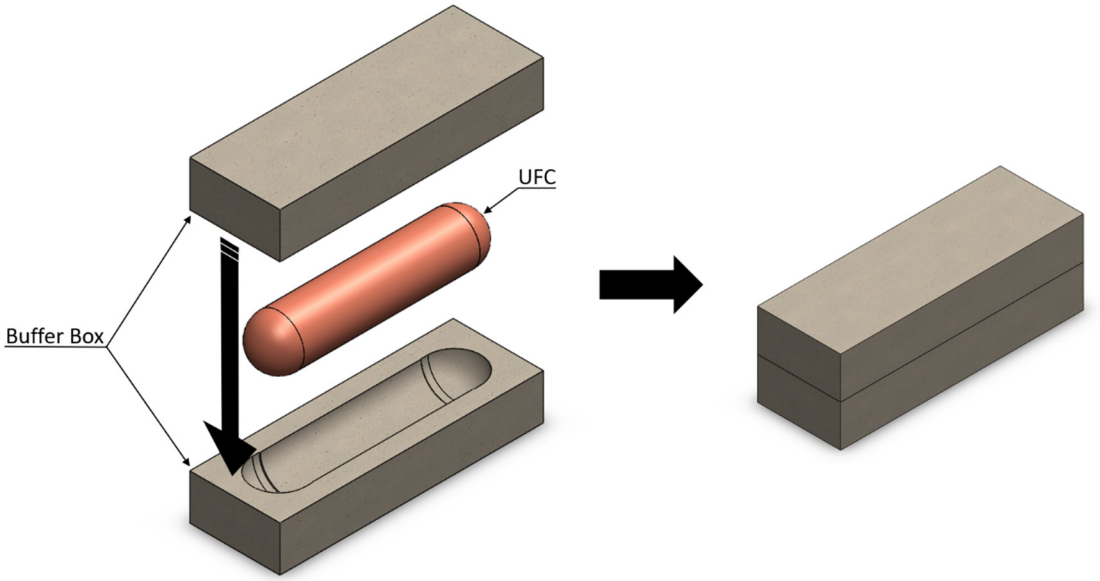


Figure A- 2: Used Fuel Container within Bentonite Buffer Box

The buffer box concept permits assembly of the highly compacted bentonite (HCB) to tight tolerances ensuring material voiding is minimized. The standard buffer box shape permits stacking and relatively simple placement within the placement room.

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NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

March 2023

Funding Canada's plan for the safe, long-term management of used nuclear fuel

Canada has a plan for its used nuclear fuel. It is called Adaptive Phased Management (APM), and it is up to the Nuclear Waste Management Organization (NWMO) to lead its implementation.

In 2007, the Government of Canada selected APM as Canada's plan for the safe, long-term management of its used nuclear fuel. The plan emerged from a three-year dialogue with Canadians and Indigenous peoples, and it reflects their preferences and priorities. Citizens have made it clear that it is important to develop a long-term approach for used nuclear fuel and not leave it for future generations.

Both the plan and the NWMO are funded by Canada's nuclear fuel waste owners.

Waste owners pay for Canada's plan

The development and implementation of Canada's long-term plan for used nuclear fuel is funded by the waste owners in Canada: Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited.

The *Nuclear Fuel Waste Act* (*NFWA*) requires each of these four companies to establish independently managed trust funds and make annual deposits to ensure the money to fund this project will be available when needed. Effectively, this means the consumers who benefit from the electricity will, over time, fund the long-term management of the waste that is generated.

Paying for the long-term management of used nuclear fuel is a relatively small portion of the cost of electricity. The cost of the APM project is only about 0.1 cent per kilowatt hour of electricity produced.

Each waste owner pays a fair share of the costs

The Minister of Natural Resources approved the funding formula in April 2009, and the NWMO is responsible for maintaining it.

Each waste owner's deposit is calculated based on the number of fuel bundles it has produced and continues to create. The amounts cover estimated fixed costs for the NWMO to construct, operate, monitor and decommission a deep geological repository, as well as variable costs associated with managing each fuel bundle.

Waste owners make annual contributions to trust funds

In 2023, the four waste owners are required to make a total trust fund deposit of $99 million.

This deposit represents the 2023 contribution towards the cost of the long-term management of the 3.2 million fuel bundles produced up to June 2022, as specified in the APM funding formula.

In addition to these trust fund contributions, waste owners are also responsible for funding the NWMO's annual operating budget.

Waste owners are also required under the *Nuclear Safety and Control Act* (*NSCA*) to provide to the Canadian Nuclear Safety Commission financial guarantees that are dedicated to nuclear waste management and decommissioning.

The NWMO anticipates new market entrants and emerging technologies

The *NFWA* considers the potential for new market entrants such as small modular reactors, and the government-approved formula used to determine funding for APM anticipated this eventuality.

For emerging technologies, the NWMO would provide a fee for service at fair and reasonable costs and determine the long-term management requirements and associated costs for the resulting fuel wastes.

Funding is in place for the entire lifecycle of Canada's plan

Many factors will affect the long-term cost of Canada's plan, including the volume of used nuclear fuel to be managed, the location and design of the deep geological repository, surrounding infrastructure, rock type and characteristics, and length of time the site will be monitored following fuel placement.

The existing inventory of used nuclear fuel in Canada is approximately 3.2 million bundles, and more bundles are produced each year as nuclear reactors generate electricity.

The NWMO completed a full update of the cost estimates for APM in 2021. These estimates provide the basis for financial planning and trust fund deposits for future years.

For planning purposes, our cost estimate is based on an expected volume of about 5.5 million fuel bundles, the projected inventory Canada's existing nuclear reactors will create through to the end of their operating lives. With this expected volume, the total lifecycle cost of APM – from the beginning of site selection in 2010 to the completion of the project about 175 years later – is approximately $26 billion (in 2020 dollars).

This figure covers many decades of lifecycle activity – stretching well into next century. That does not mean, however, that we need $26 billion today. Instead, we must calculate how much money needs to be in trust today so that it can continue to generate enough income over time to cover the costs of Canada's plan.

We know these funds will grow over time as waste owners pay into trusts and investment income provides returns. So how much do we need in trust today to cover the project's costs tomorrow and decades from now?

Based on best estimates, in 2023 present value, the funding required to be in place in order to implement the project from 2023 onwards is $10.7 billion – a sum that will grow and compound as the project advances so it is always available to cover the costs of Canada's plan.



The NWMO is responsible for determining the cost of the project and designing a system that collects the funds needed.

Funding covers pre- and post-construction and operations costs

Funding for Canada's plan must look decades ahead and base future costs on today's dollar value. The NWMO's cost estimates ensure waste owners will fund the entire cost of planning and building the repository, as well as the costs of getting the used fuel to the facility and operating it for decades to come.

Included in the $10.7 billion funding requirement is $3.1 billion for work to select a site for the repository, complete a detailed design, develop the Centre of Expertise, acquire the site, evaluate environmental impacts, and obtain a site preparation and construction licence under the *NSCA*.

These pre-construction costs are paid for by the waste owners based on the annual budget as approved by the NWMO's Board of Directors.

The additional $7.6 billion included in the estimate will allow the NWMO to complete construction, transport the used fuel to the repository, as well as operate, close, and monitor the facility. The *NFWA* requires that these post-construction costs be funded by waste owner contributions to the *NFWA* Trust Funds.

Waste owners make regular contributions to trust funds to meet the project implementation costs and ensure funds necessary for constructing the facility will be available by the time construction begins.

Trust fund balances at the end of 2022 were $4.8 billion.

Canada's plan looks a century into the future, and beyond

The NWMO expects to identify a preferred site by fall 2024. After that, further site characterization and licensing activities could take about nine years. Construction is expected to take about 10 years. In this scenario, we assume that operations could begin by about 2043.

Operations are expected to last for about 45 years, depending on the volume of used fuel to be managed. After that, the repository will be monitored for an extended period of time – we have assumed 70 years for planning purposes.

The NWMO provides regular updates on the progress of Canada's plan

The NWMO produces annual reports on our progress, which are made public. We also maintain a robust social media presence on Facebook, Instagram, Twitter and LinkedIn that provides up-to-date information. Our website (www.nwmo.ca) includes news stories about ongoing activities, technical and social engagement reports, and an archive for those interested in learning more about Canada's plan for used nuclear fuel.

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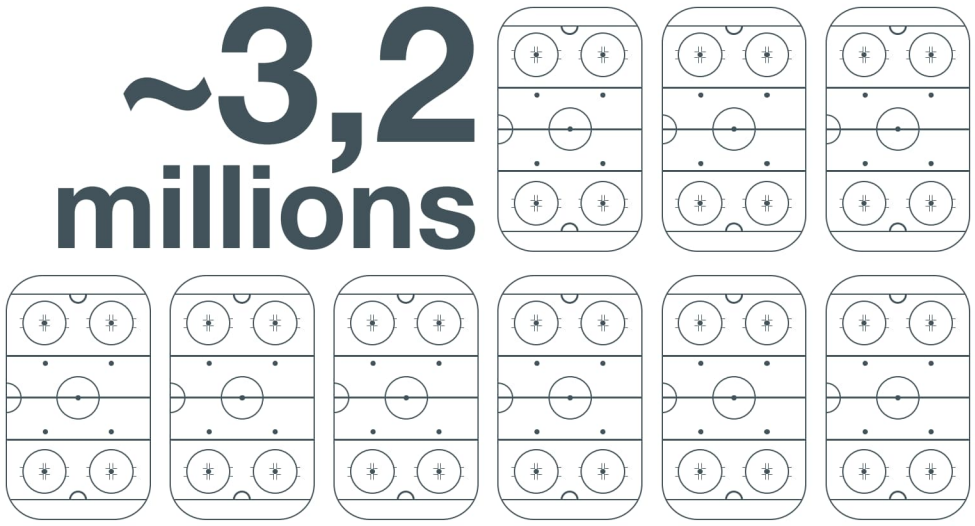
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Le combustible nucléaire irradié canadien

Les Canadiens et peuples autochtones utilisent depuis plusieurs décennies l'électricité produite par les réacteurs nucléaires CANDU exploités en Ontario, au Québec et au Nouveau-Brunswick. Le combustible nucléaire irradié est un sous-produit de ce processus.

Actuellement, le combustible nucléaire irradié est provisoirement stocké en toute sûreté sur les différents sites existants des réacteurs nucléaires au Canada. La méthode de stockage actuelle est sûre, mais elle est temporaire.

Par le biais de la *Loi sur les déchets de combustible nucléaire* (*LDCN*), le gouvernement du Canada a confié la responsabilité de la gestion à long terme sûre du combustible nucléaire irradié canadien à la Société de gestion des déchets nucléaires (SGDN). Nous avons dirigé l'élaboration d'un plan à long terme, appelé Gestion adaptative progressive (GAP), qui repose sur les valeurs et les priorités des Canadiens et des peuples autochtones et qui est conforme aux meilleures pratiques dans le monde. Nous travaillons actuellement à la mise en œuvre de ce plan.



S'il pouvait être cordé comme du bois de chauffage, l'inventaire actuel canadien d'environ 3,2 millions de grappes de combustible nucléaire irradié pourrait loger dans environ neuf patinoires de hockey, soit de la surface de la glace à la hauteur de la bande.

Les réacteurs canadiens produisent actuellement environ 90 000 grappes de combustible CANDU irradié par an. Au 30 juin 2022, on compte environ 3,2 millions de grappes de combustible nucléaire CANDU irradié au Canada. S'il pouvait être cordé comme du bois de chauffage, tout ce combustible nucléaire irradié pourrait loger dans environ neuf patinoires de hockey, soit de la surface de la glace à la hauteur de la bande. À la fin de la période d'exploitation prévue des réacteurs nucléaires canadiens existants, y compris les réfections planifiées, le nombre de grappes de combustible nucléaire CANDU irradié pourrait atteindre approximativement 5,5 millions.

Au Canada, le secteur nucléaire explore activement les nouvelles technologies telles que les petits réacteurs modulaires (PRM), le retraitement du combustible et les autres types de réacteurs avancés. Les nouvelles technologies nucléaires pourraient produire de différents types de combustible irradié, dont la SGDN sera également responsable de gérer. En date de février 2023, la SGDN est au courant de deux projets de PRM dans le processus d'autorisation réglementaire, ce qui représentera une légère augmentation de l'inventaire prévu de combustible irradié – équivalent à une augmentation d'environ deux pour cent par rapport aux 5,5 millions de grappes de combustible CANDU irradié prévues.

Quelle que soit la source du combustible, la sûreté sera toujours notre priorité absolue.

Quel est le plan à long terme prévu pour le combustible nucléaire irradié?

Le plan canadien, appelé la Gestion adaptative progressive (GAP), est à la fois une méthode technique (ce que nous envisageons de construire) et une approche de gestion (comment nous travaillerons avec les gens pour y parvenir).

Méthode technique

- Confinement et isolement centralisés du combustible nucléaire irradié dans un dépôt géologique en profondeur
- Surveillance continue
- Possibilité de récupération
- Étape *facultative* d'entreposage temporaire (non comprise dans le plan de mise en oeuvre actuel)[1]

[1] Nous ne prévoyons pas que l'étape facultative d'entreposage temporaire sera requise, puisque le combustible irradié demeurera dans les installations provisoires de stockage jusqu'à ce que le dépôt soit mis en service.

Approche de gestion

- Flexibilité dans l'échéancier et la méthode de mise en oeuvre
- Processus décisionnel progressif et adaptatif
- Adaptation aux progrès de la technologie et de la recherche, au savoir autochtone et aux valeurs sociétales
- Processus de sélection d'un site ouvert, inclusif et équitable pour trouver des hôtes informés et consentants
- Concertation soutenue avec les gens et les collectivités tout au long de la mise en oeuvre

La méthode technique aura comme aboutissement le confinement et l'isolement centralisés du combustible nucléaire irradié canadien dans un dépôt géologique en profondeur construit dans une région ayant une géologie propice située au sein d'hôtes informés et consentants. La GAP prévoit aussi la mise au point d'un système de transport qui permettra d'acheminer le combustible irradié des installations où il est actuellement entreposé jusqu'au nouveau site.

L'approche de gestion comporte des étapes réalistes et gérables, chacune marquée par des points de décision explicites. Il permet une certaine flexibilité quant au rythme et à la manière de réaliser la mise en oeuvre et favorise la concertation soutenue du public et des collectivités tout au long de sa mise en oeuvre.

Le plan canadien est le fruit d'un dialogue mené avec les Canadiens, les peuples autochtones et des spécialistes et est celui qui respecte le mieux les priorités clés jugées importantes par les citoyens. Le gouvernement fédéral a choisi le plan canadien en juin 2007.

La GAP est conçue pour répondre aux normes rigoureuses de sûreté à travers tous les éléments de sa conception et de sa mise en oeuvre. Le plan est conforme aux approches de gestion à long terme adoptées par d'autres pays dotés de programmes d'énergie nucléaire, tels que la Finlande, la Suède, la Suisse, le Royaume-Uni et la France.

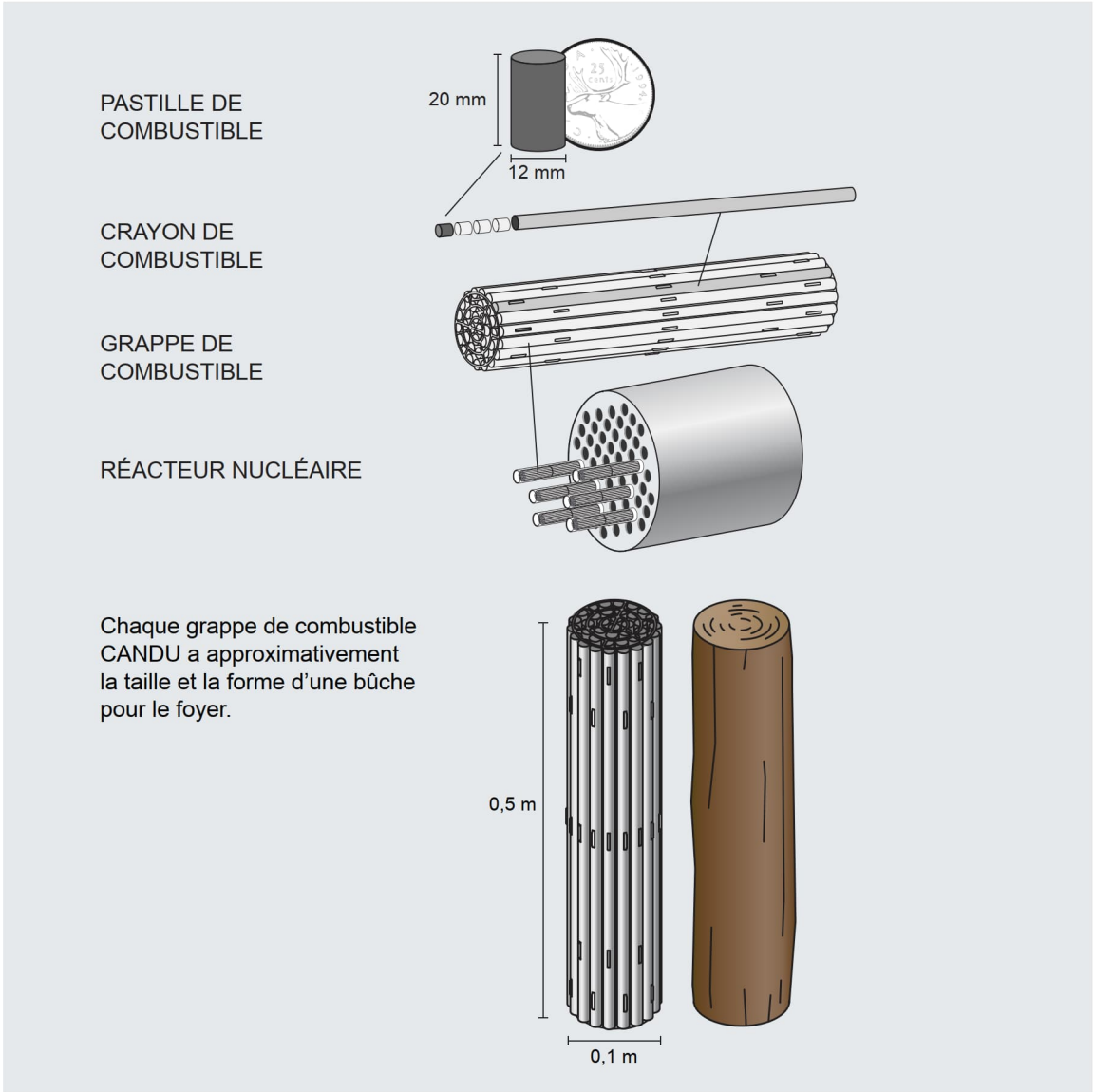
Le dépôt géologique en profondeur devra être suffisamment grand pour confiner et isoler l'inventaire du combustible irradié provenant des centrales nucléaires canadiennes.

Le plan canadien a été élaboré pour gérer le combustible nucléaire irradié canadien. Aucun combustible irradié étranger ne sera placé dans le dépôt.

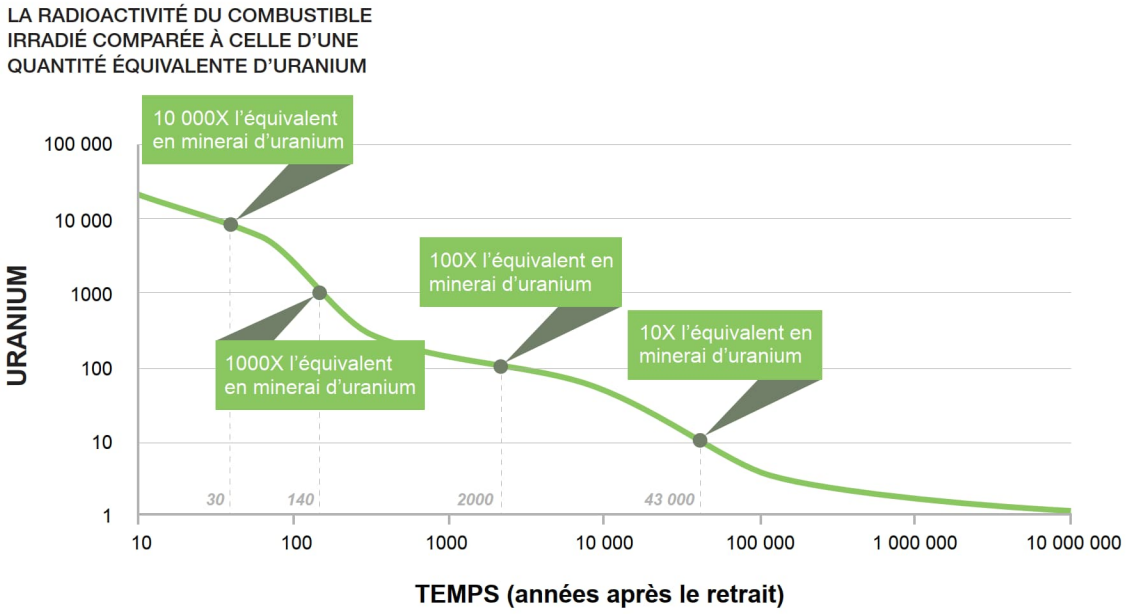
Combustible nucléaire CANDU

Au Canada, la plupart du combustible nucléaire irradié qui existe actuellement est le combustible CANDU. Ce combustible n'est pas liquide ou gazeux; c'est un solide stable. En vertu des règlements canadiens et internationaux, il n'est pas classé comme une substance inflammable, explosive ou fissile.

Le combustible nucléaire CANDU est constitué de dioxyde d'uranium (UO_2) créé à partir d'uranium naturel. Au cours de la fabrication, la poudre d'UO_2 est comprimée pour former des pastilles solides, lesquelles sont cuites afin de les transformer en céramique. Les pastilles de céramique sont insérées dans un tube composé d'un alliage de zirconium et d'étain. L'ensemble s'appelle un élément de combustible ou un crayon de combustible. Ces crayons de combustible sont soudés les uns aux autres pour former des grappes ayant chacune la forme et la taille d'une bûche pour le foyer. Chaque grappe de combustible CANDU fait environ 0,5 mètre de longueur et 0,1 mètre de diamètre, contient environ 20 kilogrammes d'uranium et possède une masse totale d'environ 24 kilogrammes.



La désintégration radioactive dans le combustible CANDU irradié au fil du temps



Bien que sa radioactivité initiale décroisse rapidement avec le temps, sa radioactivité résiduelle ainsi qu'une certaine toxicité chimique persisteront et le combustible irradié continuera de poser un risque pour la santé pendant plusieurs centaines de milliers d'années.

À la fin de sa vie utile, lorsqu'on retire le combustible CANDU d'un réacteur, il est considéré comme un déchet. Ce combustible irradié est hautement radioactif et doit être géré avec soin. Bien que sa radioactivité initiale décroisse rapidement avec le temps, sa radioactivité résiduelle ainsi qu'une certaine toxicité chimique persisteront et le combustible irradié continuera très longtemps de poser un risque pour la santé.

Il faudra environ un million d'années pour que son niveau de radioactivité atteigne celui d'une quantité équivalente d'uranium naturel.

Combustible irradié provenant de petits réacteurs modulaires ou d'autres nouveaux projets nucléaires

Le plan du Canada est conçu pour s'adapter aux changements technologiques, et nous pouvons intégrer de la flexibilité dans la conception du dépôt afin d'être prêts pour les décisions futures. Il existe un consensus international sur le fait que les dépôts géologiques en profondeur représentent la meilleure pratique pour la gestion à long terme des combustibles nucléaires irradiés provenant des petits réacteurs modulaires (PRM), du retraitement du combustible et d'autres types de réacteurs avancés.

Nous surveillons de près les projets de PRM au Canada et nous discutons avec plusieurs promoteurs de PRM, pour nous aider à nous préparer aux décisions qui pourraient modifier le volume et le type de déchets que nous sommes responsables de gérer. À la SGDN, nous nous sommes engagés à travailler avec ces promoteurs de projets pour nous assurer que les futurs types de combustibles et l'inventaire pourront être accueillis en toute sûreté.

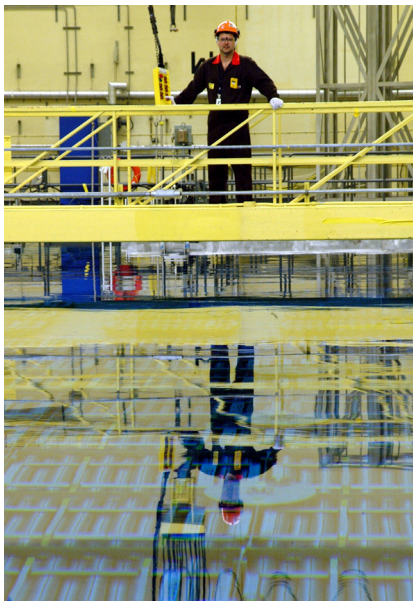
En date de février 2023, nous sommes au courant de deux projets de PRM dans le processus d'autorisation réglementaire. Nous sommes au courant d'autres propositions de PRM et à mesure qu'elles progressent, nous apporterons les modifications nécessaires à nos plans.

Nous prévoyons que ces projets de PRM mèneront à une augmentation d'environ deux pour cent par rapport au volume prévu de combustible CANDU irradié.

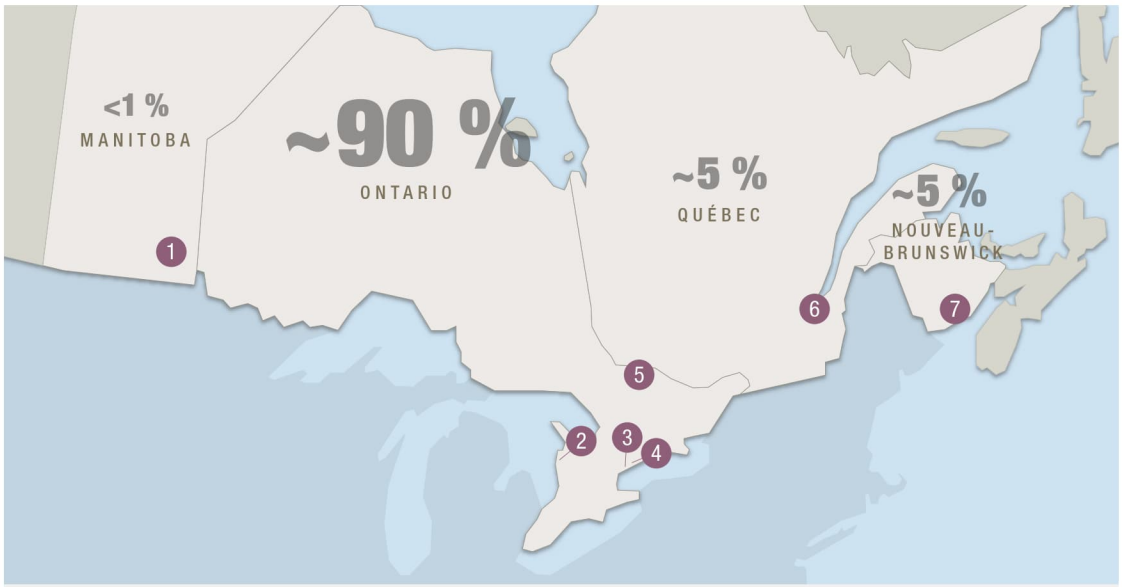
Les collectivités hôtes du dépôt géologique en profondeur prévu feront partie de la prise de décision pour tout plan de gestion du combustible nucléaire irradié lié aux PRM dans le dépôt. Par exemple, dans le cadre de discussions sur les ententes de partenariat, la SGDN travaillera avec les collectivités hôtes potentielles pour élaborer et convenir à un processus de gestion des changements futurs au type ou au volume de déchets à gérer dans le dépôt.

Comment le combustible nucléaire irradié est-il actuellement entreposé?

Lorsque les grappes de combustible nucléaire irradié sont retirées d'un réacteur, elles sont placées dans une piscine remplie d'eau pour y refroidir et perdre leur radioactivité. Au bout de sept à 10 ans, les grappes sont placées dans des conteneurs, des silos ou des enceintes de stockage à sec. Le stockage à sec est une technologie éprouvée qui est utilisée dans plusieurs pays depuis les années 80.







● **Installations provisoires d'entreposage**

1. Laboratoires de Whiteshell, Man.
2. Centrale nucléaire de Bruce, Ont.
3. Centrale nucléaire de Pickering, Ont.
4. Centrale nucléaire de Darlington, Ont.
5. Laboratoires de Chalk River, Ont.
6. Centrale nucléaire de Gentilly, Qué.
7. Centrale nucléaire de Point Lepreau, N.-B.

Le combustible nucléaire irradié est actuellement entreposé de manière sûre là où il est produit ou à proximité, dans des installations autorisées par l'organisme national de réglementation – la Commission canadienne de sûreté nucléaire. De petites quantités de combustible irradié utilisé pour la recherche-développement sont également entreposées dans des installations autorisées sur les sites des Laboratoires nucléaires canadiens appartenant à l'Énergie atomique du Canada limitée.

Le Canada s'est doté d'un cadre réglementaire rigoureux qui régit la manutention du combustible nucléaire irradié. Le combustible nucléaire irradié est en tout temps géré avec soin et blindé afin qu'aucune personne ne soit jamais exposée à une grappe non blindée.

NUCLEAR WASTE MANAGEMENT ORGANIZATION
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NUCLEAR WASTE MANAGEMENT ORGANIZATION

SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Moving forward together

An invitation to review a draft planning framework for the transportation of used nuclear fuel



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Invitation from Laurie Swami

NWMO President and CEO

Canada's plan for the safe, long-term management of used nuclear fuel calls for its central containment and isolation in a deep geological repository for the very long-term. Sometime in the 2040s, once a facility is operational, the Nuclear Waste Management Organization (NWMO) will begin transporting used fuel from interim storage facilities to the repository.

Informing this work is the knowledge that our transportation solutions are technically sound and that we can do this safely. What we respectfully seek is public input and advice on how our transportation plan can best reflect Canadian and Indigenous peoples' values and priorities.

Canadians and Indigenous peoples have consistently told us that the transportation of used nuclear fuel must take place in a safe and environmentally sound manner. Currently, we are working with municipalities and Indigenous communities to identify a single, preferred location for the deep geological repository, to be located in an area with informed and willing hosts. We expect to identify this single, preferred location in 2023.

No matter the location, used nuclear fuel will need to be transported long distances, past communities and through traditional territories to arrive at a central location for its containment and isolation for many generations to come.

What follows is the next part of an ongoing journey where we will examine, discuss and engage with communities and those interested in Canada's plan to ensure we are incorporating public feedback, technical and scientific innovation, and international best practices. All with the goal to protect people and the environment, which is at the core of Canada's plan.

This document outlines what we have heard over the course of thousands of conversations on transportation. Building on this input, we have also outlined potential elements of a transportation plan that is reflective of these conversations to date.

I invite you to review the framework, identify where we have listened well, and what additions and changes need to be made. We hope you will join the discussion as we continue to develop Canada's plan together.



1. The task ahead

Within the next 25 years, the NWMO will start to move Canada's used nuclear fuel from licensed interim storage facilities to a deep geological repository. There, it will be contained and isolated for the long period of time it remains hazardous, protecting people and the environment for generations to come.

This used fuel transportation program is part of Adaptive Phased Management (APM), Canada's plan for the safe, long-term management of used nuclear fuel. Although used fuel will not be transported to the repository for many decades, it is not too early to begin planning for this important step.

During the past several years, the NWMO has been leading a dialogue with interested Canadians, Indigenous peoples and organizations to develop a planning framework for this next phase of Canada's plan. With this document, we describe the framework that is emerging through this dialogue, as well as a proposed approach to implementing it. We invite you to join the discussion as we review and continue to shape the plan together.

2. Our shared responsibility

During the last 50 years, we have drawn power on a large scale from nuclear energy. One of the by-products of this electricity production is used nuclear fuel, a solid material that is hazardous and needs to be contained and isolated from people and the environment, essentially indefinitely.

Used nuclear fuel is currently managed in licensed storage facilities, many of which are located at nuclear power plant sites. This storage is interim and requires active care to maintain. The concrete and steel containers that currently contain the used nuclear fuel need to be replaced every 50 to 100 years, and the buildings in which these sit need to be continuously monitored and maintained.

Canada's plan puts in place a long-term management plan that will safely and securely contain and isolate used nuclear fuel in a passive manner – a manner that does not require future generations to take care of a waste they did not produce or benefit from. Canadians have said it is unfair to put the responsibility for taking care of this waste on to future generations when we have the knowledge, capacity and resources to safely and securely put in place a long-term management plan today.

We are well on our way to implementing that plan. Planning for the transportation of used nuclear fuel is the next step.

Canada's plan

APM moves towards a goal that Canadians themselves identified: safe, secure, long-term containment and isolation of used nuclear fuel produced in Canada, with flexibility for future generations to refine the approach, and adapt to experience and societal changes.

Canada's plan involves placing our country's used nuclear fuel in a deep geological repository in a suitable rock formation using a multiple-barrier system. A fundamental tenet of Canada's plan is incorporating learning, including Indigenous and Traditional Knowledge, at each step to guide a process of phased decision-making. APM is designed to be flexible and responsive to new learning, societal priorities and evolving public policy.

Developing the long-term management facility for Canada's used nuclear fuel is a national infrastructure project. The facility will be sited in an area with informed and willing hosts. Canada's plan was developed through discussions with a broad cross-section of people nationwide.

Site selection

Since 2010, the NWMO has been working collaboratively with interested communities to identify a single site where Canada's used nuclear fuel can be contained and isolated over the long-term.

Twenty-two communities initially came forward to learn about the project and explore the potential to host it in their area. A series of increasingly detailed studies to assess potential to meet the project's rigorous technical, safety and social requirements have informed a gradual narrowing down process.

Current work focusses on two remaining siting areas that have strong potential to meet the requirements of the project. We are advancing detailed technical and social studies and continuing dialogue with First Nation, Métis and municipal communities in these areas to support learning about the project and a process of shared decision-making.

We expect to select a single, preferred site in 2023.

Partnership

We are implementing the site selection process using a partnership approach. Engagement, dialogue and collaboration help ensure that any community and area that is selected to host this facility is both informed about the project and willing to host it.

Ultimately, the preferred repository site will be one that can safely and securely contain and isolate used nuclear fuel for the time period required. The project will only proceed with interested municipalities, First Nation and Métis communities, and surrounding communities working in partnership to implement it.

Transportation

Transportation of used nuclear fuel is an important component of APM. Used nuclear fuel is currently safely stored in facilities licensed by the Canadian Nuclear Safety Commission (CNSC) at or near sites where it is produced. Placing all of Canada's used nuclear fuel in a single location will require transportation from these interim storage facilities to the deep geological repository.

Transportation will involve placing these solid used fuel bundles in a transportation package that is specially designed to protect people and the environment during transportation, including in accident conditions. These transportation packages will be transported by road and/or rail, depending on the location chosen for the deep geological repository.

Transportation of radioactive material is a well-established practice with a strong track record of safety. Transportation of used nuclear fuel is subject to stringent regulation and oversight. The NWMO will need to demonstrate to regulatory authorities and the public the safety and security of any transportation system before transportation to the repository can begin.

APM transportation is expected to begin in the 2040s and take about 40 years to complete.

A few facts at-a-glance

- Used nuclear fuel is a by-product created when nuclear power plants generate electricity. It remains radioactive for a long period of time, and must be contained and isolated from people and the environment, essentially indefinitely. CANDU used nuclear fuel (the fuel used by Canadian reactors) is not a liquid or a gas – it is a solid. It is not flammable, fissile or explosive.
- At the end of 2019, Canada had approximately 2.9 million used fuel bundles in temporary storage. If Canada's existing reactors operate to the end of their planned lives, including planned refurbishment, the inventory of used fuel that will need to be shipped to the repository could be about 5.5 million bundles.
- Canada's plan was developed for managing only Canada's used nuclear fuel. No used fuel from outside Canada will be placed in the APM repository.
- There is a great deal of experience in the safe movement of used nuclear fuel and other radioactive material both in Canada and around the world. In over 50 years, there have been more than 20,000 shipments worldwide of used nuclear fuel using road, rail and water transport without serious injuries, health impacts, fatalities or environmental consequences attributable to the radiological nature of the shipments.
- When the repository begins operation many years from now, used nuclear fuel will be delivered to the repository site at a rate that allows it to be placed in the repository as it is received.
- The transportation program may involve use of road ways, railways, or a combination depending on the site selected to host the repository.
- The transportation program is expected to extend over approximately 40 years or more, based on current anticipated volumes from nuclear facilities. If an all-road approach were taken, this might involve about 620 truck shipments each year, approximately one-to-two shipments per day. If an all-rail approach were taken, this might involve about 60 train shipments each year, approximately one shipment every six days.

3. Towards a shared vision: conversations about transportation

Planning and implementing the transportation program is an important component of APM, one that will require a shared vision. During the past several years, the NWMO has been leading a dialogue with interested individuals, organizations and municipal, First Nation and Métis communities to develop a framework to support this planning. A shared vision is emerging from these conversations. It has been an interesting and constructive journey.

The NWMO has been part of thousands of conversations as part of the process of learning about and reflecting on the transportation of used nuclear fuel and requirements of any socially acceptable APM transportation plan. People have often begun conversations by expressing fear, concern and opposition to even engaging in the discussion. We often heard, “No one asked my permission to create this waste in the first place,” “Dump it in your own backyard!” and “You are talking about a mobile Chernobyl.” However, as they learned more, people moved beyond their initial fear of asking questions, examining facts, and beginning to build a shared vision for how we might move forward together.

We have heard people reflect on our shared responsibility as a society for managing the used fuel we have created. When people begin to learn about our technical capacity to safely transport this material, and the fact that it exists today and has been around for about seventy years, often they move beyond their initial fear to then considering and addressing this challenge.

There are many aspects of a planning framework where, together, we appear to have strong agreement. There are other aspects on which we don’t all agree and need to talk further together. However, our many areas of agreement form a strong foundation to begin planning and continue those discussions.

The purpose of this document is to outline the shared vision and the questions that still need to be addressed, emerging from discussions with individuals, organizations and First Nation, Métis and municipal communities. Let’s continue the conversation and further refine this vision together.



The dialogue process 2016 - 2019

The NWMO posed five key questions to encourage dialogue. These were the questions raised by communities already engaged in learning about the project and the site selection process, and the focus of their ongoing conversations. Encouraging dialogue on these questions was designed to ensure that the starting concepts, issues and framework for transportation planning and decision-making comes from the public, Indigenous peoples and communities.

The emerging framework described in this document was distilled from what we heard through these conversations. For more detail about these discussions, see “Planning Transportation for Adaptive Phased Management: Dialogue to date” (available at www.nwmo.ca/Transportation).

Question 1 What basic requirements or factors should form the starting foundation for the APM transportation plan?

Question 2 Which objectives, principles and key questions should guide development of an APM transportation plan?

Question 3 How can we ensure the design and implementation of the APM transportation plan is sufficiently inclusive to ensure good decisions are made?

Question 4 What information will we need from technical specialists to develop the plan and support decision-making?

Question 5 What factors should be considered in future decisions about modes and routes?



4. The framework emerging from dialogue

Over the course of the dialogue (2016 – 2019), we observed there are objectives, principles and expectations people appear to share when it comes to thinking about a framework for transportation planning. These areas of common ground are the starting point for the framework and are outlined in the discussion that follows.

We also heard from people about the challenges they see ahead, which will require us to work together over the coming years to develop ways to address them. Underlying this discussion, we heard a strong commitment to the importance of successfully implementing Canada's plan, including the transportation program, and acknowledgement that hard work will be needed to engage broadly and find a way to work together. We heard that there is much work to be done. It is going to take time.



a. Basic requirements – what needs to be considered in transportation planning?

In developing a transportation plan, we heard that the plan will need to address several key areas.

Safety is first and foremost on this list, and in this respect we need to consider the public, workers and the environment.

Beyond ensuring safety, minimizing impact on the environment is also considered key. This includes protecting water as the foundation for all life.

Planning for, and addressing, threats to security and potential emergency scenarios is important, as is adopting best practices for training, monitoring, tracking and auditing.

Ensuring that the program is both adaptable and sustainable is considered important to the successful completion of the transportation program given its long duration.

We heard that people have a basic 'right to know' about Canada's plan and the transportation program, and proactive communication will be key to building awareness and confidence in the program. This is often balanced by an understanding that some details must be kept confidential for security reasons.

Engagement of First Nation and Métis communities that may be affected by the program is considered very important, given historical wrongs in Canada's history and a desire to build more positive relationships going.

Safety is the primary consideration

Safety needs to be the first consideration. We need to consider the public, workers and the environment.

Protecting the environment

We need to ensure that the plan minimizes impact on the environment. The protection of water is important as it is the life-source upon which every person, plant and animal relies.

Security

We need to plan for and address possible threats.

Emergency response planning

There needs to be advance planning and preparation for potential emergency scenarios, both through technical study and putting in place a program to support first responders along the route.

Drawing on international lessons learned

We need to ensure that Canada's transportation plan for moving used nuclear fuel is informed by the best available knowledge and expertise.

Ensuring that the plan is adaptive

Considering the transportation program will extend over several decades, the plan needs to be able to accommodate changes in science and technology.

Training

Because used nuclear fuel is very hazardous, the highest standards must be met in areas such as employee qualifications, security screening, training and certification.

Monitoring, tracking and auditing

Keeping track of the used nuclear fuel at all times throughout the transportation program is essential. This includes keeping track of containers, evaluating and auditing procedures and processes, and holding people accountable.

Communication, education and engagement

People, particularly those living in communities along the route, have a 'right to know' about the project. It is important to proactively provide easily understandable information, and address questions and concerns in order to proceed.

Respectful relations with First Nation and Métis communities

Respecting Indigenous peoples and working positively and respectfully with First Nation and Métis communities is of utmost importance.

Ensuring program sustainability

The program must be on a solid financial and political foundation to ensure its sustainability through the multi-decade period required to complete it.

b. Objectives and principles

Through our ongoing dialogue we've heard the planning framework must be driven from objectives and a set of guiding principles that reflects the perspectives of Canadians and Indigenous peoples. These objectives and principles build on the basic requirements. The discussion that follows outlines what we heard.

Planning objectives

Protect the public and workers: Eliminate or minimize hazards associated with the transportation of used nuclear fuel. Safety and security form the umbrella under which all other objectives and principles must be considered. Safety includes protection of the public, workers and the environment from potential hazards associated with managing and transporting used nuclear fuel.

Security: Ensure the security of facilities, materials and infrastructure. Security is intimately related to safety but must be considered separately. The risk of malicious threat must be considered, factored in to planning and addressed in order to ensure public confidence. The plan must ensure the security of facilities, materials, infrastructure, workers and the public while transporting used nuclear fuel.

Protect the environment: Ensure that the environment is protected. We need to understand our potential impact on the environment and put in place plans to manage, if not minimize it. This includes risks to the environment through "spills," greenhouse gas emissions (carbon footprint associated with transporting the fuel) and other impacts (e.g., from improvements to transportation infrastructure). Events such as forest fires, snow storms and tornadoes that could impact transportation also need to be considered. Protecting water is very important.

Relationship with First Nation and Métis communities: Build respectful relationships with Indigenous peoples. Working positively and respectfully with First Nation and Métis communities, and understanding their unique perspectives, values and priorities is considered of utmost importance. The plan must also respect the constitutional rights of Indigenous peoples, reflect treaties, and consider that there may be unresolved claims between Indigenous peoples and the Government of Canada.

Project finances: Ensure economic sustainability of the project, without compromising safety, security and the environment. There must be financial surety in place in order to be confident that the full transportation program will be completed, and, over time, safety will not be compromised because of lack of funds. This includes a secure source of funding, and confidence there is sufficient funding to avoid the need to increase electricity rates and/or taxes in the future to cover costs.

Guiding principles

Safety: Safety should be the overarching principle guiding all APM planning and activities. Safety, security, and protection of people and the environment are central and must not be compromised by other considerations.

Regulatory requirements: Meet or exceed regulatory requirements for the protection of health, safety and the security of people and the environment. The plan must meet, and if possible exceed, all regulatory standards and requirements and respect Canada's international commitments on the peaceful use of nuclear energy.

Transparency is the key to building trust: Information used to make decisions about transportation planning must be readily available to the public. The NWMO must be transparent in its approach to its work, including its interaction with the public (e.g. in communicating potential risks). Transparency is understood to be key to gaining public trust, and therefore advancing the program. Information used to make decisions about transportation planning must be made public and readily available (e.g., transportation package certification, selection of transportation mode).

Balancing adaptability and continuity: The transportation plan needs to be flexible to continuously incorporate new learning, while maintaining continuity throughout changes in government. The planning framework must ensure that the transportation plan is flexible enough to continuously incorporate the latest and best science and technology, and provide continuity throughout the project; particularly with respect to project finances and changes in government. The program must be able to respond to changes in the regulatory framework, technology or infrastructure.

Evidence-informed decision-making: The plan must be informed by the best relevant available knowledge. This includes science, social science, local knowledge, Indigenous and Traditional Knowledge, and ethics. Knowledge holders in these areas need to be part of decision-making and involved in the process.

Incorporating Indigenous and Traditional Knowledge: Ensuring the insight from Indigenous Science, Traditional Knowledge and ways of life is interwoven throughout is important for a strong plan. This includes knowledge about the land and ecology. It also includes knowledge about developing and maintaining effective and meaningful relationships.

Responsible project management: The plan must be managed in a fiscally responsible way so that the cost of the project does not become a burden to current ratepayers or future generations. This will also provide confidence that future safety will not be compromised for cost considerations.

Informing and engaging: People, particularly those living in communities along the route, have a 'right to know' about the project and feel confident in its safety. It is important to proactively provide easily understandable information, and address questions and concerns, in order to proceed. Information needs to be provided at multiple levels of detail, from short descriptions that are easily understood by a lay audience to detailed technical reports for those who wish to review the findings in more depth.

c. Ensuring safety

Over the course of discussions, people talked a great deal about how they think about safety and how it needs to be addressed in transportation planning. Based on what we heard, a few factors are central to the public's vision and understanding.

First and foremost, a holistic approach is needed for safety that considers the public, workers and the environment (e.g. delicate ecosystems, animals, plants, water, and air). One Indigenous participant captured this sentiment in saying that he doesn't make a distinction between nature and people. So if one is hurt, all are hurt; we are all part of nature. This understanding of the need to 'look at the whole' was echoed in various ways by many people across the many discussions and appears to be a fundamental underpinning and point of agreement.

We heard that to ensure safety we need to take into account both radiation and non-radiation related impacts. For instance, we heard that measures are needed to protect people and the environment from the release of radioactive materials, and also from other impacts associated with the transportation program, such as greenhouse gas emissions. We need to consider the potential for injury from conventional traffic accidents, which may be influenced by the poor state of some roads. We also need to consider the risk of public inconvenience, for instance the potential for used nuclear fuel transportation to impact the flow of traffic, to slow traffic or contribute to traffic congestion, detours, wear and tear of roadways, and road closures.

Over the course of the discussions, we heard about the important role of science, including Indigenous Science, and evidence-based decision-making in the development and implementation of the transportation plan. We heard these technical specialists have a role to play in helping to build awareness and understanding of the program and broad public confidence in safety and readiness to proceed.

In discussions, people underlined three key streams of work they consider important to begin to establish safety:

- Ensuring a strong scientific and technical foundation for the plan to ensure best knowledge and expertise informs the plan;
- Ensuring a comprehensive testing program; and
- Ensuring a strong program of regulatory oversight and review, being able to meet or exceed regulatory requirements, and having a strong emergency response program in place.

This needs to include work to address the sensitivities and concerns of First Nation, Métis and municipal communities with respect to the science behind the plan. In the case of container testing, this needs to include consideration of the lived experience of people with direct knowledge and experience with the transportation routes.

Being assured there is stringent container testing will be particularly important. This includes an understanding of the testing already conducted to date as well as using the Canadian used fuel transportation package in a series of new and contemporary testing. We heard the program also needs to explicitly consider transportation logistics during standard and extreme weather events (e.g. snow storms, forest fires, tornadoes) and factor these in to assessment and planning.

Key public expectations are outlined in the three tables that follow.

Ensure strong scientific and technical foundation for the plan

We heard that a strong scientific and technical program needs to address regulatory requirements and reflect best practices. The technical program needs to provide:

- A tested and certified transportation package;
- A plan to meet commercial vehicle and railroad safety and security requirements;
- A transportation security plan;
- An emergency response plan;
- A plan for periodic reviews;
- A program for hiring high-quality and well-trained workers and vehicle operators;
- A plan for training and joint exercises with provincial and community emergency responders; and
- Procedures for safe and secure operations.

We heard that program activities need to include:

- Identifying and technically assessing road and rail modes of transport and mode combinations;
- Developing approaches to handling used nuclear fuel during transport, including logistics for transporting used nuclear fuel from interim storage facilities to the siting regions;
- Assessing risks associated with a range of transportation accident scenarios;
- Identifying and technically assessing transportation package options to ensure protection of the public and the environment during normal operations, as well as accident conditions;
- Studying risk and approaches to controlling exposure to the public and workers;
- Outlining an approach for emergency response and shipment security;
- Constructing and testing all equipment required for loading, transporting and unloading used nuclear fuel transportation packages, including truck trailers and/or railcars;
- Developing package designs for transportation packages, considering scenarios based on local knowledge and/or experience;
- Reviewing and reporting on experience and best practices with transportation of hazardous materials; internationally, to identify lessons that can be applied;
- Completing public and worker dose assessments associated with various package designs and scenarios for licencing review, as well as develop a program of ongoing monitoring and testing once transport of used nuclear fuel begins; and
- Securing and maintaining CNSC design certificates for road and/or rail transport packages.

Comprehensive testing program

We heard through discussions that comprehensive testing of the container, and broadly sharing the results of this testing, is important to establish public confidence in safety. We heard strong public support for the testing program that is already in place. People also shared their expectations that a range of scenarios also be addressed.

Used nuclear fuel transportation packages are designed and tested to ensure protection of the public during normal operations, as well as during accident conditions. Testing is conducted to ensure the package can survive all plausible accident scenarios without releasing its contents. These tests are conducted in sequence to simulate stresses that would cause the most damage to the package and total cumulative effects. To learn more about these tests, please see www.nwmo.ca/Transportation:

- Free-drop test: The package is dropped from nine metres (30 ft) onto a flat, unyielding surface (such as a steel-reinforced concrete pad), striking the surface in the orientation that will result in the most damage to the package.
- Puncture test: After the drop test, the same package is subjected to a one-metre (40-inch) free drop onto a 15-centimetre (six-inch) diameter steel bar at least 20 centimetres (eight inches) long.
- Thermal test: The same package used in the drop and puncture tests is then subjected to a fully engulfing petroleum fire. The fire temperature must reach 800 degrees Celsius (1,475 degrees Fahrenheit) for 30 minutes.
- Immersion test: Using either computer analysis or physical testing methods, the package is subjected to external pressure that is the same as if it were immersed under 15 metres (50 feet) of water for at least eight hours to test for leakage. The package is also subjected to an enhanced water immersion test at 200 metres (650 feet) to test its ability to withstand extreme external pressures.

Beyond these tests, people said it will be important for them to see that a broad range of accident scenarios are considered, scenarios that mirror the lived experience of people who regularly travel these routes. These scenarios include:

- Train derailments in remote areas with limited access;
- Road or rail accidents resulting in the transportation container falling from a bridge over nine metres, similar to bridges in the area;
- Accidents resulting in the transportation container falling down a steep rock-face into a water source;
- Accidents where the entire vehicle rolls down a steep rock-face;
- Accidents involving fires burning at higher than 800 degrees Celsius or for a longer duration, for instance in a remote location in the midst of a forest fire;
- Road accidents involving a head-on collision with another truck carrying dangerous goods;
- Accidents resulting in the transportation package being under water for longer than eight hours, for instance in a remote location with retrieval challenges; and
- Train derailment with other dangerous goods in the vicinity, such as the Lac Megantic and Mississauga train derailment disasters.

Meet or exceed regulatory requirements for safety and emergency response

We heard through discussions that meeting, if not exceeding, stringent regulatory requirements is important to establishing public confidence in safety. We heard support for the requirements in place and the importance of building broad awareness of these requirements as well as sharing work that demonstrates the APM transportation program's ability to meet or exceed them. This includes the three areas detailed below, as understood by the NWMO.

Safety: Packages used to transport used nuclear fuel from interim storage facilities to the repository will need to be certified by the CNSC. Radiation levels from the package need to remain below regulatory limits at all times, including during transportation accidents. In order to confirm that the transportation package will do its job, packages must pass a series of performance tests specified in the regulations to demonstrate their ability to restrict loss of contents and to provide adequate shielding.

The safety of the transportation vehicle must also be demonstrated. Transport Canada, the entity that regulates the transport of dangerous goods, has a number of checks and balances to ensure that transporters adhere to a strict set of standards that a) are meant to prevent accidents (e.g. driver training requirements); and b) provide clear direction on how to manage accident scenarios (e.g. emergency planning requirements).

Security: Security provisions during transportation need to meet CNSC regulatory requirements, including the development and implementation of a transportation security plan. Components of a security plan are expected to include:

- A complete description of the material being transported;
- Threat assessment to identify any credible threats;
- Description of mode of transportation;
- Proposed security measures (e.g. escorts or continuous tracking);
- Communication arrangements between the NWMO and the carrier along the route;
- Response arrangements between the NWMO and any policy/response forces;
- Primary and alternatives routes; and
- Provisions for stopover during transport.

Emergency response: Emergency response planning requirements will need to be met, ensuring workers and first responders are trained before shipments can begin. The NWMO will need to work with local response agencies to co-ordinate planning and preparedness activities before transportation can begin.

Early conversations with first responders to develop the planning framework indicate existing supports are available (e.g. Canadian Transport Emergency Centre) and training covers incidents involving dangerous goods, including radioactive material. Access to training can be budget-dependent. The NWMO will need to work with first responders along transportation routes to understand specific information and training requirements, and ensure that all parties have appropriate information, resources, training and a clear understanding of roles and responsibilities in the event of an accident.

d. Protecting the environment

We heard the importance of ensuring that the plan protects the environment, or at least minimizes its impact. In the discussions, people talked about the need to consider both radiation-related and more conventional impacts on the environment.

We heard that the release of radioactive material into the environment needs to be minimized, if not eliminated. We heard concern about potential for an accident or act of terror to cause used nuclear fuel to enter the soil, water and/or contaminate the air. We heard that the plan should include measures to prevent environmental damage, as well as ensure that specialized resources and response mechanisms are in place to mitigate and repair damage to the environment should an incident occur.

We heard the plan needs to also take into account and minimize more conventional impacts over the course of day-to-day transportation operations. A frequent example given was greenhouse gas emissions from trucks, trains, or other vehicles that may be used. Another example often raised was disturbance to sensitive areas from road or rail work that may be needed to support the transportation program.

We heard the transportation plan must not only ensure safety by meeting or exceeding regulatory requirements, it should go beyond this through specifically minimizing impact of the transportation program on the environment. Seeking opportunities to incorporate green technology in day-to-day operations of the transportation program was an example mentioned by many.

The protection of water is important. Expressed in different ways by different people over the course of the discussion, the importance of water was pinnacle, as it is the life source or lifeblood of the earth upon which every person, plant and animal relies. People talked about the importance of larger water bodies and also streams and rivers as connectors.

Protecting the environment

We heard that the program must include:

Measures to prevent environmental damage from radiation contamination

- These measures need to prevent or minimize used nuclear fuel escaping from the cask into the environment, including acts of terrorism and sabotage

Measures to prevent environmental damage from non-radiological impacts

- Greenhouse gas emissions from the vehicles used
- Impacts that improvements to infrastructure (e.g. widening roads, building segment of dedicated rail lines, reinforcing bridges) may have on the local environment, especially around fragile habitats

Resources and response mechanisms to mitigate and repair damage should an incident occur

- Emergency response plans are in place
- Local first responders are trained and equipped for accident scenarios

Use of green technologies

- Incorporating green technology as it becomes available

We heard the following considerations are also important to take into account:

- Impact of environmental conditions along a route on safety, such as forest fires, snow storms and tornadoes;
- Use of off-sets to make up for negative impacts on the environment (e.g. planting trees, rehabilitating habitat);
- Implementing a system of environmental monitoring of radiation and of impacts of transportation on the environment (e.g. on wildlife, sensitive habitats); and
- Impacts related to the manufacturing of transportation equipment.

e. Being inclusive

Over the course of conversations, we heard it is important to be inclusive when designing and implementing the plan. We heard this is important to ensuring good decisions are made. We also heard this is needed to ensure the project proceeds, and isn't undermined by the natural fear and concern many people may have about moving a dangerous material they don't know anything about.

Those who engaged in this dialogue were largely of a common view: there is an important role for government, an important role for experts, and an important role for critics to ensure the best knowledge and expertise are applied and the plan is safe. However, safety is not in itself sufficient. People said Canadians need to be aware and informed, and prepared to see the program implemented. They need to learn about used nuclear fuel and the ability to transport it safely. They need to become informed, to be able to ask questions and have their questions addressed.

The rights of Indigenous peoples need to be respected. Beyond that we heard there is a special duty owed by Canadians, given past history and historical wrongs to Indigenous peoples, and this means they need a special role in planning for this type of program. Non-Indigenous participants voiced this sense of responsibility in a number of different ways, although many found it difficult to define what this best looks like. Instead, they suggested this would need to be worked out over time with the First Nation and Métis communities involved. Indigenous dialogue participants talked about formal rights and Crown duty to consult and consent. We also heard from some Indigenous participants about the potential for the program to develop new ways and new relationships built on mutual respect and seeking opportunities for collaboration, shared planning and co-creation.

Raising awareness, building understanding and addressing questions and concerns that people will inevitably raise appeared to be considered essential by most who engaged in the dialogue.

Building respectful relationships with communities, both municipal and Indigenous, and informing and engaging people are among the key objectives identified for the plan. We heard that being inclusive in developing and implementing the transportation plan is important, and there was much discussion about how best to achieve this. We heard people talk with each other and reconsider their thinking over the course of the discussion and in response to the back-and-forth exchange of ideas and thinking through implications of possible approaches. Through the conversation, people grappled with what can be practically achieved, and what is workable and justified given the need to advance Canada's plan.

After much consideration and discussion among individuals and groups in a variety of engagement and dialogue settings over the past several years, a set of principles emerged to guide our first steps in moving forward together. We heard broad agreement on these principles. We heard the way forward will be challenging but, with patience and time, we can and will move forward together.

Principles and activities

Over the course of discussions, people laid out a set of principles to guide first steps:

- ***Awareness and understanding:*** Canadians should have some measure of awareness and understanding about the transportation plan. Building awareness and informing people is a primary goal of the plan and, conversely, people have a responsibility to participate in this learning;
- ***Focus on potentially affected communities:*** People who are more directly affected by the transportation program should have greater opportunity to understand the plan and to be heard. Informing people and communities along the route should be a primary focus;
- ***Special role for leaders and first responders:*** Relevant government officials, municipal leaders, first responders and scientific and technical experts should be involved. This will help to ensure good decisions are made;
- ***Right to be informed:*** People have a right to be informed about the plan. Good information and a desire to be informed are important for good decision-making; and
- ***Special role for Indigenous communities:*** Indigenous communities need to play a role in the development of the plan. They have special rights. And, given the history of continuing and past wrongs as a country, it is imperative that positive and respectful relationships be built to advance the project.

People have also outlined some key activities as a starting point

Informing people: Engaging with communities along the routes is a high priority. The objective of this engagement should be to inform residents by providing information, answering questions and addressing concerns. 'People have a right to know.' This is seen as an important NWMO responsibility.

Assuaging fear: The NWMO needs to proactively alleviate fear about the transportation of used nuclear fuel before this fear becomes entrenched. We heard that over time, there is an expectation that community engagement should be able to reassure most community residents, and the broader public, about the project and the soundness of the transportation plan. It is a responsibility of the NWMO to inform people to move them out of a state of fear.

Building relationships: Building relationships, and establishing mutual trust and respect, are important. Building relationships with First Nation and Métis communities and organizations is important to ensure Indigenous values and priorities, questions and concerns, and insight from Indigenous and Traditional Knowledge inform the plan.

f. Selecting modes and routes

Any transportation plan for used nuclear fuel will need to provide a framework for making decisions about the method we will use (modes) and the transportation pathway we will use (routes). We may need to consider using a combination of modes, such as road and rail, depending on the location chosen for a repository. While we have not yet identified a preferred site, dialogue to date has identified factors that the public expects will be considered when we are ready for detailed decision making.

In selecting modes and routes, first and foremost we heard that safety and security must be the primary consideration. We heard the pros and cons of various modes and routes must be thoroughly analyzed and the best possible decision be made based on science, with a primary focus on safety and security. Considerations reflecting best practice and experience in Canada and internationally must be used. Local knowledge and lived experience related to specific roads and routes of people living in the area and travelling those routes must also be considered.

Many factors will need to be considered, and we heard we should look to transportation specialists to advise on how best to achieve or balance individual objectives when they may conflict.

Key considerations are outlined in the tables that follow.

Considerations for the selection of modes and routes

We heard that people expect best practice and experience to be taken into account in the selection of modes and routes in order to ensure safety and security. In exploring choices between modes and between routes, people also said it will be important for them to see that factors such as the following are being considered, some of which mirror the lived experience of people who regularly travel routes in the area:

- Risk of accident (e.g. based on historical accident and operational data);
- Risk of security breach (e.g. relative ease of access);
- Adequacy of transportation infrastructure (e.g. quality of roads and tracks) with some indicating that much of their transportation infrastructure needs maintenance and modernization;
- Potential environmental impacts (e.g. on wildlife and surrounding terrain);
- Weather and the ability to adapt to seasonal changes (e.g. snow, ice, rain and floods);
- Ease of containment and access by first responders in the event of an incident;
- Analysis of the relative merits of opting for bigger loads and fewer trips versus smaller loads and more numerous trips;
- The frequency and nature of handling and transfers (particularly for worker exposure); and
- Adaptability of modes to future innovations in transportation (e.g. autonomous automobiles).

People anticipate that not all objectives will be able to be equally met; there will need to be some balancing or trade-offs between objectives. In doing so, there ought to be no compromise in safety. We heard that most people expect that transportation routes would and should be selected by experts based on a consideration of trade-offs, and pros and cons, including:

- Proximity to population centres and schools;
- Proximity to sensitive environmental areas;
- Response time for first responders/emergency response;
- Potential need to improve existing or build new infrastructure (e.g. extension of rail track);
- Conditions of the route during winter and inclement weather (e.g. days of rain and snowfall);
- Potential for traffic congestion and potential impact on commuters;
- Assessment of political and social acceptance;
- Trade-off between a longer route that goes through less densely populated areas versus a shorter route that goes through more densely populated areas; and
- The need to vary routes for security reasons.

g. The emerging framework

A framework of public expectations, principles and priorities for the APM used fuel transportation plan is emerging from these discussions and is outlined at a high level in figure 1.

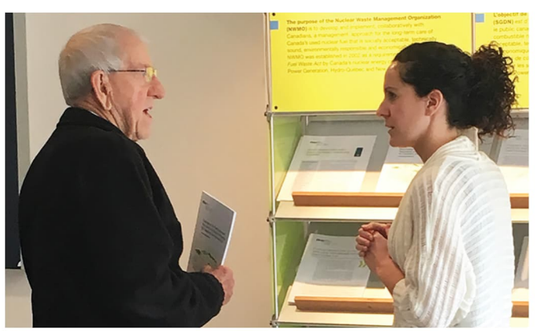
Figure 1: The transportation planning framework emerging from dialogue

a. Basic requirements:	b. Objectives and principles:	c. Ensuring safety:	d. Protecting the environment builds on safety:	e. Being inclusive:	f. The process for selecting modes and routes:
» Safety as the primary consideration » Protecting the environment » Security » Emergency response planning » Drawing on international lessons » Ensuring that the plan is adaptive » Training » Monitoring, tracking and auditing » Communication, education and engagement » Building respectful relations with First Nation and Métis communities » Ensuring program sustainability	» Attention to project finances » Ensuring transparency » Balancing adaptability and continuity » A focus on evidence -informed decision-making » Incorporating Indigenous and Traditional Knowledge » Ensuring responsible project management » A focus on informing and engaging	» Ensure strong scientific and technical foundation for the plan » Comprehensive testing program » Meet or exceed regulatory requirements for safety and emergency response	» Minimize, if not eliminate, impact on the environment	» Right and responsibility to be informed and have questions and concerns addressed » Focus on potentially affected communities » Special role for First Nation and Métis communities	» Involve experts in decision-making to build on best practice and experience » Acknowledge and take into account factors important to the public » Balance between multiple objectives without compromising safety









5. Proposed approach to implementing the framework

In the previous section, we have reported on what we heard from Canadians and Indigenous peoples, interested individuals and organizations on what will be important in planning and implementing the APM used nuclear fuel transportation program.

Based on what we heard, we understand we need to take an approach that embeds these principles and priorities in decision-making throughout planning and implementation of the transportation program. The approach needs to be flexible and adaptive and it needs to continue to involve people at key milestones along the way. In this section, we propose key elements of a potential transportation plan, or management system, for discussion. It includes:

- A plan for working together through engagement, collaboration and shared decision-making;
- A readiness checklist, to be used by the NWMO and the public together, to regularly assess preparations to initiate the transportation program; and
- A roadmap of key milestones and steps, including collaboration and shared decision-making, putting in place a strong scientific and technical foundation for the program, and meeting or exceeding regulatory requirements.



a. Collaboration and shared decision-making

We understand from what we heard that there is a need to involve people in decision-making all along the way, to ensure the program continues to reflect the principles and objectives important to the public. Here, we outline potential milestones for continuing to shape and advance the plan together.

Key milestones

1. ***Refine the draft framework and milestones (2020 - 2021):*** Dialogue and engagement to review and refine the draft framework and reflect on the proposed management system.

2. ***Review an early sample plan (2021 - 2023):*** Dialogue and engagement to review an early sample transportation plan. This plan would be general in nature, as the repository site will not yet have been selected, but could be used to further explore expectations.

3. ***Review and refine site-specific transportation plan (2023 - initiation of transportation):*** Dialogue and engagement to review an early sample site-specific transportation plan. This plan would need to continue to be refined over the years leading up to the initiation of the transportation program, but could be a basis for further exploring expectations. This might involve:

   - The NWMO working with people and organizations in the initial development of the plan, such as transportation specialists (e.g. Canadian and international scientists and engineers), federal and provincial government ministries and agencies (e.g. CNSC, Transport Canada, Public Safety Canada and provincial ministries of transportation) and Canada's nuclear power generators.

   - Interested communities, individuals and groups will need to have their questions and concerns considered and addressed as part of the transportation planning process, including first responders along potential routes and first responder associations/organizations, municipalities and municipal associations as a group with a shared interest, First Nation and Métis communities along potential routes and Indigenous organizations as a group with a shared interest; other interested individuals and groups. Communities that currently host interim storage facilities will also need to be involved in planning how used fuel is moved through their community.

4. ***Build awareness and communicate on plans as they are refined (2023 - initiation of transportation):*** Dialogue and engagement to build awareness and understanding of the APM project and transportation plan, and confidence in safety. We heard this is a critical component of any plan and it will take time and effort to accomplish this. This may include activities such as face-to-face discussion and facilitating a dedicated virtual space for learning about the plan, asking questions, hearing from transportation specialists, and addressing frequently asked questions and concerns on an ongoing basis.

5. ***Monitoring and adapting (2023 onwards):*** Ongoing review of evolving best practices, new and emerging technologies and standards, and reflection on the need to refine and adapt the program. Monitoring to include ongoing review of experience in implementing the transportation program once it begins, including impacts and mitigations, to support reflection and adaption of the program during implementation.

We understand from what we heard that evidence-based decision-making is an important part of this process. We understand we need to continue to learn, and build on best practices and evolving international and Canadian expertise, science and technical developments as we implement the program. We understand that transparency, auditing and reporting are key.

Here, we outline components of a potential program for reporting and continuous improvement to working together to shape and advance the plan.

Ongoing reporting and continuous improvement

We heard that ongoing reporting and continuous learning is important for the program to be able to adapt over time as needed. Ongoing reporting and continuous learning might include the following.

1. ***Monitoring and reporting on evolving best practice:*** Beginning in 2023 and on a triennial basis, the NWMO publishes a report with updates on best practice, new and emerging technologies and evolving state of the art, evolving standards, and how it is adapting the program in the spirit of continuous improvement.

2. ***Monitoring and reporting on ongoing impacts and mitigations:*** Once used fuel transportation begins, the NWMO monitors and regularly reports on public and environmental impacts, reportable events, and action taken in a manner that is understandable and accessible to the public.

3. ***Monitoring and reporting on project finances:*** Beginning in 2023 and on a triennial basis, the NWMO publishes a report of the status of finances for the transportation program including the project's cost and sources of funding.

b. Putting in place a readiness checklist

We understand there are a broad range of factors that need to be addressed before the NWMO and the public together will be ready to begin transporting used nuclear fuel as part of APM. Here, we outline our understanding of the factors and outcomes needed, in the form of a readiness checklist.

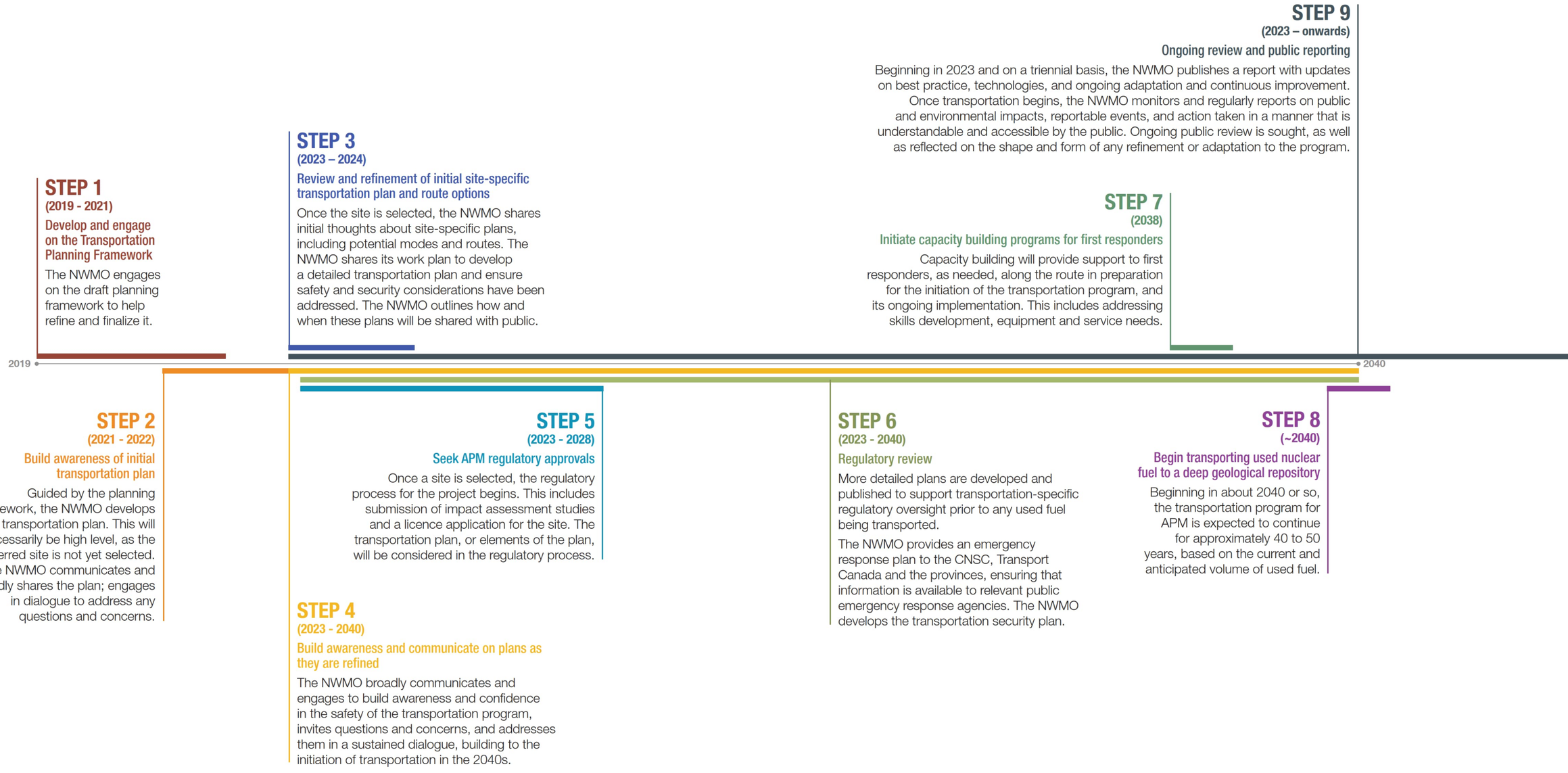
Using this checklist, we would regularly track and report on our progress in putting these necessary conditions in place. In this way, we would collectively gauge program readiness to begin with transport of the first used fuel bundle from interim storage facilities to the deep geological repository.

Readiness Checklist

- ☐ A site-specific transportation plan;
- ☐ A broad-based awareness and education program for the general public and communities along the transportation route;
- ☐ An ongoing engagement and dialogue with First Nation and Métis communities along the transportation route;
- ☐ Questions received about transportation are acknowledged, addressed and shared broadly;
- ☐ Awareness and training program for first responders along the transportation route;
- ☐ A tested and certified transportation package;
- ☐ Accident scenarios specific to transportation routes, including those that align with the lived experience of people in the area, have been covered by transportation package testing and safety has been demonstrated;
- ☐ A transportation security plan that takes into account threats of sabotage and terrorism;
- ☐ An emergency response plan that explicitly describes resources available along the route and roles and responsibilities in the event of an accident;
- ☐ An environmental management or protection plan that takes into account the carbon footprint of the transportation program and environmental response and remediation in the event of an accident;
- ☐ A confirmed plan to meet commercial vehicle and railroad safety and security requirements;
- ☐ A program for hiring high-quality and well-trained workers and vehicle operators;
- ☐ Procedures for safe and secure operations;
- ☐ A plan for periodic reviews of all required plans, certifications and procedures;
- ☐ A ‘safety audit’ program involving ongoing physical assessment of the roads, bridges, etc. of the route, to identify structural weakness; required repairs to the infrastructure of the selected route; and
- ☐ A program of reporting with updates on best practice, technologies and evolving state of the art, and ongoing activities to adapt the program in the spirit of continuous improvement.

c. Key milestones and steps

We understand from public discussion that we need to advance the plan through a sequence of steps, which include engagement, collaboration and shared decision-making; putting in place a strong scientific and technical foundation for the program; and meeting or exceeding regulatory requirements. This forms a basic road map to guide our working together with the public.



STEP 1
(2019 - 2021)

Develop and engage on the Transportation Planning Framework

The NWMO engages on the draft planning framework to help refine and finalize it.

STEP 2
(2021 - 2022)

Build awareness of initial transportation plan

Guided by the planning framework, the NWMO develops initial transportation plan. This will necessarily be high level, as the preferred site is not yet selected. The NWMO communicates and broadly shares the plan; engages in dialogue to address any questions and concerns.

STEP 3
(2023 – 2024)

Review and refinement of initial site-specific transportation plan and route options

Once the site is selected, the NWMO shares initial thoughts about site-specific plans, including potential modes and routes. The NWMO shares its work plan to develop a detailed transportation plan and ensure safety and security considerations have been addressed. The NWMO outlines how and when these plans will be shared with public.

STEP 4
(2023 - 2040)

Build awareness and communicate on plans as they are refined

The NWMO broadly communicates and engages to build awareness and confidence in the safety of the transportation program, invites questions and concerns, and addresses them in a sustained dialogue, building to the initiation of transportation in the 2040s.

STEP 5
(2023 - 2028)

Seek APM regulatory approvals

Once a site is selected, the regulatory process for the project begins. This includes submission of impact assessment studies and a licence application for the site. The transportation plan, or elements of the plan, will be considered in the regulatory process.

STEP 6
(2023 - 2040)

Regulatory review

More detailed plans are developed and published to support transportation-specific regulatory oversight prior to any used fuel being transported.

The NWMO provides an emergency response plan to the CNSC, Transport Canada and the provinces, ensuring that information is available to relevant public emergency response agencies. The NWMO develops the transportation security plan.

STEP 7
(2038)

Initiate capacity building programs for first responders

Capacity building will provide support to first responders, as needed, along the route in preparation for the initiation of the transportation program, and its ongoing implementation. This includes addressing skills development, equipment and service needs.

STEP 8
(~2040)

Begin transporting used nuclear fuel to a deep geological repository

Beginning in about 2040 or so, the transportation program for APM is expected to continue for approximately 40 to 50 years, based on the current and anticipated volume of used fuel.

STEP 9
(2023 – onwards)

Ongoing review and public reporting

Beginning in 2023 and on a triennial basis, the NWMO publishes a report with updates on best practice, technologies, and ongoing adaptation and continuous improvement. Once transportation begins, the NWMO monitors and regularly reports on public and environmental impacts, reportable events, and action taken in a manner that is understandable and accessible by the public. Ongoing public review is sought, as well as reflected on the shape and form of any refinement or adaptation to the program.

6. Regulatory decision-making

Canada has in place a stringent framework of regulation and oversight to review and approve transport of used nuclear fuel. Transportation of used nuclear fuel is regulated by the CNSC and Transport Canada. Used nuclear fuel shipments conducted as part of the APM transportation program will need to meet these requirements to ensure they are safe and secure. APM transportation operations will also need to meet federal, provincial, and local safety legal requirements, and will be inspected to ensure compliance.

Consistent with this framework of regulation and oversight, we understand that approvals for APM used nuclear fuel transportation will be given if requirements are met. Requirements focus on the strength of the transportation package and include the following:

1. **Transportation package:** Used nuclear fuel transportation packages are designed and tested to ensure protection of the public during normal operations as well as during accident conditions. The CNSC, using internationally tested standards, has the responsibility for evaluating the transportation package and certifying its design, the registration of the use of individual packages, and monitoring the package maintenance process.

   Prior to transporting used fuel in Canada, the CNSC's comprehensive regulatory framework requires a certificate for the transport package and a licence to transport. The CNSC evaluates applications to ensure that safety and security measures are technically and scientifically sound, that all requirements are met, and that the appropriate safety and security provisions are in place to protect people and the environment. Packages used to transport used nuclear fuel from interim storage facilities to the repository must be certified by the CNSC.
2. **Radiological safety:** Packages used to transport used nuclear fuel must meet radiation level requirements prescribed by the CNSC's Packaging and Transport of Nuclear Substances Regulations, 2015. Regulatory requirements for the package ensure the public and workers are safe. The package is designed and tested to ensure that in the event of an accident, the radiological release will not exceed the regulatory limits. The CNSC's Radiation Protection Regulations have set an annual radiation dose limit for members of the public to limit exposure from nuclear–related activities.
3. **Emergency response and training:** Transport Canada's Transportation of Dangerous Goods Regulations establish requirements for worker and driver training, emergency planning, safety marks, and documentation. Transportation planning needs to address these aspects and ensure that all equipment, packages, and activities for road and rail shipments meet regulatory requirements. The NWMO will need to demonstrate that all activities will be conducted by trained personnel, including emergency responders. The NWMO will also need to develop an emergency response plan and ensure workers and emergency responders are trained before shipments can begin.
4. **Security:** Security provisions during transportation need to ensure CNSC regulatory requirements are met. Security measures are aimed at preventing diversion or sabotage of the transportation package, and include a combination of engineered, physical and monitoring measures to protect the cargo, and provide for detection, alarm, recording, and communication, in the event of an occurrence.

For more information on transportation regulation and oversight, see the NWMO's brochure *Safe and Secure Transportation of Canada's Used Nuclear Fuel*.

7. Next steps - refining and confirming the framework

Canada's plan for the long-term management of used nuclear fuel, known as APM, emerged from a dialogue with the public. The starting point for this plan is that this generation is taking responsibility for the management of the used nuclear fuel it has created and is not leaving it as a burden to future generations. Canada's plan requires us all to work together to implement it. Together, we can ensure APM transportation is implemented safely, and in a manner consistent with our collective values, priorities, and perspectives.

In this document, we have reported on what we are hearing about the broad framework within which APM transportation should be planned. Building on what we heard, we also describe a flexible and adaptive approach to implementing the transportation program, which continues to involve people at key milestones along the way, responsive to what people said is most important.

The planning framework, and proposed implementation approach, are described here for discussion. We invite you to join the discussion, review the framework and implementation approach, and help shape it going forward. In 2021 we will publish an updated document, including a refined framework and implementation approach that reflects this further discussion. We look forward to hearing from you.

Share your thoughts!

1. **The framework:** In the document, we have outlined what we heard from the public, from interested individuals and organizations, and from Indigenous peoples on what will be important in planning and implementing the APM used nuclear fuel transportation program. We have described the framework emerging from these discussions.

   Have we accurately heard and reflected the priorities and objectives shared to date? Does the transportation planning framework include what is most important? What needs to be added/ changed? What needs further discussion over the coming years?

2. **The implementation approach:** Based on what we heard, we understand that a flexible and adaptive approach, which continues to involve people at key milestones along the way, needs to be taken to implement the program.

   Is the proposed implementation approach responsive to what people said is most important? What needs to be added/ changed? What needs further discussion?

3. **Looking forward: Please share your thoughts on additional considerations that need to be addressed.**

8. Share your thoughts

The dialogues continues. Please share your thoughts as we refine this plan together.

1. **The framework:** In the document, we have outlined what we heard from the public, from interested individuals and organizations, and from Indigenous peoples on what will be important in planning and implementing the APM used nuclear fuel transportation program. We have described the framework emerging from these discussions.

   Have we accurately heard and reflected the priorities and objectives shared to date? Does the transportation planning framework include what is most important? What needs to be added/ changed? What needs further discussion over the coming years?

2. **The implementation approach:** Based on what we heard, we understand that a flexible and adaptive approach, which continues to involve people at key milestones along the way, needs to be considered when implementing the program. We have proposed:

   Is the proposed implementation approach responsive to what people said is most important? What needs to be added/changed? What needs further discussion?

3. **Looking forward: Please share your thoughts on additional considerations that need to be addressed.**

Name: _____

Organization (if appropriate): _____ Date: _____

Address: _____

Email (optional): _____ Tel. (optional): _____

Would you like your comments posted on the NWMO website? Yes No

Please share your thoughts on transportation planning

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February 2018

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Small Modular Reactors: Managing Used Fuel

The Nuclear Waste Management Organization (NWMO) is responsible for implementing Canada's plan for the safe, long-term management of used nuclear fuel – including that created using new or emerging technologies.

Canada has been using CANDU nuclear reactors to generate electricity for more than half a century. Used nuclear fuel is a by-product of this process. In the future, new nuclear technologies and decisions about nuclear power generation made by governments, operators and regulators may also result in different types of used fuel.

Canada's plan, known as Adaptive Phased Management (APM), requires used nuclear fuel to be contained and isolated in a deep geological repository. This approach is consistent with international best practice for managing high-level radioactive waste.

Small Modular Reactors

In Canada, there is an active research sector exploring new technologies such as small modular reactors (SMRs), fuel reprocessing and other types of advanced reactors.

> We encourage organizations developing new concepts to work with us to identify the types of fuel waste that may result.

SMRs may provide an alternative to large-scale nuclear reactors. They could come with less up-front capital costs, simpler designs and could run with fewer workers. They could also be purchased and constructed in a modular way. They may even generate less long-lived, high-level waste requiring management in a deep geological repository.

Adapting to New Knowledge

Canada's plan will be implemented over many decades, and a fundamental tenet is incorporating new knowledge. We will adapt plans in response to advances in technical learning and international best practices, ongoing public input, Indigenous Knowledge, changes in public policy and evolving societal expectations and values.

We encourage organizations developing new concepts to work with us to identify the types of fuel waste that may result. The planning to accommodate this material will take time, and starting early will ensure we are prepared to manage all of Canada's used nuclear fuel when the repository begins operating.

The specific amount and type of used fuel to be placed in the repository will be agreed with host communities using the best information available and through an open and transparent process. Regulatory review processes and approvals, which are required by law before the facility can be constructed and operated, will be based on an agreed fuel inventory and will also involve an open and transparent consultation process.

The NWMO and Used Nuclear Fuel

The NWMO was established as a not-for-profit organization in 2002 in accordance with the *Nuclear Fuel Waste Act* (*NFWA*) to manage all of Canada's nuclear fuel waste. Today, a comprehensive process is well underway to identify a suitable repository site with an informed and willing host. We expect to identify a preferred site by about 2023.

Ensuring Safety

Fuel waste will need to meet certain criteria to ensure the NWMO can accept it and meet all safety requirements.

- **Physical requirements**
  Waste forms in the repository must be a durable, solid material that will not react chemically or release radionuclides rapidly should they come into contact with groundwater. For waste forms not considered durable, the waste owner would be responsible for converting them into a durable waste form before we could accept them for management in the repository.

> Waste forms in the repository must be a durable, solid material.

- **Characterization requirements**
  To accept fuel waste for management in the repository, we will need detailed information about characteristics such as physical, chemical and elemental composition, radionuclides, handling information and the length of time since it was removed from the reactor.

» **Repository requirements**
Once we have sufficient information about new types of fuel to be managed, we will determine potential impacts to repository designs. For example, new types of fuel may need to be packaged and arranged differently than current design concepts allow.

» **Transportation requirements**
The waste form must be transportable to the repository site, ideally fitting into a standard NWMO transport package. If not, there would be incremental costs to develop and license an appropriate transport package. There must also be an acceptable route to safely move the waste to the repository.

Costs for Waste Owners

The implementation of Canada's plan is funded by Canada's major owners of used nuclear fuel. Each waste owner makes annual deposits to trust funds to ensure the money needed over the life of the project is available by the time construction begins. These contributions are based on the number of used CANDU fuel bundles each member is expected to generate.

The *Nuclear Fuel Waste Act* considers the potential for new market entrants, and the government-approved formula used to determine funding for APM anticipated this eventuality.

For emerging technologies, the NWMO would provide a fee for service at fair and reasonable costs to determine the long-term management requirements and associated costs for the resulting fuel wastes. If a new technology is deployed and there is a new fuel waste owner, the NWMO would determine the long-term costs and establish the appropriate funding mechanism for accommodating these wastes.

> "…the *NFWA* requires the NWMO to provide its services to new waste owners for managing nuclear fuel waste over the long-term at a fair and reasonable cost." Minister of Natural Resources, April 2009, in letter approving funding formula.

Waste owners are responsible for interim storage of their used fuel waste until the repository is in place. They are also responsible for managing other types of waste, such as low- and intermediate-level waste or radioactive medical waste. This approach is consistent with Canada's radioactive waste policy framework.

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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A NEXT STEP
Part of Canada's Radioactive Waste Review

INTEGRATED STRATEGY FOR RADIOACTIVE WASTE

Report submitted to Canada's Minister of Natural Resources

June 2023



nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Land acknowledgment

The Nuclear Waste Management Organization (NWMO) acknowledges that we have worked in many different Indigenous territories since the inception of the organization. We are grateful to the Indigenous and municipal communities that have worked with us over the past 20 years.

We further acknowledge that today we are working in northwestern Ontario in the traditional territory of Wabigoon Lake Ojibway Nation with the community of Wabigoon Lake Ojibway Nation and the Township of Ignace.

In southern Ontario, we are working in the traditional territory of Saugeen Ojibway Nation (SON) with the two SON communities – Chippewas of Nawash Unceded First Nation and Chippewas of Saugeen First Nation – and the Municipality of South Bruce.

We further acknowledge that in both the northwest and the south, we have the privilege of working with other First Nations and organizations, with Métis communities and the Métis Nation of Ontario, and many municipal communities that have all expressed an interest in learning about our work.

As part of our commitment to Reconciliation, we recognize both the historic and current injustices far too many Indigenous communities endure. We pledge to do our part to encourage well-being in communities with which we work.

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Executive summary

Canada can take a lot of pride in its position as a world leader in the development and deployment of nuclear technologies, a position established over decades and a strong foundation of technical excellence and operational know-how upon which we can build. Now more than ever, nuclear energy is recognized as a vital tool in meeting climate targets, achieving a net-zero emissions economy by 2050 and ensuring a continued safe and secure energy system in the face of global challenges. Achieving these goals successfully depends on more than just having the right technology and resources in place; Canadians and Indigenous peoples want assurance that there is a long-term strategy for the radioactive waste that results.

The Government of Canada already took the important step of modernizing Canada's radioactive waste management framework through publication, in March 2023, of a revised Policy for Radioactive Waste Management and Decommissioning (hereafter referred to as the Policy).[1] As part of the government's radioactive waste management policy review, in fall 2020, Canada's Minister of Natural Resources tasked the Nuclear Waste Management Organization (NWMO) with leading a separate engagement process with Canadians, Indigenous peoples and industry representatives to inform the development of an integrated long-term management strategy for all Canada's radioactive waste, in particular low- and intermediate-level waste for which there are not currently long-term plans in place.[2] The task recognized the NWMO's 20 years of expertise in engaging Canadians and Indigenous peoples on plans for the safe, long-term management of used nuclear fuel. In developing this, the NWMO was asked to provide:

- A description of the current waste management situation in Canada in terms of current and future volumes, taking into account potential small modular reactor waste, characteristics, locations and ownership of the waste;
- An update on current plans and progress in advancing long-term management and disposal solutions for Canada's wastes, as well as the gaps that must be addressed;
- Conceptual approaches for dealing with our current and future radioactive waste inventory, including technical options for long-term management or disposal of the various waste types and options for the number of long-term waste management facilities in Canada; and
- Considerations regarding the staging, integration, establishment and operation of long-term waste management facilities.

This Canadian Integrated Strategy for Radioactive Waste (ISRW) is the beginning of a new era in waste management in Canada. It represents a next step, an evolution in waste disposal in Canada. This strategy is a first for Canada and closes the gaps in waste disposal of all Canada's radioactive waste from current electricity generation and production of life-saving medical isotopes, with an eye to the future.[3]

Since that original tasking, the importance of this strategy has taken on new relevance as new technologies such as small modular reactors are beginning to move forward. These reactors would also produce waste that would have to be safely managed. This strategy has been written with flexibility to incorporate these wastes into the appropriate waste stream using Canada's waste classification: high-level waste, including used nuclear fuel, intermediate-level waste, low-level waste, and uranium mine and mill waste. The strategy has also been developed to ensure respect for Indigenous rights and treaties is foundational to future activities.

This integrated strategy is informed by the Policy, what we heard from our engagement with Canadians and Indigenous participants, and the expert input received from the various studies commissioned during this process. Where the Policy provides direction, this integrated strategy does not duplicate or extend the Policy's mandate. As a result, the draft ISRW recommendations that were published for public review in August 2022 have been modified to reflect Policy direction.

This strategy makes two fundamental recommendations and sets out four implementation principles to ensure Canada has long-term disposal facilities for all its radioactive wastes. The recommendations and implementing principles are as follows and are further defined in this report:

Recommendation 1	Intermediate-level waste and non-fuel high-level waste to be disposed of in a deep geological repository with implementation by the NWMO
Recommendation 2	Low-level waste to be disposed of in multiple near surface disposal facilities with implementation by waste generators and waste owners
Implementing principle 1	Consent of the local communities and Indigenous peoples in whose territory future facilities will be planned must be obtained in siting.
Implementing principle 2	Design of facilities should prioritize the protection of water.
Implementing principle 3	Long-term caretaking should be established for disposal facilities.
Implementing principle 4	We need to take action now and not defer to future generations.

Radioactive waste in Canada

Canada has been a leader in the development and application of nuclear technologies for over half a century, relying on nuclear energy to power communities and supply radioisotopes for nuclear medicine and other innovative research, and valuable industrial applications. These activities create radioactive waste that are classified according to the degree of containment and isolation that is necessary to ensure the safety of people and the environment. In Canada, there are four general classes of radioactive waste:

- High-level waste (HLW);
- Intermediate-level waste (ILW);
- Low-level waste (LLW); and
- Uranium mine and mill waste.

Each class of waste requires its own type of storage and disposal methods commensurate with its short- and long-term risk from the radioactivity and/or heat it generates. All radioactive waste in Canada is safely managed in accordance with international standards at facilities licensed by the Canadian Nuclear Safety Commission (CNSC). However, not all radioactive waste in Canada has long-term disposal plans.

Gaps in long-term disposal plans for radioactive waste in Canada

The table below represents the approximate volumes and percentage of radioactive waste with no long-term disposal plans that were identified as part of the development of this integrated strategy. This includes both current and projected future waste from existing nuclear facilities. It is important to note that about 84 per cent of the radioactive waste in Canada has an existing long-term waste management plan. Of the 16 per cent of the total radioactive waste that has no long-term waste management plan, 14 per cent is low-level waste, and only about two per cent is intermediate-level waste with less than 0.01 per cent of total volume being non-fuel high-level radioactive waste.

Table 1: Waste with no long-term disposal plan

Waste type	Volume (m^3)	Percentage of total radioactive waste in Canada
High-level waste (non-fuel)[4]	<10	<0.01
Intermediate-level waste	51,000	2
Low-level waste	294,000	14
Uranium mine and mill	No gaps – Existing plans in place	–
Approximately 84 per cent of total radioactive waste in Canada already has long-term waste disposal plans.		

Technical options and inventories

Based on an international benchmarking study, the following potential options were identified to address the gaps in long-term waste management plans for radioactive waste specifically for low- and intermediate-level waste in Canada. Rolling stewardship is not a disposal option and does not represent international best practice. However, it was included in the engagement process to provide participants with a range of long-term management solutions (storage and disposal) to best inform the strategy.

Near surface disposal facility options:

1. Engineered containment mound
2. Concrete vault
3. Shallow rock cavern

Deep disposal options:

4. Deep geological repository
5. Deep borehole

Long-term storage:

6. Rolling stewardship

The above options were assessed from a technical perspective against the volume and characteristics of the inventories of low- and intermediate-level waste that were provided by the waste generators and waste owners. The volume included projected inventories based on existing CANDU (Canada Deuterium Uranium) reactor fleet and lifecycle assumptions and did not include volume of waste that may be generated from future technologies such Small Modular Reactors (SMR). A further study on cost estimates of implementing the various technical options was also conducted to help with the assessment of various options.[5]

Based on this technical assessment, Canada's low-level waste should be disposed of in the types of near surface disposal facilities mentioned above. However, the engineered containment mound is suitable and most economical for bulk low-level waste such as soil, given the low concentration of radionuclides and the large volume of this type of waste. The concrete vault is suitable for all low-level waste, given the increased containment and structural integrity provided; however, taking economics into account, it is most suitable for non-bulk radioactive waste.

Based on the technical assessment, the disposal options for intermediate-level waste could be a deep geological repository or a deep borehole. However, the most suitable option is a deep geological repository as the deep borehole option was found to be approximately 10 times more expensive per cubic metre, of waste than a deep geological repository. Furthermore, the deep borehole option is only capable of disposing of part of the intermediate-level waste inventory due to its size limitations.

Integrated strategy

Over the course of two years of engagement with Canadians, Indigenous peoples and industry representatives, as well as review of international best practices for optimum technical solutions, the NWMO has developed the following integrated strategy for the various radioactive waste streams in Canada. There are three existing gaps where some low-level, intermediate-level and non-fuel high-level radioactive wastes do not currently have disposal plans.

To address these gaps and consistent with what the NWMO heard from stakeholders and Indigenous peoples and the direction of the Policy, two fundamental recommendations, and four implementation principles have been developed to ensure that Canada has disposal facilities for all its radioactive wastes. The strategy is shown in the table and illustration that follow; it does not replace existing long-term disposal projects currently in progress, but rather includes these plans.

Table 2: Integrated strategy for all current and projected radioactive waste

Waste classification	Type of waste	Existing long-term disposal plan	Current responsibility for implementation	Integrated strategy
High-level waste (HLW)	Used fuel	Yes	NWMO	No change – Deep geological repository
	Non-fuel	No	–	Deep geological repository Responsibility for implementation of long-term waste disposal plan: NWMO
Intermediate-level waste (ILW)	ILW produced in various nuclear facilities	No	–	Deep geological repository Responsibility for implementation of long-term waste disposal plan: NWMO
	ILW produced at Nuclear Power Demonstration facility and Whiteshell Reactor 1	Yes	Canadian Nuclear Laboratories	No change – In-situ decommissioning
Low-level waste (LLW)	Port Hope historic LLW	Yes	Canadian Nuclear Laboratories	No change – Port Hope Area Initiative
	LLW owned by Atomic Energy of Canada Limited at Chalk River	Yes	Canadian Nuclear Laboratories	No change – Near surface disposal facility
	LLW produced at Nuclear Power Demonstration facility and Whiteshell Reactor 1	Yes	Canadian Nuclear Laboratories	No change – In-situ decommissioning
	LLW produced in various nuclear facilities	No	–	Multiple near surface disposal facilities Responsibility for implementation of long-term waste disposal plan: Waste generators/owners
Uranium mine and mill waste[6]	Tailings facilities near point of generation	Yes	Uranium mines and mill tailings companies, and applicable provincial and federal governments	No change – Disposal facilities near point of waste generation

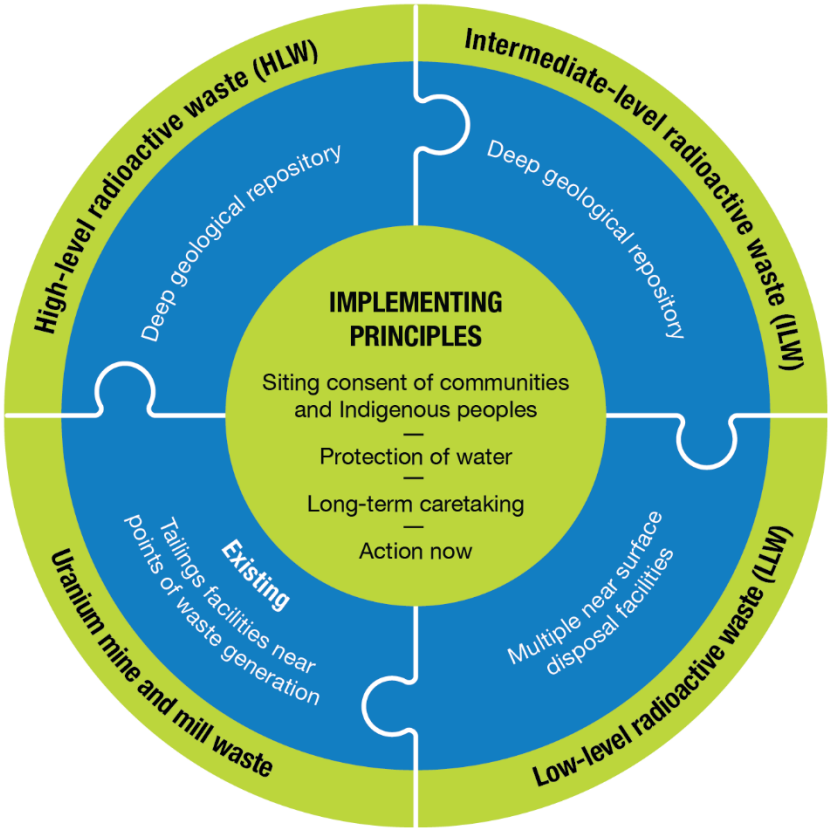


Figure 1: Canada's Integrated Strategy for Radioactive Waste

Recommendations and principles for implementation of Canada's Integrated Strategy for Radioactive Waste

Recommendations

RECOMMENDATION 1: INTERMEDIATE-LEVEL WASTE AND NON-FUEL HIGH-LEVEL WASTE TO BE DISPOSED OF IN A DEEP GEOLOGICAL REPOSITORY WITH IMPLEMENTATION BY THE NWMO

- The NWMO, as Canada's leading organization for deep geological disposal, to site and build a deep geological repository for Canada's intermediate-level waste (ILW) and non-fuel high-level waste (HLW), with funding provided by waste generators and waste owners.
- The NWMO to prepare a detailed plan defining the process to select a site for the repository, inclusive of engagement strategy and funding approach, taking into account experience and learnings gained from implementing other siting processes for nuclear facilities. This siting process is separate from the NWMO's work to site Canada's plan for used nuclear fuel.
- This plan is to outline the process to determine the technical and social acceptability requirements for siting a repository, consistent with the Policy, and the implementing principles outlined hereafter.
- This plan is to also include the expected timelines for siting and construction of the repository.
- It is expected that defining the site selection process could take 12 to 18 months, at which point the NWMO will report back to Natural Resources Canada on the approach.

RECOMMENDATION 2: LOW-LEVEL WASTE TO BE DISPOSED OF IN MULTIPLE NEAR SURFACE DISPOSAL FACILITIES WITH IMPLEMENTATION BY WASTE GENERATORS AND WASTE OWNERS

- Waste generators and waste owners to site and build near surface disposal facilities for those low-level waste with no long-term disposal plan, consistent with international best practices, considering characteristics, volume, proximity to the existing interim waste facilities, community acceptance and technical considerations.
- The option of multi-waste producer facilities or centralized regional facilities to also be explored to balance the number of facilities with the distance that the waste would need to be transported. Centralized regional facilities could provide economies of scale and could ensure fair access to disposal facilities for small waste generators. Regional facilities could be provincial, cover multiple provinces or be multiple facilities within one province, depending on several factors such as volume of waste, transportation distances and cost.
- More detailed implementation plans by waste generators and waste owners to be developed in an open and transparent manner, with early and ongoing engagement consistent with the Policy.

Implementing principles

Based on extensive input from Canadians and Indigenous peoples, the following four implementing principles were highlighted as a priority for any new waste facilities to be developed as part of the strategy; these are further described in Chapter 4.

IMPLEMENTING PRINCIPLE 1: CONSENT OF THE LOCAL COMMUNITIES AND INDIGENOUS PEOPLES IN WHOSE TERRITORY FUTURE FACILITIES WILL BE PLANNED MUST BE OBTAINED IN SITING.

This consideration was prioritized by the majority of participants in the engagement sessions. Consent of the impacted Indigenous communities is also aligned with Canada's measures taken for the implementation of the *United Nations Declaration on the Right of Indigenous Peoples Act* (*UNDA*). This critical consideration extends to all future disposal facilities for radioactive waste. Indigenous communities in siting areas must have early and meaningful engagement and ongoing involvement in all phases of any waste disposal project, regardless of size, through capacity building among Indigenous peoples, information sharing and collaboration.[7] In addition, laws, regulatory processes and Indigenous consultation protocols, developed and implemented in areas where future facilities will be planned, should be respected.

IMPLEMENTING PRINCIPLE 2: DESIGN OF FACILITIES SHOULD PRIORITIZE THE PROTECTION OF WATER.

The Policy requires that radioactive waste management, including disposal, be carried out in an integrated manner that prioritizes the health, safety and security of people and the environment, which includes water.[8] While safety can be demonstrated from a technical standpoint regardless of location, it may be difficult to obtain societal support for facilities located in close proximity to major sources of drinking water. This was a priority for most participants in the NWMO's engagement processes who felt strongly that waste disposal sites should not be built near sources of drinking water as they felt these could contaminate it and affect their way of life. While participants indicated that facilities should be located away from any major water sources, the reality of the Canadian landscape is that this would not be feasible. Protection of water is paramount, and therefore, any disposal facilities must meet the highest standards of environmental and water protection.

IMPLEMENTING PRINCIPLE 3: LONG-TERM CARETAKING SHOULD BE ESTABLISHED FOR DISPOSAL FACILITIES.

There should be oversight of the waste and of the facilities for as long as future generations deem it to be necessary to ensure that the environment remains protected. This means that the knowledge of the type of waste, its location and their associated monitoring plans need to be transferred to future generations to determine whether they continue to be adequate or necessary. This is consistent with the Policy, which "recognizes the time frames associated with the management of radioactive waste and the associated obligations to ensure ongoing responsibility of radioactive waste disposal facilities, locations, and sites once closed, so it remains safe and secure for people and the environment in perpetuity".[9] In addition, Indigenous communities with nuclear waste facilities should be part of conversations around land stewardship. This is consistent with expectations on waste generators and waste owners in the Policy to work in partnership with Indigenous peoples to gain a greater understanding of their Indigenous Knowledge and advice with regards to radioactive waste management and decommissioning projects.

IMPLEMENTING PRINCIPLE 4: WE NEED TO TAKE ACTION NOW AND NOT DEFER TO FUTURE GENERATIONS.

There is a need to have and implement an integrated strategy for all Canada's radioactive waste with a sense of urgency rather than leaving this to future generations. This is consistent with the Policy requirement on waste owners and generators to collaborate with other waste owners or generators on their plans for the advancement, development and implementation of comprehensive and nationally integrated radioactive waste management solutions in a timely manner, and to decommission facilities, locations and sites within an appropriate time frame to reduce the burden on future generations.[10] The implementation of the ISRW will require firm ongoing commitment and support from government, with a structure that will be empowered to deliver on the objectives of the strategy, regardless of changes in government. This urgency to take actions must be appropriately balanced with Canada's commitment to Reconciliation with Indigenous peoples.

Summary of engagements

In 2021, the NWMO began engaging with waste generators and waste owners and interested Canadians and Indigenous peoples, conducting public opinion research, hosting a summit to hear from diverse voices, listening to citizens in a series of engagement sessions in communities where waste is stored today, hosting roundtable discussions, and organizing technical workshops. In total, the NWMO engaged in over 75 activities offered in a variety of formats (see Figure 2 that follows) over a period from January 2021 to April 2023, with a total of nearly 4,000 participants. The NWMO committed to reporting on the engagement process throughout and created a project hub to make information available to participants throughout the process – radwasteplanning.ca.

Indigenous engagement

The NWMO is committed to Reconciliation and to ensuring relationships with Indigenous communities are fostered in a meaningful way.

As part of engagement on this integrated strategy, the NWMO sought to gain Indigenous perspectives and recommendations, from those who participated, to foster existing relationships, and create new ones to share thoughts, priorities and concerns. The NWMO humbly acknowledges that while efforts were made to engage on a broad level with Indigenous communities, there were some limitations to comprehensive engagement, including no engagement with Inuit participants. While the term

"Indigenous" is used in the report, it encompasses only the First Nation and Métis participants listed in the What We Heard Report – Indigenous Engagement, and comments reflected are not meant to represent these voices as a whole.[11]

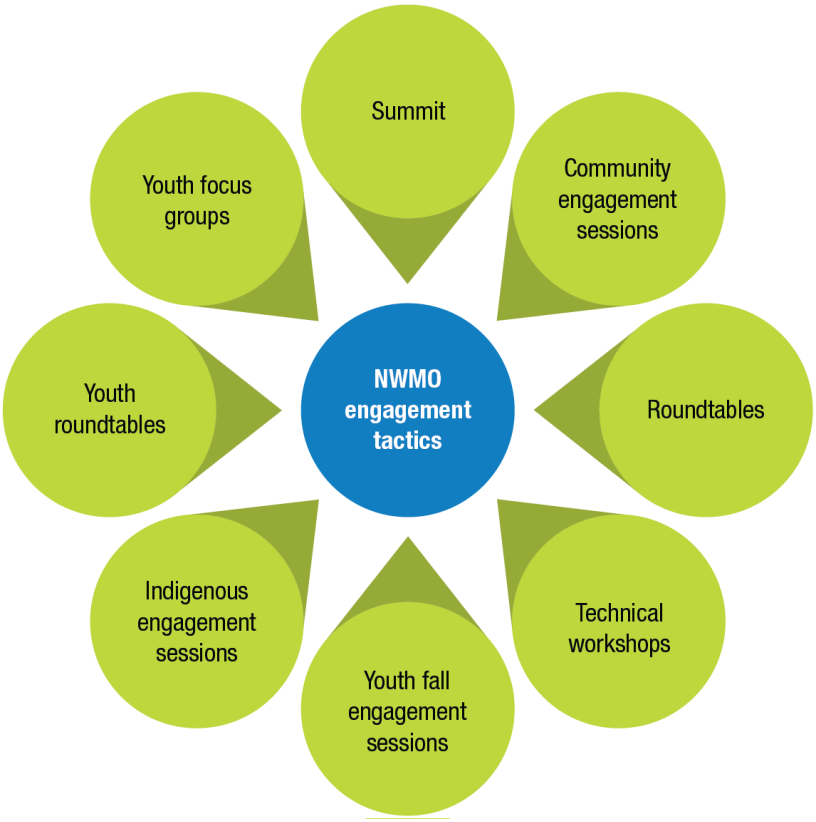


Figure 2: ISRW engagement activities

Key themes arising from NWMO engagement activities

The following summarizes the key themes that emerged during engagement on Canada's Integrated Strategy for Radioactive Waste.

KEY THEME 1 – SAFETY IS PARAMOUNT

The most prominent theme that emerged throughout the engagement was the importance of safety in every aspect of the development and implementation of the Integrated Strategy for Radioactive Waste. Participants prioritized safety over cost efficiency. As a key priority, safety should be considered through a long-term lens so that the strategy is able to respond to future risks and ensure safety in unpredictable and potentially unstable future conditions in the environment, government, society and technology.

KEY THEME 2 – THE TIME TO ACT IS NOW

There is a need for an integrated strategy, and the approach to the long-term management of low-level and intermediate-level waste should be determined. There was general agreement that it was the right thing to do to have and to implement a plan for all Canada's radioactive waste, and to do so with a sense of urgency rather than leaving this to future generations.

KEY THEME 3 – COMMUNICATION AND TRANSPARENCY

Participants were adamant that clear, fact-based, inclusive communication that provides context in a relevant, accessible and unbiased way is essential. Transparency, including clear, open and ongoing communication about decisions and processes, is very important. Transparency about the waste and any potential risks associated with it is also needed, as is effective communication providing context when necessary. Some participants expressed the importance of having more visibility of waste inventories, as they exist today, and what could be expected in the future.

KEY THEME 4 – TRUST AND RELATIONSHIPS WITH INDIGENOUS COMMUNITIES

Meaningful engagement and ongoing relationship building with Indigenous communities must be central to developing and implementing the plan. Listening to Indigenous peoples is important to restore trust, bridge relationships and affirm the importance of Reconciliation. Ensuring that Indigenous Knowledge was incorporated along with western science was also identified as important to a strategy that would address the far future, as well as more immediate considerations. Participants wanted the strategy to reflect Indigenous communities' right to Free, Prior and Informed Consent and to avoid exploitative practices with respect to Indigenous involvement.

KEY THEME 5 – EDUCATION AND ENGAGEMENT

Full engagement is required to achieve real buy-in for a strategy that will work for people in Canada, and the importance of youth engagement was emphasized. Education is vital to enable potentially impacted people and communities to be appropriately informed, and needs to be further integrated into discussions to help Canadians and Indigenous peoples understand the unique challenges posed by radioactive waste and how safety is assured. Learning from science-based best practices internationally was also identified as an important pathway to ensuring both public safety and cost effectiveness, which are both important, now and in the long term. Youth saw a need for an intergenerational education strategy to cultivate a sense of responsibility for the long-term strategy implementation among young people.

KEY THEME 6 – SUSTAINABILITY AND THE ENVIRONMENT

In addition to the safety of the community and its residents, minimizing the carbon footprint and protecting the environment, in particular water, over the long term were important. Participants shared that we needed to be mindful of the climate emergency to ensure that every aspect of this strategy is sustainable, considers the risks posed by climate change, respects the environment and protects waste sources for all future generations. The goals of minimizing environmental impacts should be viewed through a life cycle approach and include the construction of facilities and transportation of radioactive waste. Participants were acutely aware of the history of environmental racism in Indigenous communities, and environmental justice is a key consideration when discussing how many facilities to build and where.

KEY THEME 7 – TRANSPORTATION

Participants had many questions about the risks associated with transportation and the consequences of transportation accidents on the safety of the radioactive waste being transported, and generally preferred to minimize the transportation of radioactive waste to reduce any associated risks. Other concerns around transportation included cost, potential increase of greenhouse gas emissions and potential environmental impacts from building new access roads. Participant views on the relative risks of transportation influenced their views on having one central repository for low-level waste and for intermediate-level waste, or having multiple disposal facilities closer to where the waste is produced. There was an expressed desire to be included in plans for transportation in traditional territories.

KEY THEME 8 – SHARED RESPONSIBILITY FRAMEWORK/INDEPENDENCE OF ACCOUNTABLE ENTITY

There were varying perspectives regarding who should be responsible for the oversight of the strategy. There were differences of opinion about the role of industry, but there was general agreement that there should be a single entity with appropriate expertise that is independent from the implementers, subject to regulated safety and environmental oversight. The governance of such an entity was subject to different ideas, with some suggesting that the oversight governance should be comprised of industry, civil society organizations, and Indigenous peoples, and others focusing on ensuring the oversight remained independent and included the right expertise. There was broad support for the waste owners to finance the strategy.

KEY THEME 9 – ROLLING STEWARDSHIP AND WASTE DISPOSAL

A majority supported the idea of finding solutions to permanently dispose of the waste now, and not leaving the decision for future generations. Uncertainty about climate change, and whether changes to government or society in the long term could leave waste vulnerable under indefinite storage arrangements were some of the concerns that were cited. Participants wanted to see intermediate-level waste treated the same as high-level waste and disposed of in a deep geological repository. However, there were others that saw rolling stewardship as the preferred strategy, in particular for low-level waste, because of considerations such as potential future technology innovations, ensuring that the waste was not forgotten, and the ability to constantly monitor the waste to ensure that any environmental impacts could be identified and remediated before causing significant harm, especially to the water table.

KEY THEME 10 – COLLOCATION AND CENTRALIZATION

There was a range of responses from participants who felt minimizing the number of facilities could have advantages. Participants acknowledged the difficulty in finding willing and informed host communities, and obtaining the Free, Prior and Informed Consent of Indigenous peoples made multiple sites more challenging. However, there were concerns about the impact of a single location on the transportation of waste. Some participants cautioned about the importance of ensuring appropriate technical arrangements for different waste types located in the same facility, while others noted the cost advantages of consolidating expertise and facilities in a single location.

The majority preferred using a centralized facility for intermediate-level waste to enable greater control and oversight over its long lifespan, with potential cost and time savings. Centralizing intermediate-level waste was seen as preferable to limit potential risk exposure to one location instead of potentially endangering multiple ecological zones. The idea of collocation and centralization was more broadly supported for intermediate-level and high-level waste, than it was for low-level waste and intermediate-level waste. The volumes of low-level waste are greater, and participants generally felt that leaving it nearer to the sites where it was generated or stored, rather than transporting it vast distances, was preferable. Regardless of the option preferred, community willingness was identified as a pillar for any disposal facility.

KEY THEME 11 – A STRATEGY BY AND FOR CANADIANS AND INDIGENOUS PEOPLES

It was clear that participants want this to be a strategy created by and for Canadians and Indigenous peoples and that this is key to have buy-in. An inclusive strategy is a reflective strategy. In addition, the ISRW should consider the unique conditions and environment of Canada, including the size of the country, the diversity of Canadians and Indigenous peoples, and the changing climate.

Chapter 1: Developing the integrated strategy

Context: The NWMO was asked by the federal government to engage Canadians, Indigenous peoples, and waste generators and waste owners to develop an Integrated Strategy for Canada's Radioactive Waste (ISRW), recognizing that the decisions made today will impact future generations.

Introduction

As part of the government's radioactive waste management policy review, in fall 2020, Canada's Minister of Natural Resources tasked[12] the NWMO with leading a separate engagement process with Canadians, Indigenous peoples and industry representatives to inform the development of an integrated long-term management strategy for all Canada's radioactive waste, in particular low- and intermediate-level waste for which there are not currently long-term plans in place. The task recognized the NWMO's 20 years of expertise in engaging Canadians and Indigenous peoples on plans for the safe, long-term management of used nuclear fuel.



Figure 3: ISRW background

This strategy represents a next step – to identify and address gaps, and to look further into the future. Although all Canada's radioactive waste is safely managed today, not all Canada's radioactive waste has a long-term disposal plan that will ensure the safety of people and the environment well into the future.

Gaps exist in the long-term disposal plans for low- and intermediate-level waste, and Canada lacks an integrated strategy. This integrated strategy was developed in a way that reflects input received, international scientific consensus and best practices from around the world to ensure that people and the environment are protected long into the future. In collaboration with waste generators and waste owners, government, Indigenous peoples, civil society organizations, and interested Canadians, the NWMO has focused on the following:

1. A description of the current waste management situation in Canada in terms of current and future volumes, taking into account potential small modular reactor waste, characteristics, locations and ownership of the waste;
2. An update on current plans and progress in advancing long-term management and disposal solutions for Canada's wastes, as well as the gaps that must be addressed;
3. Conceptual approaches for dealing with our current and future radioactive waste inventory, including technical options for long-term management or disposal of the various waste types and options for the number of long-term waste management facilities in Canada; and
4. Considerations regarding the staging, integration, establishment and operation of long-term waste management facilities.



Figure 4: The NWMO's approach to ISRW development

The NWMO is deeply committed to a transparent, inclusive engagement process and wants to emphasize that there were no pre-determined outcomes. The NWMO committed to reporting on the engagement process throughout and created a project hub to make information available to participants throughout the process – radwasteplanning.ca.

Context – Radioactive waste in Canada

Radioactive waste is any material (liquid, gaseous or solid) that contains a radioactive nuclear substance for which no further use is foreseen. It comes mostly from nuclear power generation and other kinds of nuclear fission or technology, like research and medicine. Because it is hazardous to most forms of life and the environment, it requires careful management and is highly regulated by government agencies.

In Canada, radioactive waste is created from uranium mining and processing, nuclear medicine, nuclear fuel fabrication, nuclear reactor operations, research and development activities, radioisotope manufacture and use, and decommissioning activities.

Radioactive waste classifications

Radioactive waste is classified according to the degree of containment and isolation that is necessary to ensure safety, with additional consideration given to the hazardous potential of different classes of waste and the time frame associated with the hazard. In Canada, there are four general classes of radioactive waste:

- High-level waste (HLW);
- Intermediate-level waste (ILW);
- Low-level waste (LLW); and
- Uranium mine and mill waste.

Each class of waste requires its own type of storage and disposal methods commensurate with its short- and long-term risk from radioactivity and/or heat generated from the waste. Careful management of the waste, including its storage and long-term disposal, ensures that people and the environment are protected from harmful levels of radiation and other hazards.

Waste containing amounts of radioactive material too small to pose a hazard is not considered to be radioactive waste. As such, waste with radionuclide content below established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations) may be disposed of using conventional means such as sending the waste to a local landfill.[13]

High-level waste

High-level radioactive waste is primarily used nuclear fuel and/or is waste that generates significant heat via radioactive decay. High-level waste is associated with penetrating radiation; thus shielding is required. High-level waste also contains significant quantities of long-lived radionuclides necessitating long-term isolation. Placement in deep, stable geological formations at depths of several hundred metres or more below the surface is recommended for the long-term management of high-level waste.

Intermediate-level waste

Intermediate-level radioactive waste is generated primarily from power plants, prototype and research reactors, test facilities, and radioisotope manufacturers and users, including some medical applications. Intermediate-level waste generally contains long-lived radionuclides in concentrations that require isolation and containment for periods greater than several hundred years. Intermediate-level waste needs no provision, or only limited provision, for heat dissipation during its storage and disposal. Due to its long-lived radionuclides, intermediate-level waste generally requires a higher level of containment and isolation than can be provided in near surface repositories. Waste in this class may require disposal at greater intermediate depths of the order of tens of metres to a few hundred metres or more.

Low-level waste

Low-level radioactive waste comes from operating reactors and from medical, academic, industrial and other commercial uses of radioactive materials. Low-level waste contains material with radionuclide content above established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations), but generally has limited amounts of long-lived activity. Low-level waste requires containment and isolation for periods of up to a few hundred years. An engineered near surface disposal facility is typically appropriate for low-level waste.

Uranium mine and mill tailings

Uranium mine and mill tailings are a specific type of radioactive waste generated during the mining and milling of uranium ore and the production of uranium concentrate. In addition to tailings, mining activities typically result in the production of large quantities of waste rock as workings are excavated to access the ore body. The wastes contain long-lived radioactivity that does not decrease significantly over extended time periods. In general, long-term management in near surface facilities adjacent to mines and mills is the only practical option for these wastes, given the large volumes of waste generated in mining and

milling operations. The table below identifies some examples of radioactive waste according to their classification.

Table 3: Radioactive waste classification in Canada

High-level waste	Intermediate-level waste	Low-level waste	Uranium mine and mill waste
Primarily used nuclear fuel	Filters, resins and used reactor components Medical/industrial sources	Mop heads, rags and paper towels Medical isotopes	Tailings and waste rock generated by the mining and milling of uranium ore
Significant heat generated	No or little heat generated	No heat generated	No heat generated
Containment and isolation for hundreds of thousands of years	Containment and isolation for periods greater than several hundred years	Containment and isolation up to a few hundred years (less than 300 years)	Long-lived radioactivity does not decrease significantly over extended time periods
Deep geological repository	Deep geological repository	Near surface repository	Near surface repository
Significant quantities of long-lived radionuclides necessitating long-term isolation	Generally, requires a higher level of containment and isolation than can be provided in near surface repositories	More radioactive than clearance levels and exemption quantities	Only practical option for these wastes, given the large volumes of waste generated

Oversight

In Canada, matters that relate to nuclear activities and substances are under the jurisdiction of the Government of Canada. Natural Resources Canada (NRCan) is responsible for determining Canada's nuclear energy policies, including those that concern radioactive waste. Canada's Policy for Radioactive Waste Management and Decommissioning establishes the roles and responsibilities of the Government of Canada, as well as waste generators and waste owners.[14] The Policy is based on four priorities as follows:

1. Protection of health, safety and security of people and the environment, and ensuring nuclear non-proliferation;
2. Inclusive engagement, openness and transparency on radioactive waste management and decommissioning matters;
3. Recognition of Canada's deep commitment to building partnerships and advancing Reconciliation with Indigenous peoples related to the management of radioactive waste and decommissioning, based on the recognition of rights, respect, collaboration and partnership; and
4. Global excellence in the fields of radioactive waste management and decommissioning.

The Policy requires that the federal government "maintains and updates, as necessary, a national legislative and regulatory regime, centred on an independent nuclear regulator that makes decisions using inclusive, open and transparent public hearings, to oversee and regulate radioactive waste management and decommissioning, including funding requirements, in accordance with waste management and decommissioning plans".[15]

In addition, the Policy also requires the federal government to oversee the development, maintenance and implementation, by waste generators and owners, of an integrated strategy for Canada's radioactive waste to address long-term plans for waste management, which would be reviewed and updated as appropriate upon request from the Minister of Natural Resources.

Process for the development of ISRW and recommendations

In 2020, the NWMO was tasked by NRCan to develop an Integrated Strategy for Radioactive Waste. As part of the development of this ISRW, the NWMO undertook a number of activities and assessments, including international benchmarking, technical assessments and engagement with the public, Indigenous peoples and various stakeholders.

The NWMO first began in 2020 by commissioning an international benchmarking report on the long-term management of low- and intermediate-level waste.[16] This report provided an overview of the technical options being implemented or pursued, from a survey of over 22 countries. From this international benchmarking, the NWMO retained five potential disposal options for low- and intermediate-level waste in Canada. Rolling stewardship is not a disposal option and does not represent international best practice. However, it was included in the engagement process to provide participants with a range of long-term management solutions (storage and disposal) to best inform the strategy.

This was followed by a compilation of inventory data and the commissioning in 2021 of an assessment of the potential options from a technical point of view.[17] Later in 2021, a complementary cost estimate report was commissioned to assess the relative costs of implementing the potential technical options.[18]

The NWMO developed a set of principles that are comprised of what the organization had heard previously from Canadians and Indigenous peoples. These initial principles were included in public opinion research and refined by participants at the Canadian Radioactive Waste Summit, the first of the engagement events for the development of an Integrated Strategy for Radioactive Waste, held on March 30-April 1, 2021. The principles that emerged were used as the basis for discussion in the community engagement sessions. All the work undertaken by the NWMO was anchored on these principles. The full text of the principles is included in Appendix A.



Figure 5: Guiding principles

Quantitative opinion data was collected through two surveys: a survey conducted with a panel of representative Canadians and a survey open to all. Our online surveys provided an opportunity for Canadians and Indigenous peoples to identify potential priorities, principles and considerations for developing a comprehensive strategy. It also provided us with valuable perspectives, opinions and feedback that will help ensure the best options are in place for the management of Canada's radioactive waste. Both surveys looked at the same set of issues, mostly using the exact same questions. The two surveys also provided essentially the same fact-based background information on the topic (e.g., levels of radioactive waste, current waste management practices, international practices).

In early 2021, the NWMO commissioned the first survey, a deliberative survey of representative Canadians (representative survey) on the development of an integrated strategy for the long-term management of radioactive waste.[19] The research was conducted during the last two weeks of January 2021. A random sample of 1,625 adult residents of Canada completed the representative survey online. Prior to gathering respondent input, the questionnaire provided fact-based background information on the issues (e.g., types of radioactive waste, current waste management practices, international practices).

A similar format was used for the second survey (open survey), which was open from May to December 2021.[20] One of the distinguishing features of this online open survey is that it was open to all to allow anyone with an interest to contribute. A total of 345 people participated in the open survey. Of note, the open survey included an informational video on transportation and another on the regulation of radioactive waste in Canada, whereas the initial representative survey did not.

From an engagement perspective, the NWMO engaged in a multitude of activities offered in a variety of formats over a period of 18 months from January 2021 to June 2022, with a total of nearly 4,000 participants. Additional engagement with some Indigenous communities continued after the public comment period closed until such time that NRCan's revised Policy was published.

In January 2021, the NWMO launched a website for the ISRW, distinct and separate from the NWMO website. This website was the hub for all information related to the ISRW. Presentations and reports are posted there to maximize transparency. Registration for most engagement activities was also conducted through this website. Social media was leveraged for promotion of engagement activities, reaching approximately 1 million people.

Held on March 30-April 1, 2021, the Canadian Radioactive Waste Summit was the kickoff of the engagement process to develop the ISRW.[21] It was designed to provide a safe, shared space for multiple voices to be heard, connect participants in new and meaningful ways, and showcase diverse voices and perspectives on the important issues related to developing an integrated strategy for Canada's radioactive waste.

Invited speakers represented Indigenous peoples, civil society organizations, industry, municipal officials, youth and international perspectives. The three-day event was free of charge and open to anyone interested. It was not a technical event; rather, it aimed to create the opportunity for participants who may not be familiar with all the issues to hear from a diversity of voices expressing different considerations and to be able to ask questions and participate in breakout sessions to explore these topics and share their ideas.

The remainder of the engagement activities can be divided into the following categories: community engagement sessions open to all; roundtables with industry, academics, civil society organizations, and federal and provincial civil servants; youth engagement; and Indigenous engagement.

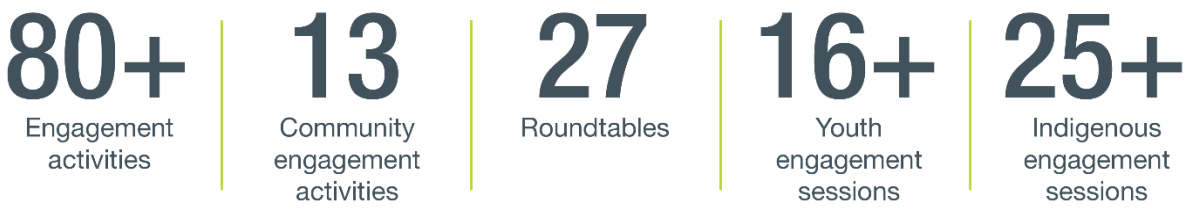


Figure 6: Engagement sessions across multiple participant groups

In these engagements, participants were invited to take part in a discussion on three key topics that would help inform the development of an Integrated Strategy for Canada's Radioactive Waste:

1. The first focused on identifying what is most important to get right when developing an Integrated Strategy for Canada's Radioactive Waste.
2. The second focused on how we best deal with Canada's low- and intermediate-level waste over the long term (considered separately).
3. The third focused on who should be responsible for implementing the strategy.

These discussion topics helped identify key considerations that participants view as being necessary to include in an integrated strategy.

In addition, the NWMO hosted six technical workshops for experts and laypersons: three on low-level waste and three on intermediate-level waste. During the sessions, participants were asked to comment on the report, and asked if the order of recommended options is prioritized in the way they felt it should. Participants were encouraged to focus on the technical options in isolation of other factors that will come into the final strategy recommendations.

The NWMO published a series of What We Heard reports to capture the input provided during the various engagement activities.[22] See Appendix B: Matrix of input from engagement activities, by participant

grouping, to see the contributions of various participant groups to the development of themes and ideas captured within the recommendations.

It should be noted that several civil society organizations declined to participate in the development of the ISRW. Civil society organizations that did participate made a valuable contribution to the dialogue, and their comments are captured and reflected in this report.

It is disappointing that some groups declined to participate, as we want to ensure all perspectives have an opportunity to be heard. We continued to reach out throughout the process and invited these groups to provide input on what steps we could take to address their concerns with participating to ensure their perspective is considered. They chose not to engage with the NWMO.

The civil society organization Nuclear Waste Watch convened the Radioactive Waste Review Group in 2019, and in April 2022, it released a document, entitled “An Alternative Policy for Canada on Radioactive Waste Management and Decommissioning.” The NWMO reviewed this document and considered the relevant inputs as part of the development of the strategy.

The NWMO published a draft ISRW in August 2022 for a 90-day public comment period.[23] Submissions on the draft ISRW, continued engagement with interested Indigenous peoples and the publication of the Policy informed this final ISRW document.

Timeline

The NWMO was tasked with leading the ISRW engagement in November 2020. We launched our engagement process in January 2021 with a representative survey, concluded our public engagement in April 2022 and published the draft ISRW for a 90-day public comment period in August 2022. Indigenous engagement, however, continued up until the time of publication of this integrated strategy.

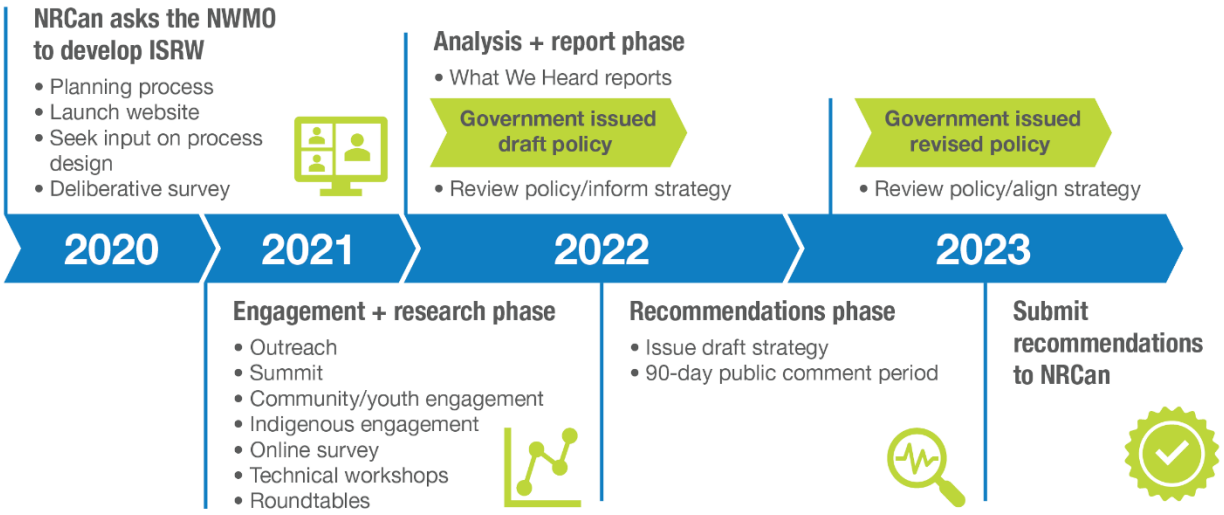


Figure 7: ISRW timeline

Technical options considered for ISRW development

From the international benchmarking report commissioned in 2020, the NWMO retained six potential options for further discussion and assessment, as defined in the following table.

Table 4: Summary of technical options retained for assessment

Engineered containment mound Engineered containment mounds are used in Canada for some low-level waste, specifically near Port Hope, Ont., and there are similar facilities around the world.	• Suitable for low-level waste that will not reduce in volume or compact over time, contaminated soil or concrete; • Uses layers of natural materials in combination with synthetic materials; • May be constructed in several types of soil; • Similar to the design of a landfill for domestic waste; and • In operation in Canada, France, Sweden and the United States.
Concrete vault Concrete vaults are widely used around the world for the disposal of low-level radioactive waste. A concrete vault repository is easy to construct and operate. It is also modular in its design, which means that additional vaults can be added to increase its capacity as needed.	• Simple, modular design; • Expandable according to need; • Suitable for low-level waste in various packages, including waste that may become compacted over time such as clothing and paper products; • May be constructed in several types of soil; and • In operation in the Czech Republic, France, Japan, Slovakia, Spain and the United Kingdom.
Shallow rock cavern Shallow rock caverns could potentially be suitable for the disposal of low-level waste. A series of rock caverns are excavated at a nominal depth of 50 to 100 metres below the surface in low permeability rock. They are accessed from the surface by a small system of ramps and tunnels.	• Suitable for low-level waste, including waste that may reduce in volume or compact over time such as paper products; • Requires suitable geology; • Makes use of natural barriers; • Buildings on the surface are relatively small; and • In operation in Finland and Sweden.
Deep geological repository Deep geological repositories are recognized as one of the best practice methods to dispose of waste that requires isolation for more than a few hundred years such as intermediate- or high-level waste.	• International best practice for intermediate- and high-level waste requiring isolation for more than a few hundred years; • Requires suitable geology; • Makes use of natural and engineered barriers; and • In operation in Hungary and the United States.
Deep borehole This emerging technology could potentially be beneficial for smaller quantities of intermediate-level waste. The method would require drilling a series of narrow boreholes to a depth of about 500 to 1,000 metres into which waste packages would be lowered, creating a stack deep underground.	• Relatively simple to construct and operate, compared to larger facilities; • May be suitable for small volumes of intermediate-level waste; • Requires suitable geology; • Makes use of natural barriers; • Limited in size; and • None in operation at the time of publication.
Rolling stewardship Rolling stewardship for the long-term storage of low- and intermediate-level waste would involve multi-generational intervention. Although there are advocates of this approach for the long-term management of nuclear waste, rolling stewardship is not recognized	• A way to manage waste indefinitely, not to dispose of it. Keeps options open for the future; • Assumes future technology will present a permanent disposal option; • Requires continuous monitoring, inspection and renewal of waste packages and storage facilities for many years; • Requires work and investment by future generations;

internationally as a preferred method for the disposal of nuclear wastes.	• Not recognized internationally as a method for the disposal of radioactive waste; and • In operation in the Netherlands.



Chapter 2: Waste inventory and gaps in long-term disposal plans

Context: Almost 84 per cent of all radioactive waste in Canada has a long-term disposal plan. This Canadian Integrated Strategy for Radioactive Waste represents a point in time when we can take action to address the gaps in long-term waste disposal of all Canada's radioactive waste from current electricity generation and production of life-saving medical isotopes, with an eye to the future.

All radioactive waste in Canada is safely managed in accordance with international standards at facilities licensed by the Canadian Nuclear Safety Commission. However, not all radioactive waste in Canada has long-term waste management plans. As part of developing this ISRW, the NWMO commissioned a study to evaluate the gaps in long-term plans in Canada's low- and intermediate-level radioactive waste inventory at a summary level, to categorize and group the radioactive waste, and to identify suitable long-term management options for each radioactive waste category.

The six potential options retained for the long-term management of Canada's low- and intermediate-level radioactive waste based on international benchmarking were assessed against the inventory of radioactive waste with no long-term waste management plans, and the report, titled Nuclear Waste Management Organization's Integrated Strategy for Radioactive Waste (ISRW) Initial Plan Development Characterization and Options Project Report (referred to as the Report on technical options), was prepared.[24]

Used fuel was not included in this study since it is being addressed through the NWMO's Adaptive Phased Management project, as mandated by the *Nuclear Fuel Waste Act*. Similarly, uranium mine and mill waste was excluded from the assessment as it is already being managed in existing long-term management facilities.

For the purposes of this Report on technical options, a summary level of detail was gathered about the current and projected future inventories from the current existing major Canadian waste generators and waste owners. The Report on technical options identified existing and future Canadian low- and intermediate-level radioactive waste with no current long-term management plans and presented an integrated assessment for the long-term management of this waste. This includes waste from nuclear medicine, nuclear fuel fabrication, nuclear reactor operations, research and development activities, radioisotope manufacture and use, and decommissioning activities.

The waste was grouped into categories of similar nature for the purpose of long-term management. In general, the waste was grouped based on radiological classification (i.e., low- and intermediate-level radioactive waste) and physical configuration (i.e., bulk material, packaging, size, etc.).

The table that follows shows the status of long-term disposal plans for various radioactive waste types in Canada.

Table 5: Status of existing long-term waste disposal plans in Canada

Waste classification	Type of waste	Existing long-term disposal plan	Current responsibility for implementation of long-term plan	Percentage of total waste volume that does not have a long-term disposal plan
High-level waste (HLW)	Used fuel	Yes	NWMO	0
	Non-fuel	No	–	<0.01
Intermediate-level waste (ILW)	ILW produced in various nuclear facilities	No	–	2
	ILW produced at Nuclear Power Demonstration facility and Whiteshell Reactor 1	Yes	CNL	0
Low-level waste (LLW)	Port Hope historic LLW	Yes	CNL	0
	LLW owned by Atomic Energy of Canada Limited at Chalk River	Yes	CNL	0
	LLW produced at Nuclear Power Demonstration facility and Whiteshell Reactor 1	Yes	CNL	0
	LLW produced in various nuclear facilities	No	–	14
Uranium mine and mill waste[25]	Tailings facilities near point of generation	Yes	Uranium mines and mill tailings companies, and applicable provincial and federal governments	0
	84 per cent of radioactive waste has long-term disposal solutions 16 per cent of radioactive waste has no long-term disposal solutions			

Gaps in long-term disposal plans for radioactive waste in Canada

Almost 84 per cent of all radioactive waste in Canada has a long-term disposal plan. The waste volumes with no long-term waste management plan (in the ISRW scope) include current and future Canadian low- and intermediate-level radioactive waste that has no current long-term management plans, totalling approximately 294,000 m^3 of low-level waste and 51,000 m^3 of intermediate-level waste and less than 10 m^3 of high-level non-fuel radioactive waste (see below).

Table 6: Waste with no long-term disposal plan

Waste type	Volume (m^3)	Percentage of total radioactive waste in Canada
High-level waste (non-fuel)[26]	<10	<0.01
Intermediate-level waste	51,000	2
Low-level waste	294,000	14
Uranium mine and mill	No gaps – Existing plans in place	N/A
Approximately 84 per cent of total radioactive waste in Canada already has long-term waste disposal plans.		

It should be noted that options for the remainder of the total inventory (high-level waste, uranium mines and mills waste, low-level waste under the responsibility of Atomic Energy of Canada Limited) are not covered in this report because there are already facilities or plans in place to address them. Refer to Appendix C: Status of long-term waste management projects in Canada, for the status of current plans and progress in advancing long-term storage and disposal solutions for Canada's radioactive waste.

The figure below shows the proportions of radioactive waste without long-term plans as percentages of the total waste volume. The amount of waste with no long-term disposal plan is approximately 16 per cent of all radioactive waste in Canada. Of that gap, the Report on technical options found that 15 per cent is intermediate-level waste (ILW), and 85 per cent is low-level waste (LLW).

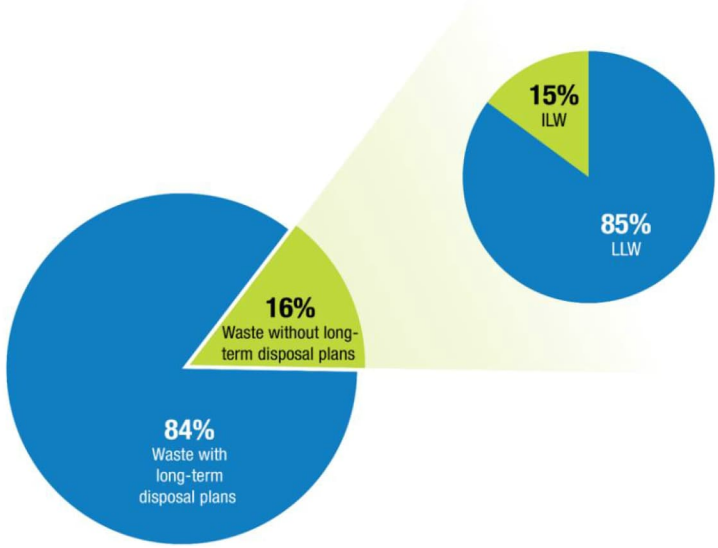


Figure 8: Waste without long-term plans as percentages of total waste volume

For reference, the current total radioactive inventory in Canada is presented below, indicating that most of the current volume of radioactive waste in Canada is low-level waste.

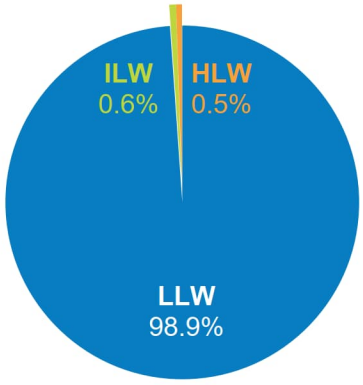


Figure 9: Total Canadian radioactive waste inventory as of 2019

OWNERS OF RADIOACTIVE WASTE WITH NO LONG-TERM DISPOSAL PLAN

The table below identifies the owners of the low- and intermediate-level waste for which there are currently no long-term disposal plans. Additional details can be found in the Report on technical options.[27]

Table 7: Volumes of LLW and ILW with no long-term disposal plan by waste owner

Waste owner	Non-fuel HLW volume (m^3)[28]	ILW volume (m^3)	LLW volume (m^3)
Ontario Power Generation	<6	40,000	270,000
Hydro-Québec	N/A	1,000	18,000
NB Power	N/A	780	2,270
Cameco	N/A	N/A	2,000
Other	N/A	1,000	1,740
Atomic Energy of Canada Limited/Canadian Nuclear Laboratories (excludes existing LLW/ILW planned projects)	<4	8,200	N/A

FUTURE RADIOACTIVE WASTE INVENTORY FROM EMERGING TECHNOLOGIES

There is significant interest in investing in additional nuclear generation for electricity and manufacturing applications internationally and in Canada to address climate change. Some of this new generation may be using the CANDU technology; some may be other technologies, including small modular reactors based on pressurized or boiling water reactor technology and advanced reactors. These may generate waste with different characteristics that are being assessed. At this time, the ISRW has been written with flexibility to incorporate these wastes into the appropriate waste stream using Canada's waste classification: high-level waste including used nuclear fuel, intermediate-level waste and low-level waste.

Over time, waste management will progress, either through implementation of the waste disposal facilities identified in the strategy, through deployment of new technologies such as small modular reactors, or through new uses for nuclear technology such as advancements in medical isotopes or to address societal demands. Canada's ISRW will require regular updates on the progress of the strategy and any future waste streams that may be generated. The progress on the implementation of this integrated strategy will have to be reviewed on a regular interval to ensure the strategy is implemented effectively and incorporates all waste streams that may be generated in the future.



Chapter 3: What we heard

Context: In 2021, the NWMO began engaging with Canadians and Indigenous peoples, conducting public opinion research, hosting a summit to hear from diverse voices, listening to citizens in a series of engagement sessions in communities where waste is stored today, and hosting roundtable discussions and technical workshops.

Digital promotion of engagement opportunities

The public engagement on the ISRW was designed to provide safe shared spaces for multiple voices to be heard and to connect participants in new and meaningful ways. The engagement opportunities were free of charge and open to anyone interested.

As it was important to encourage wide participation, the NWMO used various outreach and promotional tools, including social media (owned and paid), email and community partner outreach to broaden our existing reach to relevant audiences in order to raise awareness, and stimulate registration and participation for activities such as the Canadian Radioactive Waste Summit, ISRW open survey and community engagement sessions.

To encourage wide participation, the NWMO used paid promotion on the ISRW's social media channels and struck a balance between our project-specific channels (Facebook and Twitter) and the official languages (English/French).

Ads deployed on Facebook and Twitter advertising the Canadian Radioactive Waste Summit, a deliberative ISRW open survey and community engagement sessions were shown and seen over 1.91 million times across Canada, reaching a total of 1,153,878 people with invitations for opportunities to participate.

Key themes from engagement

This section presents the commonly heard themes that arose over the course of the engagement activities across the country and is not a reflection of each of the individual comments that were made. The NWMO published a series of What We Heard reports to capture the input provided during the various engagement activities. Additional details about these activities can be found in Appendix B: Matrix of input from engagement activities, by participant group.

Key theme 1 – Safety is paramount

The most prominent theme that emerged throughout this engagement was the importance of safety in every aspect of the development and implementation of the Integrated Strategy for Radioactive Waste. We heard from participants that safety was important in every aspect of the nuclear waste strategy; protecting the environment was a key consideration across all sectors.

We heard that as a key priority, safety should be considered through a long-term lens. This is important so that the strategy is able to respond to future risks and ensure safety in unpredictable and potentially unstable future conditions in the environment, government and technology. For the youth participants, this meant choosing solutions that offer the highest level of safety in terms of storage and isolation of waste; integrating climate and social change modelling as part of risk management; embedding flexibility and adaptability into the strategy; and using governance approaches that provide consistency and accountability. Participants prioritized safety over cost efficiency.

Safety was also the main theme in all discussions with Indigenous peoples. Conditions may change over the long term and anticipate future risks, including environmental disasters, climate change and social disruptions. Participants identified the need for embedding flexibility and adaptability into the strategy and building in checks and balances in case of failures and changes to the status quo.

Participants raised concerns about location, storage, containment and transportation of the waste as key factors in the final decision. We heard from participants that in the future when any waste disposal project is undertaken, the design would need to be suitable for the location, waste volumes and waste characteristics, and meet regulatory requirements.

Key theme 2 – The time to act is now

We heard that an integrated strategy was needed, and the approach to the long-term management of low- and intermediate-level waste should be determined. We also heard that the current lack of a disposal facility for intermediate-level waste meant higher risk because the waste is being stored above ground in interim storage facilities, and that this should be addressed as a priority. There was general agreement that to have and to implement a plan for all Canada's radioactive waste, and to do so with a sense of urgency rather than leaving this to future generations, is the right thing to do.

Key theme 3 – Communication and transparency

Communication and transparency were common themes among all participants. In general, participants in all engagement activities were adamant that clear, fact-based, transparent, inclusive communication that provides context is essential. We heard that we need to be completely transparent about the waste and any potential risks associated with it. Some participants expressed the importance of having more visibility of waste inventories, as they exist today, and what could be expected in the future.

Participants defined transparency in communication as providing all the key information in a relevant, accessible and unbiased way. Transparency also includes providing regular and frequent check-ins and updates to the impacted communities and stakeholders. Similar to the theme on education, participants

underlined the importance of transparent information and communication for meaningful engagement and building trusting relationships.

Participants stated the waste generators and waste owners need to clearly communicate the roles and responsibilities of the various stakeholders in the nuclear energy field. In addition, many participants expressed the importance of disclosure when hazardous goods are transported through their traditional territories and the sharing of industry emergency plans.

We heard that the ISRW needed to consider the social dimension and emphasize consensus building, transparency and informed consent. We heard that there seemed to be an abundance of technical discussions about waste, but not enough about the social or political aspects.

Key theme 4 – Trust and relationships with Indigenous communities

There was support expressed by participants to ensure trust and relationships are built with Indigenous communities in developing the plan and implementing it. Ensuring that Indigenous Knowledge was considered along with western science was identified as important to a strategy that would address the far future, as well as more immediate considerations. Indigenous participants emphasized that this information must come from the Knowledge Holders and need to be engaged and included at all steps of project development, implementation and operation. It is not an instrument to be used by proponents to bypass the inclusion of the community or its input.

We heard that meaningful engagement and ongoing relationship building with Indigenous communities is a priority for young people. Participants wanted the strategy to include a requirement to observe Indigenous communities' right to Free, Prior and Informed Consent and to be mindful of exploitative practices with respect to Indigenous involvement. They expressed that the strategy should be centering Indigenous perspectives, expertise and worldviews, and contribute to Indigenous sovereignty through building structures for Indigenous communities to take back control over the long-term stewardship of their land. This includes embedding Indigenous communities and leaders within the management and oversight of the strategy and supporting capacity building for Indigenous communities to take part in these processes.

Meaningful commitment to Reconciliation with Indigenous communities was a key finding in the Indigenous engagement sessions. There is a need for broad, diverse and comprehensive partnerships, especially with communities that may be directly impacted, as key to making good decisions. Accountable to legacy issues and being open to inclusion from Indigenous communities and collaboration is a must to ensure partnerships and Reconciliation.

Treaty rights and title, including the duty to Consult, and Free, Prior and Informed Consent, were at the forefront of most Indigenous engagement sessions. Most participants specifically emphasized the importance of being included by way of meaningful engagement or consultation in development and implementation of any strategy or project relating to nuclear energy.

Key theme 5 – Education and engagement

Many participants across the sessions highlighted the importance of education through public engagement during the development of the strategy and expressed that education is vital for success.

We also heard that education needs to be further integrated into our discussions. Participants shared that they want to contribute to the strategy, but sometimes need more information. Some participants expressed that they did not have enough information to make adequate judgment as part of the discussion. This highlighted the need for further public education so that Canadians and Indigenous peoples understand the unique challenges posed by radioactive waste. Some felt that it was difficult to consider the technical options without also looking at cost, environmental and safety factors, including

waste descriptions and makeup, and the application of the waste hierarchy (what happens before storage, including other uses).

Participants recognized the importance of expertise, but had a strong desire to learn more themselves to contribute to the strategy, and noted that experts were required to educate and provide options. Education is vital to help Canadians and Indigenous peoples understand the unique challenges posed by radioactive waste, and how safety is assured. Participants also expressed that education was essential to address misinformation about radioactive waste.

Education was highlighted as a key factor when engaging Indigenous communities and people in the decision-making process. Participants recognized that their education on radioactive waste, options for disposal facilities, benchmarking in other countries, and Canada's use of nuclear energy was low. Some groups located in siting areas possessed a higher level of familiarity, but overall, different levels of knowledge may impact the choice of facilities.

We heard that participants wanted to learn more about all aspects of the strategy to make better informed decisions that could contribute towards the overall strategy. We heard that learning from science-based best practices internationally is an important pathway to ensuring both public safety and cost effectiveness, which are both important, now and in the long term, and provides valuable data and expertise. However, participants, in particular youth, generally supported the idea of a made-in-Canada solution that would consider the unique conditions and environment of Canada, including the size of the country, the diversity of Canadians and Indigenous peoples, and the changing climate.

We heard that relevant and accessible education about radioactive waste management is a requirement for creating meaningful engagement opportunities for all groups. Some participants noted that the public is not typically engaged until a solution is presented in their community. They expressed a desire to be engaged early in the development of any plans. We heard that engagement should continue to be an important aspect of this strategy and any plans going forward.

Youth participants wanted to see broad engagement across diverse stakeholder groups and ongoing engagement and relationship building with impacted communities and Indigenous peoples. Participants felt that youth perspectives should be an integral part of any future planning and management strategy. They saw a need for an intergenerational education strategy to cultivate a sense of responsibility for the long-term strategy implementation among young people.

Key theme 6 – Sustainability and the environment

In addition to the safety of the community and its residents, we heard that minimizing the carbon footprint and protecting the environment, in particular water, over the long term were important. Participants shared that we needed to be mindful of the climate emergency to ensure that every aspect of this strategy is sustainable, consider the risks posed by climate change, respect the environment, and protect water sources for all future generations.

We heard from youth that protection of land, water and the environment needs to be a top priority. Participants expressed that waste disposal sites should not be built near water as they can contaminate it and affect their way of life. They also noted that the goal of minimizing environmental impacts should be viewed through a life cycle approach and include the construction of facilities and transportation of radioactive waste.

Land protection and minimizing the impact on the land and the natural environment, including disruptions to wildlife and lands used for ceremonial and traditional purposes, was a priority for Indigenous peoples. Participants expressed a preference for technical options that would have the least environmental impact. They felt that options that place waste underground or that can be restored or covered with vegetation appear to address this priority of environmental impact. Minimizing visual impacts was also highlighted as an important consideration, especially from participants that have seen other types of industrial facilities near where they live.

Many Indigenous participants also identified protecting water sources and minimizing impacts on water sources as priorities. The recommendation that no facility or disposal site be located near water sources was a common theme.

We heard a broad and repeated consensus from participants that waste minimization should be further pursued. Industry and civil society organizations both advocated for the importance of minimizing waste. Further, it was identified that there may be opportunities for Canada to invest in technologies to support waste minimization initiatives. Accurate waste characterization was also identified as important to ensure that waste is managed and disposed of in accordance with the hazard.

Youth participants were acutely aware of the history of environmental racism in Canada, especially towards Indigenous communities. They saw environmental justice as a key consideration when discussing how many facilities to build and where. Participants wanted to ensure that the strategy does not disproportionately place the responsibilities and risks associated with radioactive waste management on some communities.

Key theme 7 – Transportation

We heard from participants that transportation is a particularly important aspect of the long-term plan and that when radioactive waste is transported, it must be done safely. We heard that people have many questions about the risks associated with transportation, and the consequences of transportation accidents on the safety of the radioactive waste being transported. We heard that people generally preferred to minimize the transportation of radioactive waste to reduce any associated risks. Participant views on the relative risks of transportation influenced their views on having one central repository for low-level waste and for intermediate-level waste, or having multiple disposal facilities closer to where the waste is produced.

While participants understood that transportation of radioactive waste is heavily regulated, they were concerned about the potential risks associated with transporting the waste over large distances and near built-up areas. Participants wanted to ensure there are risk mitigation and incident response plans in place. Other concerns around transportation included cost, potential increase of greenhouse gas emissions and potential environmental impacts from building new access roads.

Transportation of hazardous waste through traditional territories with no consultation, engagement or notification was an expressed concern of Indigenous peoples. The safety of waste through sensitive areas with no communication or inclusion of an emergency management plan is of the utmost concern. The potential impact of transportation of waste on or through communities and traditional territories was a common theme in all Indigenous engagement sessions.

Key theme 8 – Shared responsibility framework/independence of accountable entity

There were varying perspectives regarding who should be responsible for the implementation of the ISRW. There were differences of opinion about the role of industry, but there was general agreement that there should be a single entity with appropriate expertise that is independent from government and industry, but subject to regulated safety and environmental oversight.

The governance of such an entity was subject to different ideas, with some suggesting that the organization’s governance should be comprised of industry, civil society organizations and Indigenous peoples, and others focusing on ensuring the organization remained independent and included the right expertise. Some saw this organization as a government body or government-led, while others wanted to see this organization being more independent. A shared perspective among these responses was that this organization should include multi-stakeholder representation with Indigenous communities playing a key, if not the lead, role.

There was a mix of responses about the role of waste generators and waste owners in strategy implementation. Some participants wanted to see waste generators and waste owners playing a stronger role, with government oversight. Others felt that the role of waste generators and waste owners should be limited to fiscal responsibility and engagement in a multi-stakeholder process. There was broad support for the polluter pays approach for financing the strategy.

Indigenous participants noted the importance of collaboration among multiple stakeholders and highlighted the important roles to be played by the government, Indigenous communities and industry in the responsibility of disposing radioactive waste and implementing the strategy.

Key theme 9 – Rolling stewardship and waste disposal

We heard differing views on rolling stewardship versus ultimate disposal of radioactive waste. Most participants supported the idea of finding solutions to permanently dispose of the waste now, not leaving the decision for future generations, and that intermediate-level waste should be disposed of in a deep geological repository. However, some individuals expressed a preference for rolling stewardship, where the waste remains above ground where it is today, so that monitoring of the waste would be assured over the long term and the location of the waste would not be forgotten. Many participants, including youth, were open to either approach as long as safety was ensured.

A considerable number of participants included a caveat that stressed the need for perpetual monitoring, for as long as the waste is hazardous, regardless of the option chosen. These participants noted the importance of having assurance that someone was overseeing the waste and keeping waste generators and waste owners accountable.

For those who saw rolling stewardship as the preferred strategy, some of the considerations included the possibility of future technology innovations, ensuring that the waste was not forgotten, and the ability to constantly monitor the waste to ensure that any environmental impacts could be identified and remediated before causing significant harm, especially to the water table. Some participants found rolling stewardship to be a good solution for low-level waste. They felt it provided better oversight and created the possibility of taking advantage of future technological advances for recycling or reusing this waste.

Some of the concerns cited by those who preferred disposal to rolling stewardship included uncertainty of impacts arising from climate change, and whether changes to government or society in the long term could leave waste vulnerable under indefinite storage arrangements. Other concerns were around deferring the responsibility of dealing with radioactive waste to future generations and the risks associated with forgetting about these facilities, facility failure or mismanagement.

We heard that industry preferred a broad, flexible framework allowing waste generators and waste owners to consider all the strategies, methods and acceptable technologies that can ensure safety.

Key theme 10 – Collocation and centralization

We heard a range of responses from participants who felt collocating waste could have advantages. Participants acknowledged the difficulty in finding willing and informed host communities, and obtaining the Free, Prior and Informed Consent of Indigenous peoples, made multiple sites more challenging. However, there were concerns about the impact of a single location on the transportation of waste. Some participants cautioned about the importance of ensuring appropriate technical arrangements for different waste types located in the same facility, while others noted the cost advantages of consolidating expertise and facilities in a single location.

The idea of collocation and centralization was more broadly supported for intermediate- and high-level waste, than it was for low- and intermediate-level waste. The volumes of low-level waste are greater, and participants generally felt that leaving it nearer to the sites where it was generated or stored, rather than transporting it vast distances, was preferable.

We heard an overall openness from youth to collocation strategies for all types of waste. However, participants noted that they required more information about how different types of waste are managed and the implications around collocation.

Responses showed that most participants considered specialized and more decentralized facilities to be an appropriate strategy for low-level waste due to lower risks associated with this waste, leaving waste nearer to the sites where it was generated or stored, rather than transporting it vast distances. One recommendation that received broad support was to explore building several facilities around the country (multiple facilities, but a limited number of them). Participants expressed a greater preference for using centralized facilities for intermediate-level waste.

Participants indicated that the best option for intermediate-level waste is deep disposal. Some of the participants expressed support for the longer-lived intermediate-level waste to be emplaced with the high-level waste.

The majority of participants believed that there were cost advantages to collocation, including repackaging, surveillance and monitoring. Some participants identified potential concerns related to the characteristics of the waste such as heat and gas generation that could impact the feasibility of collocating intermediate- and high-level waste.

Some participants discussed collocating low- and intermediate-level waste. However, most participants felt that when it comes to low-level waste, any disposal facility should be built separately from that for intermediate-level waste.

Key theme 11 – A strategy by and for Canadians and Indigenous peoples

Overall, across sessions, it was clear participants want this to be a strategy created by and for the people and that this is key to have buy-in. It is important that various groups such as Indigenous communities, technical and scientific experts, academics, host communities and surrounding municipalities have their voices heard during the engagement process. An inclusive strategy is a reflective strategy.

Additionally, youth generally supported the idea of a made-in-Canada solution that would consider the unique conditions and environment of Canada, including the size of the country, the diversity of Canadians and Indigenous peoples, and the changing climate.

What we heard from surveys

One of the ways we explored what is most important to people regarding the long-term management of Canada's radioactive waste was through our online open survey. Our online open survey provided an opportunity for Canadians and Indigenous peoples to identify potential priorities, principles and considerations for developing a comprehensive strategy. It also provided us with valuable perspectives, opinions and feedback that will help ensure the best options are in place for the management of Canada's radioactive waste.

One of the distinguishing features of this online open survey is that it was open to all. Thus, throughout this report, we refer to it as the "open survey." This open survey complements the research that was conducted during the last two weeks of January 2021, in which a random sample of n=1,625 adult residents of Canada provided input online. A total of 345 people participated in the open survey.

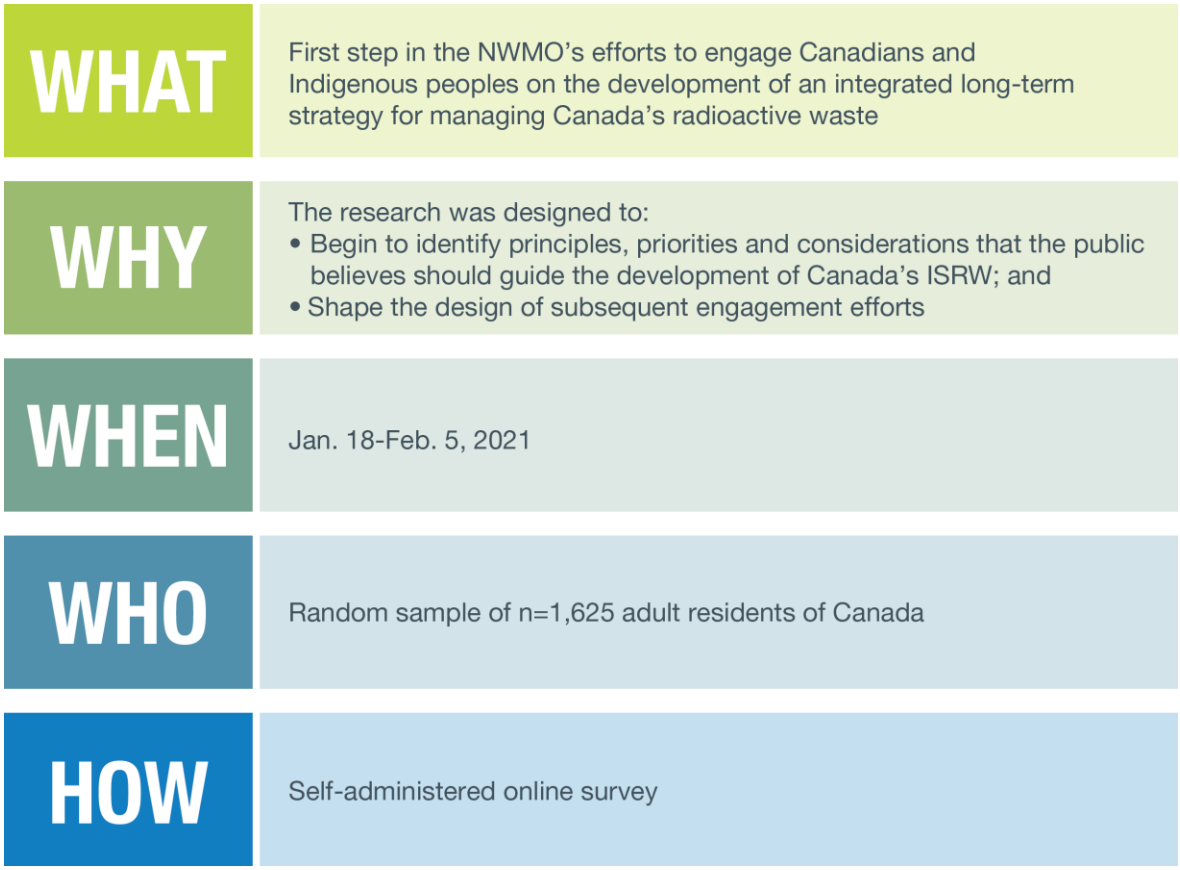


Figure 10: Overview of survey methodology

Both surveys looked at the same set of issues, mostly using the exact same questions. The two surveys also provided essentially the same fact-based background information on the topic (e.g., levels of radioactive waste, current waste management practices, international practices). Of note is that the open survey included an informational video on transportation and another on the regulation of radioactive waste in Canada, whereas the representative survey did not.

Overall, the results of the two surveys are consistent. It also seems apparent that overall, open survey respondents are more knowledgeable about the management of radioactive waste (18 per cent are employed by the nuclear industry and 10 per cent are public sector employees). The views of nuclear industry members are much more homogeneous and unequivocal, but their views are generally consistent with those of other open survey respondents.

Priorities

Priorities were examined by means of a paired trade-off exercise involving a total of 10 items (i.e., each was randomly "paired" against the other nine a roughly equal number of times). Obtaining the "active support" of non-Indigenous and Indigenous communities near facilities are top priorities, along with having "a separate not-for-profit organization" responsible for implementing Canada's strategy. At the bottom are "minimizing transportation" and "minimizing costs to electricity ratepayers."

In comparison, representative survey respondents placed relatively higher priority locating waste disposal facilities away from the Great Lakes and population centres. They also placed more emphasis on reducing transportation.

PERCEIVED PROS AND CONS OF POTENTIAL APPROACHES TO RADIOACTIVE WASTE MANAGEMENT

The surveys shifted from examining principles and priorities, to gathering input on more tangible considerations (e.g., the use of one versus several disposal facilities). Consistent with the findings from the representative survey, respondents expressed an overall preference for not leaving radioactive waste on the surface, especially intermediate-level waste. This approach is thought to be safer, as well as more responsible vis-a-vis future generations.

Views are relatively divided on the merits of having a single centralized facility versus a decentralized approach based on multiple facilities. There is plurality support for decentralization when it comes to managing low-level waste, and for centralization with respect to intermediate-level waste. The key trade-off is viewed as being between reducing the perceived risks associated with transportation against the design, construction, monitoring and accountability benefits that would come from having everyone focus on one facility. In the representative survey, a decentralized approach was somewhat preferred for both levels of waste.

Consistent with other results from the survey, most respondents expressed a preference for the creation of a separate organization to implement Canada's strategy, feeling this approach is more likely to protect the public interest (e.g., more government involvement, higher profile/more visible organization). The survey included six attitudinal questions that examined people's level of comfort/trust in the organizations involved in waste management and in regulations.

Over half of respondents (56 per cent) say they have "complete confidence" in the regulations surrounding radioactive waste management, which is 10 percentage points higher than the representative survey result.

Respondents are divided on whether radioactive waste owners can implement a "safe and secure" strategy for the long-term management of Canada's low- and intermediate-level waste: 44 per cent think they can, while 42 per cent do not.

Consistent with the representative survey results, open survey respondents are more comfortable with having the federal government lead the implementation of a strategy for the long-term management of low- and intermediate-level waste, than with waste owners in the lead (59 per cent versus 38 per cent).

Similarly, most (61 per cent) agreed that the long-term management of all radioactive waste in Canada should be the responsibility of a separate not-for-profit organization. In the representative survey, the corresponding number was 70 per cent.

We also find that compared to those who participated in the representative survey, open survey respondents are more likely to view low- and intermediate-level waste as less concerning. This is also echoed in their written comments.

Input into the final ISRW

The NWMO published a draft integrated strategy in August 2022. This was made available for a 90-day public comment period, and the recommendations were also made available for public comment on the RadWastePlanning ISRW project website. As part of the draft comment period process, the NWMO also commissioned independent outreach to some of the youth participants who previously contributed to the engagement process, for their review of the recommendations. Public comments on the website, together with formal written submissions, informed this final integrated strategy. In addition, this integrated strategy was informed by ongoing dialogue with Indigenous peoples, whose engagement extended beyond that of the Canadian public and stakeholders. Finally, the release of the Government of Canada's Policy in March 2023 provided vital input against which to align the integrated strategy. Refer to Appendix D, for a summary of changes to the recommendations from the draft ISRW to this final ISRW.



Chapter 4: Assessment of the technical options

Context: In 2021, the NWMO commissioned an assessment of the options. The purpose of this study was to evaluate Canada's low- and intermediate-level radioactive waste inventory at a summary level, to categorize and group the radioactive waste, and to identify suitable long-term management options for each radioactive waste category.

Technical options

The six potential options retained for the long-term management of Canada's low- and intermediate-level radioactive waste based on international benchmarking were assessed. These six options are described below.

Engineered containment mound

Engineered containment mounds are a type of engineered near surface disposal facility that sees waste packages placed on a waterproof base and then covered over with thick layers of natural materials such as clay and soil. Layers of synthetic materials such as high-density polyethylene are also incorporated to prevent release of radiation to the environment. These facilities usually have wastewater collection and treatment systems as well. The engineered containment mound is generally suitable for low-level waste that will not reduce in volume or compact over time.

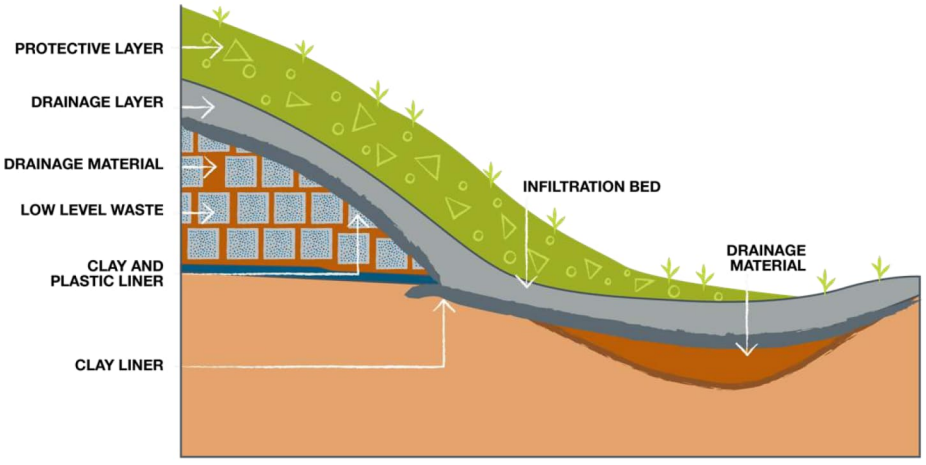


Figure 11: Engineered containment mound

Concrete vault

Concrete vaults are a type of engineered near surface disposal facility widely used around the world for the disposal of low-level radioactive waste. Concrete vaults look like large concrete boxes, and a repository would be made up of a series of these. Each one would have its own drainage system and an “earthen cover system” engineered from multiple layers of soil and with grass or other plants growing on top. This disposal method can be used in a wide variety of soil conditions. It is also modular in its design, which means that additional vaults can be added to increase its capacity as needed.

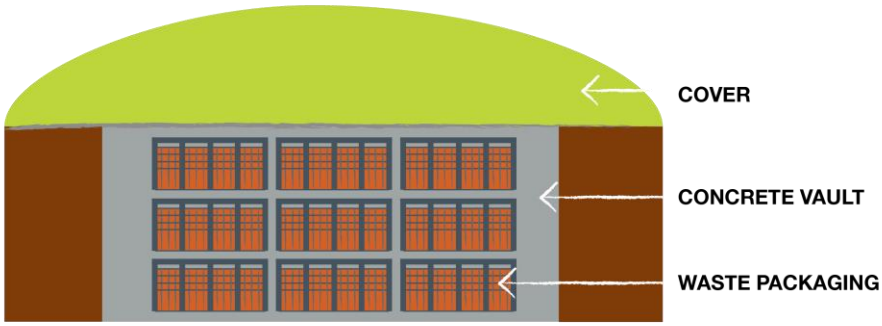


Figure 12: Concrete vault

Shallow rock cavern

The shallow rock cavern is an engineered near surface disposal method sometimes used for the disposal of low-level waste, or low- and intermediate-level waste. A series of rock caverns are excavated at a nominal depth of 50 to 100 metres below the surface in low permeability rock. They are accessed from the surface by a small system of ramps and tunnels.

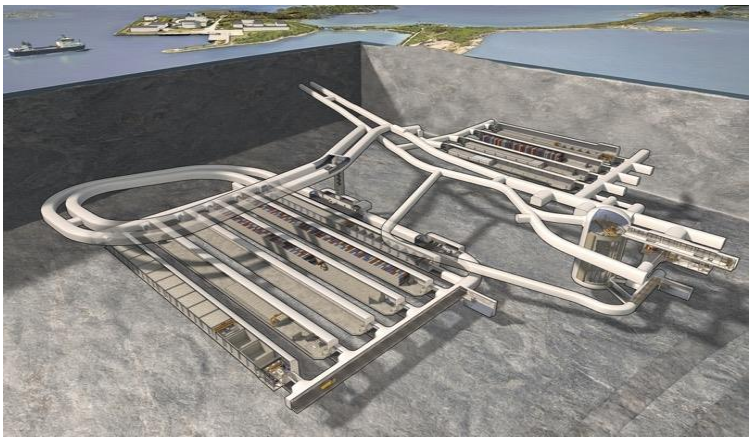


Figure 13: Shallow rock cavern (SFR repository, Sweden)

Deep geological repository

A deep geological repository typically consists of a network of underground tunnels and placement rooms for radioactive waste constructed several hundred metres below the surface. Repositories are designed to use a system of multiple barriers: engineered barriers such as waste containers and natural barriers like the rock itself work together to contain the waste and isolate it from people and the environment.

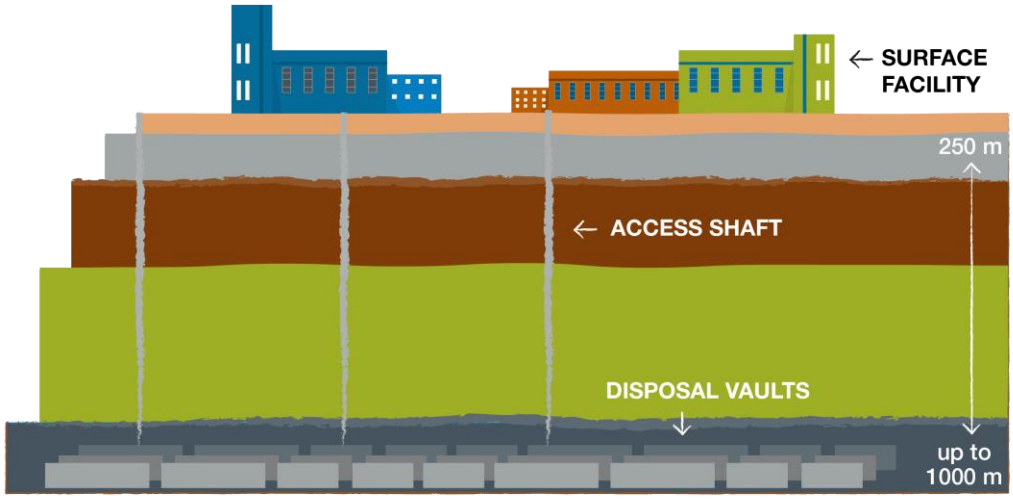


Figure 14: Deep geological repository

Deep borehole

Deep borehole disposal is an emerging technology for waste that requires isolation for more than a few hundred years. It may be suitable for the disposal of small volumes of intermediate-level waste. The series of narrow boreholes are created to a depth of about 500 to 1,000 metres into which waste packages would be lowered, creating a stack deep underground.

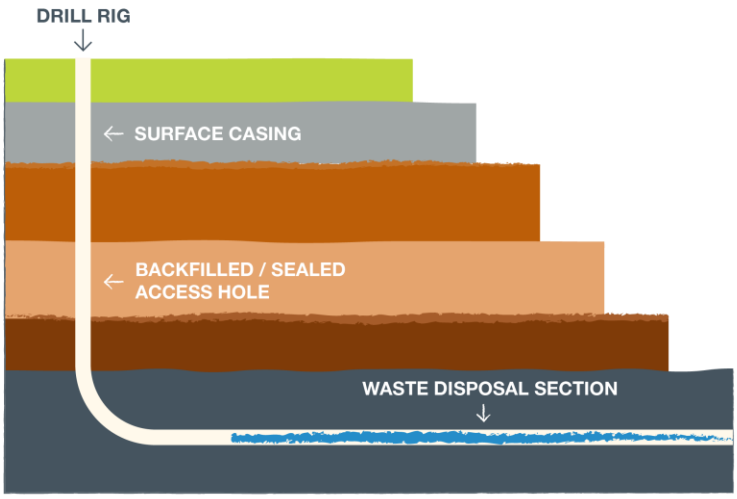


Figure 15: Deep borehole disposal

Rolling stewardship (not a disposal option)

Rolling stewardship is an approach to managing radioactive materials for which there is no disposal solution in the near term. Under rolling stewardship, the radioactive waste is stored on the surface where human controls can safely contain, isolate, monitor and secure it for many generations indefinitely, i.e., roll the radioactive waste forward from generation to generation (a succession of stewards). This concept assumes that technology will eventually resolve the problem for the long-term management of the waste, potentially by finding methods to destroy or neutralizing it.

Technical assessment of the options

For the purposes of this initial plan, a summary level of detail was gathered about the current and projected future inventories from the current major Canadian waste generators and waste owners. This study identified existing and future Canadian low- and intermediate-level radioactive waste with no current long-term management plans and presented an integrated assessment for the long-term management of this waste. The waste was grouped into categories of similar nature for the purpose of long-term management. In general, the waste was grouped based on radiological classification (i.e., low-level waste (LLW) and intermediate-level waste (ILW)) and physical configuration (i.e., bulk material, packaging, size, etc.).

The study made the following assumptions in preparing each waste owner's radioactive waste inventory for analysis:

- All liquid waste is assumed to be solidified (e.g., via incineration, vitrification, grouting, solidification agent, as required).
- Unless quantified by the waste owner, additional decontamination and volume reduction practices were not assumed in this study.
- Projected operational waste is assumed to be packaged in the same physical configuration as an existing operational waste of the same source. For example, Ontario Power Generation's low-level non-processible waste is currently stored in steel containers, so any future production of low-level non-processible waste is assumed to be confined in steel containers as well.
- It is assumed that all long-term management options can accept nuclear waste with non-nuclear hazardous properties because non-nuclear hazardous waste facilities employ engineered containment measures similar to those present in near surface nuclear waste disposal facilities, including waterproofing, leachate control and monitoring. Additional design considerations may be required to address all non-nuclear hazards at the detailed design stage.
- Waste owner inventory volumes have been rounded, given the level of uncertainty present at this time. This is considered a reasonable simplification, given the level of detail required for this study.

The radioactive waste groups were assessed against each long-term management option based on technical feasibility and practicality. Each waste group was assigned one of four levels of applicability, shown in the legend of Table 8: Assessment results of options by waste type.

Table 8: Assessment results of options by waste type

Repository type	LLW (bulk material)	LLW (other)	ILW (general)	ILW (small)
Engineered containment mound	Y Most suitable for large volumes of bulk LLW	Y2	N	N
Concrete vault	Y2	Y Internationally accepted practice for LLW disposal	N	N
Shallow rock cavern	Y2	Y Internationally accepted practice for LLW disposal; large objects may require segmentation or volume reduction	N	N
Deep geological repository	Y3	Y2	Y Internationally recognized best practices for ILW disposal; large objects may require volume reduction	Y Internationally recognized best practices for ILW disposal
Deep borehole	N	N	N	Y2
Rolling stewardship	Y3	Y3	N	N

Matrix of applicability	
Y	Applicable and recommended for the allocated waste group
Y2	May be applicable to the waste group, but would require further study
Y3	Conceptually feasible, but after considering risk factors, is impractical
N	Not suitable for the allocated waste group

It was identified that all low-level waste might be disposed of at a near surface facility (i.e., engineered containment mound, concrete vault or shallow rock cavern), whereas all intermediate-level waste must be disposed of in a deep geological repository or deep borehole. Typically, low-level waste can be disposed of in a higher level of containment (i.e., deep underground), but intermediate-level waste cannot move to a lower level of containment (i.e., near the surface). This is demonstrated by the deep geological repository, which is technically feasible for the full low- and intermediate-level waste inventory.

The engineered containment mound was determined to be the most suitable option for bulk low-level waste such as soils and demolished concrete, given the low concentrations of radionuclides and the large volume of waste. Additional low-level waste may be suitable for the engineered containment mound, depending on the specific safety case of the disposal facility.

The concrete vault and shallow rock cavern were considered the most suitable option for non-bulk low-level waste, given the increased containment and structural integrity offered (concrete barrier or rock mass) compared to the engineered containment mound. These long-term management options may also be suitable for bulk low-level waste, noting that the containment and isolation offered by these options exceed what is required for bulk material. Additionally, the co-disposal of non-bulk low-level waste in a deep geological repository was considered as an alternative.

The International Atomic Energy Agency (IAEA) states that intermediate-level radioactive waste can be disposed of in different types of facility depending on its characteristics. While disposal could be by emplacement in a facility constructed in caverns, vaults or silos a few tens of metres below ground level, this option was not retained for intermediate-level waste in the ISRW inventory given its long-lived characteristics. From the international benchmarking undertaken, the deep geological repository emerged as the preferred approach to intermediate-level waste long-term management and was therefore considered the most suitable option for all the intermediate-level waste. The Organisation for Economic Co-operation and Development endorses the strong scientific consensus regarding the use of deep geological repositories for the disposal of nuclear wastes. The consensus has been developed after decades of scientific analyses, engineering tests, development and operation of underground research laboratories.

Deep boreholes are considered an alternative long-term management option for small dimensional intermediate-level waste such as disused sealed sources and spent ion exchange resins. Deep boreholes are best applied to a decentralized disposal approach (i.e., with multiple borehole locations across Canada) in order to reduce the need for radioactive waste transportation. Further investigation on the applicability of this option is required as the technology develops.

Rolling stewardship is a potential near-term waste management solution, but is not considered to be a practical solution for all low- or intermediate-level waste in the long term given the uncertainties associated with costs, climate change and societal evolution.

Rolling stewardship may be feasible for certain types of low-level waste that decay quickly allowing their free release or conventional disposal in several decades, but not for wastes that will remain radioactive for several hundred years or longer. Detailed characterization data would allow the half-life of the waste inventory to be assessed and potentially identify any shorter-lived low-level waste as rolling stewardship candidates. However, rolling stewardship is not in line with international best practices for the long-term management of radioactive waste. Additional cost considerations include the potential need to repackage waste as waste containers degrade for centuries, as well as the potential need for new, specialized long-term facilities.

Given the summary level of detail gathered for this initial plan, there is an opportunity to further engage each waste owner and investigate the characterization of the waste in future studies.

Technical workshops were held to discuss the results of the technical assessment. Separate workshops were held to address low- and intermediate-level waste. As well, separate workshops were offered to technical experts and laypersons; participants self-selected which option they preferred. During the workshops, participants were guided through a series of questions by an independent bilingual facilitator to obtain their views on the topic of “Does the order of recommendations for the storage of low- or intermediate-level waste stand?”

Focusing solely on the technical options for the long-term management of low- and intermediate-level waste, participants agreed with the order of recommended options as illustrated as follows.

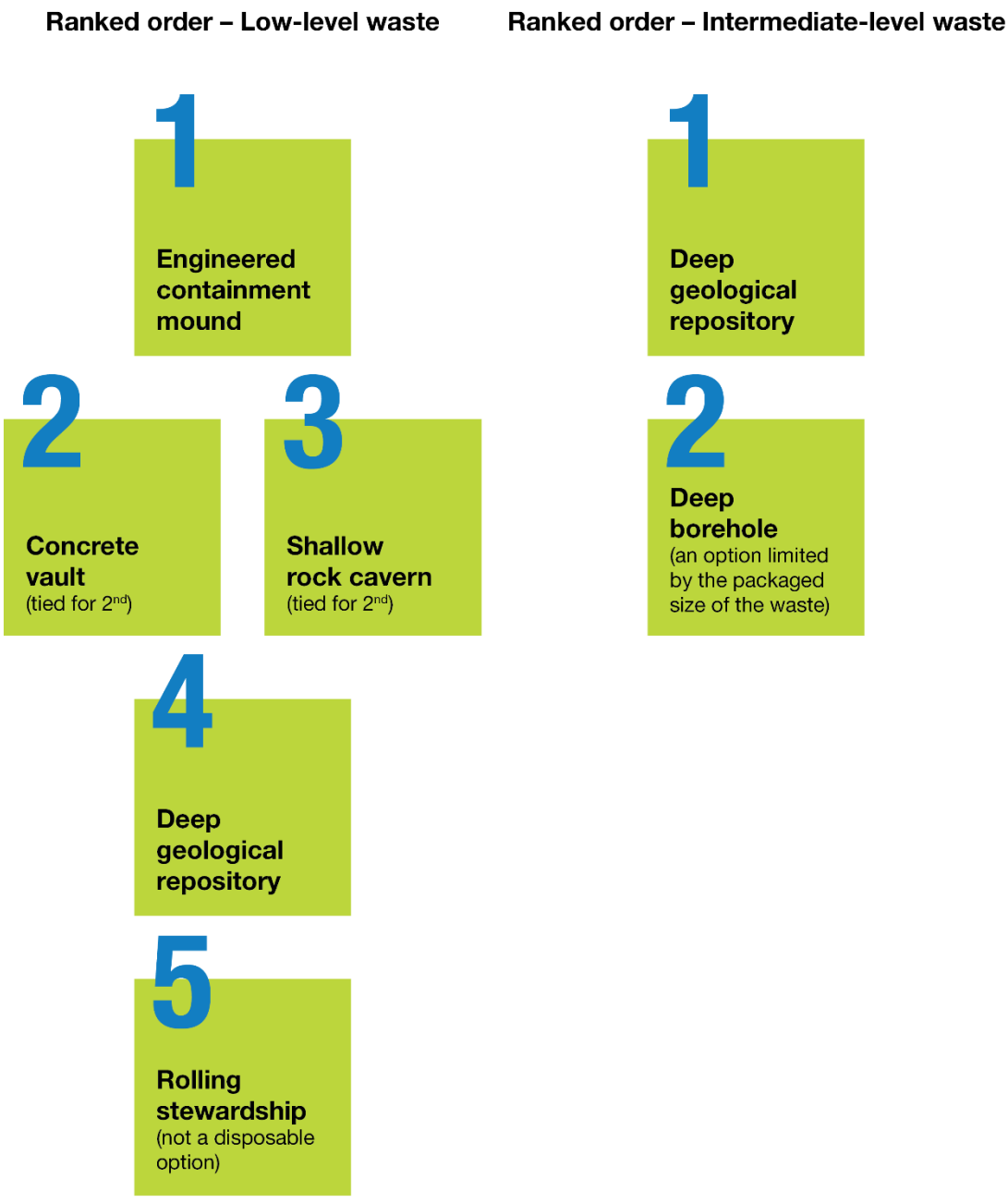


Figure 16: Ranking of technical options arising from workshops

Participants identified the importance of other decision factors such as safety, environment, transportation and cost.

Analysis of costs

To further support the analysis, the NWMO commissioned a cost estimate report of the six technical options.[29] This cost estimate was prepared in conjunction with the technical assessment study. The purpose of this cost assessment was to provide indicative costs per unit volume of waste for the potential long-term management options.

The cost estimate was developed in accordance with the Association for the Advancement of Cost Engineering cost estimating guidelines and recommended practices for a Class 5 cost estimate. A preliminary design basis and cost basis were established for each option based on publicly available information and input from subject matter experts in nuclear and non-nuclear industries. It is emphasized that this report was prepared for the relative cost comparison of different waste disposal options on a per-unit-volume basis and should not be used for the absolute cost estimate of the overall cost of individual options. Rolling stewardship is presented as three sub-options (300, 500 and 1,000 years) for relative comparison with other options.

For each option, the lifecycle cost was determined through a bottom-up approach to cost estimating for each development phase (siting, regulatory approvals, design and construction, operation, decommissioning and closure, and monitoring). Common infrastructure and facilities were identified for each long-term management option (e.g., offices, utilities, security, etc.) and were estimated on a general basis. Facilities-specific costs are also identified and estimated for each long-term management option. Costs that depend on facility size (i.e., total waste volume) were separated to identify variable costs. Fixed and variable costs were separately estimated to determine the economy of scale of each facility type if the facility design inventory changes from the reference scenario.

The study assumes that new waste management facilities will be built. For all facility types, except for the deep borehole, the cost estimate assumed the site development would occur in a new greenfield environment, in an unspecified general location with good access to infrastructure and trades personnel, and at a reasonable distance from developed urban areas. Since deep boreholes were assumed to be built on existing waste management sites with existing infrastructure, utilities and support amenities, the site development costs are excluded from the deep borehole estimates.

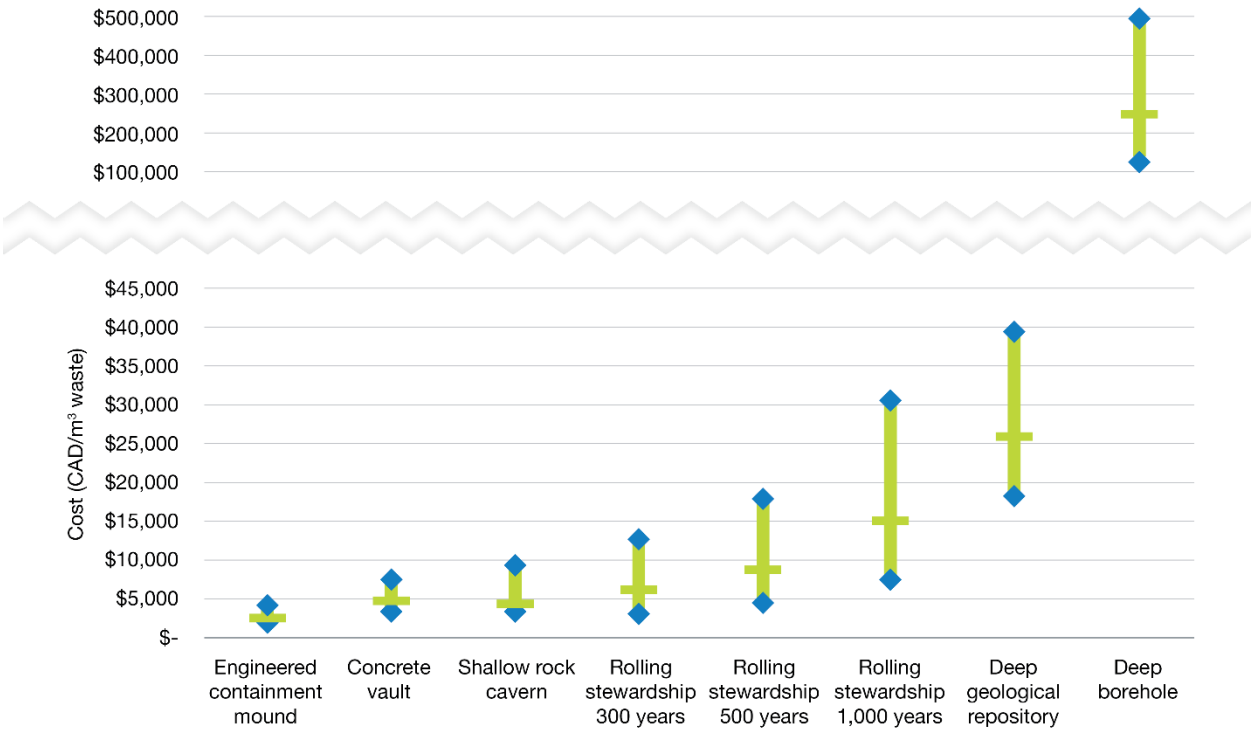


Figure 17: Cost summary of each long-term management option, with accuracy range

The waste volumes under the ISRW scope include current and future Canadian low- and intermediate-level waste that has no current long-term management plans, totalling approximately 294,000 m^3 of low-level waste and 51,000 m^3 of intermediate-level waste. The technical study showed that rolling stewardship, engineered containment mound, concrete vault and shallow rock cavern are not suitable for the long-term management of intermediate-level waste. It is therefore assumed that the reference facilities for rolling stewardship, engineered containment mounds, concrete vaults and shallow rock caverns are sized to host the low-level waste inventory, and the reference facilities for a deep geological repository and deep boreholes are sized to host the intermediate-level waste inventory.

The cost estimate assumed the reference management scenarios and facility sizes for each option based on the recommendations made in the technical assessment report. It should be noted that the per-unit-volume cost of each long-term management facility benefits from economies of scale, and the results shown in this report can vary if the reference waste volume changes. The influence of economies of scale is shown below (note that accuracy range and deep borehole not shown for clarity).

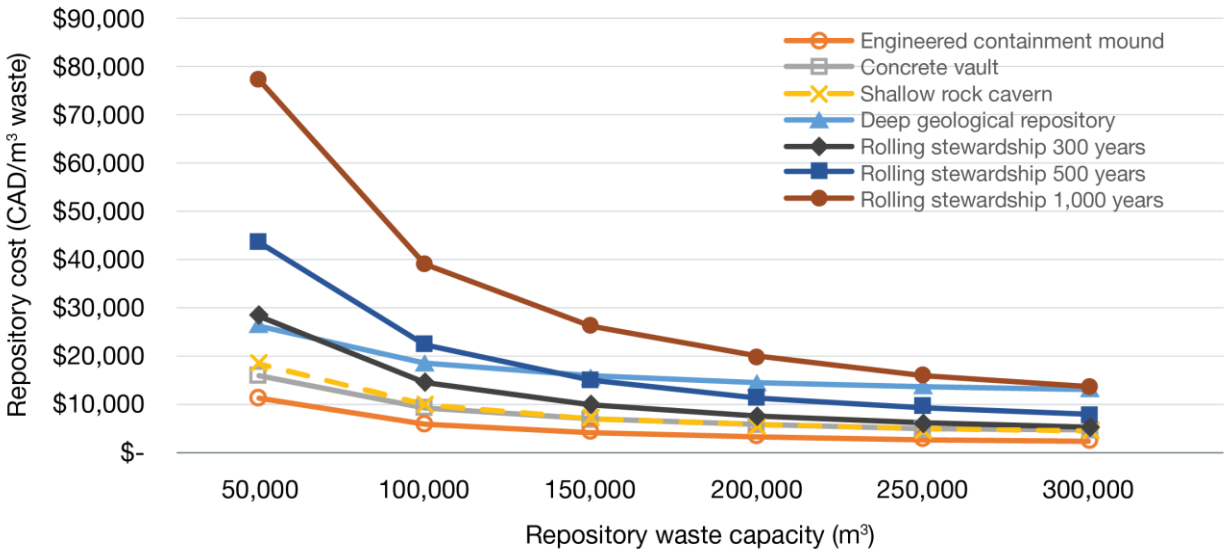


Figure 18: Indicative effect of changing facility size on per-unit-cost

As discussed previously, the four lowest cost options (engineered containment mound, concrete vault, shallow rock cavern and 300-year rolling stewardship) are only considered suitable for low-level waste. The engineered containment mound was found to be the least expensive option on average, but as noted in the technical assessment, it may not be suitable for the entire low-level waste inventory. However, the accuracy ranges of all four options overlap, so further investigation and definition are recommended to confirm the most economical option as one of several option evaluation criteria.

For intermediate-level waste disposal, the deep borehole option was found to be approximately 10 times more expensive than the deep geological repository per unit volume of waste. Furthermore, the deep borehole option is only capable of disposing of part of the ISRW intermediate-level waste inventory. A deep geological repository would be required to dispose of the remaining intermediate-level waste. Thus, the additional high cost of a deep borehole may not be suitable for intermediate-level waste under the ISRW scope.

Transportation costs and the implementation of a decentralized approach (i.e., multiple spread-out facilities) or a collocated approach (i.e., a single facility with one or more long-term management options) were not considered in this cost estimate. The cost associated with radioactive waste processing and/or conditioning is not considered as part of this estimate. However, a deep borehole repackaging plant is considered as part of this estimate since repackaging is necessary for the deep borehole to be feasible with the current ISRW waste inventory.



Chapter 5: Integrated strategy and associated recommendations

Context: In collaboration with waste generators, waste owners, government, Indigenous peoples and interested Canadians, the NWMO focused on identifying gaps in current plans for the long-term management for radioactive waste and providing technical options to address these gaps.

Integrated strategy

This Canadian Integrated Strategy for Radioactive Waste (ISRW) is the beginning of a new era in waste management in Canada. This represents a next step, an evolution in waste disposal in Canada. This strategy is a first for Canada and closes the gaps in long-term waste management of all Canada's radioactive waste from current electricity generation and medical isotopes with an eye to the future.

Over the course of two years of engagement with Canadians, Indigenous peoples and industry representatives, as well as review of international best practices for optimum technical solutions, the following ISRW in Canada has been developed for the various radioactive waste streams. There are three existing gaps where some low-, intermediate- and non-fuel high-level radioactive wastes do not currently have long-term waste management plans.

To address these gaps and consistent with what the NWMO heard from stakeholders and Indigenous peoples and the direction of the Radioactive Waste Management and Decommissioning Policy (Policy), two fundamental recommendations and four implementation principles have been developed to ensure that Canada has disposal facilities for all its radioactive wastes. The strategy shown in the table and illustration that follow does not replace existing long-term disposal projects currently in progress, but rather includes these plans.

As new technologies such as small modular reactors emerge, these nuclear applications would also produce waste that would have to be safely managed. At this time, this strategy has been written with flexibility to incorporate these wastes into the appropriate waste stream using Canada's waste classifications: low-, intermediate- and high-level waste, the latter of which includes used nuclear fuel.

Over time, as waste management progresses, either through implementation of the waste disposal facilities identified in this strategy or through deployment of new technologies to address societal demands or climate change, Canada's ISRW would have to be updated to ensure the strategy continues to support all waste streams that may be generated in the future.

The integrated strategy is illustrated as follows.

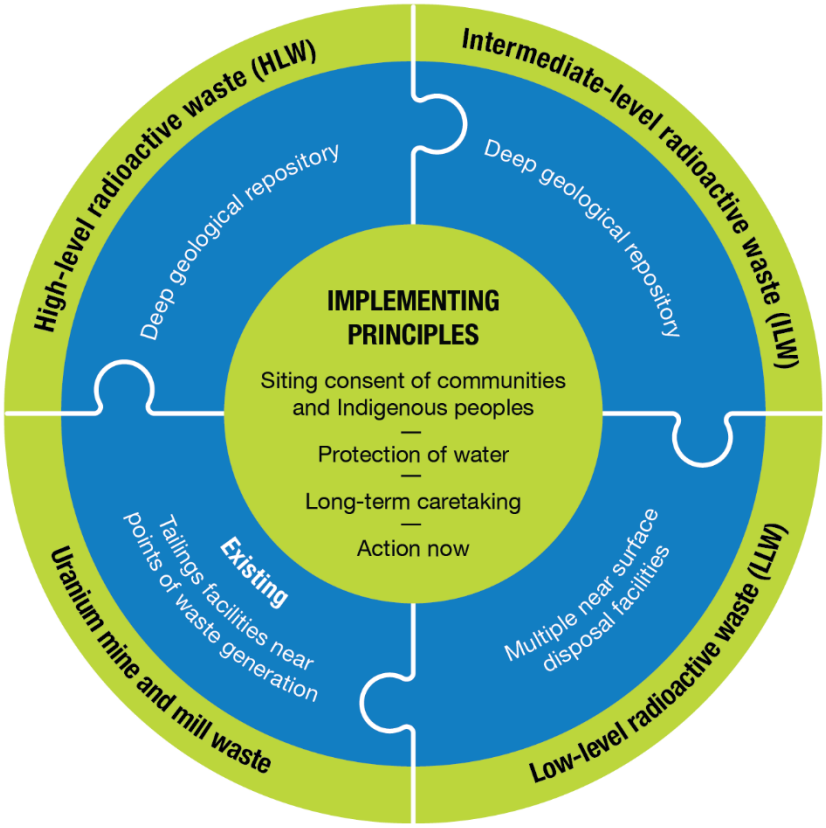


Figure 19: Integrated Strategy for Radioactive Waste

Table 9: Integrated strategy for all current and projected radioactive waste

Waste classification	Type of waste	Existing long-term disposal plan	Current responsibility for implementation	Integrated strategy
High-level waste (HLW)	Used fuel	Yes	NWMO	No change – Deep geological repository
	Non-fuel	No	–	Deep geological repository Responsibility for implementation of long-term waste disposal plan: NWMO
Intermediate-level waste (ILW)	ILW produced in various nuclear facilities	No	–	Deep geological repository Responsibility for implementation of long-term waste disposal plan: NWMO
	ILW produced at Nuclear Power Demonstration facility and Whiteshell Reactor 1	Yes	Canadian Nuclear Laboratories	No change – In-situ decommissioning
Low-level waste (LLW)	Port Hope historic LLW	Yes	Canadian Nuclear Laboratories	No change – Port Hope Area Initiative
	LLW owned by Atomic Energy of Canada Limited at Chalk River	Yes	Canadian Nuclear Laboratories	No change – Near surface disposal facility
	LLW produced at Nuclear Power Demonstration facility and Whiteshell Reactor 1	Yes	Canadian Nuclear Laboratories	No change – In-situ decommissioning
	LLW produced in various nuclear facilities	No	–	Multiple near surface disposal facilities Responsibility for implementation of long-term waste disposal plan: Waste generators/owners
Uranium mine and mill waste[30]	Tailings facilities near point of generation	Yes	Uranium mines and mill tailings companies, and applicable provincial and federal governments	No change – Disposal facilities near point of waste generation

High-level waste

High-level radioactive waste is primarily used nuclear fuel. The NWMO is mandated under the *Nuclear Fuel Waste Act* to develop and implement a long-term solution for used nuclear fuel from Canada's reactors. Adaptive Phased Management is the name of Canada's plan for the long-term management of used nuclear fuel. It consists of the centralized containment and isolation of Canada's used fuel in a deep geological repository in an area with suitable geology and informed and willing hosts.

However, there are also small amounts of non-fuel high-level radioactive waste in Canada. To address the non-fuel high-level waste, disposal in a deep geological repository along with the intermediate-level waste is recommended as part of the integrated strategy.

Intermediate-level waste

The long-term management of very small volume of Canada's intermediate-level waste is being addressed by existing projects undergoing regulatory reviews. However, most of the intermediate-level waste has no long-term waste management plan. To address this, disposal in a deep geological repository is recommended as part of the integrated strategy.

Low-level waste

The long-term management of some of Canada's low-level waste is being addressed by existing facilities or projects undergoing regulatory reviews. Through the Port Hope Area Initiative, Canadian Nuclear Laboratories (CNL) manages 1.7 million m^3 of historic low-level waste in engineered above ground mounds. In addition to the Port Hope Area Initiative, CNL has submitted a licence application for the construction and operation of a near surface disposal facility at the Chalk River Laboratory site. The proposed disposal facility will be an engineered containment mound that will hold up to 1 million m^3 of low-level waste. To address the remainder of Canada's low-level waste, multiple near surface disposal facilities are recommended as part of the integrated strategy.

Uranium mine and mill waste

More than 200 million tonnes of uranium mill tailings have been generated in Canada since the mid-1950s. There are 25 tailings sites in Ontario, Saskatchewan and the Northwest Territories, 22 of which no longer receive waste material. The three remaining operational tailings management facilities are located near the point of waste generation in Saskatchewan. At this time, there are no gaps, and no additional facilities are recommended as part of the integrated strategy.

Refer to Appendix C: Status of long-term waste management projects in Canada for more information about existing waste disposal projects.

Implementation of the integrated strategy

In addition to the technical options recommended to address the long-term management of the waste, the integrated strategy contains four implementing principles, which are based on what we heard from various participants to be the priority for any new nuclear waste facilitities to be developed as part of the strategy. The integrated strategy recommendations and the implementing principles are discussed in greater detail below.

Recommendations for the implementation of the strategy

The following recommendations consider the inputs obtained from international benchmarking, stock-taking, technical and cost estimate assessments, and all engagement activities. These recommendations when taken along with the existing disposal projects in operation or undergoing regulatory assessments at the time of writing form a complete strategy to address all existing and future waste in Canada.

See Appendix B: Matrix of input from engagement activities, by participant grouping to see the contributions of various participant groups to the development of themes and ideas captured within the recommendations.

RECOMMENDATION 1: INTERMEDIATE-LEVEL WASTE AND NON-FUEL HIGH-LEVEL WASTE TO BE DISPOSED OF IN A DEEP GEOLOGICAL REPOSITORY WITH IMPLEMENTATION BY THE NWMO

- The NWMO, as Canada's leading organization for deep geological disposal, to site and build a deep geological repository for Canada's intermediate-level waste (ILW) and non-fuel high-level waste (HLW), with funding provided by waste generators and waste owners.
- The NWMO to prepare a detailed plan defining the process to select a site for the repository, inclusive of engagement strategy and funding approach, taking into account experience and learnings gained from implementing other siting processes for nuclear facilities. This siting process is separate from the NWMO's work to site Canada's plan for used nuclear fuel.
- This plan is to outline the process to determine the technical and social acceptability requirements for siting a repository, consistent with the Policy and the implementing principles outlined below.
- This plan is to also include the expected timelines for siting and construction of the repository.
- It is expected that defining the site selection process could take 12 to 18 months, at which point the NWMO will report back to Natural Resources Canada on the approach.

Background information

Disposal of intermediate-level waste aligns with international best practices and was preferred over rolling stewardship by the majority of participants. From a technical and societal point of view, disposal of intermediate-level waste in a deep geological repository emerged as the best option to isolate the waste from the environment. This approach would also be able to accommodate non-fuel high-level waste.

Participants expressed a preference for technical options that would have the least environmental impact. They felt that options that place waste underground or that can be restored or covered with vegetation appear to address this priority of environmental impact. Minimizing visual impacts was also highlighted as an important consideration especially from participants that have seen other types of industrial facilities near where they live.

From a quantitative point of view, a majority of respondents, 60 per cent in the open survey and 63 per cent in the representative sample, preferred that intermediate-level waste be managed over the long term using a specially designed disposal facility deep underground. In contrast, only 13 per cent in the open

survey (10 per cent in the representative sample) opted for continued surface storage. 12 per cent in the open survey (20 per cent in the representative sample) found either approach acceptable, as long as all federal and international safety regulations are met.

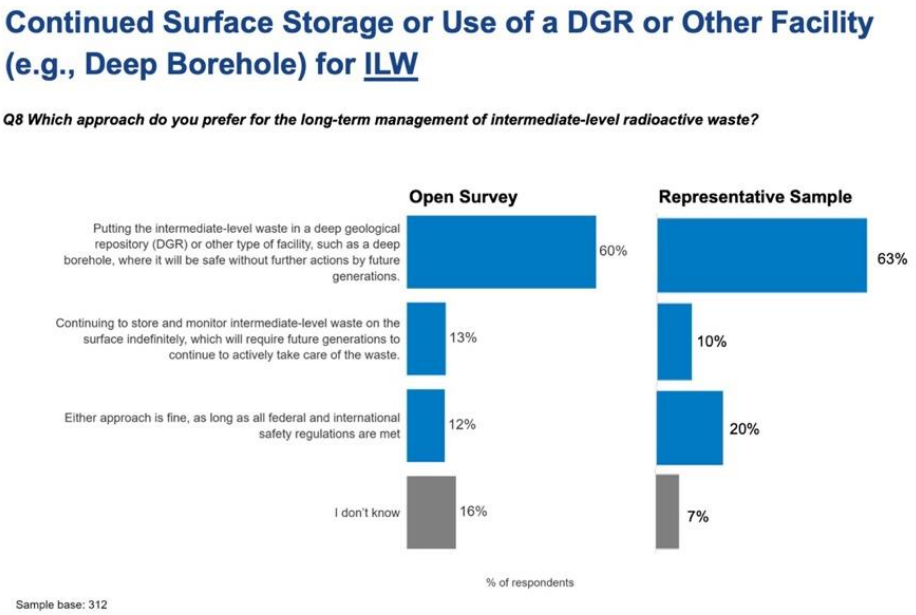


Figure 20: Continued surface storage or use of a DGR or other facility for ILW

We heard that having one central place in the country for intermediate-level waste would be preferable to several regional facilities. From a societal perspective, collocation with high-level waste in a technically suitable site with willing host communities has the same level of support as a separate deep geological repository for intermediate-level waste. From a financial perspective, collocation with high-level waste would have economies of scale, including sharing of resources and infrastructure. However, further analysis, taking into account social and technical considerations, would need to be undertaken.

From the engagement, some participants expressed it could be acceptable for some of the intermediate-level waste to go into the same deep geological repository as high-level waste (collocation). Participants stated that collocation with high-level waste makes sense financially and is currently done in other parts of the world. We also heard that because of the low volume of intermediate-level waste in Canada (less than one per cent of the total waste volume), it should be combined with high-level waste for permanent disposal rather than at a separate disposal facility.

Other participants expressed a preference for one community hosting a single site for low-level waste, and another community hosting a single site for intermediate-level waste. We also heard that a single distinct intermediate-level waste disposal facility could potentially be more socially acceptable than a combined facility, or multiple facilities for intermediate-level waste. Some participants felt having a separate deep disposal site was the best option for high-level waste and intermediate-level waste. Some had questions about the technical viability of mixing intermediate-level and high-level waste. In all instances, participants identified community consent as necessary.

From a quantitative perspective, a 36 per cent plurality of respondents in the open survey preferred a centralized collocated option, which involves transporting intermediate-level waste to a single disposal facility that would also house both used nuclear fuel and intermediate-level waste. In contrast, 25 per cent opted for a facility separate from used nuclear fuel for the long-term management. Almost a quarter

thought either approach is fine, as long as all federal and international safety regulations are met. This is one of the few instances where the results of the open survey differ from those of the representative survey. In the latter, building distinct facilities at separate locations was the most popular (selected by 34 per cent), while collocation of intermediate-level waste with used nuclear fuel was preferred by only 25 per cent of the respondents. We also found a higher proportion of these respondents were ambivalent about the direction to take (33 per cent).

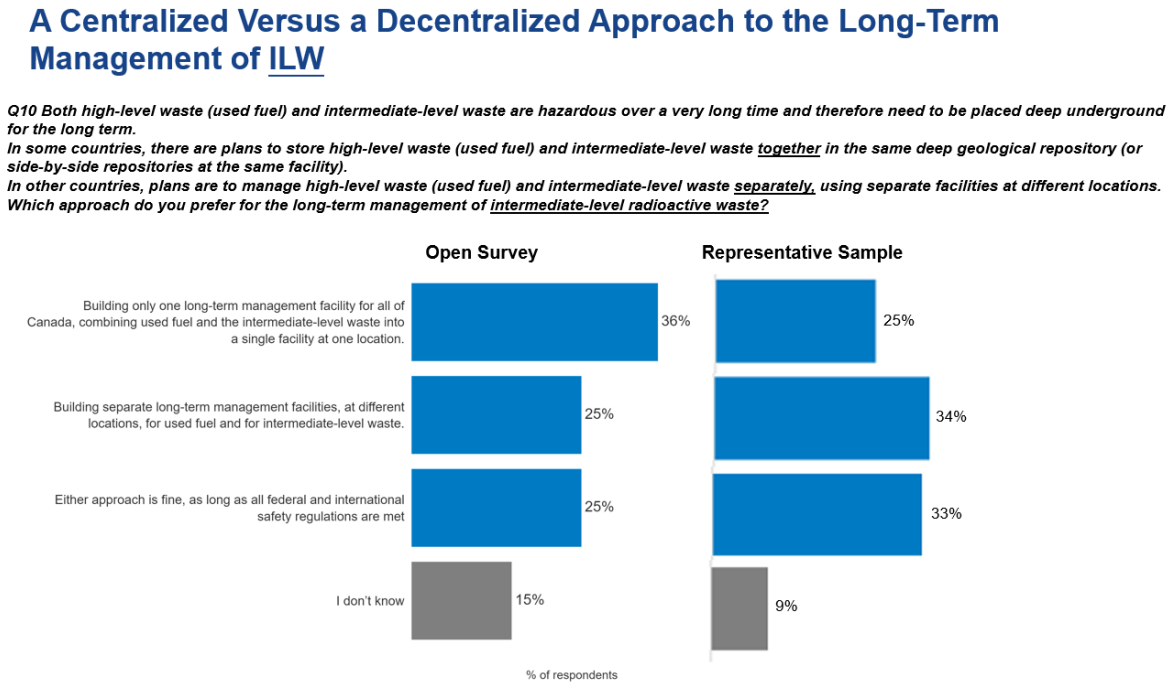


Figure 21: Centralized versus decentralized approach to long-term management of ILW

Given that all intermediate-level waste would be disposed of in a single facility, a single, dedicated implementer would provide the greatest efficiency, as it is for used nuclear fuel. With our structure and our expertise in deep geological repositories, the NWMO is recommended as the implementer for intermediate-level waste. The waste owners would maintain the responsibility for funding the long-term management of intermediate-level waste, consistent with the Policy.

Some participants expressed support for the NWMO to play this role, emphasizing the importance for joint responsibility between a federally mandated, arm's-length body and waste owners, where waste owners fund the projects. They stated that this organization should take on Canadian and international best practices in a way that would not be impacted by elections or political process. We heard that a government regulated central body would alleviate public concerns. We also heard that to implement the strategy effectively, any organization needs to be independent of the regulator, independent of government and free from government interference, while following policy and regulations.

Participants were comfortable with an independent central agency, preferably not-for-profit, in charge of handling the waste, a single entity that has the community's trust and federal support with a board of directors comprising diverse stakeholder representation.

RECOMMENDATION 2: LOW-LEVEL WASTE TO BE DISPOSED OF IN MULTIPLE NEAR SURFACE DISPOSAL FACILITIES WITH IMPLEMENTATION RESTING WITH WASTE GENERATORS AND WASTE OWNERS

- Waste generators and waste owners to site and build near surface disposal facilities for those low-level waste with no long-term disposal plan, consistent with international best practices, considering characteristics, volume, proximity to the existing interim waste facilities, community acceptance and technical considerations.
- The option of multi-waste producer facilities or centralized regional facilities to also be explored to balance the number of facilities with the distance that the waste would need to be transported. Centralized regional facilities could provide economies of scale and could ensure fair access to disposal facilities for small waste generators. Regional facilities could be provincial, cover multiple provinces or be multiple facilities within one province, depending on several factors such as volume of waste, transportation distances and cost.
- More detailed implementation plans by waste generators and waste owners to be developed in an open and transparent manner, with early and ongoing engagement consistent with the Policy.

Background information

Disposal of low-level waste aligns with international best practices and was preferred by the majority of participants, over rolling stewardship. From a technical, financial and societal point of view, near surface disposal is the best option to contain the waste until it no longer poses a hazard. Near surface disposal options were assessed as suitable for Canada's low-level waste from a technical perspective. They are also the most affordable options from an economic perspective.

From the engagement, participants expressed that near surface disposal for low-level waste is an acceptable approach because low-level waste has lower risk and a shorter period in which it is hazardous. Some participants expressed that placing low-level waste deep underground was not commensurate with the lower level of risk, technical requirements and international practice. They were also of the opinion that over-engineering facilities would not be fiscally responsible and that it would be difficult to justify the cost of deep geological disposal for low-level waste. Some felt that there are lessons to be learned from the management of conventional waste, where Canada's expertise in low hazard landfills is recognized. We also heard participants were comfortable with storing low-level waste both at surface level and at a shallow depth below surface level in purpose-built disposal facilities.

From a quantitative point of view, a strong plurality of respondents, 48 per cent in the open survey and 41 per cent in the representative sample, preferred that low-level waste be managed over the long term using a specially designed disposal facility. In contrast, only 14 per cent in the open survey (eight per cent in the representative sample) opted for continued surface storage. 26 per cent found either approach acceptable, as long as all federal and international safety regulations are met. This number was, however, much higher in the representative sample at 46 per cent.

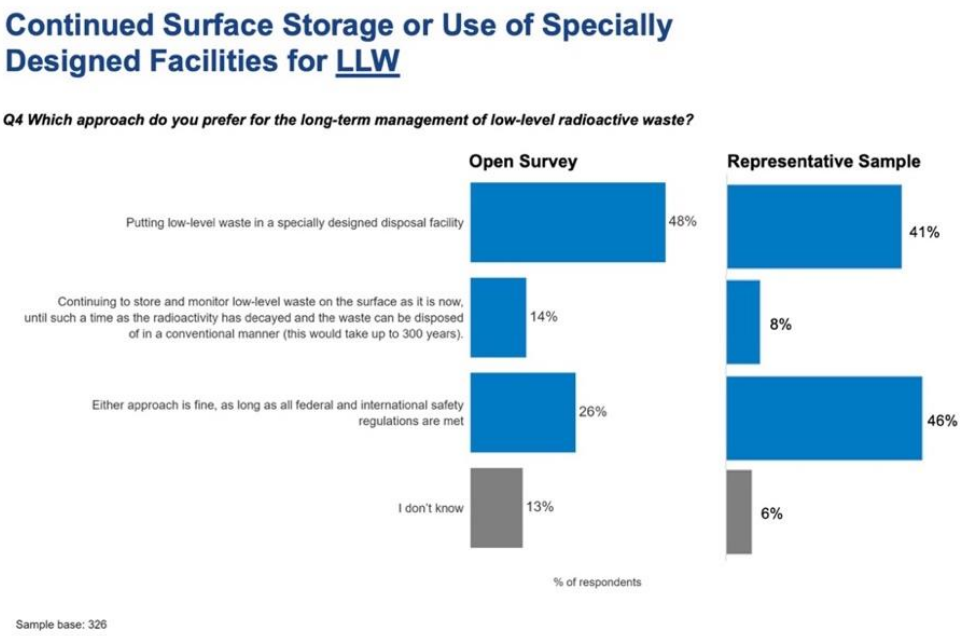


Figure 22: Continued surface storage or use of specially designed facilities for LLW

The concrete vault and shallow rock cavern emerged as suitable technical approaches to address all the low-level waste in the ISRW inventory. Either option is suitable from a technical perspective to accommodate all the low-level waste and would provide the greatest flexibility for future waste, but the shallow rock cavern option does require more specific site characteristics.

The engineered containment mound was the option most often preferred from a societal and financial perspective; however, based on preliminary technical assessments and conservative assumptions, it was assessed to be suitable for only some of the LLW that has no long-term waste management plan. It could be suitable for a larger proportion of the low-level waste, contingent on more detailed analysis of the waste and its packaging. At this time, for the ISRW inventory, the engineered containment mound could be considered in combination with either one or both of the other near surface disposal facility options.

Multiple facilities were preferred from a societal point of view given the large volumes of waste and transportation considerations. Centralization does garner significant support as well, and financially, economies of scale may favour this approach. Further detailed analysis, including the cost of transportation, is needed.

The concept of regional facilities should be further explored to minimize the number of facilities and the distances that the waste would need to be transported. The regional concept may also play a pivotal role in ensuring that there are disposal facilities available to small waste generators. Regional facilities could be provincial, cover multiple provinces or be multiple facilities within one province, depending on several factors such as volume of waste, transportation distances and cost. We heard that transportation costs should not be the only consideration when determining if a centralized facility should be built. Transportation considerations should be balanced with potential impacts on Indigenous communities that already have a portion of the radioactive waste on their lands, and also depends on their consent and willingness for hosting the future waste facilities. Further study is needed to help with such decision.

When discussing centralization versus decentralization of long-term storage and disposal facilities, many participants expressed a concern around ensuring equitable distribution of the responsibility and the risks from these facilities. They wanted to ensure that this burden is not placed on some communities over others, and having several waste sites would contribute to social justice, with waste stored near to where

it is produced. Some participants expressed that a single facility would increase transportation costs and risks and that having multiple facilities would be a fairer approach to host communities who would share the burden of hosting waste. Other participants identified the risk of an event occurring with only one single repository for all Canada's radioactive waste. They expressed concern that if all the waste were in a single location, the impact of an event could be more significant and thus preferred multiple locations.

Others favoured multiple locations to avoid long distance transportation. We heard from some participants that because there was a significantly higher volume of low-level waste versus intermediate-level waste, there should be more facilities for low-level waste. Participants felt that the further the waste is transported, the greater the risk of transportation accidents. Some youth favoured the strategy of building multiple facilities across Canada to help reduce these risks. Additionally, participants noted that given Canada's size, the transportation of low-level waste from across the country would not be environmentally sustainable.

From a quantitative point of view, 38 per cent in the open survey and 43 per cent in the representative sample opted for a decentralized approach to the long-term management of low-level waste, building several low-level waste disposal facilities, each close to where a significant amount of waste is being produced and stored. Centralization garnered 23 per cent in the open survey (20 per cent in the representative sample). 26 per cent found either approach acceptable, as long as all federal and international safety regulations are met. This number was slightly higher in the representative sample at 32 per cent.

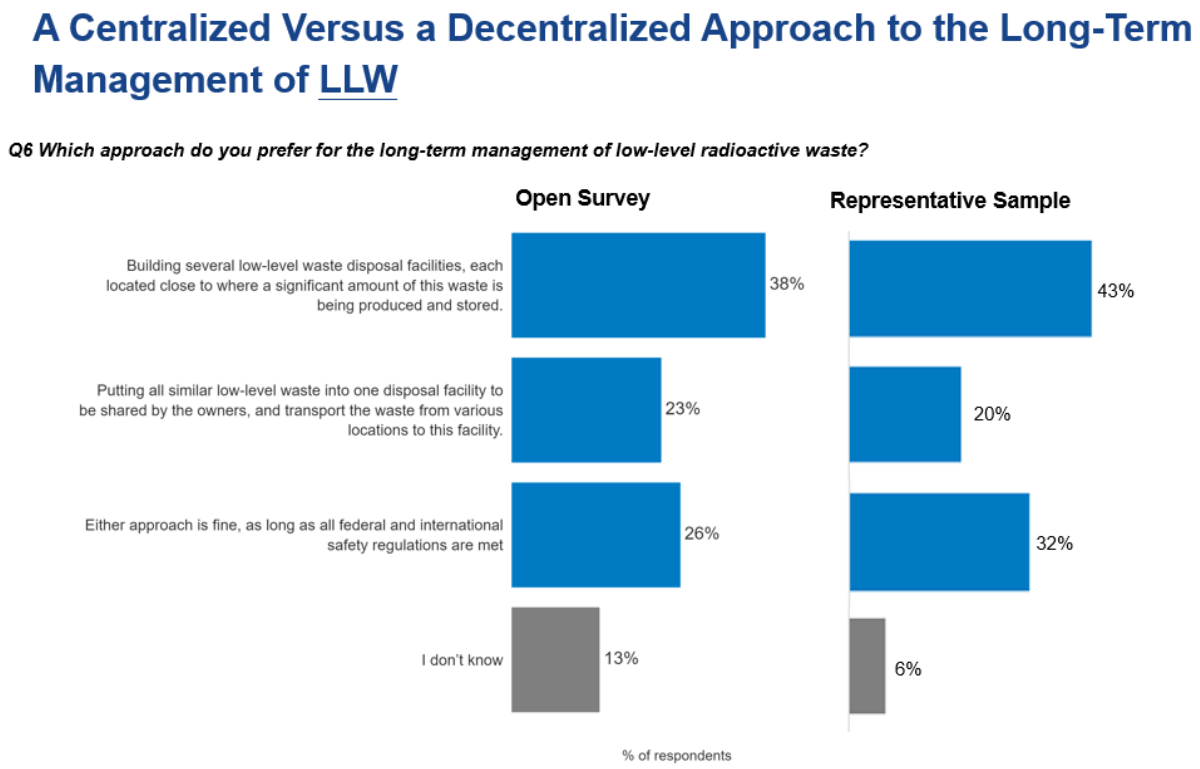


Figure 23: Centralized versus decentralized approach to long-term management of LLW

With regards to implementation, responsibility for low-level waste should remain with the waste owners working collaboratively to ensure that there are disposal facilities for all low-level waste, regardless of ownership or quantity. Collaboration will be key in the implementation of the regional concept and in

ensuring that there are disposal facilities available to small waste generators through commercial agreements and at a fair and reasonable cost.

Through engagement, we heard from some participants that the organizations producing waste today may be best positioned to take on a greater responsibility as part of the ISRW implementation because they would understand the type of waste they are producing. Some participants noted that they would be open to waste generators and waste owners implementing the strategy under supervision and oversight from the government, with the waste owners responsible for their strategy and selecting the specific technology for the disposal of their waste considering the inventory, siting, geology and waste characteristics. Having an oversight body in place to ensure that the waste is safely managed, to solve problems and to enforce proper rules was seen as beneficial. However, participants also stated that in the past, waste owners were only self-interested and not willing to take other waste, regardless of proximity. We heard that key producers of small to modest volumes of waste are unlikely to have the capacity to implement the requisite waste facilities, so it is crucial that whoever implements the strategy must provide access to small waste generators.

Some participants expressed the need for everyone to collaborate on the implementation of the strategy, but that it may not be ideal for a single entity to be responsible. They felt that shared responsibility is important and needs to be nationally aligned, with different companies coming together in a collaborative approach. They noted that industry should retain responsibility for the implementation of the strategy with appropriate approvals and oversight by a trusted independent arm's-length organization.

From a quantitative point of view, although we see a clear preference among open survey respondents (by a ratio of 5:1) and the representative survey for creating an organization separate from the waste owners to implement Canada's strategy for the long-term management of low- and intermediate-level waste, the phrasing of the question did not allow respondents to provide different answers for different waste types. In fact, some people believe that different approaches could and should be used for low-level waste and intermediate-level waste, given that the latter requires containment for longer time periods. Thus, waste owners could continue to manage low-level waste, but a more collective approach could be used for intermediate-level waste (as it is for used nuclear fuel, which has a single implementer to advance Canada's plan).

Implementing principles

Based on extensive input from Canadians and Indigenous peoples, four implementing principles have been developed as follows. These are consistent with the Policy.

IMPLEMENTING PRINCIPLE 1: CONSENT OF THE LOCAL COMMUNITIES AND INDIGENOUS PEOPLES IN WHOSE TERRITORY FUTURE FACILITIES WILL BE PLANNED MUST BE OBTAINED IN SITING

This consideration was prioritized by the majority of participants in the engagement sessions. Consent of the impacted Indigenous communities is also aligned with Canada's measures taken for the implementation of the *United Nations Declaration on the Right of Indigenous Peoples Act* (*UNDA*). This critical consideration extends to all future disposal facilities for radioactive waste, including the possible collocation of intermediate-level waste with used fuel. This necessitates discussions with the core communities in the siting areas for various future long-term radioactive waste facilities to understand their expectations around consent.

Consistent with the Policy, Indigenous communities in siting areas must have early and meaningful engagement and ongoing involvement in all phases of any waste disposal project, regardless of size, through capacity building among Indigenous peoples, information sharing and collaboration.[31] In addition, laws, regulatory processes and Indigenous consultation protocols, developed and implemented in areas where future facilities will be planned, should be respected.

IMPLEMENTING PRINCIPLE 2: DESIGN OF FACILITIES SHOULD PRIORITIZE THE PROTECTION OF WATER

While the safety of the various technical options can be demonstrated from a technical standpoint for a variety of locations, it may be difficult to obtain societal support for long-term radioactive waste facilities located in close proximity to major sources of drinking water. There were concerns about the perceived danger radioactive waste poses to humans and the risk when transporting and housing waste near waterways. Indigenous youth participants, in particular, underlined the importance of protecting water, including groundwater. While participants indicated that facilities should be located away from any major water sources, the reality of the Canadian landscape is that this would not be feasible.

The Policy requires that radioactive waste management and decommissioning activities, including transportation and disposal, are carried out in a comprehensive and integrated manner that prioritizes the health, safety and security of people and the environment, and ensures nuclear non-proliferation.[32] Consistent with this, protection of water is paramount, and therefore, any disposal facilities must meet the highest standards of environmental and water protection. Sources of potable water should be protected, and oceans should not be considered an option for any nuclear development, disposal or storage, now or in the future.

IMPLEMENTING PRINCIPLE 3: LONG-TERM CARETAKING SHOULD BE ESTABLISHED FOR DISPOSAL FACILITIES

There should be oversight of the waste and facilities for as long as future generations deem it to be necessary to ensure that the environment remains protected. This concept also includes the transfer of knowledge of the waste and where it is located with future generations and ensuring that the waste is not forgotten. Roles should be created and included for future generations to ensure continuity and to monitor waste. These roles should include the periodic review of the monitoring plans to determine whether they continue to be adequate or necessary. Regardless of the option selected, most participants supported the implementation of environmental monitoring over the long term. They felt that stewardship and monitoring of the environment and of the waste from generation to generation is required.

Since nuclear stations and existing waste facilities are located on the territory of Indigenous peoples, Indigenous communities should be leading conversations around land stewardship, consistent with expectations on waste owners in the Policy to work in partnership with Indigenous peoples to gain a greater understanding of their Indigenous Knowledge and advice with regards to radioactive waste management and decommissioning projects. These communities possess Indigenous Traditional Knowledge and should be at the forefront of any development that may disturb the land, threaten waters and impact traditional uses. It should also be ensured that economic benefits are shared with the local consenting communities.[33]

IMPLEMENTING PRINCIPLE 4: WE NEED TO TAKE ACTION NOW AND NOT DEFER TO FUTURE GENERATIONS

One of the objectives of the Policy is to have key elements of Canada's radioactive waste disposal infrastructure in place and planning well underway for the remaining facilities necessary to accommodate all Canada's current and future radioactive wastes by 2050. In the development of the strategy, participants told us that there is a need for a strategy that is integrated, and that the approach to the long-term management of low-level and intermediate-level waste should be determined. There was general agreement that the right thing to do was to have and to implement a plan for all Canada's radioactive waste, and to do so with a sense of urgency rather than leaving this to future generations. This is consistent with the input received 20 years ago by the NWMO as part of the study on the long-term management of used fuel.

This is also aligned with the Policy requirement on waste owners and generators to collaborate together on their plans for the advancement, development and implementation of comprehensive and nationally integrated radioactive waste management solutions in a timely manner, and to decommission facilities,

locations and sites within an appropriate time frame to reduce the burden on future generations.[34] The implementation of the ISRW will require firm ongoing commitment and support from government, with a structure that will be empowered to deliver on the objectives of the strategy, regardless of changes in government. This urgency to take actions must be appropriately balanced with Canada's commitment to Reconciliation with Indigenous peoples.

Additional recommendations outside the scope of the ISRW

The integrated strategy did not consider reprocessing of used nuclear fuel. Reprocessing, the purpose of which would be to extract fissile material from nuclear fuel waste for further use, is not presently employed in Canada, and so, it is outside the scope of the Policy, and therefore, outside the scope of the integrated strategy. If reprocessing is ever brought forward, the radioactive waste from such a project would fall within the scope of the Policy and would then be considered in future updates of the ISRW.

The integrated strategy did not consider options for waste minimization, including volume reduction, beyond those planned and quantified by the waste generators and waste owner. Subject to future study, the integrated strategy may benefit from a holistic upstream approach to waste reduction prior to disposal. Furthermore, an integrated approach may open avenues of waste processing resulting from economies of scale that have not yet been accessible for smaller waste owners.

The integrated strategy did not consider legacy waste and issues or resolutions.

Appendices and glossary

Appendix A: Guiding principles

The NWMO developed a set of principles that are comprised of what the organization had heard previously from Canadians and Indigenous peoples. These initial principles were included in public opinion research and refined by participants at the Canadian Radioactive Waste Summit, the first of the engagement events for the development of an Integrated Strategy for Radioactive Waste, held on March 30-April 1, 2021.

The principles that emerged were used as the basis for discussion in the community engagement sessions. All the work undertaken by the NWMO was anchored on these principles.

The illustration and full text of the principles is included below.



Figure 24: Guiding principles

The strategy must have safety as the overarching principle guiding its development and implementation. Safety, including the protection of human health, must not be compromised by other considerations.

The strategy must ensure the security of facilities, materials, infrastructure and information.

The strategy must ensure that the environment is protected, including the protection of the air, water, soil, wildlife and habitat.

The strategy must be developed and implemented to meet or exceed regulatory requirements for the protection of health, safety and the security of people and the environment.

The strategy must be informed by the best available knowledge. This includes Indigenous Traditional Knowledge, science, social science, local knowledge and international best practices. Ensuring that Traditional Knowledge and ways of life are interwoven throughout is important for a strong strategy. This includes knowledge about the land and environment. It also includes values and principles about developing and maintaining effective and meaningful relationships.

The strategy must respect Indigenous rights and treaties and consider that there may be unresolved claims between Indigenous peoples and the Crown.

The strategy must be developed in a transparent manner that informs and engages the public, including youth and Indigenous peoples. It is important to proactively provide easily understandable information to those most likely to be affected by implementation of the strategy. Questions and concerns must be heard, acknowledged and addressed. Information used to develop the strategy will be readily available to the public.

The strategy must be developed and implemented in a fiscally responsible way to ensure that the cost of the project does not become a burden to current electricity ratepayers, taxpayers or future generations.

Where possible, the strategy should make use of existing projects for the long-term management of Canada’s nuclear waste.

Appendix B: Matrix of input from engagement activities, by participant group

The tables in this appendix display the contributions of various participant groups to the development of themes and ideas captured within the recommendations. Each table represents the main themes arising from the key focus areas of discussion held during various engagement sessions:

1. Disposal versus rolling stewardship;
2. Collocation versus centralization; and
3. Responsibility for implementation.

Each table shows the various groups with whom we engaged along the top, and a summary of the main ideas generated from the discussion along the left side. A chevron indicates when a theme was identified by a group.

The themes along the left are arranged by relative frequency, with those themes higher in the table appearing more frequently than those lower in the table.

All the summary statements from what we heard during our engagement sessions were grouped into like ideas while noting their participant group of origin. A subjective value for intensity of associated comments was assigned, as was a subjective value for the breadth of audience from which we heard the comment.

Table 10: Disposal versus rolling stewardship

Category	Indigenous peoples	Community	Civil society organization	Academia	Industry	Municipal	Government	Open	Youth
Disposal preferred	»	»	»	»	»		»	»	»
Disposal – ILW + Collocation			»	»	»	»			»
Ongoing monitoring + stewardship	»	»	»		»			»	
Rolling stewardship	»	»	»	»				»	»
Rolling stewardship – LLW		»		»	»	»			»
Disposal – LLW				»	»				»
Rolling stewardship – ILW		»		»				»	
Defence-in-depth			»						
Disposal – Evolution of societal considerations				»			»		
Disposal – Technology considerations + flexibility					»				
No preference									»
Other – Urgency			»		»				
Disposal – LLW (multiple technical options)					»				
Other – Retrievability			»						
Other – Waste minimization		»							

» Heard from this group during our various engagements

Table 11: Collocation versus centralization

Category	Indigenous peoples	Community	Civil society organization	Academia	Industry	Municipal	Government	Open	Youth
Multiple facilities		»	»	»	»	»			»
Siting – Away from water	»	»	»					»	»
ILW – Collocation with HLW	»	»	»	»	»		»	»	
LLW – Multiple sites		»			»			»	»
LLW – Near surface disposal		»		»	»		»		
Multiple sites – Near point of generation		»	»	»	»	»		»	
ILW – Single site – Separate location		»		»		»	»		
LLW – Collocation with ILW		»	»	»		»		»	
LLW – Multiple sites – Near point of generation	»			»		»			
LLW – Single site	»			»	»	»			
LLW – Multiple sites – Regional	»			»					»
Multiple sites – Regional					»		»	»	
Separate facilities for LLW and ILW		»		»	»				
Siting away from population centres	»						»		»
Collocation					»				
ILW – Few sites								»	»
ILW – Multiple technical options					»				
Adaptability of strategy				»					
Environmental			»						

ILW – DGR					»				
ILW – Near surface			»						
LLW – Hazardous waste sites				»					
Processing – Stabilization and solidification		»							

» Heard from this group during our various engagements

Table 12: Responsibility for implementation

Category	Indigenous peoples	Community	Civil society organization	Academia	Industry	Municipal	Government	Open	Youth
Governance – Diverse representation	»	»	»	»				»	»
Multiple organization – Collaboration – Industry and Indigenous peoples	»	»		»	»				
Single organization – Service provider	»	»	»			»		»	»
Single organization – Arm's-length federal agency	»	»		»	»		»	»	
Single organization – Independent from industry		»	»					»	»
Multiple organizations – Industry led		»		»	»		»		»
Financial stewardship – Responsibility of waste owners		»			»		»		»
Other – Integration and co-ordination of implementation				»	»	»	»		
Single organization – Government led			»		»				»
Single organization – NWMO or equivalent	»				»				»
Financial stewardship					»				
Financial stewardship – Independent funding							»		
Governance – CNSC or CNA led						»			
Governance – Independent from industry			»						
Governance – Indigenous led									»
Governance – NWMO model							»		
Multiple organizations – Waste type specific				»					

Other – Process		»							
Other – Abolish CSA role and follow IAEA			»						
Single organization – Service provider				»					
Single organization – HLW				»					
Single organization – ILW				»					
Single organization – GOCO				»					

» Heard from this group during our various engagements

Appendix C: Status of long-term waste management projects in Canada

Adaptive Phased Management

In 2002, the Government of Canada mandated the establishment of the NWMO through the *Nuclear Fuel Waste Act*. The NWMO is an independent, non-profit organization that is funded by the waste owners in Canada: Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited. The NWMO has been progressing the implementation of our long-term management strategy for used nuclear fuel from Canada's nuclear reactors; thus no further recommendations or long-term solutions have been provided for used nuclear fuel in this ISRW.

Currently, Canada's used nuclear fuel is stored at licensed, above-ground facilities. While this approach is safe, it is widely recognized as inappropriate over the long term. Canadians and Indigenous peoples have clearly expressed that they recognize the importance of taking action on a long-term solution today and not leaving it for future generations.

Canada's plan for used nuclear fuel, known as Adaptive Phased Management, emerged through a three-year dialogue with specialists and the public. It is based on the values and objectives they identified. In 2007, the Government of Canada selected Adaptive Phased Management as the country's plan and directed the NWMO to implement it.

A significant milestone is now on the horizon for the NWMO, as we expect to select the site for the deep geological repository in 2024. Initially, 22 communities expressed interest in learning more about the project and exploring their potential to host it. Over the course of the past decade, the NWMO has narrowed down the potential siting areas to just two, both located in Ontario—the Wabigoon Lake Ojibway Nation (WLON)-Ignace area in the northwest and the Saugeen Ojibway Nation (SON)-South Bruce area in the south.

Adaptive Phased Management includes a technical plan, as well as a phased and flexible implementation plan.

It is both a technical method (what we plan to build) and a management approach (how we will work with people to get it done). The technological approach involves developing a deep geological repository in a suitable rock formation to safely contain and isolate used nuclear fuel. The management approach involves phased and adaptive decision-making, supported by public engagement and continuous learning.

The project will only proceed in an area with informed and willing hosts. Together with the potential siting areas, we continue to explore the potential for partnership and look at how the project could enhance community well-being.

The work the NWMO is conducting today is laying the foundation for a transition to a new series of activities once a preferred site is selected. We will then initiate regulatory processes, construct a Centre of Expertise and begin to transition operations to the site.

The deep geological repository uses a multiple-barrier system designed to safely contain and isolate used nuclear fuel over the very long term. Constructed more than 500 metres below ground, the repository will consist of a network of placement rooms that will store the used nuclear fuel.

At the surface, there will be facilities where the used fuel is received, inspected and repackaged into purpose-built containers encased in a buffer box, before being transferred to the main shaft for underground placement. There will also be facilities for administration, quality, security, processing of sealing materials and ongoing operation of the site.

The repository will include a centralized services area that will allow for underground ventilation through three shafts located within a single, secure area. The layout also includes multiple access tunnel arms that will let our technical specialists situate the placement rooms in areas with the most suitable rock. The buffer boxes will be arranged in the horizontal placement rooms, and any spaces left over will be backfilled with bentonite pellets.

To prepare for the regulatory decision-making process and construction, the NWMO has begun work on site-specific conceptual designs of the repository layout based on information from geoscience assessments and initial borehole drilling in the potential siting areas. This is an iterative process—as the NWMO develops additional site-specific information, we will continue to evolve the design of the repository. The proposed site in the WLON-Ignace area would be located in crystalline rock, and in the SON-South Bruce area, it would be in sedimentary rock.

Rigorous safety standards govern the project. The NWMO has committed to meet or exceed all applicable federal and provincial regulatory requirements to protect the health, safety and security of people and the environment for generations to come.

A series of engineered and natural barriers will work together to safely contain and isolate used nuclear fuel within the repository. Each barrier will provide a unique and stand-alone level of protection, while serving as a backstop to the last barrier. If any of these barriers were to fail, another would be there to ensure any dangerous materials remain contained or isolated.

The first barrier is the fuel pellet. Fuel pellets are a very stable, solid ceramic, made from highly durable baked uranium dioxide powder. They are stored end-to-end in long tubes made of a strong, corrosion-resistant metal.

The second barrier is the fuel bundle, made from a very corrosion-resistant material called Zircaloy, which contains a number of these tubes.

The third barrier is a copper-coated steel container. These containers are engineered to resist corrosion and are strong enough to keep the used nuclear fuel completely contained until its radioactivity decreases to safe levels. They are designed to survive underneath 3,000 metres of snow, ice and meltwater, 800 metres of rock and dirt, groundwater, and surrounding clay pressure.

The fourth barrier is a buffer box made of highly compacted bentonite clay that encases each container. Bentonite clay is a natural material proven to be a powerful barrier to water flow. It is very stable, as observed in natural formations that are hundreds of millions of years old. It also naturally prevents microbial growth, which will help maintain the integrity of the container over a long time.

The fifth barrier is the rock itself, which will protect the repository from disruptive natural events, water flow and human intrusion.

Canadian Nuclear Laboratories' near surface disposal facility, Nuclear Power Demonstration facility, Whiteshell Reactor 1 and Port Hope Area Initiative

The greatest volume of radioactive waste managed by Canadian Nuclear Laboratories (CNL) is low-level waste. CNL has been progressing the implementation of its long-term management strategy for low-level waste from operational, decommissioning and environmental remediation activities; thus no further recommendations or long-term solutions have been provided for the low-level waste CNL manages on behalf of Atomic Energy of Canada Limited (AECL) in this ISRW.

CNL has submitted a licence application to amend the Chalk River Laboratories operating licence to authorize the construction of the near surface disposal facility at the Chalk River Laboratories site. The proposed disposal facility will be an engineered containment mound that will hold up to 1 million m^3 of low-level waste and further enable the environmental cleanup mission underway at AECL-owned sites.

In addition to the near surface disposal facility, CNL has proposed the in-situ disposal of the Nuclear Power Demonstration facility and Whiteshell Reactor 1, which will complete the decommissioning of these two below-grade reactors and ensure long-term safety of the public and the environment. The validity of managing the low- and intermediate-level waste at these two reactors through this proposed approach is demonstrated through a robust safety case and complies with all applicable regulatory requirements.

Near surface disposal facility

The near surface disposal facility is a key facility required to enable CNL to conduct environmental remediation of contaminated soils and materials that are already present at the Chalk River Laboratories site to protect the environment, including the Ottawa River. The near surface disposal facility has been specially designed as a permanent solution to reduce environmental risk and isolate low-level radioactive waste, in accordance with international guidance and regulatory requirements.

The near surface disposal facility will only hold low-level radioactive waste. This waste consists of building materials (mainly from the revitalization underway at Chalk River Laboratories), contaminated soils and general items such as discarded mops, protective clothing and rags that have become marginally contaminated. Ninety per cent of the waste proposed for the near surface disposal facility is already at Chalk River Laboratories, five per cent comes from hospitals and universities, and five per cent comes from other AECL-owned sites.

The main feature of the proposed facility will be an engineered containment mound with natural and synthetic barriers that are designed to work together to isolate the waste materials from the environment for more than 550 years, hundreds of years after the radioactivity of the waste will have decayed to levels found naturally in the environment.

The near surface disposal facility will also feature a wastewater collection and treatment system that will remove radiological and chemical contaminants so that the treated effluent is safe to humans and the environment for discharge. Treated wastewater will be sampled prior to discharge to the environment to ensure that discharge targets are met.

CNL will expand its already extensive environmental monitoring of Chalk River Laboratories, the sampling of air, water and groundwater, to include the near surface disposal facility. The Environmental Assessment for the near surface disposal facility project does not predict any signifi-cant impacts to humans or the environment, with the implementation of mitigation measures. Ongoing monitoring of the near surface disposal facility and surrounding environment will confirm these predictions and the effective use of the mitigation measures.

The proposed facility would be licensed under the *Nuclear Safety and Control Act*, and subject to the associated regulations and independent regulatory oversight from the Canadian Nuclear Safety Commission. A two-part public hearing on the Environmental Assessment and the application to authorize

the construction of the near surface disposal facility took place in the first half of 2022. At the time of writing of this report, a decision is pending.

Nuclear Power Demonstration facility

CNL is proposing to complete the closure of the Nuclear Power Demonstration facility, ensuring the long-term safety of humans and the environment. The proposed approach, known as in-situ disposal, completes the decommissioning, and contains and isolates the remaining empty systems and components below grade in bedrock. The approach is to demolish the above-grade structure and place the debris into open areas in the below-grade structure, then to implement engineered barriers, including grouting below grade and constructing a cap and cover system to ensure waste is isolated and contained. The result is a permanent disposal facility. The waste remains in place, avoiding handling, shipping and building another storage facility elsewhere.

The federal environmental assessment for this project is ongoing, and CNL submitted the revised draft Environmental Impact Statement to the Canadian Nuclear Safety Commission in December 2021. The Canadian Nuclear Safety Commission has requested that CNL provide further revisions to information provided in the revised draft Environmental Impact Statement for the Nuclear Power Demonstration Closure Project.

CNL continues to work with Indigenous communities and public stakeholders to ensure interests and concerns are reflected in the revised Environmental Impact Statement and addressed by the project.

Following submission of the updated Environmental Impact Statement, the next step in the environmental assessment process is a technical review by Indigenous, federal and provincial representatives. CNL is endeavouring to submit a final Environmental Impact Statement, incorporating all comments provided since 2015 by the public, Indigenous communities, interest groups, and federal and provincial bodies, in late 2024.

Whiteshell Reactor 1

The decommissioning of Whiteshell Laboratories began in 2003, after the Canadian Nuclear Safety Commission approved an overall decommissioning framework and then issued a site decommissioning licence. Since that time, redundant buildings have been demolished, and new enabling facilities for waste handling have been constructed. The next major step in the plan is the decommissioning of the Whiteshell Reactor 1 (WR-1) itself, one of the largest and most complex facilities on the site.

CNL is proposing to decommission and leave the reactor in place at the Whiteshell site. All fuel and bulk liquids have been removed, and what remains are the structural components of the reactor such as the vessel, piping and concrete.

CNL’s proposed approach – in-situ decommissioning – minimizes the risks to the health, safety and security of the public, workers and the environment. It avoids the necessity of transporting contaminated components and finding another location and facility for disposal.

The proposal for that project was sent to the Canadian Nuclear Safety Commission for approval in 2017. CNL has submitted an updated WR-1 Project Environmental Impact Statement to the Canadian Nuclear Safety Commission. A federal, provincial and Indigenous technical review has been completed, and CNL is working to address outstanding requests for information. CNL is planning for a licence hearing on the project in late 2024.

Port Hope Area Initiative

CNL has also made significant progress on the Port Hope Area Initiative, which involves the cleanup of approximately 1.7 million m^3 of historic low-level waste from various sites in Port Hope and Port Granby. The historic low-level waste is being emplaced in engineered above ground mounds where the waste will be safely contained, with ongoing long-term monitoring and maintenance of the new facilities into the future.

The Port Hope Area Initiative represents the Government of Canada's commitment to the cleanup and safe, local, long-term management of historic low-level radioactive waste in two southern Ontario municipalities – Port Hope and Clarington. The waste is the result of radium and uranium processing in Port Hope between 1933 and 1988 by the former Crown corporation Eldorado Nuclear Limited and its private-sector predecessors.

The Port Hope Area Initiative is based on community-recommended solutions for the cleanup and safe, long-term management of approximately 1.7 million m^3 of low-level waste. It is currently one of Canada's largest environmental remediation projects.

The Port Hope Area Initiative is being carried out as two projects – the Port Hope Project and the Port Granby Project. Each project has three phases: Phase 1 – Planning/regulatory approval; Phase 2 – Implementation; and Phase 3 – Long-term monitoring and maintenance. Phase 2 of the Port Granby Project was completed in 2022, with the removal and transfer of more than 1.3 million tonnes of historic waste from a legacy site on the shore of Lake Ontario, to the newly built facility where the waste is now safely stored for the long term. The Port Hope Project is currently in Phase 2.

Through its Historic Waste Program Management Office, CNL is implementing the Port Hope Area Initiative on behalf of AECL, a federal Crown corporation. The Historic Waste Program Management Office brings together a diverse and specialized staff from government, private industry and consulting backgrounds in fields such as engineering, environmental sciences, industrial safety, financial management, contract administration, communications and scheduling to implement the projects.

The Port Hope long-term waste management facility is located in the Municipality of Port Hope. The facility provides safe, long-term storage for approximately 1.2 million m^3 of historic low-level radioactive waste being cleaned up in the community as part of the Port Hope Project. The Port Granby long-term waste management facility is situated in the hamlet of Port Granby, located in southeast Clarington.

Each long-term waste management facility includes an engineered above ground mound to isolate the historic low-level radioactive waste by securely encasing it on the top, bottom and sides with thick, multiple layers of natural and specially manufactured materials.

These layers form components of the cover and baseliner that, independently, are robust enough to prevent contaminants from entering the environment. Together, they function as multiple backup safety systems.

The multi-component cover system will reduce surface water infiltration through the waste, provide protection of the mound from inadvertent intrusion into the waste, and reduce levels of gamma radiation on the surface of the mound to background levels.

Monitoring systems are installed within the mound and around the perimeter of the long-term waste management facility site.

Uranium mines and mills

(Adapted from Appendix 6 of Seventh Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management)[35]

Waste owners are operating long-term management facilities for Canada's waste from uranium mines and mills; thus no additional long-term waste management solutions or recommendations were provided for uranium mines and mills waste in this ISRW.

KEY LAKE

McArthur River ore is processed at the Key Lake mill. The McArthur River mine and Key Lake mill suspended production for an indeterminate period and have been in care and maintenance since January 2018. Uranium mills and operational tailings management facilities exist at Key Lake. Non-operational tailings management areas are located at Key Lake.

Tailings management

The purpose of tailings management at Key Lake is to isolate and store the waste residue from the milling process so that the public and environment are protected from any future impact. Conceptually, this effort involves containing the solids and treating the water to achieve quality standards acceptable for release to the environment. The waste metal precipitates removed during water treatment are disposed of as solids in the tailings management facility.

From 1983 to 1996, waste from the Key Lake mill was deposited in an above-ground tailings management facility that covered an area 600 metres by 600 metres (36 hectares) and 15 metres deep. The tailings management facility was constructed five metres above the groundwater table using engineered dikes for perimeter containment and a modified bentonite liner to seal the bottom and isolate the tailings from the surrounding soil infrastructure.

Since 1996, the mined-out Deilmann open pit has been used as the tailings management facility. Commissioned in January 1996, it is used to store tailings produced by milling a blend of McArthur River ore and special waste from McArthur River and Key Lake. The tailings management facility has a bottom drainage layer constructed on top of the basement rock at the bottom of the mined-out pit. Tailings are deposited on top of this drainage layer, and water is continually pumped out to promote the solids consolidation of overlying tailings.

Tailings were initially deposited into the pit by sub-aerial deposition, with water extracted from the tailings mass through the bottom drain layer and the raise well pumping system. The facility later changed to sub-aqueous deposition by allowing the pit to partially flood.

Tailings are deposited under the water cover using a tremie pipe system which offers benefits in terms of the placement and attenuation of radon emissions. In this system, tailings are placed in the mined-out pit using a "natural surround" containment strategy. The residual water extracted from the tailings mass is collected for treatment. The consolidated tailings form a low-permeability mass relative to the higher-permeability area surrounding the tailings.

After decommissioning, groundwater will follow the path of least resistance (i.e., around the tailings rather than through them), which minimizes environmental impacts. At the end of 2019, the Deilmann tailings management facility contained 6.18 million tonnes of tailings.

Waste rock management

Waste rock management facilities include two special waste storage facilities and three waste rock storage areas. The waste rock disposal areas comprise primarily benign rock and therefore do not have containment or seepage collection systems. The special waste contains low (uneconomic) levels of uranium and other potential contaminants, so this material is contained in engineered facilities that

consist of underliners and seepage collection systems. While operating, material from the special waste areas is reclaimed for blending with high-grade McArthur River ore for the Key Lake mill feed. All other waste rock areas are inactive.

To reduce the decommissioning liability associated with the Deilmann north waste rock pile, approximately 1.3 million m^3 of nickel-rich waste rock were excavated and disposed of in the Gaertner pit in 1998. In addition, an additional 300,000 m^3 was processed and used in the Deilmann tailings management facility west wall stabilization project in 2013. Similarly, in 2017, a total of 57,320 m^3 of nickel-rich waste rock was removed from the Gaertner waste rock pile and placed on the south bench of the Deilmann tailings management facility.

RABBIT LAKE

Rabbit Lake entered an indefinite period of care and maintenance, suspending mining and milling operations in mid-2016. Uranium mills and operational tailings management facilities exist at Rabbit Lake. Non-operational tailings management areas are also located at Rabbit Lake.

Tailings management

The Rabbit Lake above-ground tailings management facility is about 53 hectares in area and contains approximately 6.5 million tonnes of tailings which were deposited between 1975 and 1985. These tailings are all derived from the processing of the original Rabbit Lake ore deposit. The tailings within the above-ground tailings management facility are confined by earth-filled dams at the north and south ends, and by natural bedrock ridges along the east and west sides. The above-ground tailings management facility is currently undergoing long-term stabilization and progressive reclamation.

The original Rabbit Lake open pit mine was converted to a tailings management facility in 1986 using pervious surround technology. Since its commissioning, the Rabbit Lake in-pit tailings management facility has been used as a tailings repository for ore from the Rabbit Lake, B-zone, D-zone, A-zone and Eagle Point mines (see Figures 6.2 and 6.3). At the end of 2019, the Rabbit Lake in-pit tailings management facility contained 9.13 million tonnes (dry weight) of tailings.

The pervious surround, consisting of sand and crushed rock, is placed on the pit floor and walls before the tailings deposition. The pervious material allows the excess water contained in the tailings to drain to an internal seepage collection system, and it allows the water contained in the surrounding host rock to be collected, which maintains a hydraulic gradient towards the facility during operations. The collected water is treated prior to its release to the environment. Upon final decommissioning and return to normal hydrogeologic conditions, groundwater will flow preferentially through the pervious surround rather than through the low permeability tailings. Discharge of contaminants will be limited to diffusion across the tailings/pervious surround interface.

Waste rock management

The Rabbit Lake site contains a number of clean and mineralized stockpiles of waste rock produced in the course of mining the various local deposits since 1974. Some of the waste rock has been used for construction material. For example, waste rock was used to construct the road and pervious surround for the Rabbit Lake in-pit tailings management facility. Eagle Point special waste is stockpiled on a lined storage pad until it is returned underground as backfill. Some waste rock piles were used as backfill and cover material in their respective pits. One rock pile, consisting primarily of Rabbit Lake sediments, has been contoured and vegetated.

Current projections are that no waste rock will remain on the surface at Eagle Point after the mining and backfilling of mined-out stopes is complete. The A-zone (28,307 m^3 of clean waste) and D-zone (200,000 m^3 of primarily lake-bottom sediments) waste rock piles have been flattened, contoured and vegetated. The B-zone waste pile contains an estimated 5.6 million m^3 of waste material stored on a pile covering an area of 25 hectares. The B-zone pile was contoured and reclaimed through the installation of an engineered cover followed by a one-metre till cover, complete with vegetation and drainage channels to

promote controlled runoff. All the special waste from the A-zone (69,749 m^3), B-zone (100,000 m^3) and D-zone (131,000 m^3) open-pit mines was returned to the pits and covered with layers of waste rock and/or clean till before the mined-out pits were allowed to flood.

There are approximately 6.89 million m^3 of predominantly sandstone waste rock with some basement rock and overburden tills stored on the West 5 waste rock pile adjacent to the Rabbit Lake in-pit tailings management facility. Mineralized waste is stored on four piles (630,000 m^3) adjacent to the Rabbit Lake mill. Runoff and seepage from these areas are collected in the Rabbit Lake in-pit tailings management facility.

MCCLEAN LAKE

Uranium mills and operational tailings management facilities exist at McClean Lake.

Tailings management

McClean Lake is the only uranium mill constructed in North America in the last 20 years. The mill and tailings management facility feature state-of-the-art efforts for worker and environmental protection when processing high-grade uranium ore. Open-pit mining of the initial ore body (the John Everett Bates or JEB pit) began in 1995. After the ore was removed and stockpiled, the pit was developed as a tailings management facility (see Figures 6.4 and 6.5). The design of the tailings management facility has been optimized for performance, both during operation and for the long term, by employing key features such as:

- Production of thickened tailings within the mill process (addition of lime, barium chloride and ferric sulphate) to remove potential environmental contaminants from the solution and yield geotechnically and geochemically stable tailings;
- Transport of the tailings from the mill to the tailings management facility through a continuously monitored pipe-in-pipe containment system;
- Final subaqueous tailings placement within the mined-out JEB pit for long-term, secure containment in a below-ground facility;
- Use of natural surround as the optimum approach for long-term groundwater diversion around the consolidated tailings plug;
- Subaqueous tremie placement (from a floating barge) of the thickened tailings below a water cover in the pit; this method minimizes the segregation of fine and coarse material, prevents the freezing of the tailings and enhances radiation protection by using the water cover to attenuate radon emissions;
- A bottom filter drain feeding a dewatering drift and raise wells to allow collection and treatment of discharged pore water during tailings consolidation;
- Recycling of pit water by floating barge and a pipe-in-pipe handling system; and
- Complete backfilling of the pit upon decommissioning with clean waste rock and a till cap.

At the end of this reporting period (March 31, 2020), the JEB tailings management facility contained 2.244 million tonnes (dry weight) of tailings.

Waste rock management

Open-pit mining at McClean Lake has progressed from one pit to the next, and has included the JEB, Sue A, Sue B, Sue C and Sue E pits (see Figures 6.6 and 6.7). Mining was completed at the Sue B open pit on Nov. 26, 2008. Open-pit mining has not occurred at McClean Lake since the completion of Sue B.

The majority of the wastes removed from the JEB and Sue C open pits were overburden material or sandstone. The overburden and clean waste rock stockpiles are located near the pits. The pad for the waste rock stockpile has been constructed using overburden. Special waste from the Sue C and JEB pits was stockpiled during mining and was subsequently backhauled into the Sue C pit after the completion of mining.

Wastes (exclusive of the overburden) from the Sue A pit were deposited into the mined-out Sue C pit. This was a conservative approach, given the uncertainty about segregating special waste based on its arsenic content. Waste rock is segregated into clean and special waste based on acid-generating potential (using a simple laboratory test), radiological content (using the ore scanner) and a key non-radiological contaminant (arsenic, using an X-ray fluorescence scanner that was successfully tested during Sue A mining and subsequently implemented in the segregation procedures). Special waste from Sue E was also placed in the mined-out Sue C pit, while clean waste was placed in a separate Sue E waste rock stockpile.

Material removed from the Sue B pit was classified as special waste and placed in the mined-out Sue E pit below an elevation of 400 metres above sea level. As of Dec. 31, 2019, the total waste rock inventory at McClean Lake was 51.2 million tonnes of clean material (primarily waste rock) and 10.2 million tonnes of mineralized waste rock (special waste).

CIGAR LAKE

Tailings management

Cigar Lake does not have a mill and does not produce tailings. Cigar Lake ore is processed at the McClean Lake mill, and the resulting tailings are deposited in the JEB tailings management facility. Uranium mining was suspended at Cigar Lake in March 2020.

Waste rock management

There are four mine rock waste stockpiles (stockpile A clean rock, A1 concrete and benign rock, B low-grade contaminated waste including wood, metal and rock, and C potentially reactive-acid waste rock) in operation at Cigar Lake. The current inventories are the result of mine development and operation at the site. The waste rock is classified as either clean or benign waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock (stockpiles B and C) are temporarily stored on engineered lined containment storage areas. Leachate from these areas is contained and collected for treatment in the mine water treatment plant. When possible, clean or benign waste rock is used as fill or construction material on-site. While some potentially acid-reactive waste rock may be used as backfill in the mine, the majority of this material is expected to be eventually transported to the McClean Lake mine site for disposal in a mined-out pit. At the end of 2019, stockpile B contained 2,373 m^3 and stockpile C contained 378,541 m^3. All potentially acid-generating mine rock (remaining stockpile C) is to be transported and disposed of at McClean Lake in a purpose-engineered in-pit repository. No mineralized mine rock, potentially acid generating rock or other contaminated or mineralized waste materials will remain on the surface after decommissioning is complete.

MCARTHUR RIVER

Tailings management

McArthur River does not have a mill and does not produce tailings. During operation, McArthur River ore is processed at the Key Lake mill. Production at the McArthur River mine and Key Lake mill was suspended for an indeterminate period of time; the mine and mill have been in care and maintenance since January 2018.

Waste rock management

The McArthur River operation generates waste rock from production mining, development mining and exploration drilling. The waste rock is classified as either clean waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock are temporarily stored on engineered lined containment storage pads. Leachate from these pads is contained and pumped to effluent treatment facilities. The segregated clean waste rock is disposed of on a pile that does not include the leachate containment and control systems.

The mineralized waste rock is shipped to the Key Lake operation and used as blend material for the ore feed to the Key Lake mill. The potentially acid-generating waste is crushed and screened, and the coarse material is used as aggregate for underground concrete backfilling operations. The clean waste is used for general road maintenance, both on-site and on the haul road between McArthur River and Key Lake.

Appendix D: Revision summary – Draft (August 2022) to final (June 2023) ISRW

The NWMO published a draft integrated strategy in August 2022. This was made available for a 90-day public comment period, and the recommendations were also made available for public comment on the RadWastePlanning ISRW project website.[36] As part of the draft comment period process, the NWMO also commissioned independent outreach to some of the youth participants who previously contributed to the engagement process, for their review of the recommendations. A total of 29 public comments on the website and 33 formal submissions were received from members of the public, Indigenous communities, industry, a civil society organization, municipal government, provincial and federal agencies, and academia during the public comment period. In addition, two further submissions were received from Indigenous communities after the public comment period had ended, which addressed the draft ISRW. Public comments on the website, together with formal written submissions informed this final integrated strategy. In addition, this integrated strategy was informed by ongoing dialogue with Indigenous peoples, whose engagement extended beyond that of the Canadian public and stakeholders. Finally, the release of the Policy in March 2023 provided vital input against which to align the integrated strategy.

A summary of substantive changes between the draft ISRW and this final integrated strategy is as follows. Changes to the document to bring clarity or precision are not included.

Table 13: Revision summary

Final ISRW recommendation or implementing principle	DRAFT ISRW recommendation	Justification for change
Recommendation #1: Intermediate-level waste and non-fuel high-level waste to be disposed of in a deep geological repository with implementation by the NWMO	Intent unchanged – renumbered. Recommendation #2: Intermediate-level waste should be disposed of in a single deep geological repository with implementation by a single organization – the NWMO.	Reorganized numbering to align with high- to low-level waste classification. Clearly defines the small amount of non-fuel high-level waste within the recommendation. Included information detailing a siting process to provide context on next steps and to stay consistent with the Policy.
Recommendation #2: Low-level waste to be disposed of in multiple near surface disposal facilities with implementation by waste generators and waste owners	Intent unchanged – renumbered. Recommendation #1: Low-level waste should be disposed of in multiple near surface facilities with implementation resting with the waste owners.	Reorganized numbering to align with high- to low-level waste classification.
N/A	Recommendation #3: A third-party organization, independent of the implementing organization, should oversee the implementation of the strategy.	Recommendation 3 removed as it is addressed by the Policy (Sec. 2.1), which states that the federal government oversees the development, maintenance and implementation, by waste generators and owners, of an integrated strategy for Canada's radioactive waste to address long-term plans for waste management, which will be reviewed and updated as appropriate upon request from the Minister of Natural Resources.
Implementing principle #1: Consent of the local communities and Indigenous peoples in whose territory future facilities will be planned must be obtained in siting.	Intent unchanged. Recommendation #4: Consent of the local communities and Indigenous peoples in whose territory future facilities will be planned must be obtained in siting.	This recommendation is addressed by the Policy (Section 3.4).
Implementing principle #2: Design of facilities should prioritize the protection of water.	Intent unchanged. Recommendation #5: Design of facilities should prioritize the protection of water.	This recommendation is addressed by the Policy as it prioritizes the environment, which includes water (Section 1).
Implementing principle #3: Long-term caretaking should be established for disposal facilities.	Intent unchanged. Recommendation #6: Long-term caretaking should be established for disposal facilities.	This recommendation is addressed by the Policy (Section 1.4).

Implementing principle #4: We need to take action now and not defer to future generations.	Intent unchanged. Recommendation #7: We need to take action now and not defer to future generations.	This recommendation is addressed by the Policy (2nd vision statement and Section 2.1 (ii)).

Glossary of terms and acronyms

Bulk material: Material that is granular in nature such as soil, demolished concrete or construction/demolition waste.

Concrete vault: Concrete vaults are a type of engineered near surface disposal facility widely used around the world for the disposal of low-level radioactive waste (low-level waste). Concrete vaults look like large concrete boxes, and a repository would be made up of a series of these. Each one would have its own drainage system and an “earthen cover system” engineered from multiple layers of soil and with grass or other plants growing on top. This disposal method can be used in a wide variety of soil conditions. It is also modular in its design, which means that additional vaults can be added to increase its capacity as needed.

Deep borehole: Deep borehole disposal is an emerging technology for waste that requires isolation for more than a few hundred years. It may be suitable for the disposal of small volumes of intermediate-level waste. The series of narrow boreholes are created to a depth of about 500 to 1,000 metres into which waste packages would be lowered, creating a stack deep underground.

Deep geological repository: A deep geological repository typically consists of a network of underground tunnels and placement rooms for radioactive waste constructed several hundred metres below the surface. Repositories are designed to use a system of multiple barriers: engineered barriers such as waste containers and natural barriers like the rock itself work together to contain the waste and isolate it from people and the environment.

Disposal: The placement of radioactive waste without the intention of retrieval.

Engineered containment mound: Engineered containment mounds are a type of engineered near surface disposal facility that sees waste packages placed on a waterproof base and then covered over with thick layers of natural materials such as clay and soil. Layers of synthetic materials such as high-density polyethylene are also incorporated to prevent release of radiation to the environment. These facilities usually have wastewater collection and treatment systems as well. Engineered containment mounds are suitable for low-level waste that will not reduce in volume or compact over time.

High-level waste: High-level radioactive waste is primarily used nuclear fuel and/or is waste that generates significant heat via radioactive decay. High-level waste is associated with penetrating radiation, thus shielding is required. High-level waste also contains significant quantities of long-lived radionuclides necessitating long-term isolation. Placement in deep, stable geological formations at depths of several hundred metres or more below the surface is recommended for the long-term management of high-level waste. Non-fuel high-level waste is mainly disused Cobalt-60 sealed sources.

Intermediate-level waste: Intermediate-level radioactive waste is generated primarily from power plants, prototype and research reactors, test facilities, and radioisotope manufacturers and users. Intermediate-level waste generally contains long-lived radionuclides in concentrations that require isolation and containment for periods greater than several hundred years. Intermediate-level waste needs no provision, or only limited provision, for heat dissipation during its storage and disposal. Due to its long-lived radionuclides, intermediate-level waste generally requires a higher level of containment and isolation than can be provided in near surface repositories. Waste in this class may require disposal at greater intermediate depths of the order of tens of metres to a few hundred metres or more.

Long-term management: The long-term management of radioactive nuclear waste by means of storage or disposal.

Low-level waste: Low-level radioactive waste comes from operating reactors and from medical, academic, industrial and other commercial uses of radioactive materials. Low-level waste contains material with radionuclide content above established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations), but generally has limited amounts of long-

lived activity. Low-level waste requires containment and isolation for periods of up to a few hundred years.[37] An engineered near surface disposal facility is typically appropriate for low-level waste.

Radionuclide: A material with an unstable atomic nucleus that spontaneously decays or disintegrates, producing radiation. Nuclei are distinguished by their mass and atomic number.

Rolling stewardship: Rolling stewardship is an approach to managing radioactive materials for which there is no disposal solution in the near term. Under rolling stewardship, the radioactive waste is stored on the surface where human controls can safely contain, isolate, monitor and secure it for many generations indefinitely, i.e., roll the radioactive waste forward from generation to generation (a succession of stewards). This concept assumes that technology will eventually resolve the problem for the long-term management of the waste, potentially by destroying or neutralizing it.

Shallow rock cavern: The shallow rock cavern is an engineered near surface disposal method sometimes used for the disposal of low-level waste, or low- and intermediate-level waste. A series of rock caverns are excavated at a nominal depth of 50 to 100 metres below the surface in low permeability rock. They are accessed from the surface by a small system of ramps and tunnels.

Small modular reactors: Small modular reactors are advanced reactors that produce electricity of up to 300 MW(e) per module, which is less than current power generation reactors.

Waste: In the context of this report, waste is assumed to be a radioactive waste, unless specified otherwise (e.g., non-nuclear waste).

Waste owner: The radioactive waste owner is the organization currently responsible for the radioactive waste.

Waste producer: The radioactive waste producer is the organization whose operations produce radioactive waste.

Acronyms

AACE	Association for the Advancement of Cost Engineering
AECL	Atomic Energy of Canada Limited
APM	Adaptive Phased Management
CANDU	Canada Deuterium Uranium
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
DGR	Deep geological repository
HLW	High-level waste
HQ	Hydro-Québec
ILW	Intermediate-level waste
ISRW	Integrated Strategy for Radioactive Waste
LLW	Low-level waste
N/A	Not applicable
NPD	Nuclear Power Demonstration
NRCan	Natural Resources Canada
NSDF	Near surface disposal facility
NWMO	Nuclear Waste Management Organization
OPG	Ontario Power Generation
PHAI	Port Hope Area Initiative
SMR	Small modular reactor
WR-1	Whiteshell Reactor 1

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Nuclear Fuel Waste Projections in Canada – 2022 Update

NWMO-TR-2022-17 November 2022

T. Reilly

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ABSTRACT

Title: **Nuclear Fuel Waste Projections in Canada – 2022 Update**
Report No.: **NWMO-TR-2022-17**
Author(s): T. Reilly
Company: Nuclear Waste Management Organization
Date: November 2022

Abstract

This report summarizes the existing inventory of used nuclear fuel wastes in Canada as of June 30, 2022 and forecasts the potential future nuclear fuel waste from the existing reactor fleet as well as from proposed new-build reactors. While the report focuses on power reactors, it also includes prototype, demonstration and research reactor fuel wastes held by AECL, which are included in the NWMO mandate.

As of June 30, 2022, a total of approximately 3.2 million used CANDU fuel bundles (about 61,130 tonnes of heavy metal (t-HM)) were in storage at the reactor sites, an increase of about 84,193 bundles since the 2021 NWMO Nuclear Fuel Waste Projections report.

For the existing reactor fleet, the total projected number of used fuel bundles produced to end of life of the reactors is approximately 5.5 million used CANDU fuel bundles (approximately 106,100 t-HM). The projection is based on the published plans to refurbish and life extension for all Darlington and Bruce reactors, as well as continued operation of Pickering A until 2024 and Pickering B until September 2026.

Used fuel produced by potential new-build reactors, including small modular reactors (SMRs) will depend on the size and type of reactor and number of units deployed. New-build plans are at various stages of development. The impacts of any future decisions on reactor refurbishment, new nuclear build or advanced fuel cycle technologies made by the nuclear utilities in Canada on projected inventory of nuclear fuel waste will be incorporated into future updates of this report.

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1. INTRODUCTION

1.1 BACKGROUND

The Nuclear Waste Management Organization (NWMO) is responsible for the long-term management of Canada's nuclear fuel waste (Canada 2002).

The NWMO will continually review and adjust its implementation plans as appropriate consistent with the external environment. As part of this process, the NWMO annually publishes the current and future potential inventories of used fuel amounts and types from existing and future reactors (Gobien and Ion 2021). This document provides an update as of June 2022.

Decisions on new nuclear reactors, advanced fuel cycles or other changes in energy choices will not be made by the NWMO. They will be made by the utilities in conjunction with government and regulators. However, it is important that NWMO is prepared for these potential changes so that the NWMO can plan for the long-term management of used fuel arising from such decisions. As part of this, the NWMO maintains a watching brief on alternative technologies (NWMO 2022).

1.2 SCOPE

This report summarizes the existing inventory of used nuclear fuel wastes in Canada as of June 30, 2022 and forecasts the potential future nuclear fuel waste from the existing reactor fleet as well as from proposed new reactors. The report focuses on power reactors, but also includes information on prototype, demonstration and research reactor fuel wastes held by Atomic Energy of Canada Limited (AECL).

1.3 CHANGES SINCE THE 2021 REPORT

The primary changes to the Canadian nuclear landscape since the 2021 report are:

a) An increase in the total amount of used fuel currently in storage, due to another year of reactor operation.

b) Darlington Unit 3 refurbishment continues with reassembly of the 480 fuel channels being completed in July 2022 (OPG 2022a). Unit 3 was shut down in July 2020, its refurbishment started in September 2020, and its refurbishment is expected to be complete in Q1 of 2024 (OPG 2021a).

c) Darlington Unit 1 was removed from operation in February 2022 to initiate refurbishment. Refurbishment of Unit 1 is expected to be completed by Q2 of 2025 (OPG 2022b).

d) Bruce Power continues the major component replacement at Unit 6 with replacement of the eight steam generators completed in December 2021 (Bruce Power 2021). Unit 6 refurbishment was initiated in January 2020 and is expected to be complete in Q4 of 2023.

e) Pickering B Units 5-8 will operate until September 2026, extended from the end of 2025 (Ontario 2022).

The combined effects of these changes on the current and projected used fuel inventory are:

a) An increase in the total amount of used fuel currently in storage from June 30, 2021 to June 30, 2022.

	June 30, 2021	**June 30, 2022**	**Net change**	
Wet storage	1,428,645	1,418,651	-9,994	bundles*
Dry storage	1,677,763	1,771,950	94,187	bundles
TOTAL	**3,106,408**	**3,190,601**	**84,193**	**bundles**

** Note: A negative number means more used fuel was transferred from wet to dry storage than was produced during the year.*

b) No significant changes to the overall projected future total number of used fuel bundles (see Section 2.2). The forecast presented in this report is most similar to the high scenarios from the previous versions of this report.

2. INVENTORY FROM EXISTING REACTORS

2.1 CURRENT INVENTORIES

Table 1 summarizes the current inventory of nuclear fuel waste in Canada as of June 30, 2022. The inventory is expressed in terms of number of CANDU used fuel bundles and does not include fuel which is currently in the reactors (which is not considered to be "nuclear fuel waste" until it has been discharged from the reactors).

As of June 30, 2022 there are approximately 3.2 million bundles in wet or dry storage. This is equivalent to approximately 61,130 tonnes of heavy metal (t-HM). Further details on the existing reactors can be found in Appendix A and fuel types in Appendix B.

Table 1: Summary of Nuclear Fuel Waste in Canada as of June 30, 2022

Location	Waste Owner	Wet Storage (# bundles)	Dry Storage (# bundles)	TOTAL (# bundles)	Current Status
Bruce A	OPG(1)	338,982	270,720	**609,702**	- 4 units operational
Bruce B	OPG(1)	341,618	449,654	**791,272**	- 3 units operational, - 1 unit undergoing refurbishment.
Darlington	OPG	313,530	315,173	**628,703**	- 2 units operational, - 2 units undergoing refurbishment.
Douglas Point	AECL	0	22,256	**22,256**	- permanently shut down 1984
Gentilly 1	AECL	0	3,213	**3,213**	- permanently shut down 1977
Gentilly 2	HQ	0	129,925	**129,925**	- permanently shut down 2012
Pickering A	OPG	385,045	443,524	**828,569**	- 2 units operational, 2 units non-operational since 1997 (permanently shut down 2005)
Pickering B	OPG				- 4 units operational
Point Lepreau	NBPN	39,476	126,898	**166,374**	- operational
Whiteshell	AECL	0	2,301	**2,301**	- permanently shut down 1985; see Note (2).
Chalk River	AECL	0	4,886	**4,886**	- predominately fuel bundles from the NPD reactor (permanently shut down 1987) and natural UO_2 fuel from other reactors
		~0	~3,400	**~3,400**	- research fuels; see Note (3)
	Total	**1,418,651**	**1,771,950**	**3,190,601**	

Notes:

AECL = Atomic Energy of Canada Limited
HQ = Hydro-Québec
NBPN = New Brunswick Power Nuclear
OPG = Ontario Power Generation Inc.

1) OPG is responsible for the used fuel that is produced. Bruce reactors are leased to Bruce Power for operation.
2) This value includes UO_2 and uranium carbide bundles from the WR-1 reactor, 360 natural UO_2 bundles from the Douglas Point reactor, miscellaneous CANDU bundles, and various experimental fuel types, commercial fuel pieces, and hot cell remnants in CANDU-bundle sized cans.
3) This estimate is the mass-based estimate of the number of bundle equivalents in the AECL inventory and includes the majority of the research reactor and experimental fuel in the AECL fuel inventory. The remaining inventory items will be assessed with respect to their suitability for disposal in the APM deep geological repository and have therefore been excluded at this time.

Figure 1 summarizes the history of wet and dry storage of used fuel in Canada to the end of June 2022. Initially, all fuel was wet-stored in the station used fuel storage bays. Dry storage was initiated in the 1970s at shutdown AECL prototype reactors. Starting in the 1990s, older fuel in the wet bays at the operating power reactors has been transferred to dry storage on an ongoing basis. In the future, the inventory in wet storage will remain relatively constant (since wet bay space is fixed), while the inventory in dry storage will continue to grow over time.

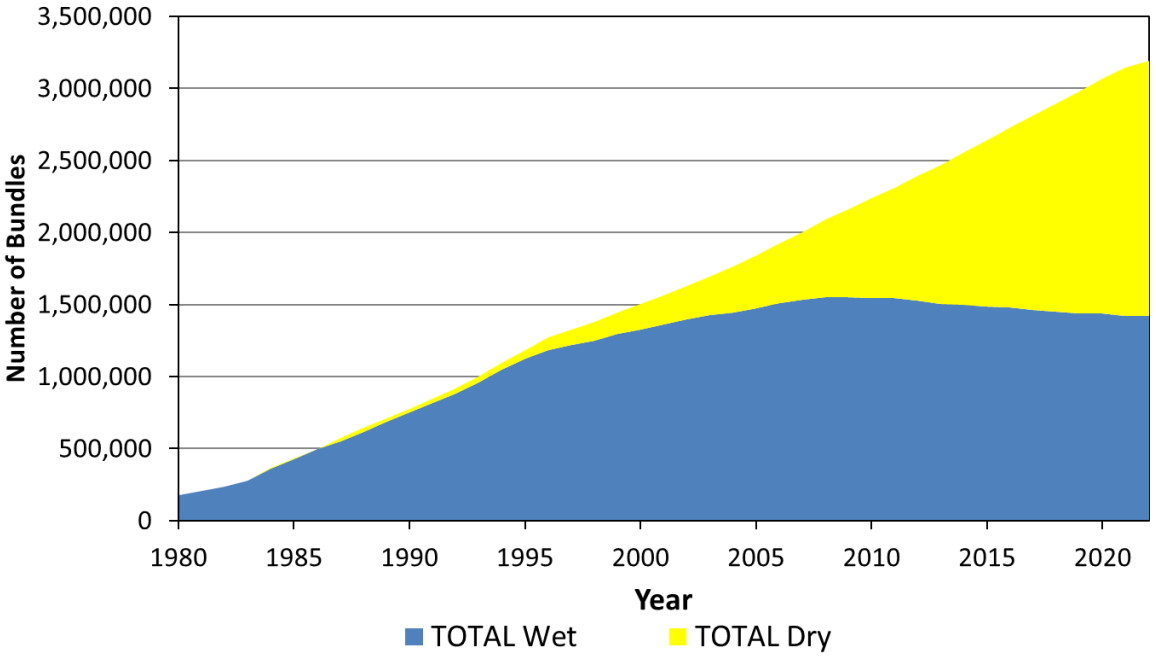


Figure 1: Summary of Used Fuel Wet and Dry Storage History

2.2 PROJECTED NUCLEAR FUEL WASTE

The current forecast of future nuclear fuel waste is summarized in Table 2. This forecast is based on NWMO's assumptions used for planning purposes only and may differ from the business planning assumptions used by the reactor operators.

This estimate is based on the latest published plans for refurbishment and life extension for the current reactor fleet, uses conservative assumptions, and includes a number of uncertainties, as described below.

The current projection in Table 2 is based on the following:

1. Only existing CANDU stations are included in the forecast. with the following assumptions regarding refurbishment: (Ontario 2022, OPG 2021a, Bruce Power and IESO 2015, NB Power 2019):

    - Reactors that have been permanently shut down do not restart (Gentilly-2, Pickering A Units 2 and 3).
    - Reactors that have been refurbished (Bruce A Units 1 and 2, Darlington Unit 2 and Point Lepreau) and reactors that will be refurbished (Darlington Units 1, 3 and 4, Bruce A Units 3 and 4 and Bruce B) with new sets of pressure tubes and other major components will operate for about 30 effective full power years (EFPY).
    - Pickering A Units 1 and 4 will operate until the end of 2024 and Pickering B Units 5–8 will operate until 2026[1].

2. Fuel in reactor core is removed prior to a refurbishment and not re-used. No fuel is generated during the refurbishment period. End-of-life total includes final reactor core fuel.

3. The forecast for each station is calculated as *[(June 2022 actuals) + (number of years from June 2022 to end-of-life) * (typical annual production of fuel bundles)]*, rounded to nearest 1,000 bundles.

    The forecast annual production of fuel bundles is a conservative estimate for each station, resulting in a conservative projection of the overall total. An analysis of the last 5-year forecast vs actuals across all units indicates the forecast total was high by up to 9,500 bundles/year. Projected over the next 30 years, and applying the 5-year average on a station by station basis, this could indicate the current total is high by up to 200,000 bundles.

4. Units are assumed to operate until December 31 of the shutdown year.

    The forecast conservatively assumes operation to end of year of shutdown. If an earlier (mid-year) shutdown were assumed for all stations, the total would be reduced by about 46,000 bundles.

5. Units operate to current end of life dates.

    Changes to the estimated end-of-life dates for refurbished reactors would result in changes to the overall forecast. For example, a potential 3 year extension or reduction of operation of all stations relative to current plans, assuming the highest typical annual bundle production, would affect the total bundle count by +/- about 92,000 bundles per year. Assuming a future 3 year extension/reduction for all units would affect the bundle count by about +/- 280,000 bundles.

[1] Ontario has asked OPG to update its feasibility assessment for refurbishing Pickering B units at the Nuclear Generating Station, based on the latest information, as a prudent due diligence measure to support future electricity planning decisions. Refurbishment of Pickering Nuclear Generating Station could result in an additional 30 years of operations and used fuel arisings.

6. Total mass of heavy metals (e.g. uranium) in fuel is based on an average bundle mass of heavy metal specific to each reactor type.

7. Current projection does not include new reactors, such as small modular reactors (SMRs).

In summary, the approximate 5.5 million used fuel bundles forecast represents the best estimate based on current plans. Its associated uncertainty could include +/- 0.28 million bundles (based on 3-year early or delayed shutdown of all current units), up to -0.2 million bundles (based on conservatism in projection), and about -0.05 million bundles (for mid-year end-of-life shutdown vs assumed end-of-year shutdown).

The forecast is subject to potential changes on annual basis, to account for reactor operators' updated plans for refurbishment and life extension, as well as for adjustments in calculations to reflect the most up-to-date numbers of bundles in storage versus previous year's projections.

Table 2: Summary of Projected Nuclear Fuel Waste from Existing Reactors

Location	Unit	Startup	Total to June 2022 (# bundles)	Typical Annual Production (bundles/a)	Refurbishment Schedule (Start-End)[8]	Forecast[6]	
						Shutdown[9]	(# bundles)
Bruce A	1	1977	609,702	20,500[2]	Complete	2043	1,230,000
	2	1977			Complete	2043	
	3	1978			01/2023 – 06/2026	2061	
	4	1979			01/2025 – 12/2027	2062	
Bruce B	5	1985	791,272	23,500[2]	07/2026 – 06/2029	2062	1,687,000
	6	1984			01/2020 – 12/2023	2058	
	7	1986			07/2028 – 06/2031	2063	
	8	1987			07/2030 – 06/2033	2063	
Darlington	1	1992	628,703	22,000[2]	01/2022 – 06/2025	2053	1,279,000
	2	1990			Complete	2049	
	3	1993			09/2020 – 03/2024	2052	
	4	1993			07/2023 – 12/2026	2055	
Douglas Point	-	1968	22,256	0[3]	-	1984	22,256
Gentilly 1	-	1972	3,213	0[3]	-	1977	3,213
Gentilly 2	-	1983	129,925	0[3]	-	2012	129,925
Pickering A	1	1971	828,569	7,200[4]	Complete	2024	936,000
	2	1971			-	2005	
	3	1972			-	2005	
	4	1973			Complete	2024	
Pickering B	5	1983		14,500[2]	-	2026	
	6	1984			-	2026	
	7	1985			-	2026	
	8	1986			-	2026	
Point Lepreau	1	1983	166,374	4,800	Complete	2040	260,000
Whiteshell	-	1965	2,301	0[3]	-	1985	2,301
Chalk River/ NPD/other	-	-	~8,286	0[5]	-	-	~8,286
Total (bundles)			**3,190,601**	**92,500**			**5,557,071[1]**
(t-HM)[7]			**61,130**	**1,770**			**106,100**

Notes:

1) This represents the best estimate based on current plans and includes conservative assumptions and uncertainties.
2) Based on 4 reactors operating.
3) Reactor is permanently shut down and not producing any more fuel.
4) Based on 2 reactors operating.
5) Future forecasts do not include research fuels. Chalk River does not produce any CANDU power reactor used fuel bundles. However, it may receive bundles from power reactor sites from time to time for testing. This will not affect overall total numbers of bundles, since they will be subtracted from the reactor site.
6) Totals may not add exactly due to rounding to nearest 1,000 bundles for future forecasts.
7) “tonnes of heavy metals” (t-HM) based on an average of bundle mass specific for each reactor type.
8) Assumes units under refurbishment do not produce fuel and annual fuel production rates are scaled accordingly.
9) Assumes units operate until December 31 of the shutdown year and the core is defueled in the following year, except for Pickering B which is assumed to operate until September 2026.

3. INVENTORY FROM POTENTIAL NEW REACTORS

There are two categories of proposed new reactor projects:

- projects which have received or are currently undergoing regulatory approvals; and
- potential projects which have been discussed by various implementing organizations (proponents), but which do not have any regulatory approvals underway.

This report focuses on the first category. However, it does not assess the probability of any of these projects proceeding. Execution of each project rests entirely with the proponent.

These new projects are not CANDU reactors, and do not produce used CANDU fuel bundles. They are also higher burnup than used CANDU fuel, so typically produce less mass of used fuel for a given amount of electric power. However, these other used fuel wastes are not directly comparable to used CANDU fuel on a mass basis as they would generally be producing more decay heat and contain more radioactivity per unit fuel mass. These are characteristics that are important for repository design, in addition to fuel mass (or volume).

In order to better visualize the characteristics of this future inventory with respect to disposal, the inventory is presented here on an equivalent thermal power basis. That is, how many used CANDU bundles would be generated in producing an equivalent amount of thermal power? This number of CANDU bundles would have experienced a similar amount of fission, and therefore have a roughly similar amount of decay heat and radioactivity as the new types of used fuel. In this report, this equivalency is used to illustrate the potential impacts of these new reactors on the inventory of fuel wastes requiring long-term management.

3.1 PROJECTS WHICH HAVE RECEIVED OR CURRENTLY UNDERGOING REGULATORY APPROVALS

3.1.1 Ontario Power Generation

Ontario Power Generation (OPG) holds a Nuclear Power Reactor Site Preparation Licence that allows preparation of the Darlington nuclear site for future construction and operation of up to 4 new reactors, with a maximum combined net electrical output of 4,800 MWe (OPG 2021b)

In December 2021 OPG announced a partnership with GE Hitachi Nuclear Energy (GEH). OPG has selected GEH to further develop the BWRX-300 SMR (small modular reactor) design to be constructed at the Darlington nuclear site by 2030 (OPG 2022c). By the end of 2022 OPG intends to begin non-nuclear site preparation activities for an SMR at Darlington and submitted an application to the CNSC for the Licence to Construct in October 2022 (OPG 2022d).

The BWRX-300 is a light water reactor (LWR) utilising low enriched fuel. The fuel is proposed to be based on Global Nuclear Fuel's (GNF) GNF2 product line and is described in Appendix B.3. It is estimated that over the reactor's expected 60-year lifetime it could result in about 2,400 GNF2 used fuel assemblies (roughly 440 t-HM initial). Based on a simple correlation to CANDU bundles on a thermal power basis, it is estimated that this would be equivalent to about 120,000 CANDU used fuel bundles.

GNF2 BWR fuel is the same type of fuel that is being planned for handling and disposal in Sweden, Finland, and Switzerland, as all three of these countries have BWR reactors discharging BWR fuel (IAEA 2019).

3.1.2 Global First Power

Global First Power (GFP), Ultra Safe Nuclear Corporation (USNC), and OPG propose to construct and operate a 5 MWe (up to 15MWth) Micro Modular Reactor (MMR) plant on AECL property at the Chalk River site. Canadian Nuclear Laboratories (CNL) and GFP signed a hosting agreement formalizing the framework under which CNL and GFP will cooperate with respect to licensing, design, siting, and other matters with respect to advancement of the SMR project (CNL 2020a).

In April 2019, Global First Power submitted to the CNSC an application to prepare site for a small modular reactor at the Chalk River Laboratories (Global First Power 2019a). In July 2019, the Federal government issued a Notice of Commencement of an environmental assessment for a SMR project at the Chalk River Laboratories (CNSC 2019). The regulatory review of this project continues; in September 2020, the CNSC has released the record of decision on the scope of the environmental assessment for Global First Power's MMR (CNSC 2020). On May 6, 2021, the CNSC determined that GFP's submissions to date were sufficient to begin technical review as a part of the licensing application process (Global First Power 2021).

The MMR is a high temperature gas-cooled reactor (HTGR) with an anticipated operational life of 20 years and a design approach with one single fuel loading at reactor start-up (Global First Power 2019b). At this stage there is limited information about the MMR fuel and its fuel waste characteristics. The fuel contains low-enriched uranium and is manufactured with Triple Coated Isotopic (TRISO) fuel particles. The MMR fuel is substantially different than CANDU fuel and the quantities and characteristics of potential fuel wastes have not been published at this time. It is estimated that over the reactor's expected 20-year lifetime, it could result in an amount of used fuel that was equivalent to about 700 CANDU used fuel bundles based on a simple correlation to CANDU bundles on a thermal power basis.

The NWMO continues to monitor the progress of the regulatory approval process of this project. As more information becomes available, additional details on TRISO fuel and potential fuel waste inventories from the proposed MMR will be included in future versions of this report.

3.2 POTENTIAL PROJECTS AND DEVELOPMENTS

Earlier feasibility studies and public discussions by provincial governments and potential proponents have been conducted for other new reactors in Ontario, Alberta, Saskatchewan and New Brunswick over several years. Other proposals include the introduction of SMRs of up to a few tens or hundreds of megawatts each for deployment in large established grids, small grids, in remote (i.e. off-grid) communities and resource extraction sites which currently rely on small-scale fossil fuel generating plants to provide heat and/or electricity (AECL 2012, HATCH 2016, SaskPower et al. 2021). The reactors are based on a variety of non-CANDU technologies, including liquid metal cooled, gas cooled, molten salt cooled and light water cooled.

Natural Resource Canada (NRCan) initiated the SMR Roadmap project with interested provinces, territories and power utilities to identify the opportunities for on and off-grid applications of SMRs in Canada. The SMR Roadmap report was published in November 2018, with recommendations in areas such as waste management, regulatory readiness and international engagement (SMR 2018). The Government of Canada launched Canada's SMR Action Plan in December 2020 (NRCan 2020).

The CNSC continues pre-licensing reviews for a variety of small modular reactor designs (CNSC 2022).

A number of utilities have continued to express interest in supporting the development of SMR technologies. For example, Global First Power, USNC and OPG formed a joint venture to own and operate a Micro Modular Reactor Project at Chalk River (Global First Power 2020); Cameco and Bruce Power launched a centre for the next generation of nuclear technologies (Bruce Power 2020); and Cameco, GE Hitachi and Global Nuclear Fuel-Americas (GNF-A) have recently announced a memorandum of understanding (MoU) to explore collaboration to advance commercialization and deployment of BWRX-300 SMRs in Canada (World Nuclear News 2021). OPG has also announced plans to advance the development of an SMR in Ontario and advance engineering and design work with three developers of grid-scale SMRs: GEH, Terrestrial Energy and X-energy (OPG 2020). At the same time, GEH has entered into memorandums of understanding (MOUs) with five Canadian companies to set up a supply chain for its SMR (World Nuclear News 2020).

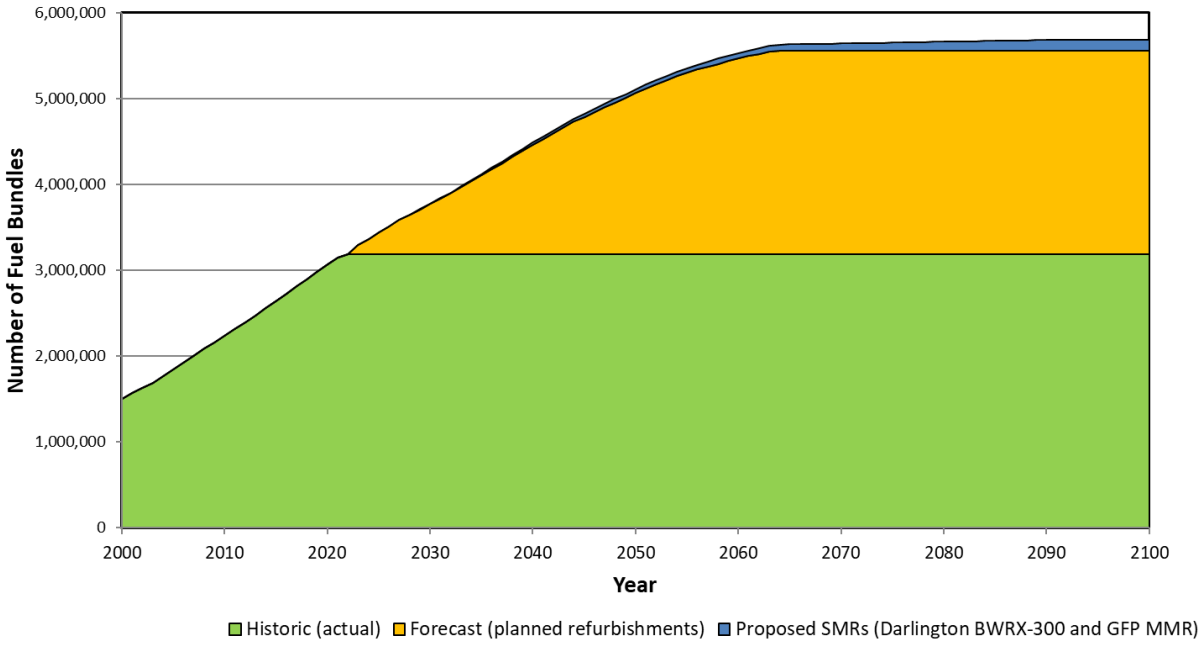
CNL looks to establish partnerships with vendors of SMR technology to develop, promote and demonstrate the technology in Canada, and recently issued a call for proposals for the second round of its Canadian Nuclear Research Initiative program (CNL 2020b). At present, four proponents are in various stages of CNL's review (CNL 2022). Global First Power is in stage 3 for the proposed 5 MWe MMR (high-temperature gas reactor) and has submitted an application for a licence to prepare site (see Section 3.1.2). Three other proponents have completed CNL's pre-qualification stage and have been invited to enter CNL's next stage of detailed review; these are U-Battery Canada Ltd. (4 MWe high temperature gas reactor), StarCore Nuclear (14 MWe high-temperature gas reactor), and Terrestrial Energy (190 MWe integral molten salt reactor). No licensing activities have been initiated for these three proposals. CNL has also formed partnerships with Moltex Energy (CNL 2020c), Ultra Safe Nuclear Corporation (CNL 2020d), New Brunswick Power (CNL 2020e), and Terrestrial Energy (CNL 2020f), to research SMR fuels and advance SMR technology in Canada and has recently started fabrication of advanced SMR fuels (CNL 2021).

The NWMO will continue to monitor these developments and the implications of new reactors as part of its Adaptive Phased Management approach.

4. SUMMARY OF PROJECTED USED FUEL INVENTORY

As of June 30, 2022 there are approximately 3.2 million used fuel bundles in wet or dry storage. Based on currently announced refurbishment and life extension plans for the existing nuclear reactor fleet in Canada, the current forecast projects a total of approximately 5.5 million bundles (see Section 2.2 for details). The existing and projected inventory from current reactor operations, reactor refurbishment and proposed SMRs, developed in previous sections, is summarized in Figure 2.

The approximately 5.5 million used fuel bundles forecast represents the best estimate based on current plans. Its associated uncertainty could include +/- 0.28 million bundles (based on 3-year early or delayed shutdown of all current units), up to -0.2 million bundles (based on conservatism in projection), -0.05 million bundles (for mid-year end-of-life shutdown vs assumed end-of-year shutdown), and approximately +0.12 million equivalent CANDU used fuel bundles from the proposed Darlington BWRX-300 and Chalk River GFP MMR projects.



Notes:

1) The existing fuel (as of end of June 2022) is shown in the green shaded area.
2) The forecast (orange shaded area) shows the additional fuel bundles that would be generated based on the announced refurbishment and life extension projects for the existing Canadian reactor fleet.
3) The proposed SMRs (blue shaded area) shows the estimated additional CANDU equivalent fuel bundles that could be generated from the Darlington BWRX-300 and Chalk River GFP MMR projects currently undergoing regulatory approvals.

Figure 2: Summary of Projected Used Fuel Inventory

Note that in addition to the CANDU fuel bundles described above, there are small quantities of other nuclear fuel waste, such as the AECL research fuels, pellets and elements, as well as used fuels from other Canadian research reactors (as listed in the Appendix A, Table A3). AECL have performed a mass-based estimate of the number of CANDU bundle equivalents for the majority of these fuels that are included in this inventory. The remaining inventory items will be assessed with respect to their suitability for disposal in the APM deep geological repository and have therefore been excluded at this time.

There are also other heat-generating radioactive wastes in Canada (such as cobalt-60 sources produced in Canadian CANDU reactors and used in industrial and therapeutic radiation devices), again in relatively small quantities (on the order of 1,000 to 2,000 fuel bundle equivalents, i.e. less than 0.1% of the projected used fuel inventory). These non-fuel, heat generating wastes are not within the NWMO's legislated mandate for long-term management of nuclear fuel waste.

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APPENDIX A: SUMMARY OF EXISTING CANADIAN REACTORS & FUEL STORAGE

Appendix A presents a summary of commercial, demonstration and research reactors in Canada. Table A1 presents a summary of commercial power reactors in Canada and their status. Table A2 presents a summary of prototype and demonstration reactors in Canada and their status. Table A3 presents a summary of research reactors in Canada and their status.

Commercial, prototype and some research reactors have storage facilities for used nuclear fuel. Table A4 presents a summary of dry storage facilities for used nuclear fuel and Figure A1 shows the location of the major storage locations in Canada.

Table A1: Nuclear Power Reactors

Location	Rating (MW(e) net)	Year In-service	Fuel Type*	Current Status (2022)
Bruce Nuclear Power Development, Ontario				
Bruce A – 1	750	1977	37 element bundle	Refurbished and operating
Bruce A – 2	750	1977		Refurbished and operating
Bruce A – 3	750	1978		Operating
Bruce A – 4	750	1979		Operating
Bruce B – 5	795	1985	37 element bundle; 37 element "long" bundle	Operating
Bruce B – 6	822	1984		Undergoing refurbishment
Bruce B – 7	822	1986		Operating
Bruce B – 8	795	1987		Operating
Darlington, Ontario				
Darlington 1	881	1992	37 element bundle; 37 element "long" bundle	Undergoing refurbishment
Darlington 2	881	1990		Refurbished and operating
Darlington 3	881	1993		Undergoing refurbishment
Darlington 4	881	1993		Operating
Gentilly, Quebec				
Gentilly 2	635	1983	37 element bundle	Permanently shut down in 2012
Pickering, Ontario				
Pickering A – 1	515	1971	28 element bundle	Refurbished and operating
Pickering A – 2	515	1971		Non-operational since 1997; Permanently shut down in 2005
Pickering A – 3	515	1972		Non-operational since 1997; Permanently shut down in 2005
Pickering A – 4	515	1973		Refurbished and operating
Pickering B – 5	516	1983		Operating
Pickering B – 6	516	1984		Operating
Pickering B – 7	516	1985		Operating
Pickering B – 8	516	1986		Operating
Point Lepreau, New Brunswick				
Point Lepreau	635	1983	37 element bundle	Refurbished and operating

*Note: refer to Appendix B for description of fuel types, and their current storage status.

Table A2: Prototype and Demonstration Power Reactors

Location	Rating (MW(e) net)	Year In-service	Fuel Type	Current Status (2022)
Bruce Nuclear Power Development, Ontario				
Douglas Point (CANDU PHWR prototype)	206	1968	19 element bundle	Permanently shut down in 1984; All fuel is in dry storage on site
Gentilly, Quebec				
Gentilly 1 (CANDU-BLW boiling water reactor prototype)	250	1972	18 element CANDU-BLW bundle	Permanently shut down in 1977; All fuel is in dry storage on site
Rolphton, Ontario				
NPD (CANDU PHWR prototype)	22	1962	19 element bundle; various prototype fuel designs (e.g. 7 element bundle)	Permanently shut down in 1987; All fuel is in dry storage at Chalk River

Table A3: Research Reactors

Location	Rating (MW(th))	Year In-service	Fuel Type	Comments
Chalk River, Ontario				
NRU	135	1957	various driver fuel and target designs (U-metal, U-Al, U_3Si-Al)	Permanently shut down in 2018. As of June 2022, the majority of NRU fuel has been transferred to dry storage.
ZED-2	0.00025	1960	various uranium fuels	Operating
NRX	42	1947	various driver fuel and target designs (U-metal, U-Al, UO_2)	Permanently shut down in 1992
MAPLE 1	10	-	U_3Si-Al driver fuel; UO_2 targets	Never fully commissioned
MAPLE 2	10	-		
Whiteshell, Manitoba				
WR-1 (organic cooled reactor prototype)	60	1965	various research and prototype fuel bundle designs (similar size and shape to standard CANDU bundles; UO_2, UC)	Permanently shut down in 1985; All fuel is in dry storage on site.
Hamilton, Ontario				
McMaster University	5	1959	U_3Si-Al fuel pins	MTR Pool type reactor; Operating.
Kingston, Ontario				
Royal Military College	0.02	1985	UO_2 SLOWPOKE fuel pins	SLOWPOKE-2 reactor; Operating.
Montreal, Quebec				
Ecole polytechnique	0.02	1976	UO_2 SLOWPOKE fuel pins	SLOWPOKE-2 reactor; Operating.

Note: the SLOWPOKE reactors can operate on one fuel charge for 20 to 40 years. Other former research reactors include the 2 MW(th) SLOWPOKE Demonstration Reactor at Whiteshell, the low power PTR and ZEEP reactors at Chalk River, and shut down / decommissioned SLOWPOKE reactors at University of Toronto, Dalhousie University, Nordion Kanata, University of Alberta and University of Saskatoon. Used fuel from these shut down research reactors is stored at the Chalk River site, Whiteshell site or has been returned to the country of origin.

Table A4: Summary of Dry Storage Facilities for Used Nuclear Fuel

Facility	Owner	Technology	Fuel Type	Year In-service
Chalk River	AECL	AECL Concrete Canister/Silo	CANDU & CANDU-like (mainly 19 element)	1992
Darlington Waste Management Facility (DWMF)	OPG	OPG Dry Storage Container (DSC)	CANDU (37 element)	2008
Douglas Point Waste Management Facility	AECL	AECL Concrete Canister/Silo	CANDU (19 element)	1987
Gentilly 1	AECL	AECL Concrete Canister/Silo	CANDU-BLW (18 element)	1984
Gentilly 2	HQ	AECL CANSTOR/MACSTOR modular concrete vault	CANDU (37 element)	1995
Pickering Waste Management Facility (PWMF)	OPG	OPG Dry Storage Container (DSC)	CANDU (28 element)	1996
Point Lepreau	NBPN	AECL Concrete Canister/Silo	CANDU (37 element)	1990
Western (Bruce) Waste Management Facility (WWMF)	OPG	OPG Dry Storage Container (DSC)	CANDU (37 element)	2003
Whiteshell	AECL	AECL Concrete Canister/Silo	CANDU & CANDU-like (various sizes)	1977

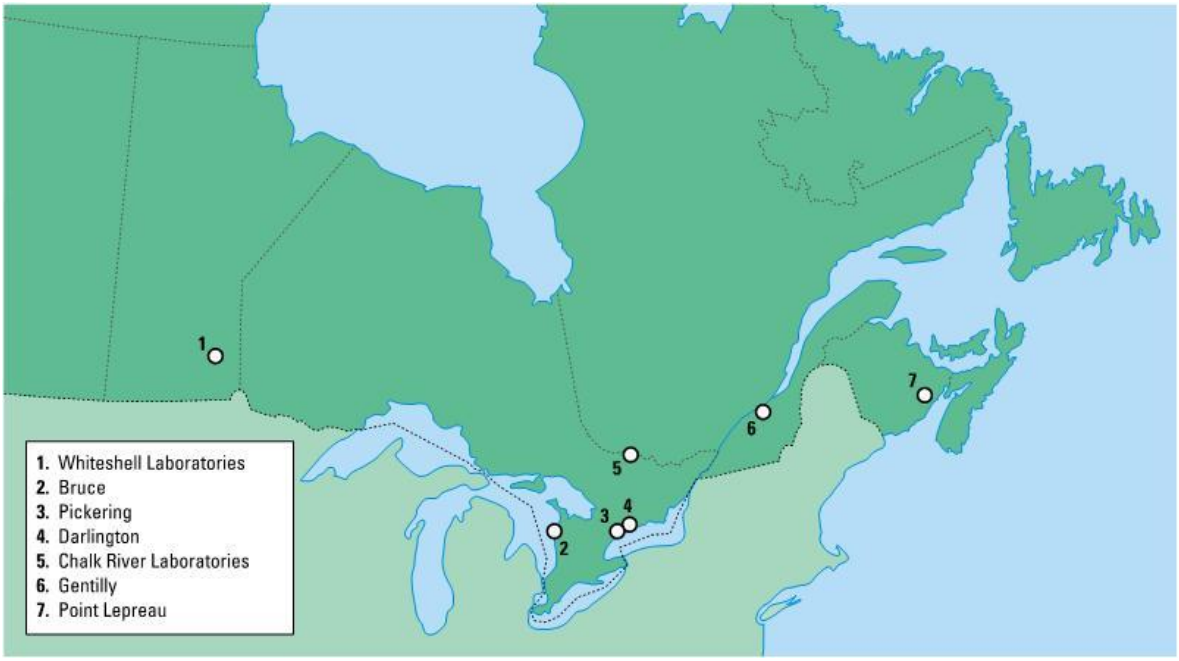


Figure A1: Current Nuclear Fuel Waste Major Storage Location in Canada

APPENDIX B: DESCRIPTION OF FUEL TYPES

Table B1 summarizes the inventory of the various bundles types in Canada as of June 2022.

Section B.1 details the physical characteristics and usage of the bundles in operating reactors.

Section B.2 details the physical characteristics and usage of the bundles in demonstration and prototype reactors.

Section B.3 details the physical characteristics and usage of the bundles in proposed BWRX-300 SMR.

Note that the physical characteristics of the bundles described in this appendix are intended to be nominal and other sources may quote different numbers.

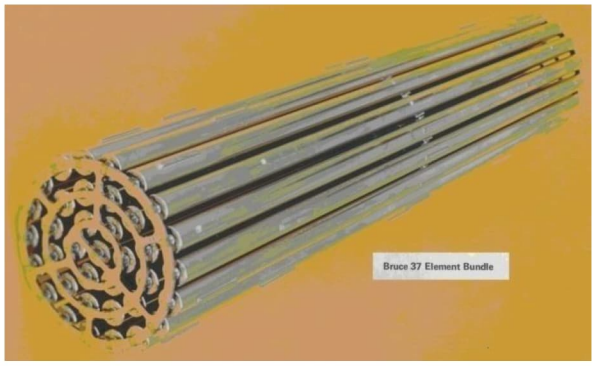
Table B1: Summary of Inventory by Bundle Type (June 2022)

CANDU Bundle Type	Where Used	Wet Storage (# bundles)	Dry Storage (# bundles)	Total (# bundles)
18 Element	Gentilly 1	-	3,213	3,213
7 Element / 19 Element	NPD, Douglas Point	-	27,446	27,446
28 Element	Pickering	385,045	443,524	828,569
37R	Bruce, Darlington, Gentilly 2, Pt Lepreau	472,589	1,154,219	1,626,808
37R Long	Bruce, Darlington	104,719	138,151	242,870
37M	Bruce, Darlington	346,099	-	346,099
37M Long	Bruce, Darlington	110,175	-	110,175
43 Element LVRF	Bruce	24	-	24
Other	AECL (various)	-	5,397	5,397
	Total	**1,418,651**	**1,771,950**	**3,190,601**

B.1 FUELS FROM OPERATING REACTORS

28 element CANDU bundle	
	**Physical dimensions:** 102.5 mm OD x 497.1 mm OL
	Mass: 20.1 kg U (22.8 kg as UO_2) 2.0 kg Zircaloy (e.g., cladding, spacers) 24.8 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2
	Typical burnup: 8,300 MW day / tonne U (200 MWh/kg U)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 28 elements (fuel pins), arranged in 3 concentric rings with 4 elements in the inner most ring, 8 elements in the second ring and 16 elements in the outer ring. - Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.	
Comments: - Used in Pickering A and B reactors	

37 element CANDU standard length bundle



Physical dimensions:
102.5 mm OD x 495 mm OL

Mass:
19.2 kg U (21.7 kg as UO_2)
2.2 kg Zircaloy (e.g., cladding, spacers)
24.0 kg total bundle weight

Fissionable material:
Sintered pellets of natural UO_2

Typical burnup:
8,300 MW day / tonne U
(200 MWh/kg U)

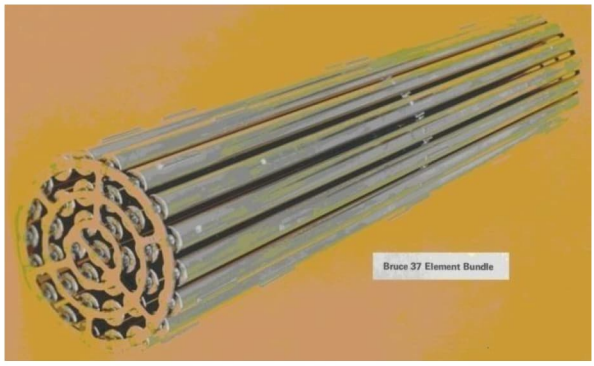
Cladding material:
Zircaloy-4

Construction:

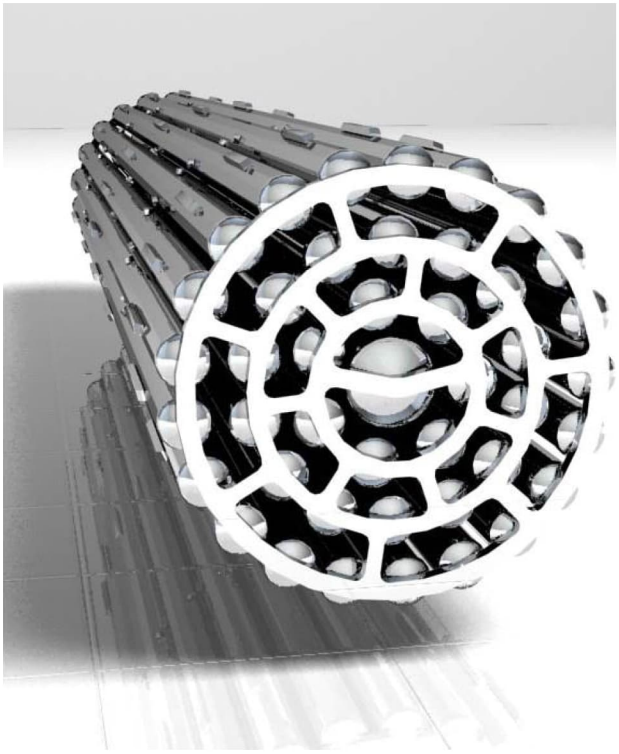
- Bundle is composed of 37 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 6 elements in the second ring, 12 elements in the third ring and 18 elements in the outer ring.
- Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.

Comments:

- Used in Bruce A and B, Darlington, Gentilly-2, Point Lepreau and EC-6 reactors (Gentilly-2 and Point Lepreau have minor construction differences on the end plates and spacers compared to the Bruce and Darlington designs).
- Two variants, designated 37R (regular) and 37M (modified), have slightly different center pin configurations and uranium masses (19.2 kg U for 37R vs 19.1 kg U for 37M). 37M is presently in use in Bruce and Darlington stations replacing prior 37R.

37 element CANDU long bundle	
	**Physical dimensions:** 102.5 mm OD x 508 mm OL
	Mass: 19.7 kg U (22.3 kg as UO_2) 2.24 kg Zircaloy (e.g., cladding, spacers) 24.6 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2
	Typical burnup: 8,300 MW day / tonne U (200 MWh/kg U)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 37 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 6 elements in the second ring, 12 elements in the third ring and 18 elements in the outer ring. - Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.	
Comments: - Similar to 37 element “standard” bundle, but is 13 mm longer. - Used in Bruce B, and Darlington reactors. - Two variants, designated 37R-long and 37M-long, have slightly different center pin configurations and uranium masses (19.7 kg U for 37R-long vs 19.6 kg U for 37M-long). 37M-long is presently in use in Bruce stations, replacing prior 37R-long.	

43 element CANFLEX LVRF bundle



Physical dimensions:
102.5 mm OD x 495.3 mm OL

Mass:
18.5 kg U (21.0 kg as UO_2)
2.1 kg Zircaloy (e.g., cladding, spacers)
23.1 kg total bundle weight

Fissionable material:
Sintered pellets of UO_2
slightly enriched to 1.0% U-235

Typical burnup:
8,300 MW day / tonne U
(200 MWh/kg U)

Cladding material:
Zircaloy-4

Construction:

- Bundle is composed of 43 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 7 elements in the second ring, 14 elements in the third ring and 21 elements in the outer ring.
- The inner central element uses Dysprosium (an element that absorbs neutrons and reduces the bundle power maintaining a flat neutronic field profile across the bundle during operation).
- Diameter and composition of fuel pins vary by ring.
- Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.

Comments:

- Has been used in Bruce B reactors in limited quantities, option for use in EC-6 reactors

B.2 FUELS FROM DEMONSTRATION AND PROTOTYPE REACTORS

7 element CANDU bundle



Physical dimensions:
82.0 mm OD x 495.3 mm OL

Mass:
13.4 – 13.5 kg U (15.2 – 15.3 kg as UO_2)
1.4 – 1.5 kg Zircaloy (e.g., cladding)
16.7 kg total bundle weight

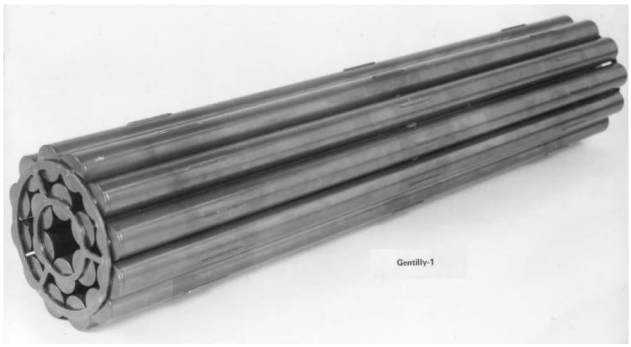
Fissionable material:
Sintered pellets of natural UO_2
Some low-enriched 7 element bundles exists at 1.4% wt ^{235}U and 2.5% wt ^{235}U enrichment

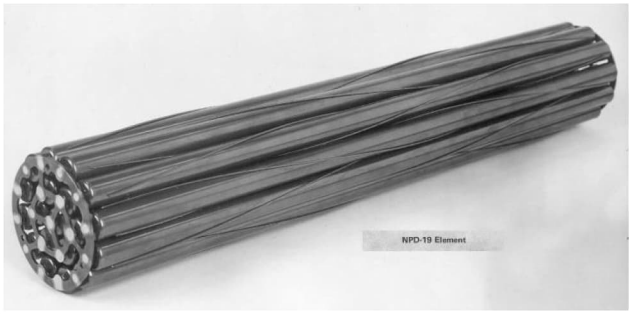
Typical burnup:
6474 MW day / tonne U
(156 MWh/kg U)

Cladding material:
Zircaloy-2
Nickel-free Zircaloy-2
Zircaloy-4

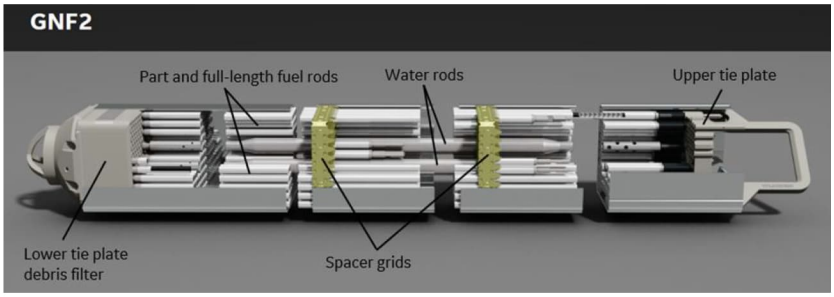
Construction:
- Bundle is composed of 7 elements (fuel pins), arranged as 1 element surrounded by a ring of 6 elements.
- Construction included wire-wrap and split-spacer fuel elements; riveted or welded end plates (only one bundle model had riveted end plates, all others had welded end plates) and thin, medium and thick walled cladding

Comments:
- Used in NPD

18 element CANDU bundle	
	**Physical dimensions:** 102.4 mm OD x 500 mm OL
	Mass: 20.7 kg U (23.5 kg as UO_2) 3.2 kg Zircaloy (e.g., cladding, spacers) 26.7 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2
	Typical burnup: 6972 MW day / tonne U (168 MWh/kg U)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 18 elements (fuel pins), arranged in 2 concentric rings with 6 elements in the inner most ring and 12 elements in the second ring. - Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.	
Comments: - Used in Gentilly 1	

19 element CANDU bundle	
	**Physical dimensions:** 82.0 mm OD x 495.3 mm OL
	Mass: 12.1 – 13.4 kg U (13.7 – 15.2 kg as UO_2) 1.4 – 2.2 kg Zircaloy (e.g., cladding) 15.8 – 16.7 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2 Some low-enriched 19 element bundles exists at up to 1.4% wt ^{235}U enrichment
	Typical burnup: 6474 MW day / tonne U at NPD 7885 MW day / tonne U at Douglas Point (156 MWh/kg U at NPD) (190 MWh/kg U at Douglas Point)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 19 elements (fuel pins), 1 element is surrounded by 2 concentric rings of fuel pins, 6 elements in the first ring and 12 elements in the outer ring. - Originally produced as a wire-wrapped bundle this design was eventually replaced with split-spacer variation.	
Comments: - Used in NPD and Douglas Point	

B.3 FUEL FROM PROPOSED GEH BWRX-300 REACTOR.

GEH BWRX-300 fuel assembly	
	**Physical dimensions:** Up to 150 mm square x 4500 mm long
	Mass: 186.5 kg U (211.6 kg as UO_2) Up to 93.4 kg metals in cladding, tie plates, channels Up to 305 kg total mass
	Fissionable material: Sintered pellets of UO_2 Batch average enrichment about 4% U-235
	Typical burnup: 40,000-50,000 MW day/tonne U
	Cladding material: Zircaloy-2
Construction: - Global Nuclear Fuel GNF2 fuel design; basically same as in some operating BWRs. - The GNF2 design contains a 10x10 array of 78 full-length fuel rods, 14 part-length rods, and two central water rods.	
Comments: - To be used in new OPG Darlington site small modular reactor	

Nuclear Fuel Waste Projections in Canada – 2020 Update

NWMO-TR-2020-06 October 2020

M. Gobien and M. Ion

Nuclear Waste Management Organization

nwmo
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Nuclear Fuel Waste Projections in Canada – 2020 Update

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ABSTRACT

Title: **Nuclear Fuel Waste Projections in Canada – 2020 Update**
Report No.: **NWMO-TR-2020-06**
Author(s): M. Gobien and M. Ion
Company: Nuclear Waste Management Organization
Date: October 2020

Abstract

This report summarizes the existing inventory of used nuclear fuel wastes in Canada as of June 30, 2020 and forecasts the potential future nuclear fuel waste from the existing reactor fleet as well as from proposed new-build reactors. While the report focuses on power reactors, it also includes prototype, demonstration and research reactor fuel wastes held by AECL, which are included in the NWMO mandate.

As of June 30, 2020, a total of approximately 3.0 million used CANDU fuel bundles (about 58,200 tonnes of heavy metal (t-HM)) were in storage at the reactor sites, an increase of about 90,250 bundles since the 2019 NWMO Nuclear Fuel Waste Projections report.

For the existing reactor fleet, the total projected number of used fuel bundles produced to end of life of the reactors is approximately 5.5 million used CANDU fuel bundles (approximately 106,500 t-HM). The projection is based on the published plans to refurbish and life extension for all Darlington and Bruce reactors, as well as continued operation of Pickering A until 2024 and Pickering B until 2025.

Used fuel produced by potential new-build reactors will depend on the size and type of reactor and number of units deployed. New-build plans are at various stages of development and the decisions about whether to proceed with individual projects, reactor technology and number of units have not yet been made.

The impacts of any future decisions on reactor refurbishment, new nuclear build or advanced fuel cycle technologies made by the nuclear utilities in Canada on projected inventory of nuclear fuel waste will be incorporated into future updates of this report.

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1. INTRODUCTION

1.1 BACKGROUND

The Nuclear Waste Management Organization (NWMO) is responsible for the long-term management of Canada's nuclear fuel waste (Canada 2002).

The NWMO will continually review and adjust its implementation plans as appropriate consistent with the external environment. As part of this process, the NWMO annually publishes the current and future potential inventories of used fuel amounts and types (Gobien and Ion 2019). This document provides an update as of June 2020.

Decisions on new nuclear reactors, advanced fuel cycles or other changes in energy choices will not be made by the NWMO. They will be made by the utilities in conjunction with government and regulators. However, it is important that NWMO is prepared for these potential changes so that the NWMO can plan for the long-term management of used fuel arising from such decisions. As part of this, the NWMO maintains a watching brief on alternative technologies (NWMO 2019).

1.2 SCOPE

This report summarizes the existing inventory of used nuclear fuel wastes in Canada as of June 30, 2020 and forecasts the potential future nuclear fuel waste from the existing reactor fleet as well as from proposed new reactors. The report focuses on power reactors, but also includes information on prototype, demonstration and research reactor fuel wastes held by Atomic Energy of Canada Limited (AECL).

1.3 CHANGES SINCE THE 2019 REPORT

The primary changes to the Canadian nuclear landscape since the 2019 report are:

a) An increase in the total amount of used fuel currently in storage, due to another year of reactor operation.

b) The plan to safely extend the life of the Pickering A Units 1 and 4 to 2024 and Pickering B Units 5 to 8 to 2025 (Ontario 2020).

c) Darlington Unit 2 returned to service in June 2020 (OPG 2020a). Darlington Unit 3 was shut down in July 2020, and its refurbishment started in September 2020, with a slight delay due in response to COVID-19 (OPG 2020b).

d) Bruce Power initiated the major component replacement at Unit 6 in January 2020. (Bruce Power 2020a). In August 2020, Bruce Power and Cameco launched the Centre for Next Generation Nuclear Technologies and support innovation and isotope production (Bruce Power 2020b).

The combined effects of these changes on the current and projected used fuel inventory are:

a) An increase in the total amount of used fuel currently in storage from June 30, 2019 to June 30, 2020.

	June 30, 2019	**June 30, 2020**	**Net change**	
Wet storage	1,448,284	1,444,092	-4,192	bundles*
Dry storage	1,486,638	1,581,081	94,443	bundles
TOTAL	**2,934,922**	**3,025,173**	**90,251**	**bundles**

** Note: A negative number means more used fuel was transferred from wet to dry storage than was produced during the year.*

b) A small increase in the overall projected future total number of used fuel bundles produced by the existing reactors to align with the current refurbishment and operational plans (see Section 2.2). The forecast presented in this report is most similar to the high scenarios from the previous versions of this report.

2. INVENTORY FROM EXISTING REACTORS

2.1 CURRENT INVENTORIES

Table 1 summarizes the current inventory of nuclear fuel waste in Canada as of June 30, 2020. The inventory is expressed in terms of number of CANDU used fuel bundles and does not include fuel which is currently in the reactors (which is not considered to be "nuclear fuel waste" until it has been discharged from the reactors) or non-CANDU-like research fuels.

As of June 30, 2020 there are approximately 3.0 million bundles in wet or dry storage. This is equivalent to approximately 58,200 tonnes of heavy metal (t-HM). Further details on the existing reactors can be found in Appendix A and fuel types in Appendix B.

Table 1: Summary of Nuclear Fuel Waste in Canada as of June 30, 2020

Location	Waste Owner	Wet Storage (# bundles)	Dry Storage (# bundles)	TOTAL (# bundles)	Current Status
Bruce A	OPG(1)	343,579	227,712	571,291	- 4 units operational
Bruce B	OPG(1)	349,396	406,646	756,042	- 3 units operational, 1 unit undergoing refurbishment. See Note (2).
Darlington	OPG	313,853	271,015	584,868	- 3 units operational, 1 unit undergoing refurbishment. See Note (2).
Douglas Point	AECL	0	22,256	22,256	- permanently shut down 1984
Gentilly 1	AECL	0	3,213	3,213	- permanently shut down 1977
Gentilly 2	HQ	3,865	126,060	129,925	- permanently shut down 2012
Pickering A	OPG	396,935	395,494	792,429	- 2 units operational, 2 units non-operational since 1997 (permanently shut down 2005)
Pickering B	OPG				- 4 units operational
Point Lepreau	NBPN	36,464	121,498	157,962	- operational
Whiteshell	AECL	0	2,301	2,301	- permanently shut down 1985. See Note (3).
Chalk River	AECL	0	4,886	4,886	- mostly fuel from NPD (permanently shut down 1987) with small amounts from other Canadian reactors and research activities
		Note (4)	Note (4)	Note (4)	- currently under assessment
	Total	**1,444,092**	**1,581,081**	**3,025,173**	

Notes:

AECL = Atomic Energy of Canada Limited
HQ = Hydro-Québec
NBPN = New Brunswick Power Nuclear
OPG = Ontario Power Generation Inc.

1) OPG is responsible for the used fuel that is produced. Bruce reactors are leased to Bruce Power for operation.
2) Bruce B and Darlington are currently undergoing refurbishment, unit-by-unit. The Bruce B first unit (Unit 6) was shut down in Jan 2020 and refurbishment is expected to be complete in Dec 2023. The Darlington first unit (Unit 2) refurbishment was completed in Jun 2020, and the refurbishment of its second unit (Unit 3) started in Sep 2020.
3) 360 bundles of Whiteshell fuel are standard CANDU bundles (from the Douglas Point reactor). The remaining bundles are various research, prototype and test fuel bundles, similar in size and shape to standard CANDU bundles, mainly from the research/prototype WR-1 reactor.
4) AECL also owns some components of research and development fuels such as fuel elements, fuel pellets and fuel debris in storage at Chalk River. While the total mass of these components is small compared to the overall quantity of CANDU fuel, their varied composition, storage form, dimensions, etc. requires special consideration for future handling. There are also small quantities (a few kg) of non-CANDU research reactor fuel.

Figure 1 summarizes the history of wet and dry storage of used fuel in Canada to the end of June 2020. Initially, all fuel was wet-stored in the station used fuel storage bays. Dry storage was initiated in the 1970s at shutdown AECL prototype reactors. Starting in the 1990s, older fuel in the wet bays at the operating power reactors has been transferred to dry storage on an ongoing basis. In the future, the inventory in wet storage will remain relatively constant (since wet bay space is fixed), while the inventory in dry storage will continue to grow over time.

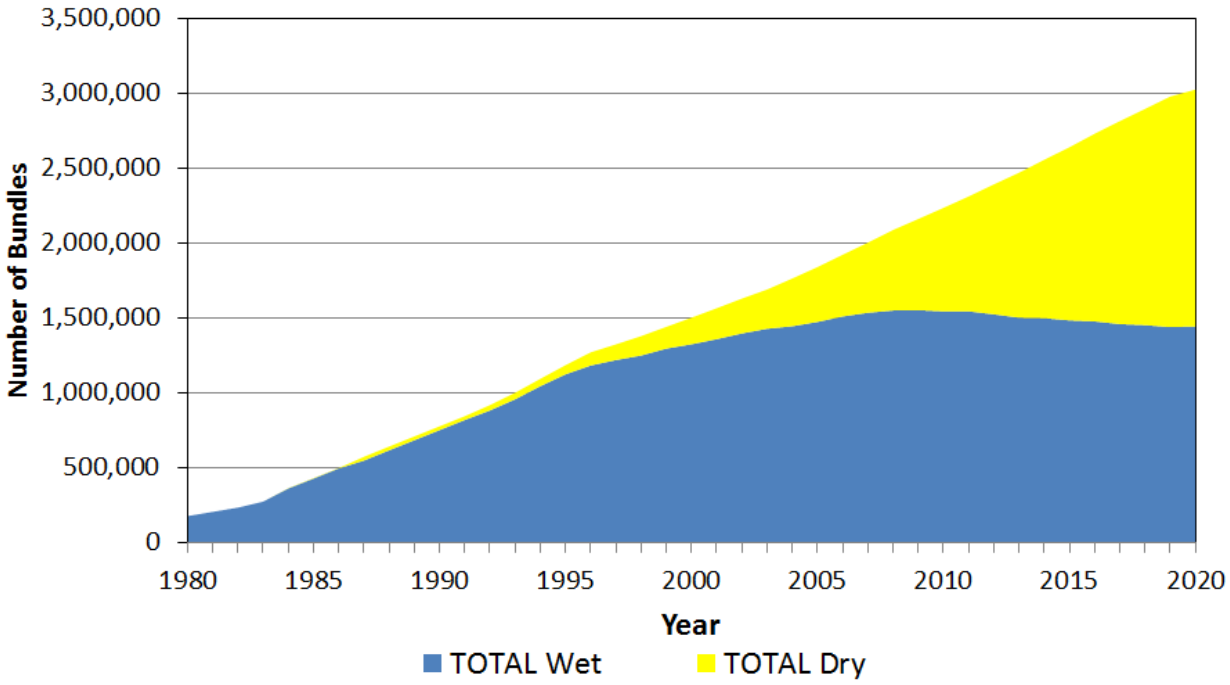


Figure 1: Summary of Used Fuel Wet and Dry Storage History

2.2 PROJECTED NUCLEAR FUEL WASTE

The current forecast of future nuclear fuel waste is summarized in Table 2. This forecast is based on NWMO's assumptions used for planning purposes only, and may differ from the business planning assumptions used by the reactor operators.

This estimate is based on the latest published plans for refurbishment and life extension for the current reactor fleet, uses conservative assumptions, and includes a number of uncertainties, as described below.

The current projection in Table 2 is based on the following:

1. Only existing CANDU stations are included in the forecast. All reactors in the existing fleet are assumed to be refurbished, except those already shut down or where there is a firm decision not to refurbish, and will be operated in accordance with current plans (Ontario 2020, OPG 2020c, Bruce Power and IESO 2015, NB Power 2019):

    - Reactors that have been permanently shut down do not restart (Gentilly-2, Pickering A Units 2 and 3);
    - Reactors where a definite decision has been made not to refurbish will operate to the end of their current announced service life only (i.e., Pickering A Units 1 and 4 will run until 2024 and Pickering B Units 5–8 will run until 2025).
    - Reactors that have been refurbished (Bruce A Units 1 and 2 and Point Lepreau) and reactors that will be refurbished (Darlington, Bruce A Units 3 and 4 and Bruce B) with new sets of pressure tubes and other major components, will operate for about 30 effective full power years (EFPY).

2. Fuel in reactor core is removed prior to a refurbishment and not re-used. No fuel is generated during the refurbishment period. End-of-life total includes final reactor core fuel.

3. The forecast for each station is calculated as *[(June 2020 actuals) + (number of years from June 2020 to end-of-life) * (typical annual production of fuel bundles)]*, rounded to nearest 1,000 bundles.

    The forecast annual production of fuel bundles is a conservative estimate for each station, resulting in a conservative projection of the overall total. An analysis of the last 5-year forecast vs actuals across all units indicates the forecast was high by about +6,200 to +8,000 bundles/year. Projected over the next 30 years, and applying the 5-year average on a station by station basis, this could indicate the current total is high by about 100,000-160,000 bundles.

4. Units are assumed to operate until December 31 of the shutdown year.

    The forecast conservatively assumes operation to end of year of shutdown. If an earlier (mid-year) shutdown were assumed for all stations, the total would be reduced by about 46,000 bundles.

5. Units operate to current end of life dates.

    Changes to the estimated end-of-life dates for refurbished reactors would result in changes to the overall forecast. For example, a potential 3 year extension or reduction of operation of all stations relative to current plans, assuming the highest typical annual bundle production, would affect the total bundle count by +/- about 92,000 bundles per year. Assuming a future 3 year extension/reduction for all units would affect the bundle count by about +/- 280,000 bundles.

6. Total mass of heavy metals (e.g. uranium) in fuel is based on an average bundle mass of heavy metal specific to each reactor type.

7. Current projection does not include new reactors, such as small modular reactors (SMRs).

   Assuming 1,000 MWe of new reactors operating for 30 years, could result in an additional 100,000-200,000 equivalent CANDU bundles, based on a simple correlation of electric power to CANDU bundles on a thermal power basis.

In summary, the approximate 5.5 million forecast represents the best estimate based on current plans. Its associated uncertainty could include +/- 0.28 million bundles (based on 3-year early or delayed shutdown of all current units), -0.10 to -0.16 million bundles (based on conservatism in projection), +0.1 to +0.2 million equivalent CANDU bundles (for a modest operation of new reactors), and about -0.05 million bundles (for mid-year end-of-life shutdown vs assumed end-year shutdown).

The forecast is subject to potential changes on annual basis, to account for reactor operators' updated plans for refurbishment and life extension, as well as for adjustments in calculations to reflect the most up-to-date numbers of bundles in storage versus previous year's projections.

Table 2: Summary of Projected Nuclear Fuel Waste from Existing Reactors

Location	Unit	Startup	Total to June 2020 (# bundles)	Typical Annual Production (bundles/a)	Refurbishment Schedule (Start-End)[8]	Forecast[6]	
						Shutdown[9]	(# bundles)
Bruce A	1	1977	571,291	20,500[2]	Complete	2043	1,233,000
	2	1977			Complete	2043	
	3	1978			01/2023 – 06/2026	2061	
	4	1979			01/2025 – 12/2027	2062	
Bruce B	5	1985	756,042	23,500[2]	07/2026 – 06/2029	2062	1,693,000
	6	1984			01/2020 – 12/2023	2058	
	7	1986			07/2028 – 06/2031	2063	
	8	1987			07/2030 – 06/2033	2063	
Darlington	1	1992	584,868	22,000[2]	01/2022 – 06/2025	2053	1,271,000
	2	1990			Complete	2049	
	3	1993			09/2020 – 03/2024	2052	
	4	1993			07/2023 – 12/2026	2055	
Douglas Point	-	1968	22,256	0[3]	-	1984	22,256
Gentilly 1	-	1972	3,213	0[3]	-	1977	3,213
Gentilly 2	-	1983	129,925	0[3]	-	2012	129,925
Pickering A	1	1971	792,429	7,200[4]	Complete	2024	932,000
	2	1971			-	2005	
	3	1972			-	2005	
	4	1973			Complete	2024	
Pickering B	5	1983		14,500[2]	-	2025	
	6	1984			-	2025	
	7	1985			-	2025	
	8	1986			-	2025	
Point Lepreau	1	1983	157,962	4,800	Complete	2040	261,000
Whiteshell	-	1965	2,301	0[3]	-	1985	2,301
Chalk River/ NPD/other	-	-	4,886	0[5]	-	-	4,886
Total (bundles)			**3,025,173**	**92,500**			**5,553,000 (See Note 1)**
(t-HM)[7]			**58,210**	**1,780**			**106,500**

Notes:

1) This represents the best estimate based on current plans, and includes conservative assumptions and uncertainties.
2) Based on 4 reactors operating.
3) Reactor is permanently shut down and not producing any more fuel.
4) Based on 2 reactors operating.
5) Future forecasts do not include research fuels. Chalk River does not produce any CANDU power reactor used fuel bundles. However, it may receive bundles from power reactor sites from time to time for testing. This will not affect overall total numbers of bundles, since they will be subtracted from the reactor site.
6) Totals may not add exactly due to rounding to nearest 1,000 bundles for future forecasts.
7) "tonnes of heavy metals" (t-HM) based on an average of bundle mass specific for each reactor type.
8) Assumes units under refurbishment do not produce fuel and annual fuel production rates are scaled accordingly.
9) Assumes units operate until December 31 of the shutdown year and the core is defueled in the following year.

3. INVENTORY FROM POTENTIAL NEW REACTORS

There are two categories of proposed new reactor projects:

- projects which have received or are currently undergoing regulatory approvals; and
- potential projects which have been discussed by various implementing organizations (proponents), but which do not have any regulatory approvals underway.

This report focuses on the first category. However, it does not assess the probability of any of these projects proceeding. Execution of the projects rests entirely with the proponent.

3.1 PROJECTS WHICH HAVE RECEIVED OR CURRENTLY UNDERGOING REGULATORY APPROVALS

3.1.1 Ontario Power Generation

OPG currently holds a 10-year Nuclear Power Reactor Site Preparation Licence that allows preparation of the Darlington nuclear site for future construction and operation of up to 4 new reactors, with a maximum combined net electrical output of 4,800 MWe. In June 2020, OPG has submitted an application to renew the licence for a new 10-year term, to maintain the option for future nuclear generating capacity at the site (OPG 2020d).

To date, OPG has not selected a reactor technology for the new build at Darlington. In its original application (OPG 2007, 2009), OPG considered four "Generation III+" reactor types, designed to operate for 60 years:

a) ***CANDU ACR 1000 (Advanced CANDU reactor)***, a 1085 MW(e) net heavy water moderated, light water cooled pressure tube reactor. Four ACR 1000 reactors would result in a total production of approximately 770,400 used fuel bundles (12,480 t-HM) over 60 years.

b) ***CANDU EC-6 (Enhanced CANDU 600 reactor)***, a 686 MW(e) net heavy water reactor, similar to the existing CANDU 600 reactors at Gentilly-2 and Point Lepreau. Four EC-6 reactors would result in a total production of approximately 1,572,000 used fuel bundles (30,000 t-HM) over 60 years.

c) ***Westinghouse AP1000***, a 1037 MW(e) net pressurized light water reactor (PWR). Four AP1000 reactors result in a total production of approximately 10,800 PWR fuel assemblies (5,820 t-HM) over 60 years.

d) ***AREVA EPR (Evolutionary Power Reactor)***, a 1580 MW(e) net PWR. Three EPR reactors would result in a total production of approximately 9,900 PWR fuel assemblies (5,220 t-HM) over 60 years.

The EC-6 uses standard CANDU fuel, with options for advanced fuel types (SEU, MOX, etc.). The other three reactor types operate with enriched uranium fuel. The ACR 1000 fuel is similar in size and shape to existing CANDU fuel bundles. The AP1000 and EPR fuel assemblies are considerably different from the CANDU fuels in terms of size and mass, but are very similar to conventional pressurized light water reactor fuels used in many other countries around the world. Further details on fuel types and potential inventories of fuel wastes are included in Appendix C.

The province, through its Infrastructure Ontario program, would select the preferred vendor. The selection process is currently suspended, however, the Ontario Government has stated that new nuclear remains an option for the future (Ontario 2017).

3.1.2 Global First Power

Global First Power, Ultra Safe Nuclear Corporation, and OPG propose to construct and operate a 5 MWe “Micro Modular Reactor” (MMR) plant on Atomic Energy of Canada Limited’s property at the Chalk River Laboratories.

In December 2018, the CNSC completed Phase 1 of the pre-licensing review of the MMR (CNSC 2019a). In April 2019, Global First Power submitted to the CNSC an application to prepare site for a small modular reactor at the Chalk River Laboratories (Global First Power 2019a). In July 2019, the Federal government issued a Notice of Commencement of an environmental assessment for a small modular reactor project at the Chalk River Laboratories (CNSC 2019b). The regulatory review of this project continues; in September 2020, the CNSC has released the record of decision on the scope of the environmental assessment for Global First Power’s MMR (CNSC 2020a).

At this stage there is limited information about the MMR fuel and its fuel waste characteristics. The MMR has a 30 year operation life (Global First Power 2019b) and quantities of potential fuel wastes are unknown at this time. The MMR fuel is substantially different than CANDU fuel. The fuel contains low-enriched uranium and is manufactured with Triple Coated Isotopic (TRISO) fuel particles.

The NWMO continues to monitor the progress of the regulatory approval process of this project. As more information becomes available, additional details on TRISO fuel and potential fuel waste inventories from the proposed MMR will be included in future versions of this report.

3.2 POTENTIAL PROJECTS AND DEVELOPMENTS

Feasibility studies and public discussions by provincial governments and potential proponents have been previously conducted for other new reactors in Ontario (Bruce Power 2008a, 2008b, 2009a), Alberta (Bruce Power 2009b), Saskatchewan (Saskatchewan 2011) and New Brunswick (MZConsulting 2008).

Other proposals include the introduction of SMRs of up to a few tens or hundreds of megawatts each in remote (i.e. off-grid) communities and resource extraction sites which currently rely on small-scale fossil fuel generating plants to provide heat and/or electricity (AECL 2012, HATCH 2016). The reactors are based on a variety of non-CANDU technologies, including liquid metal cooled, molten salt cooled and light water cooled.

Natural Resource Canada (NRCan) initiated the SMR Roadmap project with interested provinces, territories and power utilities to identify the opportunities for on and off-grid applications of SMRs in Canada. The Roadmap report was published in November 2018, containing more than 50 recommendations in areas such as waste management, regulatory readiness and international engagement (SMR 2018). The Government of Canada will launch Canada’s SMR Action Plan in November 2020 (NRCan 2020).

The CNSC is currently undergoing a number of pre-licensing reviews for a variety of small modular reactor designs (CNSC 2020b).

Canadian Nuclear Laboratories (CNL) is looking to establish partnerships with vendors of SMR technology to develop, promote and demonstrate the technology in Canada (CNL 2017). At present, four proponents are in various stages of CNL's review (CNL 2019). Global First Power has started stage 3 for the proposed 5 MWe MMR (high-temperature gas reactor) and has submitted an application for a licence to prepare site (see Section 3.1.2). Three other proponents have completed CNL's pre-qualification stage and have been invited to enter CNL's next stage of detailed review; these are U-Battery Canada Ltd. (4 MWe high temperature gas reactor), StarCore Nuclear (14 MWe high-temperature gas reactor), and Terrestrial Energy (190 MWe integral molten salt reactor). No licensing activities have been initiated for these three proposals. CNL has also formed partnerships with Moltex Energy (CNL 2020a), Ultra Safe Nuclear Corporation (CNL 2020b), New Brunswick Power (CNL 2020c), and Terrestrial Energy (CNL 2020d), to research SMR fuels and advance SMR technology in Canada.

Some utilities have continued to express interest in supporting the development of SMR technologies; for example, Global First Power, USNC and OPG formed joint venture to own, operate Micro Modular Reactor Project at Chalk River (Global First Power 2020) and Cameco and Bruce Power have launched a centre for the next generation of nuclear technologies (Bruce Power 2020b). OPG has recently announced the plan to advance the development of an SMR in Ontario and advance engineering and design work with three developers of grid-scale SMRs: GE Hitachi (GEH), Terrestrial Energy and X-energy (OPG 2020e). At the same time, GEH has entered into MoUs with five Canadian companies to set up a supply chain for its SMR (World Nuclear News 2020).

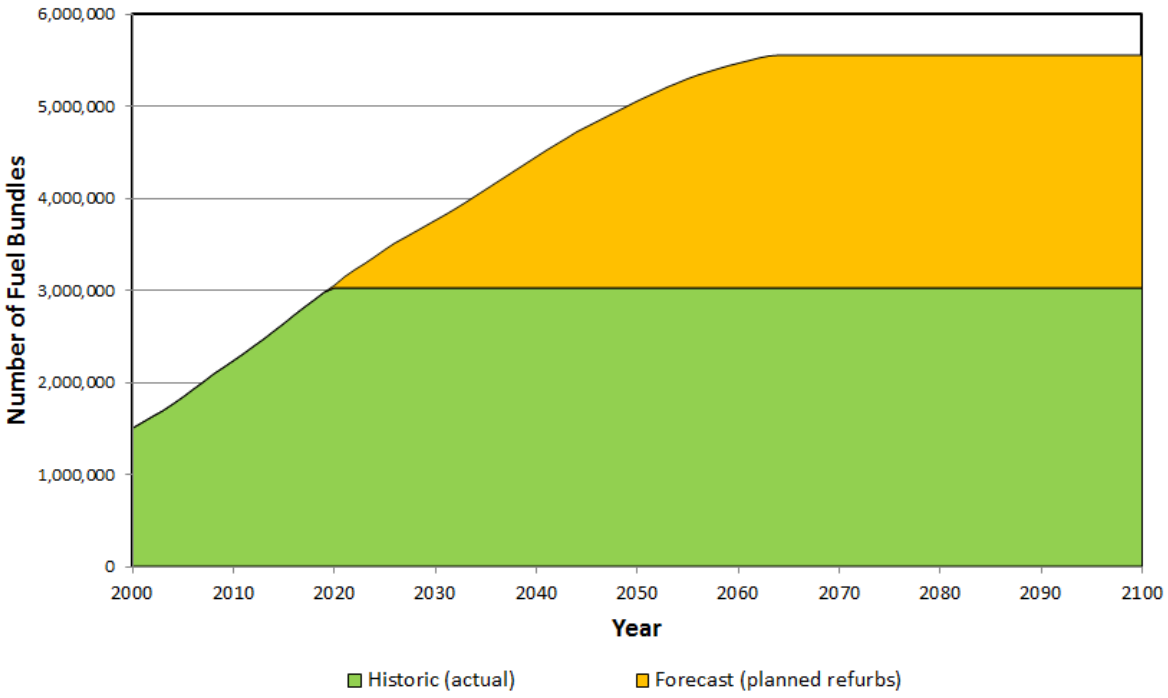
The NWMO will continue to monitor these developments and the implications of new reactors as part of its Adaptive Phased Management approach.

4. SUMMARY OF PROJECTED USED FUEL INVENTORY

As of June 30, 2020 there are approximately 3.0 million used fuel bundles in wet or dry storage. Based on currently announced refurbishment and life extension plans for the existing nuclear reactor fleet in Canada, the current forecast projects a total of about 5.5 million bundles (see Section 2.2 for details). The existing and projected inventory from current reactor operations, reactor refurbishment, developed in previous sections, is summarized in Figure 2.

No definitive decisions on new nuclear build have been made by the utilities in Canada, so they are not included in the current reference forecast.

The 5.5 million bundle forecast is a best estimate based on current plans. Its associated uncertainty could include +/- 0.28 million bundles (based on 3-year early or delayed shutdown of all current units), -0.15 to -0.21 million bundles (based on conservatism in projection), +0.1 to +0.2 million equivalent CANDU bundles (for a modest operation of new SMRs), or about +1.6 million bundle-equivalents for 3-4 new large reactors at the Darlington site.



Notes:

1) The existing fuel (as of end of June 2020) is shown in the green shaded area
2) The forecast (orange shaded area) shows the additional fuel bundles that would be generated based on the announced refurbishment and life extension projects for the existing Canadian reactor fleet

Figure 2: Summary of Projected Used Fuel Inventory

Note that in addition to the CANDU fuel bundles described above, there are small quantities of other nuclear fuel waste, such as the AECL research fuels, pellets and elements mentioned in the footnotes to Table 1, as well as used fuels from other Canadian research reactors (as listed in the Appendix A, Table A3), which are included within the NWMO's mandate for implementing the APM program, if requested by the waste owner. Some of these non-CANDU reactor fuels have been or will be returned to the country of origin, e.g. USA or France, under the terms of the original supply agreements or international agreements governing their usage.

There are also other heat-generating radioactive wastes in Canada (such as cobalt-60 sources produced in Canadian CANDU reactors and used in industrial and therapeutic radiation devices), again in relatively small quantities (on the order of 1,000 to 2,000 fuel bundle equivalents, i.e. less than 0.1% of the projected used fuel inventory). These non-fuel, heat generating wastes are not within the NWMO's legislated mandate for nuclear fuel waste.

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APPENDIX A: SUMMARY OF EXISTING CANADIAN REACTORS & FUEL STORAGE

Appendix A presents a summary of commercial, demonstration and research reactors in Canada. Table A1 presents a summary of commercial power reactors in Canada and their status. Table A2 presents a summary of prototype and demonstration reactors in Canada and their status. Table A3 presents a summary of research reactors in Canada and their status.

Commercial, prototype and some research reactors have storage facilities for used nuclear fuel. Table A4 presents a summary of dry storage facilities for used nuclear fuel and Figure A1 shows the location of the major storage locations in Canada.

Table A1: Nuclear Power Reactors

Location	Rating (MW(e) net)	Year In-service	Fuel Type*	Current Status (2020)
Bruce Nuclear Power Development, Ontario				
Bruce A – 1	750	1977	37 element bundle	Refurbished and operating
Bruce A – 2	750	1977		Refurbished and operating
Bruce A – 3	750	1978		Operating
Bruce A – 4	750	1979		Operating
Bruce B – 5	795	1985	37 element bundle; 37 element "long" bundle	Operating
Bruce B – 6	822	1984		Undergoing refurbishment
Bruce B – 7	822	1986		Operating
Bruce B – 8	795	1987		Operating
Darlington, Ontario				
Darlington 1	881	1992	37 element bundle; 37 element "long" bundle	Operating
Darlington 2	881	1990		Refurbished and operating
Darlington 3	881	1993		Undergoing refurbishment
Darlington 4	881	1993		Operating
Gentilly, Quebec				
Gentilly 2	635	1983	37 element bundle	Permanently shut down in 2012
Pickering, Ontario				
Pickering A – 1	515	1971	28 element bundle	Refurbished and operating
Pickering A – 2	515	1971		Non-operational since 1997; Permanently shut down in 2005
Pickering A – 3	515	1972		Non-operational since 1997; Permanently shut down in 2005
Pickering A – 4	515	1973		Refurbished and operating
Pickering B – 5	516	1983		Operating
Pickering B – 6	516	1984		Operating
Pickering B – 7	516	1985		Operating
Pickering B – 8	516	1986		Operating
Point Lepreau, New Brunswick				
Point Lepreau	635	1983	37 element bundle	Refurbished and operating

*Note: refer to Appendix B for description of fuel types, and their current storage status.

Table A2: Prototype and Demonstration Power Reactors

Location	Rating (MW(e) net)	Year In-service	Fuel Type	Current Status (2020)
Bruce Nuclear Power Development, Ontario				
Douglas Point (CANDU PHWR prototype)	206	1968	19 element bundle	Permanently shut down in 1984; All fuel is in dry storage on site
Gentilly, Quebec				
Gentilly 1 (CANDU-BLW boiling water reactor prototype)	250	1972	18 element CANDU-BLW bundle	Permanently shut down in 1977; All fuel is in dry storage on site
Rolphton, Ontario				
NPD (CANDU PHWR prototype)	22	1962	19 element bundle; various prototype fuel designs (e.g. 7 element bundle)	Permanently shut down in 1987; All fuel is in dry storage at Chalk River

Table A3: Research Reactors

Location	Rating (MW(th))	Year In-service	Fuel Type	Comments
Chalk River, Ontario				
NRU	135	1957	various driver fuel and target designs (U-metal, U-Al, UO_2, U_3Si-Al)	Permanently shut down on March 31, 2018. As of Jun 2020, half NRU fuel has been transferred to dry storage, with the remainder in wet storage pending transfer.
ZED-2	0.00025	1960	various uranium fuels	Operating
NRX	42	1947	various driver fuel and target designs (U-metal, U-Al, UO_2)	Permanently shut down in 1992
MAPLE 1	10	-	U_3Si-Al driver fuel; U-metal targets	Never fully commissioned
MAPLE 2	10	-		
Whiteshell, Manitoba				
WR-1 (organic cooled reactor prototype)	60	1965	various research and prototype fuel bundle designs (similar size and shape to standard CANDU bundles; UO_2, UC)	Permanently shut down in 1985; All fuel is in dry storage on site.
Hamilton, Ontario				
McMaster University	5	1959	U_3Si-Al fuel pins	MTR Pool type reactor; Operating.
Kingston, Ontario				
Royal Military College	0.02	1985	UO_2 SLOWPOKE fuel pins	SLOWPOKE-2 reactor; Operating.
Montreal, Quebec				
Ecole polytechnique	0.02	1976	UO_2 SLOWPOKE fuel pins	SLOWPOKE-2 reactor; Operating.
Edmonton, Alberta				
University of Alberta	0.02	1977	U-Al SLOWPOKE fuel pins	SLOWPOKE-2 reactor. Permanently shut down in 2017. Fuel was repatriated to US.
Saskatoon, Saskatchewan				
Saskatchewan Research Council	0.02	1981	U-Al SLOWPOKE fuel pins	SLOWPOKE-2 reactor. Permanently shut down in 2019. Fuel was repatriated to US.

Note: the SLOWPOKE reactors can operate on one fuel charge for 20 to 40 years. Other former research reactors include the 2 MW(th) SLOWPOKE Demonstration Reactor at Whiteshell, the low power PTR and ZEEP reactors at Chalk River, and shut down / decommissioned SLOWPOKE reactors at University of Toronto, Dalhousie University and Nordion Kanata. Used fuel from these shut down research reactors is stored at the Chalk River site, Whiteshell site or has been returned to the country of origin (e.g. US).

Table A4: Summary of Dry Storage Facilities for Used Nuclear Fuel

Facility	Owner	Technology	Fuel Type	Year In-service
Chalk River	AECL	AECL Concrete Canister/Silo	CANDU & CANDU-like (mainly 19 element)	1992
Darlington Waste Management Facility (DWMF)	OPG	OPG Dry Storage Container (DSC)	CANDU (37 element)	2008
Douglas Point Waste Management Facility	AECL	AECL Concrete Canister/Silo	CANDU (19 element)	1987
Gentilly 1	AECL	AECL Concrete Canister/Silo	CANDU-BLW (18 element)	1984
Gentilly 2	HQ	AECL CANSTOR/MACSTOR modular concrete vault	CANDU (37 element)	1995
Pickering Waste Management Facility (PWMF)	OPG	OPG Dry Storage Container (DSC)	CANDU (28 element)	1996
Point Lepreau	NBPN	AECL Concrete Canister/Silo	CANDU (37 element)	1990
Western (Bruce) Waste Management Facility (WWMF)	OPG	OPG Dry Storage Container (DSC)	CANDU (37 element)	2003
Whiteshell	AECL	AECL Concrete Canister/Silo	CANDU & CANDU-like (various sizes)	1977

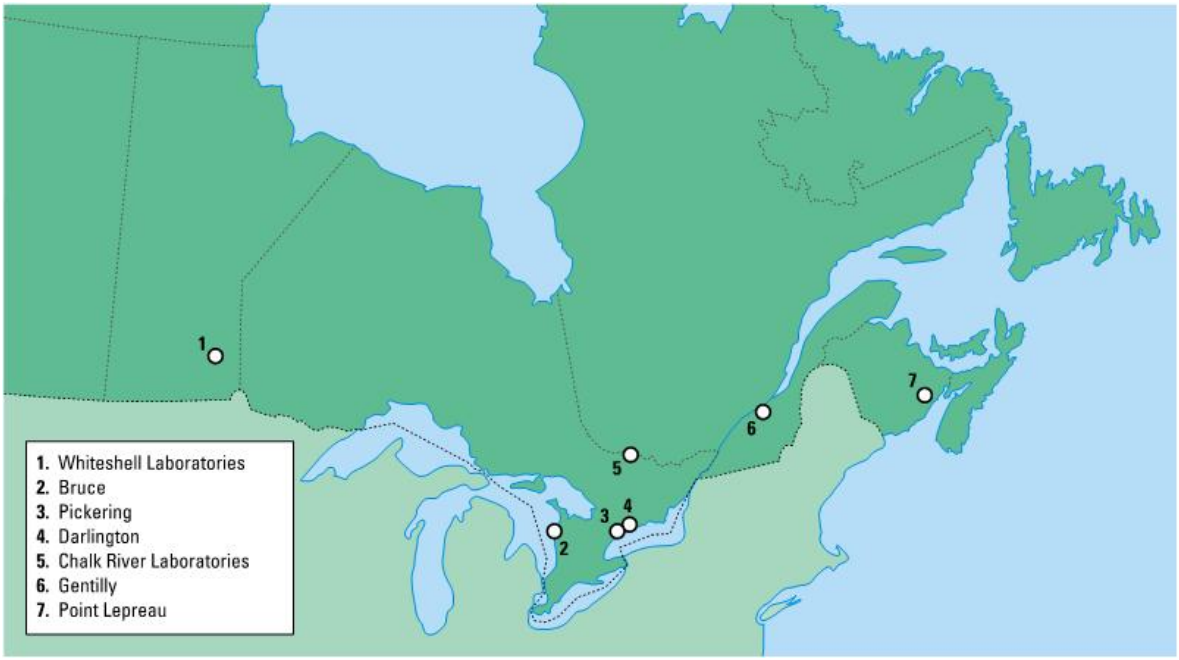


Figure A1: Current Nuclear Fuel Waste Major Storage Location in Canada

APPENDIX B: DESCRIPTION OF FUEL TYPES

Table B1 summarizes the inventory of the various bundles types in Canada as of June 2020.

Section B.1 details the physical characteristics and usage of the bundles in operating reactors. Section B.2 details the physical characteristics and usage of the bundles in demonstration and prototype reactors. Note that the physical characteristics of the bundles described in this appendix are intended to be nominal and other sources may quote different numbers.

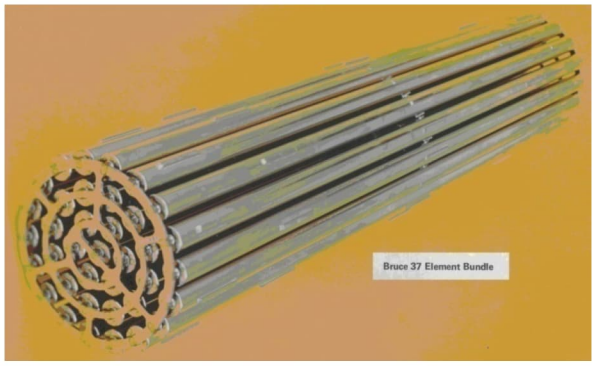
Table B1: Summary of Inventory by Bundle Type (June 2020)

CANDU Bundle Type	Where Used	Wet Storage (# bundles)	Dry Storage (# bundles)	Total (# bundles)
18 Element	Gentilly 1, Whiteshell	-	4,417	4,417
7 Element / 19 Element	NPD, Douglas Point	-	26,296	26,296
28 Element	Pickering	396,935	395,494	792,429
37R	Bruce, Darlington, Gentilly 2, Pt Lepreau	574,468	1,050,430	1,624,898
37R Long	Bruce, Darlington	133,802	102,501	236,303
37M	Bruce, Darlington	254,124	-	254,124
37M Long	Bruce, Darlington	84,739	-	84,739
43 Element LVRF	Bruce	24	-	24
Other	AECL (various)	-	1,943	1,943
	Total	**1,444,092**	**1,581,081**	**3,025,173**

B.1 FUELS FROM OPERATING REACTORS

28 element CANDU bundle	
	**Physical dimensions:** 102.5 mm OD x 497.1 mm OL
	Mass: 20.1 kg U (22.8 kg as UO_2) 2.0 kg Zircaloy (e.g., cladding, spacers) 24.8 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2
	Typical burnup: 8,300 MW day / tonne U (200 MWh/kg U)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 28 elements (fuel pins), arranged in 3 concentric rings with 4 elements in the inner most ring, 8 elements in the second ring and 16 elements in the outer ring. - Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.	
Comments: - Used in Pickering A and B reactors	

37 element CANDU standard length bundle



Physical dimensions:
102.5 mm OD x 495 mm OL

Mass:
19.2 kg U (21.7 kg as UO_2)
2.2 kg Zircaloy (e.g., cladding, spacers)
24.0 kg total bundle weight

Fissionable material:
Sintered pellets of natural UO_2

Typical burnup:
8,300 MW day / tonne U
(200 MWh/kg U)

Cladding material:
Zircaloy-4

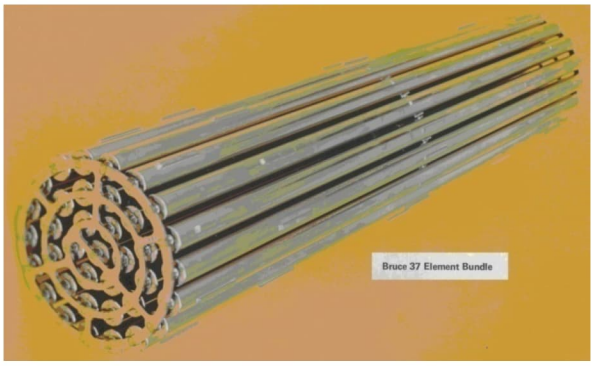
Construction:

- Bundle is composed of 37 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 6 elements in the second ring, 12 elements in the third ring and 18 elements in the outer ring.
- Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.

Comments:

- Used in Bruce A and B, Darlington, Gentilly-2, Point Lepreau and EC-6 reactors (Gentilly-2 and Point Lepreau have minor construction differences on the end plates and spacers compared to the Bruce and Darlington designs).
- Two variants, designated 37R (regular) and 37M (modified), have slightly different center pin configurations and uranium masses (19.2 kg U for 37R vs 19.1 kg U for 37M). 37M is presently in use in Bruce and Darlington stations replacing prior 37R.

37 element CANDU long bundle



Physical dimensions:
102.5 mm OD x 508 mm OL

Mass:
19.7 kg U (22.3 kg as UO_2)
2.24 kg Zircaloy (e.g., cladding, spacers)
24.6 kg total bundle weight

Fissionable material:
Sintered pellets of natural UO_2

Typical burnup:
8,300 MW day / tonne U
(200 MWh/kg U)

Cladding material:
Zircaloy-4

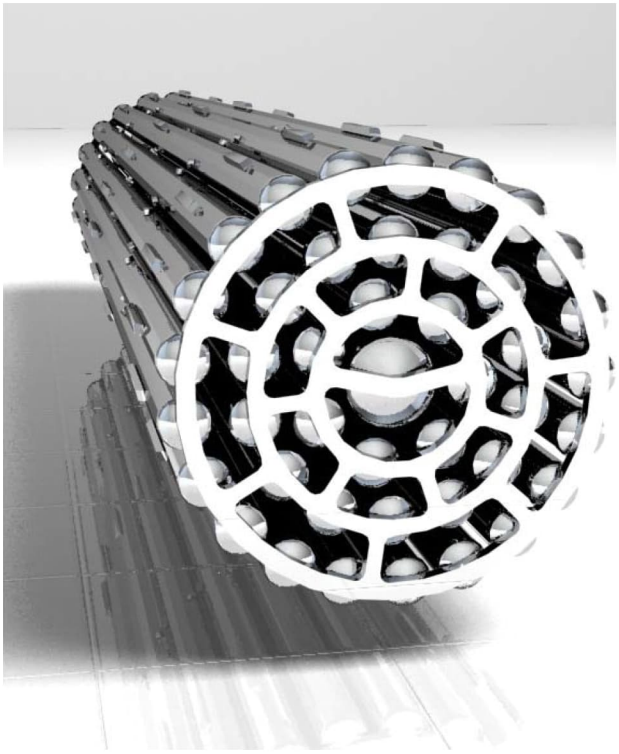
Construction:

- Bundle is composed of 37 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 6 elements in the second ring, 12 elements in the third ring and 18 elements in the outer ring.
- Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.

Comments:

- Similar to 37 element “standard” bundle, but is 13 mm longer.
- Used in Bruce B, and Darlington reactors.
- Two variants, designated 37R-long and 37M-long, have slightly different center pin configurations and uranium masses (19.7 kg U for 37R-long vs 19.6 kg U for 37M-long). 37M-long is presently in use in Bruce stations, replacing prior 37R-long.

43 element CANFLEX LVRF bundle



Physical dimensions:
102.5 mm OD x 495.3 mm OL

Mass:
18.5 kg U (21.0 kg as UO_2)
2.1 kg Zircaloy (e.g., cladding, spacers)
23.1 kg total bundle weight

Fissionable material:
Sintered pellets of UO_2
slightly enriched to 1.0% U-235

Typical burnup:
8,300 MW day / tonne U
(200 MWh/kg U)

Cladding material:
Zircaloy-4

Construction:

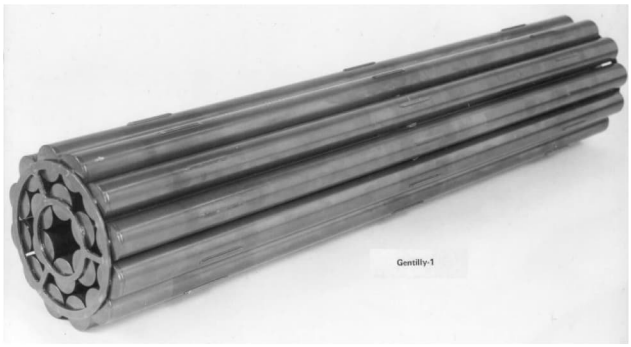
- Bundle is composed of 43 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 7 elements in the second ring, 14 elements in the third ring and 21 elements in the outer ring.
- The inner central element uses Dysprosium (an element that absorbs neutrons and reduces the bundle power maintaining a flat neutronic field profile across the bundle during operation).
- Diameter and composition of fuel pins varies by ring.
- Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.

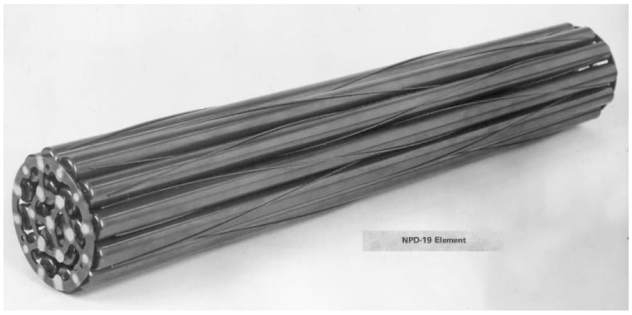
Comments:

- Has been used in Bruce B reactors in limited quantities, option for use in EC-6 reactors

B.2 FUELS FROM DEMONSTRATION AND PROTOTYPE REACTORS

7 element CANDU bundle	
	**Physical dimensions:** 82.0 mm OD x 495.3 mm OL
	Mass: 13.4 – 13.5 kg U (15.2 – 15.3 kg as UO_2) 1.4 – 1.5 kg Zircaloy (e.g., cladding) 16.7 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2 Some low-enriched 7 element bundles exists at 1.4% wt ^{235}U and 2.5% wt ^{235}U enrichment
	Typical burnup: 6474 MW day / tonne U (156 MWh/kg U)
	Cladding material: Zircaloy-2 Nickel-free Zircaloy-2 Zircaloy-4
Construction: - Bundle is composed of 7 elements (fuel pins), arranged as 1 element surrounded by a ring of 6 elements. - construction included wire-wrap and split-spacer fuel elements; riveted or welded end plates (only one bundle model had riveted end plates, all others had welded end plates) and thin, medium and thick walled cladding	
Comments: - Used in NPD	

18 element CANDU bundle	
	**Physical dimensions:** 102.4 mm OD x 500 mm OL
	Mass: 20.7 kg U (23.5 kg as UO_2) 3.2 kg Zircaloy (e.g., cladding, spacers) 26.7 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2
	Typical burnup: 6972 MW day / tonne U (168 MWh/kg U)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 18 elements (fuel pins), arranged in 2 concentric rings with 6 elements in the inner most ring and 12 elements in the second ring. - Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.	
Comments: - Used in Gentilly 1	

19 element CANDU bundle	
	**Physical dimensions:** 82.0 mm OD x 495.3 mm OL
	Mass: 12.1 – 13.4 kg U (13.7 – 15.2 kg as UO_2) 1.4 – 2.2 kg Zircaloy (e.g., cladding) 15.8 – 16.7 kg total bundle weight
	Fissionable material: Sintered pellets of natural UO_2 Some low-enriched 19 element bundles exists at up to 1.4% wt ^{235}U enrichment
	Typical burnup: 6474 MW day / tonne U at NPD 7885 MW day / tonne U at Douglas Point (156 MWh/kg U at NPD) (190 MWh/kg U at Douglas Point)
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 19 elements (fuel pins), 1 element is surrounded by 2 concentric rings of fuel pins, 6 elements in the first ring and 12 elements in the outer ring. - originally produced as a wire-wrapped bundle this design was eventually replaced with split-spacer variation	
Comments: - Used in NPD and Douglas Point	

APPENDIX C: POTENTIAL NEW BUILD FUEL CHARACTERISTICS AND QUANTITIES

Table C1 presents a summary of the major characteristics and quantities of nuclear fuels that are used in the new reactors that have been proposed in various projects. The data have been extracted from references (Bruce Power 2008a, 2008b; IAEA 2004; JRP 2011).

Table C2 summarizes the total quantity of used fuel that might be produced for the proposed new-build reactors at Darlington. As mentioned in Section 3.1.1, until decisions on reactor types, number of units and operating conditions are taken by the proponents, these forecasts remain highly speculative.

The total additional quantity of used fuel from the Darlington New Nuclear Project could be up to 1.6 million CANDU fuel bundles (30,000 t-HM), or 10,800 PWR fuel assemblies, depending on the selected reactor type.

Section C.1 details the physical characteristics and usage of the bundles in potential new-build reactors. Note that other sources may quote different numbers for fuel properties and used fuel production rates. This is generally due to the preliminary nature of some of the designs combined with the various ways some of the reactors can be operated (e.g. enrichment level and burnup, assumed capacity factors, length of operating period between re-fuelling outages for light water reactors, conservative assumptions used for environmental assessment purposes). The quantities and characteristics used for forecasting in this report will be updated as reactor types are selected and their designs are further defined.

Table C1: Summary of Fuel Types for Proposed New Reactors

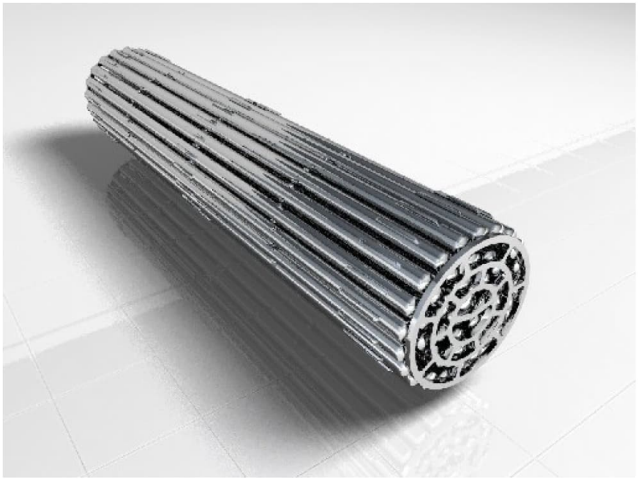
Parameter	ACR 1000	EC-6	AP1000	EPR
Reactor Type	Horizontal pressure tube, heavy water moderated, light water cooled	Horizontal pressure tube, heavy water moderated and cooled	Pressurized light water reactor (PWR)	Pressurized light water reactor (PWR)
Net / Gross Power [MW(e)]	1085 / 1165	686 / 745	1037 / 1117	1580 / 1770
Design Life	60 years	60 years	60 years	60 years
Fuel type	CANFLEX ACR fuel bundle	37 element CANDU bundle	Conventional 17x17 PWR fuel design	Conventional 17x17 PWR fuel design
Fueling method	On power	On power	Refueling shutdown every 12 to 24 months and replace portion of the core	Refueling shutdown every 12 to 24 months and replace portion of the core
Fuel enrichment	Up to 2.5% for equilibrium core	Natural U, with options for SEU (1.2%) and MOX	2.4-4.5% avg initial core 4.8% avg for reloads	Up to 5% for equilibrium core
Fuel dimensions	102.5 mm OD x 495.3 mm OL	102.5 mm OD x 495.3 mm OL	214 mm square x 4795 mm OL	214 mm square x 4805 mm OL
Fuel assembly U mass [kg initial U]	16.2	19.2	538.3	527.5
Fuel assembly total mass [kg]	21.5	24.0	789	780
# of fuel assemblies per core	6,240	4,560	157	241
Fuel load per core [kg initial U]	101,088	87,552	84,513	127,128
Annual used fuel production [t-HM/yr per reactor]	52	126	24	29
Annual used fuel production [number of fuel assemblies/yr per reactor]	3,210	6,550	45	55
Lifetime used fuel production [t-HM per reactor]	3,120	7,500	1,455	1,740
Lifetime used fuel production [number of fuel assemblies per reactor]	192,600	393,000	2,700	3,300

Note: Data extracted from references (Bruce Power 2008a; IAEA 2004; JRP 2011). Annual and lifetime data have been rounded.

Table C2: Summary of Potential Nuclear Fuel Waste from New Reactors at Darlington

Reactor	Darlington New Nuclear
Assumed operation	60 years
EC-6	
# of reactor units	4
Quantity of fuel (# bundles)	1,572,000
(t-HM)	30,000
AP 1000	
# of reactor units	4
Quantity of fuel (# assemblies)	10,800
(t-HM)	5,820

C.1 FUELS FROM POTENTIAL NEW-BUILD REACTORS

43 element CANFLEX ACR bundle	
	**Physical dimensions:** 102.5 mm OD x 495.3 mm OL
	Mass: 16.2 kg U (18.4 kg as UO_2) 3.1 kg Zircaloy and other materials in cladding, spacers, etc. 21.5 kg total bundle weight
	Fissionable material: Sintered pellets of UO_2 enriched to 2.5% U-235
	Typical burnup: 20,000 MW day/ tonne U
	Cladding material: Zircaloy-4
Construction: - Bundle is composed of 43 elements (fuel pins), arranged in 4 concentric rings with 1 element in the inner most central ring, 7 elements in the second ring, 14 elements in the third ring and 21 elements in the outer ring. - Diameter and composition of fuel pins varies by ring. - Construction includes end plates, spacers and bearing pads to improve flow characteristics and maintain structural integrity.	
Comments: - Used in ACR-1000 reactors	

AP1000 PWR fuel assembly



Physical dimensions:
214 mm square x 4795 mm OL

Mass:
538.3 kg U (613 kg as UO_2)
~176 kg ZIRLO and other materials in cladding, spacers, etc.
789 kg total weight

Fissionable material:
Sintered pellets of UO_2
enriched up to 5% U-235

Typical burnup:
60,000 MWday/tonne U

Cladding material:
ZIRLO

Construction:

- Each fuel assembly consists of 264 fuel rods, 24 guide thimbles, and 1 instrumentation tube arranged within a 17 x 17 matrix supporting structure. The instrumentation thimble is located in the center position and provides a channel for insertion of an in-core neutron detector, if the fuel assembly is located in an instrumented core position. The guide thimbles provide channels for insertion of either a rod cluster control assembly, a gray rod cluster assembly, a neutron source assembly, a burnable absorber assembly, or a thimble plug, depending on the position of the particular fuel assembly in the core.

Comments:

- Used in Westinghouse AP1000 reactors

EPR PWR fuel assembly	
	**Physical dimensions:** 214 mm square x 4805 mm OL
	Mass: 527.5 kg U (598.0 kg as UO_2) ~182 kg other materials in cladding, spacers, etc. 780 kg total weight
	Fissionable material: Sintered pellets of UO_2 enriched up to 5% U-235
	Typical burnup: 62,000 MWday/tonne U
	Cladding material: M5
Construction: - Each fuel assembly consists of 265 fuel rods and 24 guide thimbles which can either be used for control rods or for core instrumentation arranged within a 17 x 17 matrix supporting structure. The guide thimbles provide channels for insertion of either a rod cluster control assembly, a gray rod cluster assembly, a neutron source assembly, a burnable absorber assembly, a thimble plug or core instrumentation, depending on the position of the particular fuel assembly in the core.	
Comments: - Used in Areva EPR reactors	

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Avril 2023

Programmes de gestion du combustible nucléaire irradié dans le monde

Le plan de gestion à long terme du combustible nucléaire irradié canadien prévoit que le combustible sera confiné et isolé dans un dépôt géologique en profondeur. L'approche canadienne est conforme aux meilleures pratiques adoptées dans le monde. La plupart des pays produisant de l'énergie nucléaire à une échelle commerciale prévoient isoler les déchets issus de leur cycle nucléaire dans un dépôt géologique en profondeur.

Les dépôts géologiques en profondeur utilisent une combinaison de barrières ouvragées et naturelles pour confiner le combustible nucléaire irradié et l'isoler des gens et de l'environnement. Les grandes organisations de réglementation et de surveillance nucléaire dans le monde s'entendent sur le fait que les dépôts géologiques en profondeur constituent la voie responsable à suivre pour la gestion à long terme de ces matières.

Un petit nombre de pays recyclent partiellement leur combustible nucléaire irradié dans des réacteurs existants. Certains pays prévoient construire des réacteurs avancés qui pourraient aussi recycler leur combustible nucléaire irradié. Ces cycles du combustible et ces réacteurs avancés génèrent des déchets de haute activité, un sous-produit dont les caractéristiques thermiques et radiologiques sont similaires à celles du combustible nucléaire irradié. Plusieurs études réalisées de par le monde ont conclu que les déchets de haute activité issus du retraitement du combustible et des réacteurs avancés devront également être confinés et isolés dans un dépôt géologique en profondeur.

CONSTRUCTION EN COURS	
Finlande	La construction du dépôt et des installations de surface est bien avancée. La demande de permis d'exploitation a été déposée en 2021 et le dépôt devrait être mis en service en 2024 ou 2025.

DEMANDE DE PERMIS DE CONSTRUIRE UN DÉPÔT PRÉSENTÉE	
Suède	En janvier 2022, le gouvernement suédois a approuvé le système de stockage permanent proposé par SKB. La prochaine étape de la procédure d'autorisation consistera pour la Cour des terres et de l'environnement à fixer les conditions applicables aux installations. L'Autorité suédoise de radioprotection décidera également des conditions d'autorisation applicables en vertu de la Loi sur les activités nucléaires. Une fois tous les permis obtenus, il faudra environ dix ans pour construire le dépôt de combustible irradié.
France	En janvier 2023, l'Andra a déposé une demande de permis pour la construction d'un dépôt géologique en profondeur. Les travaux de construction devraient débuter en 2025.

SITE CHOISI	
Russie	La construction débutera au terme des recherches qui seront effectuées dans un laboratoire souterrain en cours de construction sur le site choisi.
Suisse	En septembre 2022, la Nagra a annoncé que le combustible nucléaire irradié de la Suisse serait entreposé à Nördlich Lägern. La Nagra prévoit présenter une demande de permis de construire en 2024.

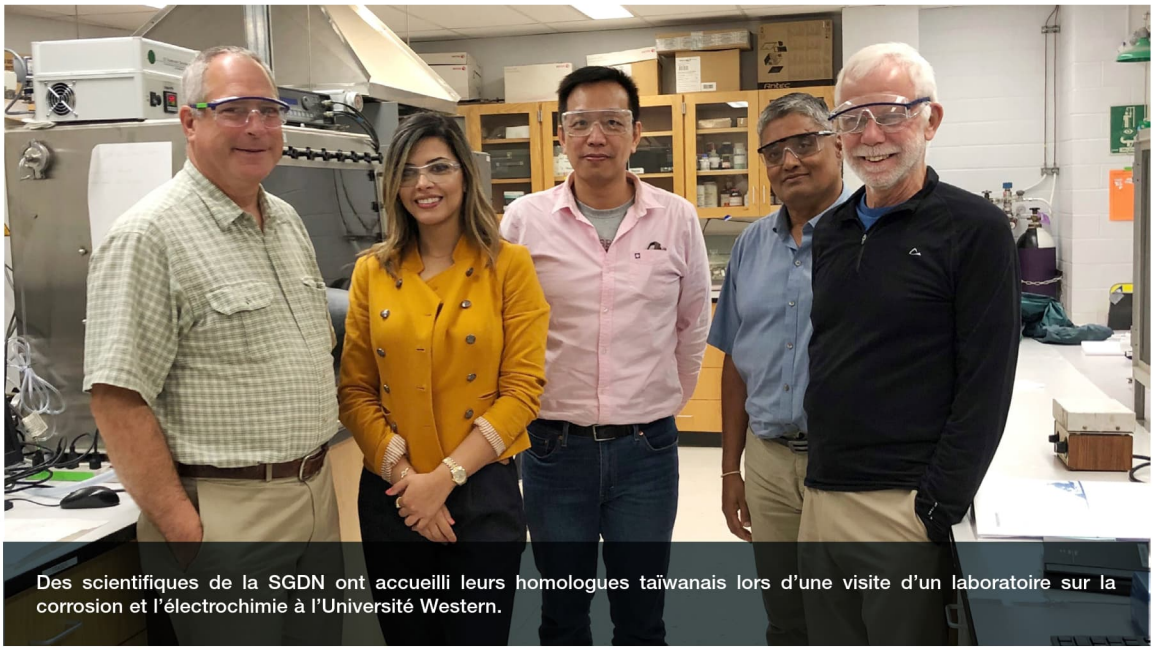
SÉLECTION D'UN SITE EN COURS	
Canada	Deux sites sont à l'étude. La sélection devrait se faire en 2024.
Chine	Un site a été choisi pour l'établissement d'un laboratoire de recherche souterrain en 2019. Il est fortement pressenti pour devenir le site du futur dépôt.
Hongrie	Le processus de sélection d'un site devrait aboutir vers 2032.
Inde	Les activités de sélection d'un site se concentrent dans la région du Rajasthan au nord-ouest.
Japon	Le processus de sélection d'un site devrait s'achever vers 2025 et l'exploitation du dépôt devrait commencer à partir de 2035 approximativement.
République tchèque	Une évaluation technique de quatre sites potentiels est en cours. La sélection du site de dépôt est prévue pour la fin des années 2030. Des tests géologiques supplémentaires seront ensuite réalisés pour confirmer le choix et le dépôt des demandes de permis est prévu pour la fin des années 2040.
Royaume-Uni	Un nouveau processus de sélection d'un site, débutant par une consultation des collectivités, a été lancé en 2018. La période initiale de consultation s'est achevée en 2019. Les résultats ont été intégrés aux documents d'évaluation des sites publiés au début de 2020. Ces documents décrivent les approches envisagées pour trouver un site en Angleterre ou dans le Pays de Galles. Depuis 2021, plusieurs partenariats ont été conclus avec des collectivités pour faire avancer les discussions sur le choix d'un site pour un dépôt géologique en profondeur de déchets radioactifs de haute activité.
Slovaquie	Deux sites font actuellement l'objet d'études détaillées, qui devraient s'achever en 2023.

Coopération et recherche internationales

La SGDN coopère sur des projets conjoints avec ses homologues d'autres pays, dont la Suède, la Finlande, la Suisse et le Royaume-Uni. Nos partenariats avec d'autres organisations de gestion de déchets radioactifs nous permettent de :

- Tirer profit de l'expérience des autres pays;
- Réaliser des études à l'aide d'installations non disponibles au Canada; et
- Veiller à ce que le choix du site, la conception du dépôt et le dossier de sûreté soient conformes aux meilleures pratiques internationales.

Certains de ces projets sont en cours dans des laboratoires de recherche souterrains. La SGDN a participé à des expériences au laboratoire du Mont Terri et au site d'essai de Grimsel, en Suisse, à l'installation ONKALO, en Finlande, et au laboratoire souterrain d'Äspö, en Suède.



Des scientifiques de la SGDN ont accueilli leurs homologues taïwanais lors d'une visite d'un laboratoire sur la corrosion et l'électrochimie à l'Université Western.



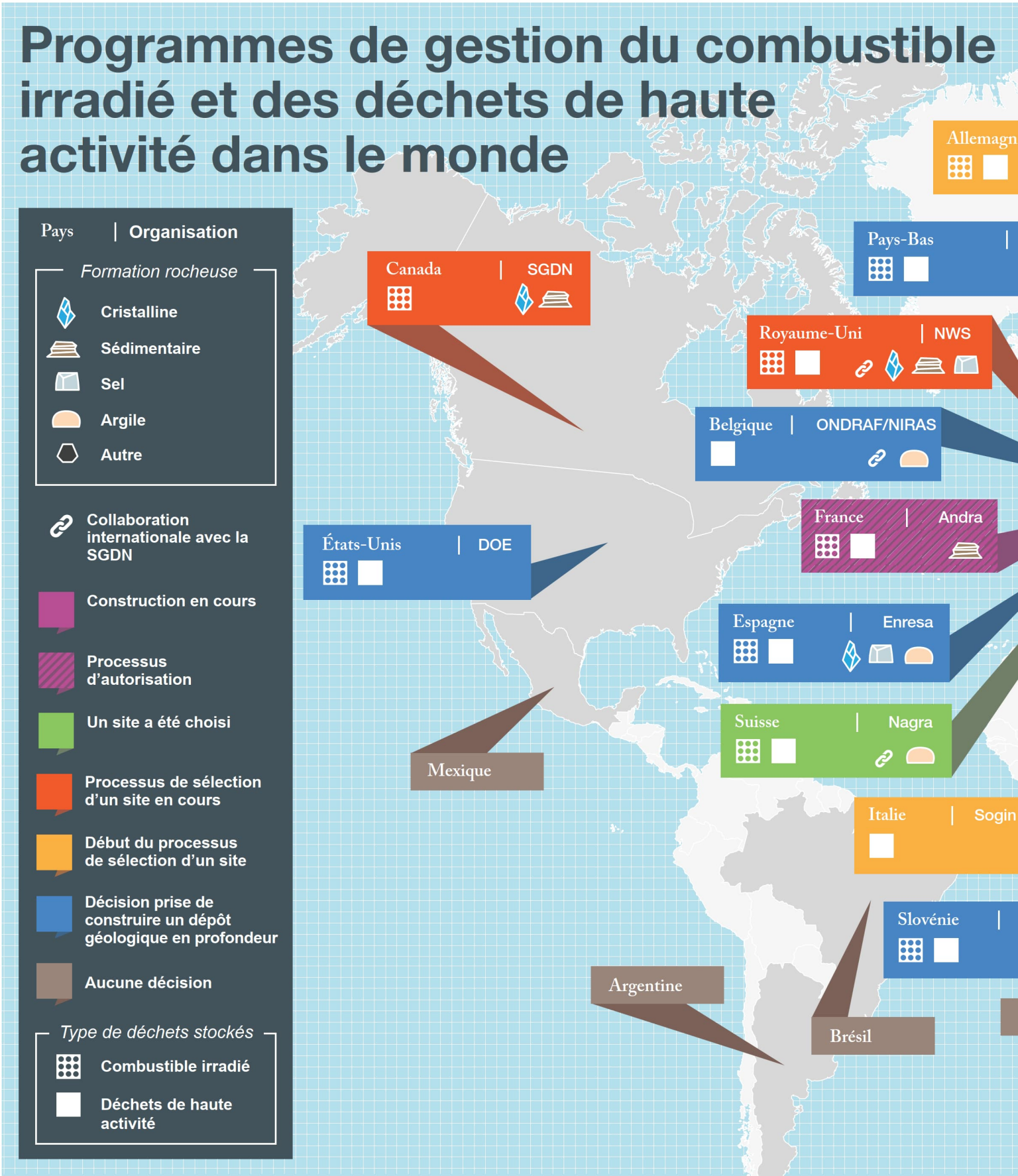
Des scientifiques de la SGDN se sont rendus en Finlande.



La SGDN a renouvelé son accord de coopération avec son homologue sud-coréen.

Pays	Exemples de collaboration internationale
Belgique Organisme national des déchets radioactifs et des matières fissiles enrichies (ONDRAF/NIRAS)	La SGDN et l'ONDRAF/NIRAS collaborent à l'évaluation de taux extrêmement faibles de corrosion afin d'estimer la stabilité dans le temps du cuivre et de l'acier dans un dépôt géologique en profondeur.
Corée du Sud Korea Hydro and Nuclear Power (KHNP)	La SGDN et la KHNP soutiennent des études sur l'intégrité à long terme des grappes de combustible CANDU.
Finlande Posiva	La SGDN tire des enseignements des essais de mise en place de conteneurs de combustible irradié et de barrières ouvragées que mène Posiva sur le site de son dépôt ONKALO.
Japon Organisation japonaise de gestion des déchets nucléaires (NUMO)	La SGDN collabore avec la NUMO à la mise au point d'un revêtement de cuivre pour conteneur de combustible irradié.
Royaume-Uni Nuclear Waste Services (NWS)	La SGDN, SKB, les NWS, COVRA et BGE mènent ensemble une étude sur l'hydrologie du pergélisol.
Suède Société suédoise de gestion du combustible et des déchets nucléaires (SKB)	La SGDN, SKB et Posiva cherchent ensemble à comprendre le comportement mécanique de la roche, notamment en menant des tests dans un laboratoire en surface en Suède. La SGDN, SKB, les NWS, COVRA et BGE mènent également ensemble une étude sur l'hydrologie du pergélisol.
Suisse Société coopérative nationale pour le stockage des déchets radioactifs (Nagra)	La SGDN et la Nagra mènent au laboratoire souterrain du Mont Terri et au site d'expérimentation de Grimsel de la Nagra un programme de recherche conjoint qui a pour but de valider leur compréhension du comportement des barrières ouvragées et des formations rocheuses dans les conditions géologiques profondes d'un dépôt.

Programmes de gestion du combustible irradié et des déchets de haute activité dans le monde




Suède | SKB
Finlande | Posiva
Russie | NO RAO
BGE
République tchèque | SÚRAO
COVRA
Slovaquie | JAVYS
Hongrie | PURAM
Japon | NUMO
Ukraine | SAUEZM
Chine | CNNC
Arménie
Iran
Romanie | ANDR
Taïwan | INER
Corée du Sud | KORAD
Pakistan
Bulgarie
Inde | AEC
ARAO
Croatie
Afrique du Sud | NRWDI
Australie

Programmes de gestion du combustible irradié et des déchets de haute activité dans le monde

Pays	Nom de l'organisation	Plan de gestion à long terme
Afrique du Sud	National Radioactive Waste Disposal Institute (NRWDI)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Allemagne	Société fédérale pour le stockage des déchets radioactifs (BGE)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Argentine	Comisión Nacional de Energía Atómica (CNEA)	Aucune décision (la décision doit être prise d'ici 2030 en vertu de la loi 25018)
Arménie		Aucune décision
Belgique	Organisme national des déchets radioactifs et des matières fissiles enrichies (ONDRAF/NIRAS)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Brésil	Comissão Nacional de Energia Nuclear (CNEN)	Aucune décision
Bulgarie	Société d'État de gestion des déchets radioactifs (SE RAW)	Aucune décision
Canada	Société de gestion des déchets nucléaires (SGDN)	Dépôt géologique en profondeur pour combustible nucléaire irradié
Chine	Compagnie nucléaire nationale chinoise (CNNC)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Corée du Sud	Agence coréenne des déchets radioactifs (KORAD)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Croatie		Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Espagne	Empresa Nacional de Residuos Radiactivos (ENRESA)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
États-Unis	Département de l'Énergie des États-Unis (DOE)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Finlande	Posiva	Dépôt géologique en profondeur pour combustible nucléaire irradié
France	Agence nationale pour la gestion des déchets radioactifs (Andra)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité

Situation	Type de géologie
Décision prise de construire un dépôt géologique en profondeur	À déterminer
Début du processus de sélection d'un site	Roche cristalline et sédimentaire et sel
Des recherches sont en cours pour identifier des sites candidats pour un dépôt géologique en profondeur de combustible nucléaire irradié ou de déchets de haute activité	À déterminer
Décision prise de construire un dépôt géologique en profondeur	L'argile est privilégiée (autres géologies étudiées dans une moindre mesure)
Processus de sélection d'un site en cours	Roche cristalline et sédimentaire
Processus de sélection d'un site en cours; laboratoire souterrain en construction sur un site potentiel	Roche cristalline
Décision prise de construire un dépôt géologique en profondeur	À déterminer
Le processus de sélection débutera vers 2050 pour trouver un site en Croatie ou en Slovénie (propriété conjointe du combustible)	À déterminer
Décision prise de construire un dépôt géologique en profondeur	Roche cristalline, argile et sel
Décision prise de construire un dépôt géologique en profondeur	À déterminer
Construction en cours; demande de permis d'exploitation déposée en 2021	Roche cristalline
Demande de permis pour la construction d'un dépôt déposée; la construction devrait commencer en 2025	Roche sédimentaire

Pays	Nom de l'organisation	Plan de gestion à long terme
Hongrie	Société publique de gestion des déchets radioactifs (PURAM)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Inde	Commissariat à l'énergie atomique (CEA)	Dépôt géologique en profondeur pour déchets de haute activité
Iran	Iran Nuclear Waste Management Company (INWM)	Aucune décision
Italie	Società Gestione Impianti Nucleari (Sogin)	Dépôt géologique en profondeur pour déchets de haute activité
Japon	Organisation japonaise de gestion des déchets nucléaires (NUMO)	Dépôt géologique en profondeur pour déchets de haute activité
Mexique		Aucune décision
Pakistan	Pakistan Atomic Energy Commission (PAEC)	Aucune décision
Pays-Bas	Organisation centrale pour les déchets radioactifs (COVRA)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
République tchèque	Autorité des dépôts de déchets radioactifs (SÚRAO)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Roumanie	Agence nucléaire pour les déchets radioactifs (ANDR)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Royaume-Uni	Nuclear Waste Services (NWS)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Russie	Opérateur national pour la gestion des déchets radioactifs (NO RAO)	Dépôt géologique en profondeur pour déchets de haute activité
Slovaquie	Société de l'énergie nucléaire et du déclassement (JAVYS)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Slovénie	Agence pour la gestion des déchets radioactifs (ARAO)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Suède	Société suédoise de gestion du combustible et des déchets nucléaires (SKB)	Dépôt géologique en profondeur pour combustible nucléaire irradié
Suisse	Société coopérative nationale pour le stockage des déchets radioactifs (Nagra)	Dépôt géologique en profondeur pour combustible nucléaire irradié et déchets de haute activité
Taïwan	Institut de recherche sur l'énergie nucléaire (INER)	Dépôt géologique en profondeur pour combustible nucléaire irradié
Ukraine	Agence d'État ukrainienne pour la gestion des zones d'exclusion (SAUEZM)	Dépôt géologique en profondeur pour déchets de haute activité

Situation	Type de géologie
Processus de sélection d'un site en cours	Argile
Processus de sélection d'un site en cours	Roche cristalline et sédimentaire et basalte
Début du processus de sélection d'un site	À déterminer
Processus de sélection d'un site en cours	Roche cristalline et sédimentaire
Décision prise de construire un dépôt géologique en profondeur	Sel et argile
Processus de sélection d'un site en cours; évaluation technique de quatre sites en cours	Roche cristalline
Début du processus de sélection d'un site	Sel, argile, roche cristalline et schistes verts
Processus de sélection d'un site en cours	Roche cristalline et sédimentaire et sel
Site choisi; laboratoire souterrain en construction	Roche cristalline
Processus de sélection d'un site en cours	Roche cristalline et sédimentaire
Un processus de sélection d'un site devrait débuter vers 2050 pour trouver un site en Croatie ou en Slovénie (propriété conjointe du combustible)	À déterminer
Demande de permis pour la construction d'un dépôt déposée	Roche cristalline
Site choisi; la Nagra prévoit déposer une demande de permis de construire d'ici 2024	Argile
Début du processus de sélection d'un site	Roche cristalline
Décision prise de construire un dépôt géologique en profondeur	Roche cristalline, argile et sel

NUCLEAR WASTE MANAGEMENT ORGANIZATION
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Inventaire des **DÉCHETS RADIOACTIFS** au **CANADA** 2019



Canada

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Inventaire des **DÉCHETS RADIOACTIFS** au **CANADA** 2019

Canada

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1.0 APERÇU DE L'INVENTAIRE DES DÉCHETS RADIOACTIFS AU CANADA

L'information contenue dans le présent document fournit un aperçu de la production, de l'accumulation des déchets radioactifs au Canada au 31 décembre 2019 ainsi que des projections. L'information et les données recueillies pour préparer l'inventaire des déchets radioactifs au Canada proviennent de rapports présentés par les propriétaires de déchets pour leurs installations de gestion des déchets.

Le présent rapport renferme de l'information et des extraits du 7e Rapport national du Canada pour la Convention commune sur la sûreté de la gestion du combustible usé et sur la sûreté de la gestion des déchets radioactifs.

Cette édition de l'Inventaire des déchets radioactifs est disponible sur le site Web de Ressources naturelles Canada à l'adresse https://www.rncan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/uranium-nuclear/17-0467%20Canada%20Radioactive%20Waste%20Report_access_f.pdf. Les éditions plus anciennes peuvent être obtenues sur demande.

Le tableau suivant présente un récapitulatif de l'inventaire des déchets radioactifs au Canada au 31 décembre 2019 et de la quantité de déchets produits en 2019.

Tableau 1. Résumé de l'inventaire des déchets radioactifs au Canada

Catégorie de déchets	Stocks de déchets à la fin de 2019	Déchets générés en 2019
Déchets radioactifs de haute activité	12 718 m^3 (0,5 %)	365 m^3
Déchets radioactifs de moyenne activité	15 681 m^3 (0,6 %)	182 m^3
Déchets radioactifs de faible activité	2 524 670 m^3 (98,9 %)	8 951 m^3
VOLUME TOTAL EN MÈTRES CUBES	2 553 069 m^3 (100 %)	9 498 m^3
Résidus issus du traitement de l'uranium	218 millions de tonnes	0,75 million de tonnes
Stériles issus de l'extraction de l'uranium	167 millions de tonnes	S. O.*
TOTAL EN TONNES	385 millions de tonnes	0,75 million de tonnes

*S. O. L'état des amas de stériles est dynamique par nature en raison des fluctuations du prix de l'uranium, qui déterminent le rapport du minerai aux stériles. Par conséquent, le taux d'accumulation annuel peut être trompeur. On utilise donc les stocks totaux des stériles pour obtenir une valeur reflétant plus fidèlement la réalité.

Comme l'indique le récapitulatif de l'inventaire, la plupart des déchets radioactifs du Canada (98,9 %) sont de faible activité, et près des trois quarts sont sous forme de sol contaminé, ce qui est le résultat de pratiques antérieures et héritées. Ces chiffres suivent la tendance à l'échelle mondiale selon laquelle la plupart des pays ont de plus grands volumes de déchets radioactifs de faible activité par rapport aux volumes beaucoup plus petits de déchets radioactifs de moyenne ou de haute activité, puisque les pratiques de travail cherchent à minimiser la production de déchets radioactifs et à limiter la contamination de l'équipement, des matériaux et du sol. Plus les déchets ont un niveau de radioactivité élevé, plus ils présentent un danger, ce qui nécessite une sophistication croissante de la manutention, du stockage provisoire et de la gestion à long terme pour assurer la protection des travailleurs, du public et de l'environnement. Par exemple, les déchets radioactifs de faible activité ont de faibles exigences en matière d'isolation et de blindage alors que les déchets radioactifs de moyenne ou de haute activité requièrent davantage de blindage pour la manutention, le stockage provisoire et l'isolation à long terme.



Signalons que dans le présent rapport, les nombres présentés pourraient ne pas correspondre exactement aux totaux affichés en raison de l'arrondissement, et les pourcentages pourraient ne pas refléter avec exactitude les nombres absolus.

1.1 Déchets radioactifs : définition et catégories

Selon le tome 1 du document d'application de la réglementation 2.11.1 de la CCSN, les déchets radioactifs au Canada désignent toute matière (liquide, gaz ou solide) renfermant une substance nucléaire radioactive pour laquelle aucune utilisation ultérieure n'est prévue. Par le truchement des parties responsables pertinentes, le gouvernement du Canada s'est engagé à assurer une gestion continue des déchets radioactifs de façon sécuritaire et respectueuse de l'environnement.

La norme CSA N292.0:F19 distingue quatre grandes catégories de déchets radioactifs au Canada :



Instaurée par le gouvernement et les intervenants de l'industrie en vue d'établir des exigences techniques pour de saines pratiques de gestion des déchets, la norme CSA N292.0:F19 est entrée en vigueur en mars 2019. Le système de classification des déchets radioactifs qu'il propose est organisé selon le degré de confinement et d'isolement requis pour assurer la sûreté à court et à long terme. Il tient également compte du risque associé aux différents types de déchets radioactifs. Une distinction précise entre les DRFA et les DRMA ne peut être établie, puisque les limites du niveau acceptable d'activité volumique diffèrent selon les radionucléides particuliers ou les groupes de radionucléides et sont fonction des aspects à prendre en compte pour la gestion à court et à long terme. Par exemple, une dose au contact de 2 millisieverts l'heure (mSv/h) a été utilisée dans certains cas pour établir une différence entre les DRFA et les DRMA. Les sections 2.0, 3.0, 4.0 et 7.0 fournissent un sommaire détaillé et un inventaire de chacune des quatre grandes catégories de déchets radioactifs.

1.1.1 Procédés qui génèrent des déchets radioactifs au Canada

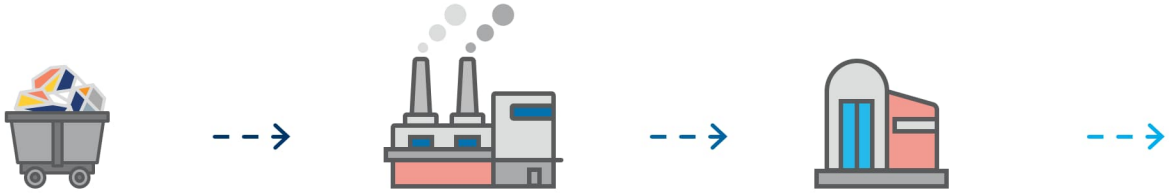
Les déchets radioactifs sont un sous-produit de l'utilisation de la technologie nucléaire au Canada. Ils sont produits à différentes étapes du cycle du combustible nucléaire, notamment l'extraction minière, le raffinage et la conversion de l'uranium; la fabrication du combustible nucléaire; les activités des réacteurs nucléaires et de recherche; et le déclassement éventuel des installations nucléaires.

Les déchets radioactifs sont également produits par d'autres activités et installations, notamment :

- Activités médicales – les matières radioactives sont utilisées à diverses fins dans l'industrie médicale, notamment pour les procédures de diagnostic des hôpitaux et des laboratoires, le traitement des maladies et la stérilisation de l'équipement;
- Activités industrielles – le secteur industriel utilise des matières radioactives pour des essais non destructifs de matériaux et de composants;

- Activités de recherche – la recherche universitaire et industrielle utilisant des matières radioactives peut produire une petite quantité de déchets radioactifs.

Figure 1. Procédés qui génèrent des déchets radioactifs au Canada



Extraction et traitement du minerai d'uranium

Traitement du minerai d'*uranium* qui produit du *concentré d'uranium*.

Raffinage

Pendant le raffinage, le concentré de minerai d'uranium provenant des activités de concentration est transformé en *trioxyde d'uranium*.

Conversion

Le trioxyde d'uranium est ensuite converti en dioxyde d'*uranium de qualité céramique* pour la fabrication de combustible destiné aux réacteurs CANDU, ou transformé en hexafluorure d'uranium pour alimenter les réacteurs à eau légère à l'étranger.

Résidus de l'extraction et de la concentration de l'uranium

Stériles (minéralisés)
Résidus de traitement

Déclassement de mines
Fermeture de mines

Les stériles et les résidus de traitement de l'uranium se trouvent dans les mines et les usines de traitement de l'uranium. Comme les quantités de résidus sont considérables et que les niveaux de radioactivité sont faibles, les sites de stockage sont habituellement déclassés sur place.

DRFA historiques (années 1930 à 1970)
Déchets provenant de la manutention, du transport, du traitement et de l'utilisation

Faible activité

Déchets incinérables
Bois de rebut, palettes, chiffons, papier, carton, caoutchouc et plastique

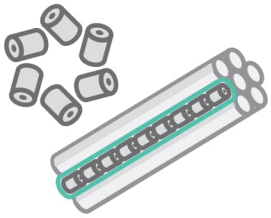
Déchets non incinérables
Filtres à air, fibre de verre, gaines en PVC, balayures de plancher, sable utilisé pour le sablage au jet, isolant, bouteilles de prélèvement, ferraille, anodes

Autres déchets
Ferraille recyclable, déchets radioactifs de drains

DRFA historiques (1930 – 1970)
Déchets provenant de la manutention, du transport, du traitement et de l'utilisation

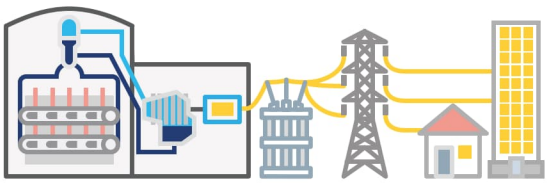
Faible activité

Autres déchets
Chiffons, papier, gants, huiles et boues d'huiles, équipement et matériaux de construction, filtres et collecteurs de poussière



Fabrication de combustible et production de grappes de combustible

Lors de la fabrication de combustible, le dioxyde d'uranium est fritté sous forme de pastilles. Ces *pastilles de combustible* sont ensuite transformées en *grappes de combustible* destinées aux réacteurs.



Réacteur Nucléaire

Les grappes de combustible sont chargées dans des réacteurs de puissance destinés à la production d'*électricité* , ou dans des réacteurs de recherche pour la production de radio-isotopes ou pour des activités de *recherche et de développement.*

Environ 15 % de l'uranium extrait au Canada sert à la production intérieure d'électricité nucléaire.

Faible et moyenne activité

Déchets incinérables
Papier, plastique, caoutchouc, coton, bois, liquides organiques

Déchets compactables
Papier, combinaisons en plastique PVC, caoutchouc, fibre de verre, pièces de métal, fûts vides

Non-Processable Waste
Déchets non traitables
Filtres, ampoules électriques, câbles, équipement usagé, débris de métaux de construction, absorbants (sable, vermiculite, abat-poussière), résine échangeuse d'ions, composants du cœur du réacteur, déchets de retubage

Liquides traitables
Déchets radioactifs de drains, solution de nettoyage chimique

Faible et moyenne activité

Déclassement d'un réacteur nucléaire

1 PHASE

Déchets incinérables
Papier, plastique, caoutchouc, coton, bois

Déchets compactables
Papier, combinaisons en plastique PVC, caoutchouc, fibre de verre, pièces de métal

Déchets non traitables
Filtres, équipement usagé, résine échangeuse d'ions, absorbants (sable, vermiculite, abat-poussière)

Liquides traitables
Déchets radioactifs de drains.
Solution de décontamination.

2 PHASE

Petites quantités de DRFMA

3 PHASE

Déchets
Comme la phase 1
+ Systèmes actifs (p. ex., composants de canaux de combustible, calandre, réservoirs du réacteur, canalisations, chaudières)

+ Structures actives (p. ex., bouclier biologique, baie de carburant

Haute activité

(Déchets de combustible nucléaire)
Stockage provisoire

En Piscine





À sec

1.1.2 Réduction des déchets radioactifs

Étant donné qu'il n'existe pas encore d'installations d'évacuation de déchets radioactifs au Canada qui se conforment aux normes N292.0 et N294 du Groupe CSA, l'accent est mis sur la minimisation, la réduction du volume, le conditionnement et le stockage provisoire ou à long terme des déchets. Le volume des déchets peut être réduit avant leur stockage en remettant en état l'espace de stockage existant, en compactant et séparant davantage les déchets, ou en utilisant une combinaison des deux méthodes.

De plus, les installations de traitement de l'uranium peuvent réduire leurs déchets par l'incinération et la récupération ou la réutilisation de métaux contenant de l'uranium.

Dans le cas des centrales nucléaires, avant le stockage, le volume des déchets radioactifs peut être réduit par incinération, compactage, évaporation de liquide, déchiquetage ou fusion de métaux. En outre, les centrales nucléaires canadiennes comportent des installations pour la décontamination des pièces et des outils, le lavage des vêtements de protection et la remise en état et la réhabilitation de l'équipement. Certains exploitants ont également recours à des services hors site.

Grâce à ces méthodes, les exploitants ont la possibilité d'obtenir une réduction de volume de 80:1 pour les déchets incinérables, c'est-à-dire les déchets qui peuvent être décomposés à l'aide d'un incinérateur, et de 5:1 pour les déchets compactables.

1.1.3 Sources radioactives scellées retirées du service

Une vaste gamme d'organismes, y compris les universités, les hôpitaux, les installations industrielles et les ministères gouvernementaux, emploient des sources radioactives scellées. Ces sources sont utilisées à des fins industrielles, médicales, commerciales et universitaires ainsi que pour des applications de recherche.

La plupart des sources radioactives scellées sont de petite taille, mais leur radioactivité peut varier de dizaines à des milliards de becquerels. Lorsque ces sources ne sont plus utilisées ou ont atteint la fin de leur durée de vie utile et qu'elles ne seront plus utilisées pour les fins autorisées, elles deviennent des sources radioactives scellées qui sont retirées du service. Elles peuvent ensuite être retournées au fabricant au Canada ou à leur pays d'origine ou être envoyées à une installation de gestion des déchets autorisée.

Au Canada, certains manufacturiers recyclent les sources radioactives scellées à la fin de leur vie utile en réutilisant les sources dégradées pour d'autres applications, en les enveloppant ou en les traitant de nouveau pour d'autres applications utiles.

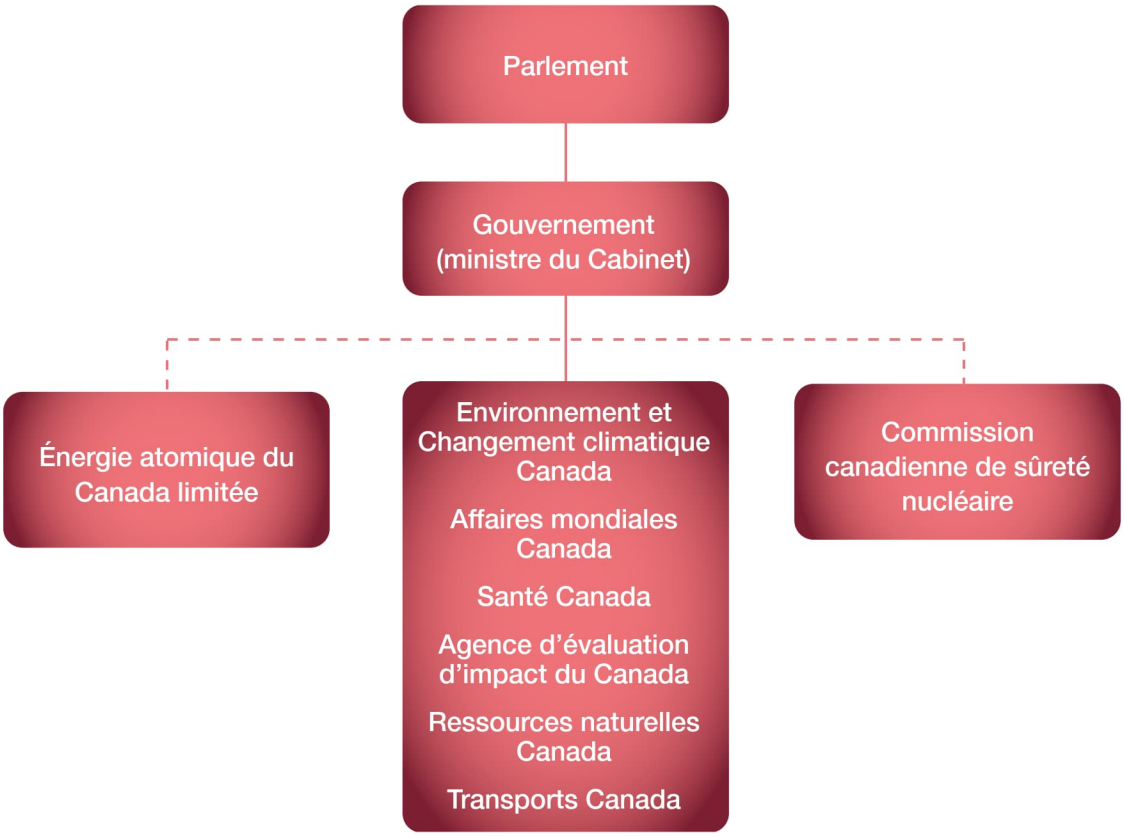
1.2 Principales organisations fédérales chargées de la surveillance, de la réglementation et de la gestion des déchets radioactifs au Canada

Ressources naturelles Canada (RNCan) est le ministère fédéral responsable de l'élaboration et de la mise en œuvre des politiques de gestion de l'uranium, de l'énergie nucléaire et des déchets radioactifs au Canada. RNCan remplit cette fonction avec le soutien d'autres ministères fédéraux qui ont des responsabilités en matière de gestion des déchets radioactifs au Canada.

Conformément à la Politique-cadre en matière de déchets radioactifs du Canada, les propriétaires de déchets radioactifs sont responsables du financement, de l'organisation, du développement et de la gestion de leurs déchets respectifs en plus d'exploiter, au besoin, des installations de gestion à long terme.

Dans le cas des DRFA historiques, le gouvernement du Canada assume la responsabilité de leur gestion de façon ponctuelle.

Figure 2. Responsabilités fédérales pour la gestion des déchets radioactifs



Environnement et Changement climatique Canada est responsable de l'administration de la *Loi canadienne sur la protection de l'environnement*. Il gère également l'Inventaire national des rejets de polluants (INRP) L'INRP est l'inventaire public canadien des émissions, des éliminations et des transferts. Les installations qui atteignent les seuils de déclaration doivent déclarer à l'INRP toute émission des installations dans l'air, l'eau ou le sol.

Affaires mondiales Canada est le ministère fédéral responsable de la promotion de la coopération et de la sécurité nucléaires, tant sur le plan bilatéral que multilatéral. Il met également en œuvre les principaux accords sur la non-prolifération et le désarmement au Canada et à l'étranger.

Santé Canada est le ministère fédéral chargé d'aider les Canadiens à maintenir et à améliorer leur santé. Dans le domaine de la radioprotection, Santé Canada contribue au maintien et à l'amélioration de la santé des Canadiens en leur fournissant des conseils et de l'information sur les risques liés aux sources naturelles et artificielles de rayonnement.

L'Agence d'évaluation d'impact du Canada (AÉIC) est responsable de l'administration de la Loi sur l'évaluation d'impact (LEI), la principale loi fédérale qui définit les exigences relatives à l'évaluation des impacts environnementaux, sanitaires, sociaux et économiques des projets proposés. En vertu de la LEI, l'AÉIC dirige l'examen de projets d'envergure et collabore avec la CCSN pour examiner les projets qui sont également assujettis à la réglementation en vertu de la LSRN. Les projets nucléaires devant être évalués en vertu de la LEI font l'objet d'une évaluation d'impact intégrée menée par une commission d'examen.

La mission de Transports Canada est d'élaborer et d'administrer les politiques, les règlements et les services connexes permettant d'assurer un réseau de transport national sûr et sécuritaire, efficace, abordable, intégré et respectueux de l'environnement. Transports Canada établit des politiques, des règlements et des normes pour assurer la sécurité, la sûreté et l'efficacité des réseaux de transport ferroviaire, maritime, routier et aérien du Canada. Ses responsabilités comprennent notamment la surveillance du transport des marchandises dangereuses, comme les substances nucléaires, et l'assurance que les développements connexes peuvent être soutenus.

1.2.1 Énergie atomique du Canada limitée

Énergie atomique du Canada limitée (EACL) est une société d'État dont le seul actionnaire est le gouvernement du Canada. Depuis près de 70 ans, EACL est un chef de file mondial dans l'élaboration d'applications pacifiques et novatrices de la technologie nucléaire. Son mandat est de soutenir la science et la technologie nucléaires et de gérer les responsabilités du gouvernement fédéral en matière de déclassement et de déchets radioactifs. EACL s'acquitte de son mandat en concluant des ententes contractuelles à long terme avec le secteur privé pour la gestion et l'exploitation de ses sites selon le modèle d'organisme gouvernemental exploité par un entrepreneur (OGEE). Les Laboratoires Nucléaires Canadiens (LNC) assument la gestion des sites d'EACL, ce qui comprend l'exploitation des laboratoires nucléaires et la réalisation d'activités de déclassement et de gestion des déchets. Les activités liées au déclassement et à la gestion des déchets radioactifs sont nécessaires pour réduire certains risques en matière de responsabilité ainsi que les dangers découlant de décennies de recherche nucléaire sur les sites d'EACL. EACL est également responsable du nettoyage et de la gestion sécuritaire et à long terme des DRFA historiques à d'autres sites au Canada dont le gouvernement du Canada a accepté la responsabilité. Cela comprend l'Initiative de la région de Port Hope (IRPH) et les activités associées au Bureau de gestion des déchets radioactifs de faible activité.

1.2.2 Réglementation des déchets radioactifs au Canada

Au Canada, la gestion des déchets radioactifs est effectuée de façon sûre, sécuritaire et respectueuse de l'environnement, conformément aux exigences de la Commission canadienne de sûreté nucléaire (CCSN), organisme de réglementation nucléaire indépendant

Bien que les ministères et les organismes fédéraux aient des responsabilités et des rôles particuliers en matière de gestion sécuritaire des déchets radioactifs, c'est la CCSN qui régit les déchets radioactifs au pays. Le mandat de la CCSN vise notamment à :

- réglementer l'utilisation de l'énergie et des matières nucléaires afin de protéger la santé et l'environnement et d'assurer la sûreté et la sécurité;
- respecter les engagements pris par le Canada à l'échelle internationale au chapitre de l'utilisation pacifique de l'énergie nucléaire;
- transmettre au public de l'information scientifique, technique et réglementaire qui est objective.

En ce qui concerne les déchets radioactifs, la CCSN réglemente les installations de gestion des déchets radioactifs du Canada afin d'en assurer une exploitation sécuritaire. Elle soumet les exploitants à des exigences rigoureuses en matière de déclaration et effectue des inspections et des vérifications pour assurer la conformité des installations aux exigences établies en matière de sécurité. La CCSN prend ses décisions en matière de réglementation de manière entièrement indépendante du gouvernement du Canada. En outre, l'industrie nucléaire est assujettie à la législation et à la réglementation des provinces et des territoires où des activités nucléaires sont menées. Lorsqu'il y a chevauchement des compétences et des responsabilités, la CCSN s'assure d'harmoniser les activités, notamment en mettant en place des groupes mixtes composés de représentants d'organismes de réglementation provinciaux et territoriaux.

1.2.3 Principales politiques et lois régissant les déchets radioactifs au Canada

Politique-cadre en matière de déchets radioactifs du Canada (1996)

La *Loi sur la sûreté et la réglementation nucléaires* (LSRN)

La *Loi sur les déchets de combustible nucléaire* (2002)

Politique-cadre en matière de déchets radioactifs

Au Canada, les déchets radioactifs sont gérés conformément à la *Politique-cadre en matière de déchets radioactifs*. Les principes énoncés dans ce document régissent les aspects institutionnels et financiers de l'évacuation des déchets radioactifs par les producteurs et les propriétaires de déchets. En bref, ces principes incluent les suivants :

- Le gouvernement fédéral doit veiller à ce que l'évacuation des déchets radioactifs soit effectuée de manière sécuritaire, respectueuse de l'environnement, complète, rentable et intégrée.
- Le gouvernement fédéral a la responsabilité d'élaborer les politiques, les règlements et les mécanismes de surveillance nécessaires pour faire en sorte que les producteurs et les propriétaires de déchets se conforment aux exigences de la loi et s'acquittent de leurs responsabilités financières et opérationnelles conformément aux plans approuvés d'évacuation des déchets.
- Conformément au principe du « pollueur payeur », les producteurs et les propriétaires de déchets sont responsables du financement, de l'organisation, de la planification, du développement et de l'exploitation des installations nécessaires à l'évacuation de leurs déchets. Il est convenu que les dispositions peuvent varier selon qu'il s'agit de DRHA, DRMA, DRFA ou de résidus d'extraction et de traitement de l'uranium.

La *Loi sur la sûreté et la réglementation nucléaires* (LSRN)

Le gouvernement du Canada a promulgué la LSRN pour régir le développement, la production et l'utilisation de l'énergie nucléaire ainsi que la production, la possession et l'utilisation de substances et d'équipement nucléaires et d'information connexe. La CCSN, organisme indépendant de réglementation de l'énergie et des matières nucléaires au Canada, a été établie dans le cadre de la LSRN.

Le cadre réglementaire de la CCSN comporte des règlements ainsi que des politiques, des normes et des guides de réglementation connexes visant l'ensemble des activités nucléaires, y compris notamment les réacteurs de puissance nucléaire; les réacteurs nucléaires ne produisant pas de puissance, y compris les réacteurs de recherche; les substances nucléaires et les appareils à rayonnement utilisés dans l'industrie, la médecine et la recherche; le cycle du combustible nucléaire, de l'extraction de l'uranium à la gestion des déchets; ainsi que l'importation et l'exportation de substances, d'équipements et de technologies nucléaires contrôlés et à double usage présentant un risque de prolifération.

La *Loi sur les déchets de combustible nucléaire* (LDCN)

La LDCN régit la gestion à long terme des déchets de combustible nucléaire (DRHA) au Canada. Cette loi énonce les responsabilités du gouvernement fédéral et des propriétaires de ces déchets. En vertu de cette loi, les sociétés d'énergie nucléaire doivent mettre en place une organisation de gestion des déchets pour élaborer et mettre en œuvre une solution à long terme pour les déchets de combustible nucléaire produits au Canada. En 2002, la Société de gestion des déchets nucléaires (SGDN) a donc été créée pour réaliser ce travail. Toujours en vertu de cette loi, l'une des responsabilités importantes du gouvernement consistait à choisir une approche de gestion à long terme des déchets de combustible nucléaire qui soit dans l'intérêt de la population canadienne et de l'environnement. Ainsi, le 14 juin 2007, le gouvernement du Canada a annoncé qu'il avait choisi l'approche de la gestion adaptative progressive (GAP) recommandée par la SGDN pour la gestion à long terme des déchets de combustible nucléaire au Canada. La SGDN doit maintenant mettre en œuvre la décision du gouvernement, conformément à la LDCN et aux autres lois et règlements pertinents.

Le ministre des Ressources naturelles est tenu d'administrer la LDCN et d'assurer que les sociétés d'énergie nucléaire et la SGDN s'y conforment.

1.3 Déchets découlant d'activités courantes

Tous les déchets produits dans le cadre d'activités courantes sont considérés comme étant des déchets d'exploitation. Ils consistent habituellement en une forme quelconque de matière jetable qui a été contaminée pendant son utilisation, par exemple, des chiffons, des gants, du papier, du carton et des combinaisons de plastique.

Les déchets d'exploitation s'accumulent régulièrement et c'est le producteur qui en assume la responsabilité. Les propriétaires ou les producteurs de déchets d'exploitation sont tenus d'assurer leur gestion courante et à long terme.

1.4 Déchets découlant d'activités de déclassement

Dans le contexte de l'industrie nucléaire, le déclassement désigne les mesures prises dans le but de mettre définitivement fin à une activité ou une installation autorisée et de le rendre à l'état final, en vue de protéger la santé et l'environnement et d'assurer la sûreté et la sécurité.

Le déclassement d'installations nucléaires et de réacteurs de recherche et de puissance est considéré comme étant terminé une fois que les activités prévues ont été menées et que l'ensemble des matières, des déchets, de l'équipement et des structures ont été gérés en toute sécurité, y compris l'assainissement des terres connexes. Ceci permet de réduire ou d'éliminer tous les risques pour le personnel, le public et l'environnement, libérant ainsi le site ou la zone des exigences en matière de contrôle réglementaire.

Le tableau 2 donne un aperçu du cycle de vie de réacteurs existants au Canada. Les dates indiquent la durée du cycle de production de combustible nucléaire usé, ainsi que de déchets d'exploitation et de déclassement.

Tableau 2. Dates de mise en service et d'arrêt des réacteurs

Entreprise – nom du site	État du réacteur en décembre 2019	Début du service	Date d'arrêt prévu	
RÉACTEURS DE PUISSANCE				
OPG – Bruce A	En service	1977–1979	2062	
OPG – Bruce B	En service	1984–1987	2063	
OPG – Darlington	En service	1990–1993	2056	
OPG – Pickering A	Unités 1 et 4 en service Unités 2 et 3 arrêtées/déclassement	1971–1973	Réacteurs 2 et 3 : 1997	Réacteurs 1 et 4 : 2022
OPG – Pickering B	En service	1983–1986	2024	
Hydro-Québec – Gentilly-2	Arrêt/déclassement	1983	2012	
Énergie NB – Point Lepreau	En service	1983	2041	
RÉACTEURS PROTOTYPES, DE DÉMONSTRATION ET DE RECHERCHE				
EACL – Douglas Point	Arrêt et déclassement partiel	1968	1984	
EACL – Gentilly-1	Arrêt et déclassement partiel	1972	1977	
EACL – RND	Arrêt et déclassement partiel	1962	1987	
EACL – NRU	Arrêt et déclassement partiel	1957	2018	
EACL – NRX	Arrêt et déclassement partiel	1947	1993	
EACL – WR-1	Arrêt et déclassement partiel	1965	1985	
EACL – ZED-2	En service	1960	À déterminer	
Université McMaster – Réacteur nucléaire	En service	1959	2024[1]	
École Polytechnique (SLOWPOKE-2)	En service	1976	2023[1]	
Saskatchewan Research Council (SLOWPOKE-2)	Déclassé	1976	2019	
Université de l'Alberta (SLOWPOKE-2)	Déclassé	1977	2017	
Collège militaire royal du Canada (SLOWPOKE-2)	En service	1985	2023[1]	

[1] Date de fin du permis d'exploitation en cours, sujet à un renouvellement avec l'approbation de la CCSN.

Déchets de déclassement

Le déclassement des réacteurs nucléaires et de leurs installations de soutien produit une quantité considérable de déchets. Ces déchets de déclassement contiennent aussi bien des DRFA que des DRMA. Les DRFA sont essentiellement composés de matériaux de construction légèrement contaminés, tandis que les DRMA contiennent des matières provenant du cœur du réacteur.

Avant de procéder au déclassement, les grappes de combustible sont retirées du cœur du réacteur. Par conséquent, on estime que ces DRHA ne sont pas des déchets de déclassement.

Phases du déclassement d'un réacteur nucléaire

La CCSN exige que le déclassement soit planifié tout au long du cycle de vie de l'installation nucléaire ou de l'activité autorisée.

Au Canada, les phases typiques de déclassement sont les suivantes :

- Phase 1 – Planification du déclassement : cette phase commence généralement au stade du choix de l'emplacement ou de la conception (ou le plus tôt possible) et se poursuit jusqu'à la phase de préparation du déclassement.

- Phase 2 – Préparation en vue du déclassement : cette phase commence avec la décision de cesser l'exploitation ou l'exécution des activités, et comprend les activités visant l'arrêt permanent ou la cessation définitive et la transition vers un état stable en vue du déclassement. Cette phase, qui débute par l'arrêt du réacteur, peut durer jusqu'à dix ans, période pendant laquelle plusieurs centaines de mètres cubes de déchets radioactifs peuvent être produits par réacteur.

- Phase 3 – Exécution du déclassement : cette phase débute lorsque commencent les activités de déclassement, lesquelles peuvent comprendre la décontamination, le démantèlement ou le nettoyage, ainsi que toute période de stockage sous surveillance, et se poursuit jusqu'à l'atteinte de l'état final.

- La surveillance au cours de cette phase peut durer jusqu'à 65 ans, période pendant laquelle de très faibles volumes de déchets radioactifs sont produits.

- Le démantèlement peut durer jusqu'à vingt ans et produira la majorité des déchets radioactifs. Ce processus peut être amorcé sans entreposage ou surveillance des déchets.

- Phase 4 – Achèvement du déclassement : cette phase consiste à vérifier que toutes les activités liées au déclassement ont été réalisées de façon satisfaisante, que l'état final a été atteint et que toute la documentation a été remplie. Le déclassement prend fin lors de la levée du contrôle réglementaire de l'installation, de l'emplacement ou du site; si la levée complète n'est pas possible, des contrôles institutionnels doivent être mis en place.

État du déclassement des réacteurs et des installations au Canada

Réacteurs de puissance

La phase 2 du déclassement du réacteur de puissance de Gentilly-2 d'Hydro-Québec ont commencé en 2012. Les plans de déclassement final, y compris les estimations du volume de déchets, sont en cours de préparation. Aucun déchet de déclassement n'a été signalé pour l'instant. Les réacteurs des unités 2 et 3 de la centrale nucléaire Pickering d'Ontario Power Generation sont à la phase 3 du déclassement.

Réacteurs de recherche et prototype et installations

On trouve au Canada trois prototypes de réacteurs de puissance. Le réacteur Douglas Point et le réacteur nucléaire de démonstration (RND) sont situés en Ontario à Douglas Point et à Rolphton, respectivement, alors que le réacteur Gentilly-1 est à Bécancour, au Québec. Chacune de ces installations a été partiellement déclassée et est actuellement à la phase 3. Un déclassement in situ du RND a été proposé par les LNC.

Les projets de déclassement sont en cours dans les installations d'EACL aux Laboratoires de Chalk River et aux Laboratoires de Whiteshell. L'étape 1 du déclassement du réacteur WR-1 de Whiteshell aux Laboratoires de Whiteshell (Pinawa, Manitoba) a pris fin en 1994; l'étape 2 du déclassement est en cours. Un déclassement in situ a également été proposé pour le réacteur WR-1.

L'Université de Toronto a terminé en 2000 le déclassement de son assemblage sous-critique. L'installation SLOWPOKE de l'Université Dalhousie a été déclassée en 2011. L'Université de l'Alberta a terminé en 2017 le déclassement de son réacteur nucléaire SLOWPOKE. Le réacteur du Conseil de recherche de la Saskatchewan a terminé le déclassement de son réacteur nucléaire SLOWPOKE en 2019.

Déclassement et remise en état des sites d'EACL

Outre les activités préliminaires de déclassement de réacteurs en cours aux Laboratoires de Chalk River et aux Laboratoires de Whiteshell d'EACL, d'autres installations et infrastructures à ces sites sont également en cours de déclassement. Mentionnons notamment le démantèlement des installations de soutien, comme les bâtiments de recherche ou de stockage qui sont devenus contaminés et redondants, ou la remise en état de terrains contaminés. Ces activités produiront des DRFA et de DRMA. La section 5.0 fournit un sommaire des déchets de déclassement qui seront produits dans l'avenir.

1.5 Projections pour les déchets radioactifs

Afin d'évaluer les besoins futurs en matière de gestion des déchets radioactifs, des projections des stocks sont présentées jusqu'à la fin de 2022, 2030, 2050 et 2100. Le prochain inventaire des déchets radioactifs étant prévu pour 2022, cette année a été choisie comme année de référence pour évaluer l'exactitude de l'ensemble des projections. Les trois dernières années de projection (2030, 2050 et 2100) ont été choisies aux fins d'harmonisation avec les exigences internationales en matière de rapports. Enfin, les projections pour 2100 ont été demandées aux propriétaires de déchets afin que les déchets découlant du déclassement de tous les réacteurs soient pris en compte dans le présent cycle de production de rapports.

Tableau 3. Volumes des déchets prévus pour l'avenir (projections pour 2022, 2030, 2050 et 2100)

Catégorie de déchets	Stocks de déchets à la fin de 2019	Stocks projetés des déchets en 2022	Stocks projetés des déchets en 2030	Stocks projetés des déchets en 2050	Stocks projetés des déchets en 2100
DRHA	12 718 m^3	13 580 m^3	15 805 m^3	21 015 m^3	22 856 m^3
DRMA	15 681 m^3	18 361 m^3	24 927 m^3	30 087 m^3	32 324 m^3
DRFA	2 524 670 m^3	2 616 087 m^3	2 732 717 m^3	3 082 690 m^3	3 410 478 m^3
Résidus issus du traitement de l'uranium	218 millions de tonnes	S. O.*	S. O.*	S. O.*	S. O.*
Stériles issus de l'extraction de l'uranium	167 millions de tonnes	S. O.*	S. O.*	S. O.*	S. O.*

*S. O. Aucune projection n'est fournie pour les stocks de résidus de traitement de l'uranium ou des stériles puisque toute hausse des stocks est fonction des niveaux de production, lesquels sont sujets aux fluctuations des prix du marché de l'uranium. Voir la section 7.4.

1.6 Installations de gestion des déchets à long terme

Un des objectifs du rapport d'inventaire triennal est de fournir un aperçu des stocks de déchets actuels et futurs afin de planifier adéquatement leur gestion à long terme. Ceci présente un intérêt particulier parce que les projets de gestion à long terme demandent de grandes périodes de planification pour tenir compte des répercussions environnementales, socio-économiques et culturelles.

Conformément à la *Politique-cadre en matière de déchets radioactifs* du Canada, les propriétaires de déchets sont responsables du financement, de l'organisation, de la planification, du développement et de l'exploitation des installations de gestion de leurs déchets.

De nombreuses initiatives sont en cours pour mettre en œuvre des solutions à long terme pour les déchets de combustible nucléaire et les déchets radioactifs. Le Canada ne procède pas au retraitement de ses combustibles usés et fait des progrès pour trouver à l'échelle nationale une solution pour les déchets de combustible nucléaire tenant compte de l'évacuation. La SGDN met en œuvre un processus volontaire de sélection d'un site pour trouver une collectivité désireuse et renseignée ayant un site adéquat pour accueillir un dépôt géologique en profondeur pour assurer la gestion à long terme des déchets de combustible nucléaire. Depuis le 31 décembre 2019, deux zones potentielles en Ontario sont engagées dans le processus. Voir la section 6.1.4 pour obtenir de plus amples renseignements à ce sujet.

EACL assume les responsabilités fédérales pour les déchets radioactifs historiques de faible activité de partout au Canada, et les travaux sont entrepris par les LNC. Notamment, l'IRPH, qui est en cours, vise la majorité des DRFA historiques. Dans le cadre de cette initiative, les LNC extraient et transfèrent approximativement 2,1 millions de mètres cubes (m^3) de sols considérablement contaminés à deux nouvelles installations de gestion des déchets à long terme. La section 6.1.3 fournit de plus amples renseignements à ce sujet.

En outre, trois installations proposées d'évacuation des DRFA et des DRMA font actuellement l'objet d'une évaluation environnementale : les LNC ont proposé trois projets : une installation d'élimination près de la surface au site des Laboratoires de Chalk River pour les DRFA d'EACL; et le déclassement in situ de deux de ses réacteurs prototypes/de recherche à l'arrêt. Les sections 6.1.1, 6.1.2, 6.1.5 et 6.1.6 fournissent des renseignements supplémentaires sur ces projets.

2.0 DÉCHETS RADIOACTIFS DE HAUTE ACTIVITÉ (DRHA)

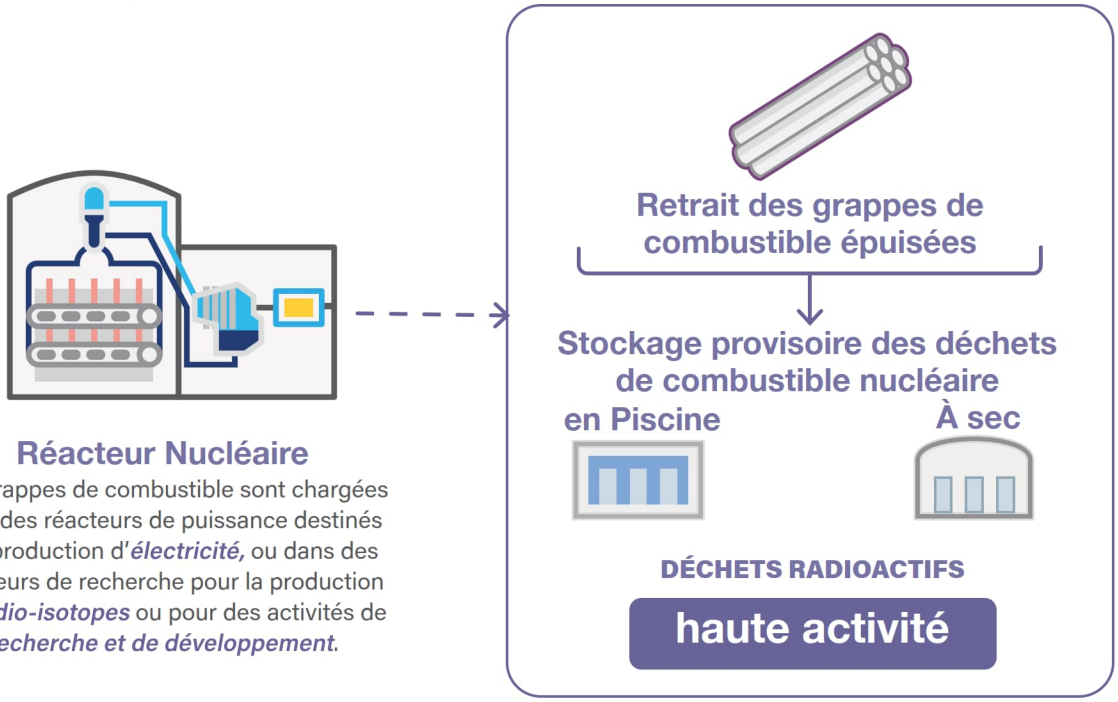
2.1 Définitions des DRHA

Selon la norme N292.0-:F19 de la CSA, un DRHA désigne du combustible nucléaire usé (irradié) qui a été déclaré « déchet radioactif » ou un « déchet produisant beaucoup de chaleur » (typiquement plus de 2 kilowatts par mètre cube) par désintégration radioactive. Certains pays et organismes utilisent l'expression « combustible usé » pour désigner ce type de déchet; toutefois, dans le présent rapport, nous opterons pour « DRHA » puisque le combustible déchargé est considéré comme un déchet, même s'il n'est pas entièrement épuisé.

Dans le présent rapport, tous les DRHA indiqués sont considérés être des déchets de combustible nucléaire conformément à la LDCN du Canada. Cette Loi définit les déchets de combustible nucléaire comme étant des grappes de combustible irradié retirées des réacteurs à fission nucléaire à vocation commerciale ou de recherche. Toutefois, l'industrie nucléaire du Canada utilise l'expression « combustible nucléaire usé », ce qui correspond à la terminologie employée dans la norme de la CSA. Au Canada, la plupart des DRHA sont des combustibles nucléaires usés découlant du cycle du combustible nucléaire et incluent les déchets provenant de centrales nucléaires, de réacteurs de puissance prototypes et de démonstration, de réacteurs de recherche et de production d'isotopes. Au Canada, il existe également des déchets radioactifs de haute activité non combustibles, qui prennent généralement la forme de sources scellées retirées du service. Au total, un stock de déchets d'environ 3 m^3 existe sous cette forme.

La plupart des DRHA sont produits lorsque le combustible nucléaire est retiré de réacteurs en service ou avant des activités de déclassement.

Figure 3. Procédés qui génèrent des déchets radioactifs de haute activité



2.2 Emplacements des DRHA

La quasi-totalité des centrales nucléaires et des sites dotés d'un réacteur de recherche entreposent sur place des DRHA (déchets de combustible nucléaire) dans des piscines de stockage ou dans une installation de stockage à sec (voir le tableau 4).



2.3 Inventaire des DRHA

Au 31 décembre 2019, les stocks totaux de DRHA au Canada s'élevaient à 12 718 m^3 (ou 3 094 591 grappes de combustible nucléaire).

Les stocks totaux de DRHA provenant des réacteurs de puissance s'élevaient quant à lui à approximativement 12 443 m^3 (ou 3 051 795 grappes) à la fin de 2019.

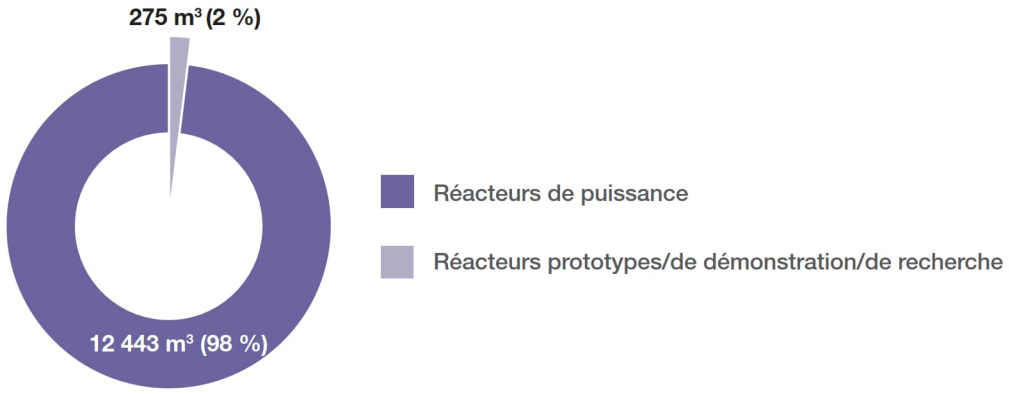
Au 31 décembre 2019, 275 m^3 (42 796 grappes) de DRHA provenaient de trois réacteurs prototypes et de démonstration à l'arrêt (Douglas Point, Gentilly-1 et RND) et d'autres activités liées à la recherche nucléaire.

Tableau 4. Inventaire des DRHA – 2019

Type de réacteur	Déchets de combustible nucléaire produits en 2019 (taux d'accumulation en 2019)		Stocks des déchets de combustible nucléaire sur place au 31 décembre 2019	
	Nombre de grappes de combustible	Vol. est. (m^3)	Nombre de grappes de combustible	Vol. est. (m^3)
Réacteurs de puissance	89 590	359	3 051 795	12 443
Réacteurs prototypes/de démonstration/de recherche	285	6	42 796	275
TOTAL DES DÉCHETS RADIOACTIFS DE HAUTE ACTIVITÉ	**89 875**	**365**	**3 094 591**	**12 718**

Remarque : « Vol. est. » signifie volume estimé.

Figure 4. Inventaire des DRHA (m^3) – 2019



DRHA produits en 2019

En 2019, les réacteurs nucléaires en service ont produit 89 590 grappes de combustible nucléaire usé ou 359 m^3 de DRHA, alors que 285 assemblages de combustible nucléaire usé—soit 6 m^3 de DRHA—ont été produits par les réacteurs de recherche des LCR.

Déchets de haute activité des réacteurs de puissance

On compte au Canada 22 réacteurs de puissance nucléaire qui appartiennent à trois services d'électricité provinciaux, à savoir : Ontario Power Generation Inc. (OPG) qui en possède 20 ainsi qu'Hydro-Québec et Énergie Nouveau-Brunswick qui en possèdent chacun un. Le réacteur Gentilly-2 d'Hydro-Québec et deux réacteurs de la centrale nucléaire de Pickering sont actuellement en état d'arrêt sécuritaire. Les 19 réacteurs en service ont une capacité de production totale de 15 000 mégawatts d'électricité.

Les DRHA, un sous-produit de la production d'énergie nucléaire, sont gérés en toute sécurité dans des installations de stockage provisoire autorisées aux sites des réacteurs nucléaires en Ontario, au Québec et au Nouveau-Brunswick. Les déchets en question resteront à ces sites jusqu'à ce qu'une solution adéquate à long terme devienne opérationnelle.

Déchets de haute activité provenant de réacteurs prototypes et de recherche

Laboratoires de Chalk River, Chalk River (Ontario)

Un réacteur de puissance nucléaire est en opération aux Laboratoires de Chalk River : le réacteur Zero Energy Deuterium (ZED-2). Les activités de recherche-développement à ces réacteurs appuient tous les aspects de la science nucléaire, notamment le développement de réacteurs, la science environnementale.

Le combustible usé issu des activités passées du Réacteur national de recherche universel (NRU), du Réacteur national de recherche expérimental (NRX) et du RND est également géré sur le site des Laboratoires de Chalk River.

Laboratoires de Whiteshell, Pinawa (Manitoba)

Les Laboratoires de Whiteshell (LW) sont à l'arrêt et font actuellement l'objet d'un déclassement. Le réacteur WR-1 a été déclassé partiellement (actuellement en stockage sous surveillance). Les DRHA (sous forme de grappes de combustible nucléaire) ont été retirés avant le déclassement du réacteur et sont gérés en toute sécurité sur place. Le déclassement in situ est la solution de déclassement proposée pour ce réacteur.

Le réacteur de démonstration SLOWPOKE des Laboratoires de Whiteshell a été entièrement déclassé.

Réacteurs universitaires

Le tableau ci-dessous présente la liste de tous les réacteurs universitaires actuellement en service au Canada. Une petite quantité de déchets de combustible est également entreposée au site du réacteur de recherche de l'Université McMaster, à Hamilton, en Ontario, tandis que les autres sites universitaires ayant un réacteur n'entreposent pas de DRHA sur place.

Titulaire du permis	Emplacement	Type et capacité
Université McMaster	Hamilton (Ontario)	De type piscine 5 MW(t)
École Polytechnique	Montréal (Québec)	SLOWPOKE-2, 20 kW(t)
Collège militaire royal du Canada	Kingston (Ontario)	SLOWPOKE-2, 20 kW(t)

2.4 Projections pour les DRHA

Les stocks projetés de DRHA pour 2022, 2030, 2050 et 2100 s'élèvent à 13 577 m^3, 15 802 m^3, 21 012 m^3 et 22 853 m^3 respectivement. Ces chiffres tiennent compte de la durée de vie des réacteurs de puissance actuels et de tout projet visant leur remise en état ou la prolongation de leur durée de vie.

Pour les années 2050 et 2100, les stocks projetés de DRHA (déchets de combustible nucléaire) provenant des réacteurs prototypes/de démonstration et de recherche existants d'EACL sont d'approximativement 271 m^3 dans les deux cas.

Figure 5. Stocks projetés de DRHA – 2050

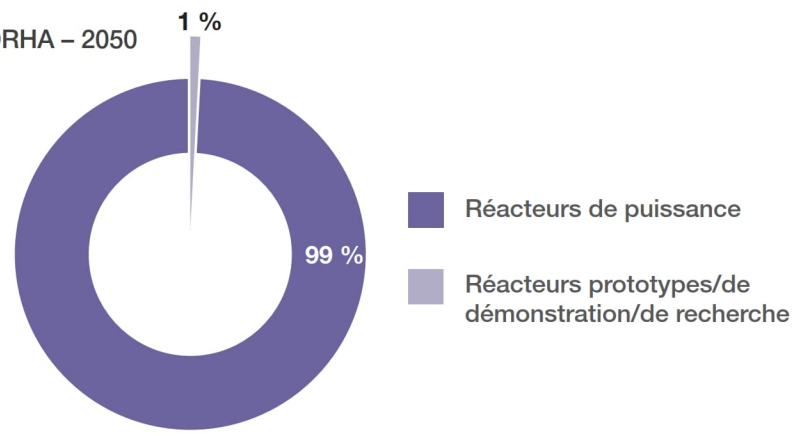


Figure 6. Stocks projetés de DRHA – 2100

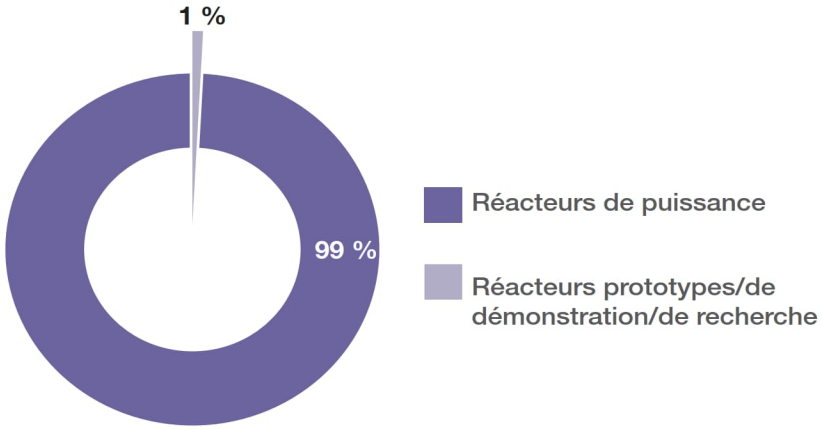


Tableau 5. Stocks projetés de DRHA – 2022, 2030, 2050, 2100

Type de réacteur	Stocks de DRHA en 2022		Stocks de DRHA en 2030		Stocks de DRHA en 2050		Stocks de DRHA en 2100	
	Nombre de grappes de combustible	Vol. est. Vol. (m^3)	Nombre de grappes de combustible	Vol. est. Vol. (m^3)	Nombre de grappes de combustible	Vol. est. Vol. (m^3)	Nombre de grappes de combustible	Vol. est. Vol. (m^3)
Réacteurs de puissance	3 264 188	13 305	3 810 401	15 530	5 088 507	20 741	5 539 829	22 582
Réacteurs prototypes/ de démonstration/de recherche	42 859	275	42 899	275	42 794	274	42 794	274
PROJECTIONS TOTALES DES STOCKS DE DÉCHETS RADIOACTIFS DE HAUTE ACTIVITÉ	**3 307 047**	**13 580**	**3 853 300**	**15 805**	**5 131 301**	**21 015**	**5 582 623**	**22 856**

Note: Est. Vol. stands for Estimated Volume.

Plan du Canada en matière de gestion à long terme des DRHA

À l'heure actuelle, au Canada, les DRHA sont provisoirement entreposés en toute sécurité dans des installations autorisées. Ils resteront à ces sites jusqu'à ce qu'une solution adéquate soit trouvée pour leur gestion à long terme.

Lorsque des DRHA (combustible nucléaire usé) sont retirés d'un réacteur, ils doivent être indéfiniment isolés en toute sécurité et gardés à l'écart des organismes vivants. La Société de gestion des déchets nucléaires (SGDN) a été créée en 2002, conformément à la LDCN, pour assumer la responsabilité de la gestion à long terme des déchets de combustible nucléaire au Canada. En 2007, le gouvernement du Canada a opté pour la GAP comme approche de gestion à long terme de ces déchets. À la fois une méthode technique et un système de gestion mettant l'accent sur l'adaptabilité, la GAP consiste à confiner et à isoler ces déchets dans un dépôt géologique en profondeur. Elle vise en soi à trouver un site sécuritaire, au sein d'une collectivité hôte consentante, où mettre en place un dépôt pour gérer les déchets à long terme. Cette initiative nationale d'infrastructure de haute technologie sera menée pendant bon nombre de décennies et sera sujette à une étroite surveillance et à de vastes approbations réglementaires. Pour plus de renseignements, veuillez consulter le site Web suivant : www.nwmo.ca/fr.

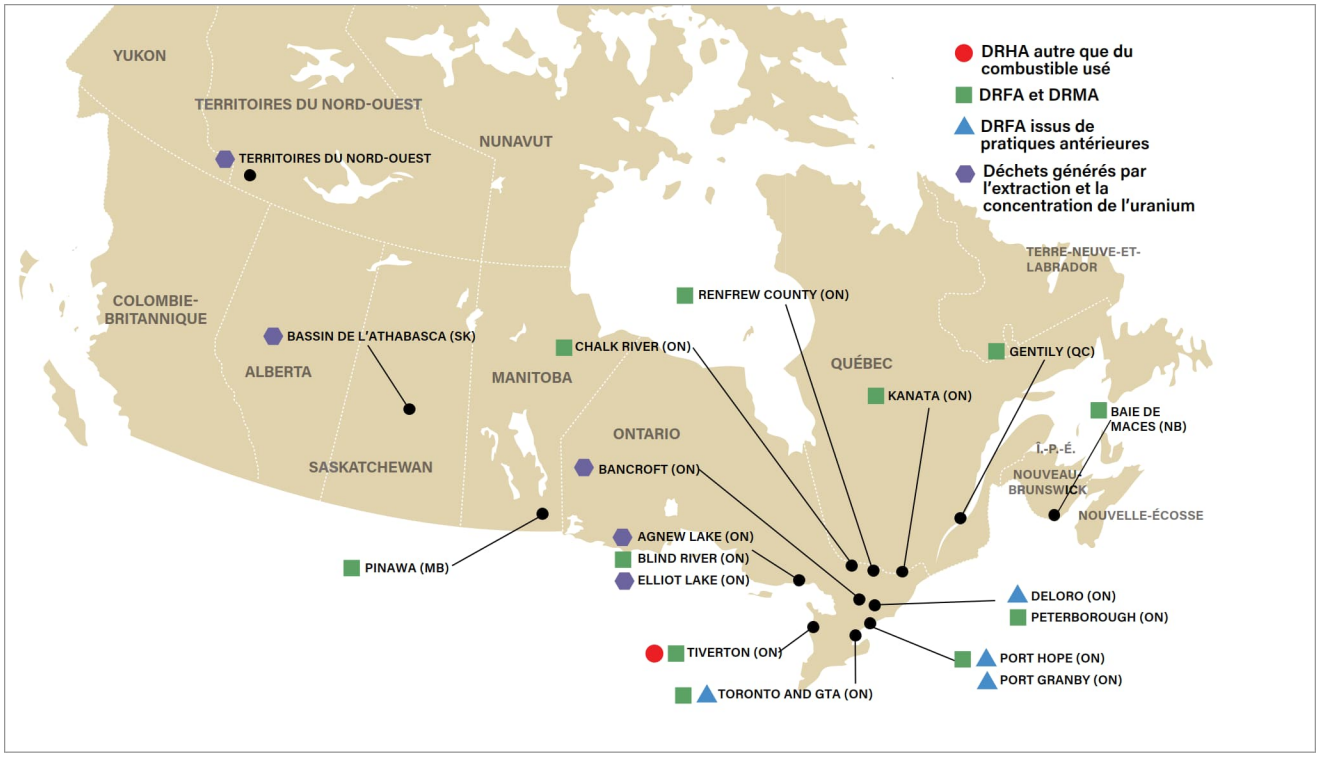


3.0 DÉCHETS RADIOACTIFS DE MOYENNE ACTIVITÉ

3.1 Définition des DRMA

Selon la défnition pr oposée par la norme N292.0:F19 de la CSA, les DRMA sont des déchets émettant habituellement des niveaux de rayonnement suffsamment pénétrant pour exiger un blindage pour leur manutention et leur stockage provisoire. Ce type de déchet radioactif n'exige généralement que peu de dispositions, voire aucune, pour la dissipation de la chaleur au cours de la manutention, du transport et de la gestion à long terme. Cependant, en raison de leur niveau de radioactivité globale, certains DRMA (p. ex., déchets de remise à neuf) pourraient nécessiter une gestion de la chaleur à court terme. Les résines et les fltr es d'échange ionique sont des exemples de DRMA.

3.2 Emplacements des déchets non combustibles



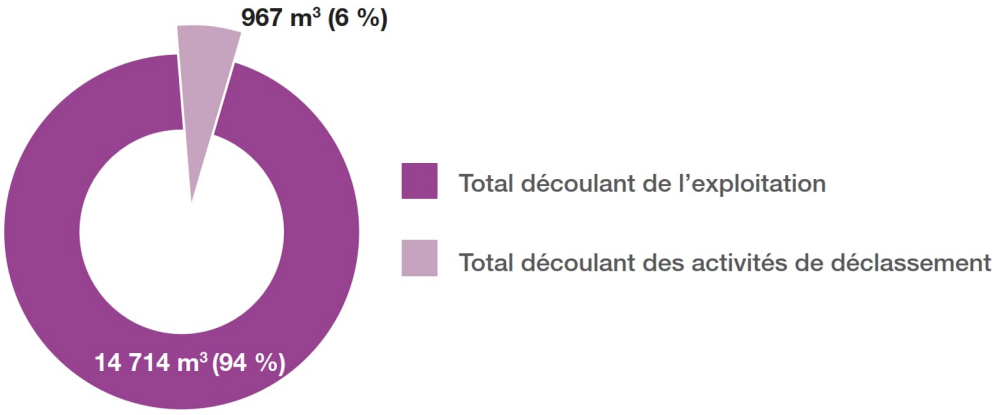
3.3 Inventaire des DRMA

À la fn de 2019, on comptait 15 681 m ^{3} de DRMA stockés au Canada, y compris approximativement 157 m^3 de DRMA liquides stockés dans des réservoirs aux LCR. Les DRMA sont stockés en toute sécurité dans des installations provisoires situées un peu partout au pays. En 2019, la production de DRMA s'élevait à environ 182 m^3

Tableau 6. Inventaire sommaire des DRMA – 2019

Catégorie globale	Inventaire des DRMAau 31 décembre 2019 (m^3)
Total découlant de l'exploitation	14 714
Total découlant des activités de déclassement	967
Grand Total	**15 681**

Figure 7. Inventaire des DRMA – 2019



3.3.1 DRMA découlant d'activités courantes

À la fin de 2019, les stocks totaux de DRMA découlant de l'exploitation s'élevaient à 14 714 m^3. Les déchets issus du cycle du combustible nucléaire et de la production d'isotopes représentent 13 664 m^3 de ce stock total. Le cycle du combustible nucléaire et la production d'isotopes comprennent les déchets provenant des réacteurs de puissance ainsi que des installations de production d'isotopes.

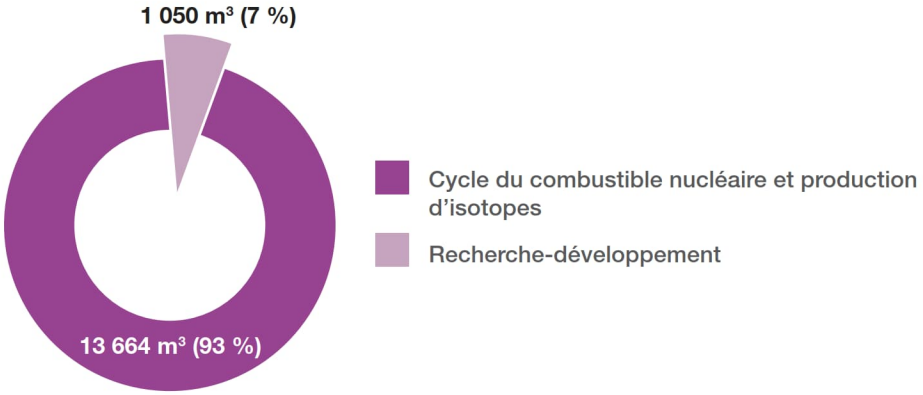
Tableau 7. Inventaire des DRMA d'exploitation et de déclassement – 2019

Secteur	Taux d'accumulation des DRMA en 2019 (m^3)	Stocks de DRMA au 31 décembre 2019 (m^3)
DÉCHETS D'EXPLOITATION		
Cycle du combustible nucléaire et production d'isotopes	144	13 664
Recherche-développement	25	1 050
DÉCHETS DÉCOULANT D'ACTIVITÉS DE DÉCLASSEMENT		
Cycle du combustible nucléaire et production d'isotopes	0	0
Recherche-développement	13	967
STOCK TOTAL DES DÉCHETS RADIOACTIFS DE MOYENNE ACTIVITÉ	**182**	**15 681**





Figure 8. Inventaire des DRMA d'exploitation – 2019



Réacteurs de puissance

En 2019, 169 m³ de DRMA provenaient d'activités d'exploitation, les 19 réacteurs de puissance au Canada produisant 144 m³ de ce volume.

Cette même année, OPG et Bruce Power ont collectivement exploité un total de 18 réacteurs produisant au total 134 m³ de DRMA d'exploitation, alors qu'Énergie NB n'a produit que 7 m³ de DRMA d'exploitation. Hydro-Québec a déclaré que, bien que le site de Gentilly-2 soit à l'étape 2 du déclassement, il a produit 3 m³ de DRMA dans le cadre de ses activités courantes. En outre, les installations de production des isotopes, de raffinage et de conversion de l'uranium ainsi que de fabrication du combustible nucléaire au Canada ont signalé qu'aucun DRMA n'avait été produit.

Recherche-développement nucléaire

En 2019, les activités de recherche-développement nucléaire à EACL ont produit 25 m³ de DRMA.

3.3.2 DRMA découlant d'activités de déclassement

Au 31 décembre 2019, les stocks totaux de DRMA provenant des activités de déclassement des réacteurs prototypes et de recherche s'élevaient à 967 m³. Le taux de production de déchets pour 2019 était de 13 m³ de DRMA. Aucune centrale nucléaire n'ayant encore été déclassée au Canada, il n'y a donc eu aucun DRMA produit par le cycle de combustible nucléaire. Le volume entier des DRMA découlant des activités de déclassement figurant dans l'inventaire appartient à EACL.

3.4 Projections pour les DRMA

Les projections pour les DRMA en 2022, 2030, 2050 et 2100 proviennent des propriétaires des déchets, comme indiqué dans l'aperçu présenté à la section 1.7.

L'inventaire projeté en 2050 des DRMA découlant de l'exploitation et du déclassement s'élève à 30 087 m³. Le déclassement de tous les réacteurs de puissance et de recherche devrait être achevé en 2100, ce qui fera passer ce volume à 32 324 m³.

Stocks projetés de DRMA d'exploitation

On prévoit que les stocks projetés de DRMA découlant de l'exploitation augmenteront au fil du temps. Les volumes découlant de l'exploitation projetés en 2022, 2030, 2050 et 2100 s'élèvent à 17 144 m^3, 21 228 m^3, 23 002 m^3 et 23 688 m^3 respectivement.

Les déchets d'exploitation continueront de constituer une grande partie des stocks de DRMA jusqu'en 2040 environ, année lors de laquelle débutera le déclassement (phase 3) de certains réacteurs de puissance (Bruce B, Gentilly-2 et Pickering A et B), ainsi que de certains réacteurs de recherche et prototypes (Gentilly-1 et Douglas Point).

Les projections des volumes de DRMA reposent sur l'hypothèse selon laquelle aucune nouvelle installation nucléaire d'importance, y compris de nouveaux réacteurs de puissance nucléaire, ne sera mise en service d'ici 2050 et, par conséquent, qu'il n'y aura pas de nouvelles sources de DRMA d'activités en cours. On suppose aussi que les taux de production des déchets recensés en 2019 sont représentatifs de ce qui sera produit à l'avenir, sauf avis contraire de la part des producteurs (p. ex. les services publics d'électricité).

Stocks projetés de DRMA provenant d'activités de déclassement

On prévoit que les stocks de DRMA découlant d'activités de déclassement pourraient atteindre jusqu'à 7 085 m^3 d'ici 2050, puis jusqu'à 8 636 m^3 d'ici 2100.

Les projections d'inventaire des DRMA de déclassement ont été fournies par les propriétaires de ces déchets et reposent sur les plans de déclassement soumis à la CCSN. Des plans de déclassement préliminaires sont en place pour de nombreux sites, mais des incertitudes persistent en ce qui concerne le calendrier et le volume de déchets.

Tableau 8. Stocks projetés de DRMA – 2022, 2030, 2050, 2100

Secteur	Stocks de DRMA en 2022 (m^3)	Stocks de DRMA en 2030 (m^3)	Stocks de DRMA en 2050 (m^3)	Stocks de DRMA en 2100 (m^3)
DÉCHETS D'EXPLOITATION				
Cycle du combustible nucléaire et production d'isotopes	15 744	19 690	21 404	21 940
Recherche-développement	1 400	1 538	1 598	1 748
DÉCHETS DÉCOULANT D'ACTIVITÉS DE DÉCLASSEMENT				
Cycle du combustible nucléaire et production d'isotopes	0	158	258	1 545
Recherche-développement	1 217	3 541	6 827	7 091
PROJECTIONS TOTALES DES STOCKS DE DÉCHETS RADIOACTIFS DE MOYENNE ACTIVITÉ	**18 361**	**24 927**	**30 087**	**32 324**

Figure 9. Stocks projetés de DRMA – 2050

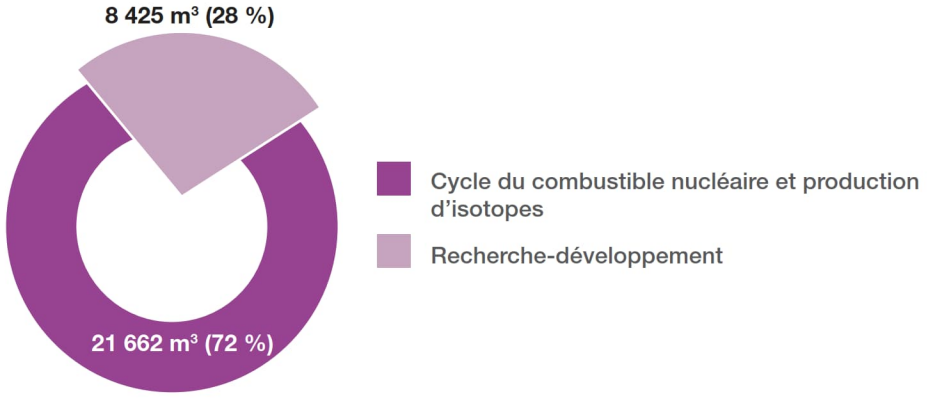
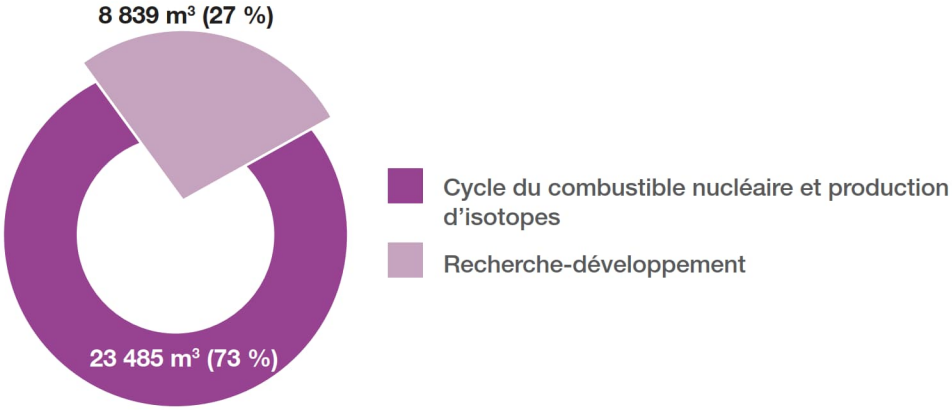


Figure 10. Stocks projetés de DRMA – 2100





4.0 DÉCHETS RADIOACTIFS DE FAIBLE ACTIVITÉ (DRFA)

4.1 Définition des DRFA

Selon la définition proposée par la norme N292.0:F-19, les DRFA sont des déchets renfermant des matières ayant une teneur en radionucléides supérieure aux seuils autorisés et aux quantités d'exemptions, mais dont la radioactivité à long terme est habituellement limitée. Les DRFA n'exigent habituellement pas un blindage important pour leur manutention et leur stockage provisoire. Ces déchets doivent faire l'objet d'une isolation et d'un confinement pendant une centaine d'années. Toutefois, de plus longues périodes sont requises pour les DRFA qui renferment du radium et de l'uranium de longue période.

Les DRFA peuvent notamment comprendre des matières, chiffons et vêtements protecteurs contaminés. Les déchets comprennent aussi les sols contaminés et les déchets découlant des toutes premières activités de l'industrie canadienne du radium.

4.2 Inventaire des DRFA

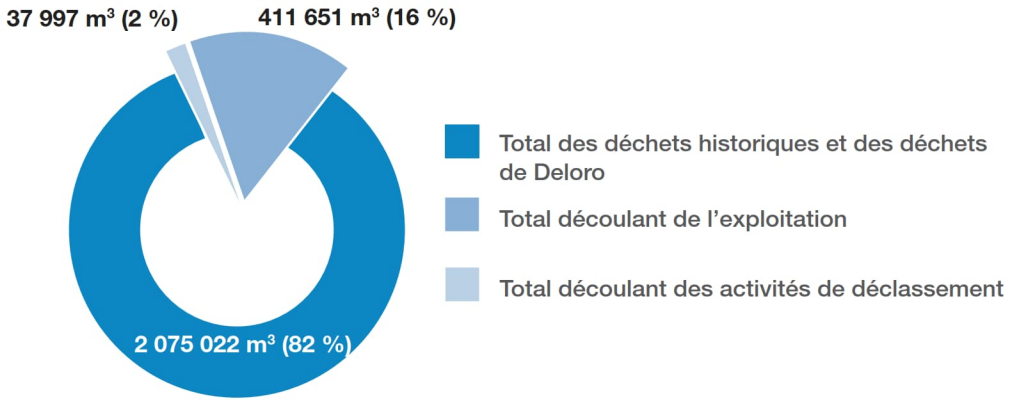
À la fin de 2019, on comptait environ 2,5 millions de m^3 de DRFA stockés au Canada, la plupart étant des déchets historiques prenant principalement la forme de sols contaminés. Seulement 18 % des DRFA du pays proviennent d'activités d'exploitation et de déclassement en cours. À l'heure actuelle, les DRFA sont gérés en toute sécurité sur place ou dans des installations de stockage provisoires ou à long terme.

Tableau 9. Inventaire sommaire des DRFA – 2019

Catégorie globale	Stocks de DRFA au 31 décembre 2019 (m^3)
Total des déchets historiques et des déchets de Deloro	2 075 022
Total découlant de l'exploitation	411 651
Total découlant des activités de déclassement	37 997
Grand Total	**2 524 670**

Au 31 décembre 2019, les stocks totaux de DRFA, à l'exception des déchets historiques, s'élevaient à 449 648 m^3. Les DRFA produits en 2019 représentaient environ 8 951 m^3.

Figure 11. Inventaire des DRFA – 2019



4.2.1 Déchets historiques

EACL est responsable du nettoyage et de la gestion à long terme des déchets historiques au Canada. Ce travail est entrepris par les LNC.

Parfois, il faut procéder à des travaux d'assainissement sur des propriétés n'appartenant pas au gouvernement fédéral, mais dont le propriétaire d'origine a disparu. Dans ces situations, le gouvernement fédéral analyse chaque cas avant d'accepter ou de refuser la responsabilité de gérer ces déchets. En mars 2001, le gouvernement du Canada et les municipalités de la région de Port Hope, dans le sud de l'Ontario, ont conclu une entente fondée sur des propositions de collectivités visant à nettoyer et à gérer à long terme une grande partie des déchets historiques du Canada, ce qui a mené au lancement de l'IRPH. En 2012, le gouvernement du Canada a annoncé un financement de 1,28 milliard de dollars pour la mise en œuvre de l'IRPH. Le nettoyage a débuté en décembre 2019 avec le retrait de déchets et leur transfert dans l'une des collectivités. Pour obtenir de plus amples renseignements, visitez le site Web du projet à l'adresse **https://www.phai.ca/fr/**.

Des déchets historiques se trouvent à divers endroits au Canada, y compris en Ontario, en Alberta et dans les Territoires du Nord-Ouest. Dans certains cas, les déchets prennent la forme d'une contamination du minerai d'uranium. À bon nombre de ces sites, des matières ont été stockées provisoirement en attendant l'élaboration et la mise en œuvre d'une solution de gestion à long terme. Les LNC effectuent continuellement une surveillance, des inspections et une maintenance à tous les sites de stockage et d'exploitation.

Au nombre des déchets que l'on trouve à ces sites, mentionnons des artefacts ou des matériaux de construction contaminés en surface. Ailleurs, les déchets renferment des sols de faible radioactivité contaminés au radium.

Origine des DRFA historiques

Les DRFA historiques proviennent de la manipulation, du transport et de l'utilisation du minerai d'uranium dans le passé. Dans les années 1930, de l'uranium (minerai de pechblende) a été découvert à Port Radium, dans les Territoires du Nord-Ouest. En 1932, Eldorado Gold Mines Limited a établi une mine à Port Radium et des installations de raffinage à Port Hope, en Ontario. Le minerai était envoyé dans le sud de l'Ontario, en passant d'abord par l'Itinéraire de transport dans le Nord (ITN), d'une série de cours d'eau navigables et de portage de 2 200 km reliant Port Radium, dans les Territoires du Nord-Ouest, et Fort McMurray, en Alberta. Une fois arrivé à destination, le minerai était chargé dans des wagons ferroviaires puis envoyé à Port Hope, en Ontario, pour être raffiné.

Entre les années 1930 et 1960, des déversements sont survenus le long de l'ITN aux points de transfert dans les avions, les bateaux, les camions et les trains ainsi qu'à la raffinerie. Au début des années 1970, on a constaté qu'il y avait des cas de contamination et on a dressé la liste des sites contaminés le long de l'Itinéraire de transport dans le Nord, à la raffinerie de Port Hope et dans les environs, et dans d'autres régions du sud de l'Ontario où se pratiquaient des opérations de récupération du radium et de peinture de cadrans au radium.

Stocks de DRFA historiques au Canada

Les stocks totaux de DRFA historiques sont d'environ 2,1 millions de mètres cubes.

Région de Port Hope (Ontario)

Au Canada, la majorité des DRFA historiques (> 98 %) sont situés dans la région de Port Hope. Parmi ces déchets, 550 000 m^3 sont gérés dans l'installation de gestion des déchets de Welcome (municipalité de Port Hope), 765 622 m^3 (depuis le 31 décembre 2019) sont gérés dans l'installation de gestion des déchets à long terme de Port Granby (municipalité de Clarington). Une autre quantité de 720 000 m^3 de matériaux se trouve dans la municipalité de Port Hope et il est prévu de les assainir dans le cadre de l'IRPH.

Région du Grand Toronto (Ontario)

De nombreux propriétaires de petits sites de la région du Grand Toronto ont travaillé avec EACL et les LNC au fil des ans pour gérer leurs petits volumes de déchets de faible activité associés aux anciennes activités de peinture lumineuse au radium et à d'autres activités des années 1930. Au total, 4 900 m^3 de déchets demeurent sous la responsabilité fédérale après leur traitement, leur reclassification, et la détermination de la partie propriétaire ou responsable de leur gestion.

Déchets de Deloro

Les déchets de Deloro sont des DRFA provenant des résidus d'usines de concentration d'uranium qui ont été à nouveau traités à Deloro, en Ontario, pour en extraire du cobalt. Le gouvernement fédéral n'a pas accepté la responsabilité de la gestion des déchets de Deloro, même s'ils résultent d'anciennes pratiques dont on ne peut raisonnablement attribuer la responsabilité au propriétaire d'origine. Par conséquent, ces déchets représentent une catégorie à part parmi les DRFA issus de pratiques historiques, car ils ne correspondent pas complètement à la définition de « déchet historique ».

Le gouvernement de l'Ontario a accepté de prendre la responsabilité de ces déchets et le ministère de l'Environnement de l'Ontario (MEO) a achevé l'assainissement de l'ancien site de la mine de Deloro. Environ 34 500 m^3 de sols contaminés par des DRFA et de résidus historiques sont stockés sur le site.

4.2.2 DRFA découlant d'activités courantes

Les DRFA produits par les activités nucléaires de l'exploitation, dans les réacteurs de puissance et de recherche et dans les installations de science et de technologie nucléaires, s'accumulent régulièrement. Les propriétaires ou les producteurs de déchets d'exploitation sont tenus d'assurer leur gestion courante et à long terme.

À la fin de 2019, les stocks totaux de DRFA découlant de l'exploitation s'élevaient à 411 651 m^3.

Installations de fabrication de combustible nucléaire et réacteurs de puissance

En 2019, un total de 3 434 m^3 de DRFA provenaient d'activités d'exploitation, les 19 réacteurs de puissance nucléaire au Canada produisant 779 m^3 de ce volume.

En 2019, Ontario Power Generation et Bruce Power ont exploité collectivement un total de 18 réacteurs et produit 665 m^3 de DRFA. La Société d'énergie du Nouveau-Brunswick a produit 71 m^3 de DRFA de ses activités d'exploitation. Un total de 43 m^3 des DRFA produits en 2019 provenaient du raffinage et de la conversion de l'uranium ainsi que de la fabrication de combustible nucléaire.

Tableau 10. Inventaire des DRFA – 2019

Secteur	Taux d'accumulation des DRFA en 2019 (m^3)	Stocks de DRFA au 31 décembre 2019		
		Déchets (m^3)	Sol cont. (m^3)	Total (m^3)
DÉCHETS D'EXPLOITATION				
Cycle du combustible nucléaire et production d'isotopes	779	118 793	0	118 793
Recherche-développement	2 655	136 582	156 276	292 858
DÉCHETS DÉCOULANT D'ACTIVITÉS DE DÉCLASSEMENT				
Cycle du combustible nucléaire et production d'isotopes	0	1 500	200	1 700
Recherche-développement	5 517	32 095	4 202	36 297
TOTAL	**8 951**	**288 970**	**160 678**	**449 648**

Remarque : Sol cont. est l'abréviation de sol contaminé.

Recherche-développement nucléaire

Au 31 décembre 2019, les stocks totaux de DRFA découlant de la recherche-développement nucléaire s'élevaient à 329 155 m^3. EACL a géré 160 478 m^3 de sol contaminé au cours de sa longue histoire en recherche-développement nucléaire. Ce sol contient également des déchets retirés de divers endroits au Canada, notamment de plusieurs sites en Ontario dans les années 1970. De plus, certains DRFA provenant d'autres producteurs (principalement des hôpitaux et des universités) sont gérés par les Laboratoires de Chalk River d'EACL.

Figure 12. Inventaire des DRFA d'exploitation – 2019

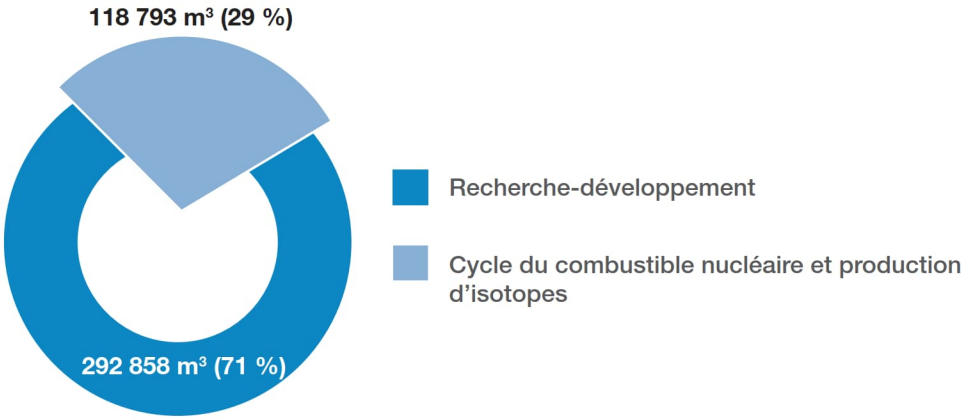
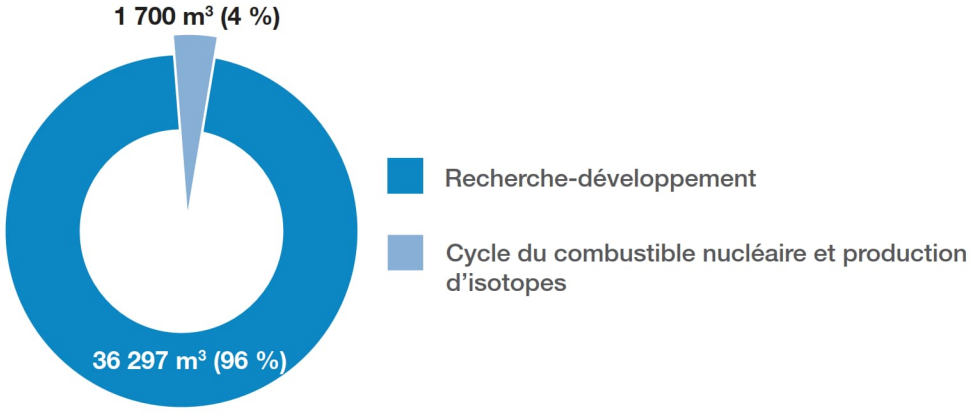


Figure 13. Inventaire des DRFA de déclassement – 2019






HYSTER
GARRETT
270
ONTARIO POWER GENERATION

4.2.3 DRFA découlant d'activités de déclassement

Au 31 décembre 2019, les stocks totaux de DRFA au Canada provenant de toutes les activités de déclassement s'élevaient à 37 997 m^3. Le taux de production de déchets provenant d'activités de déclassement pour 2019 était de 5 517 m^3 de DRFA.

4.3 Projections pour les DRFA

Les projections pour les DRFA en 2022, 2030, 2050 et 2100 proviennent des propriétaires de déchets.

Étant donné les activités de réduction des déchets qui sont prévues, notamment grâce à l'incinération, le volume des déchets devrait diminuer dans certains cas.

Les stocks de DRFA découlant de l'exploitation et du déclassement projetés en 2050 s'élèvent à 970 490 m^3 et on prévoit que ce chiffre atteindra 1 298 278 m^3 d'ici 2100.

Stocks projetés de DRFA d'exploitation

Au 31 décembre 2019, les stocks totaux de DRFA découlant d'activités d'exploitation s'élevaient à 411 651 m^3. On prévoit que ce chiffre atteindra approximativement 421 347 m^3 d'ici 2050 et 442 042 m^3 d'ici 2100.

Les déchets d'exploitation continueront de constituer une grande partie des stocks de DRFA jusqu'en 2040 environ, année lors de laquelle débutera le déclassement (phase 4) de certains réacteurs de puissance (Bruce B, Gentilly-2 et Pickering A et B) et de certains réacteurs de recherche et prototypes (Gentilly-1 et Douglas Point).

Les projections des volumes de DRFA reposent sur l'hypothèse selon laquelle aucune nouvelle installation nucléaire d'importance, y compris de nouveaux réacteurs de puissance nucléaire, ne sera mise en service d'ici 2050 et, par conséquent, qu'il n'y aura pas de nouvelles sources de DRFA d'activités en cours. On suppose aussi que les taux de production des déchets recensés en 2019 sont représentatifs de ce qui sera produit à l'avenir, sauf avis contraire de la part des producteurs (p. ex. les services publics d'électricité).

Tableau 11. Stocks projetés de DRFA – 2022, 2030, 2050, 2100

Secteur	Stocks de DRFA en 2022 (m^3)	Stocks de DRFA en 2030 (m^3)	Stocks de DRFA en 2050 (m^3)	Stocks de DRFA en 2100 (m^3)
DÉCHETS D'EXPLOITATION				
Cycle du combustible nucléaire et production d'isotopes	108 851	114 201	112 706	110 001
Recherche-développement	294 994	299 281	308 641	332 041
DÉCHETS DÉCOULANT D'ACTIVITÉS DE DÉCLASSEMENT				
Cycle du combustible nucléaire et production d'isotopes	1 000	6 638	127 826	309 210
Recherche-développement	99 042	200 397	421 317	547 026
TOTAL	**503 887**	**620 517**	**970 490**	**1 298 278**

Stocks projetés de DRFA provenant d'activités de déclassement

Pour les années 2050 et 2100, les stocks projetés de DRFA découlant du déclassement s'élèvent à 549 143 m^3 et 856 236 m^3, respectivement.

Les projections quant aux stocks projetés de DRFA découlant d'activités de déclassement ont été fournies par les propriétaires de ces déchets et reposent sur les plans de déclassement soumis à la CCSN. Des plans de déclassement préliminaires sont en place pour de nombreux sites, mais des incertitudes persistent quant au calendrier et au volume de déchets.

Figure 14. Stocks projetés de DRFA – 2050

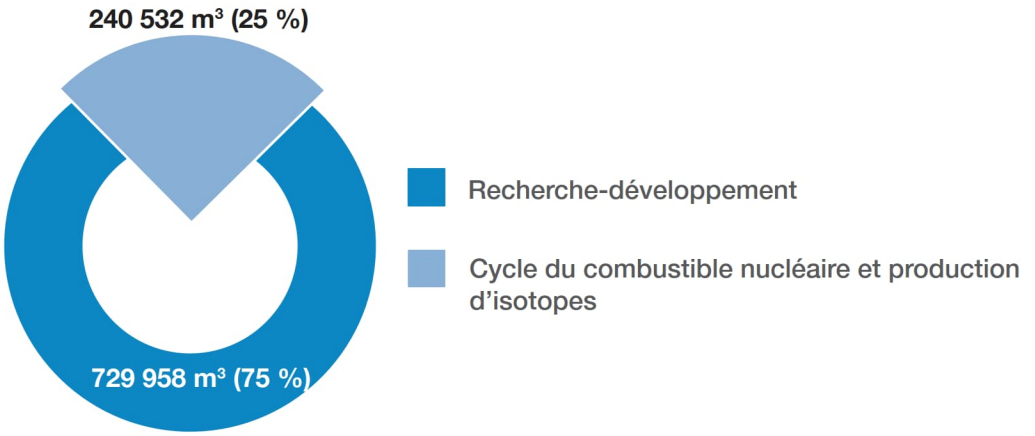
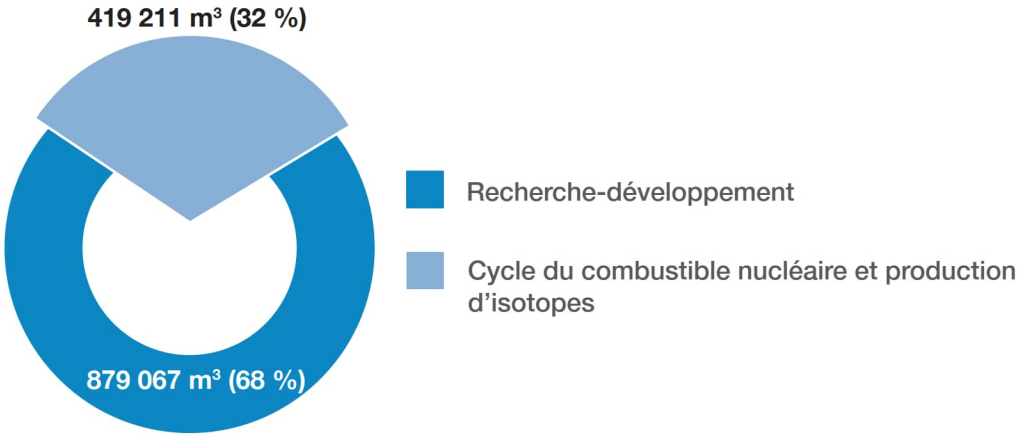


Figure 15. Stocks projetés de DRFA – 2100

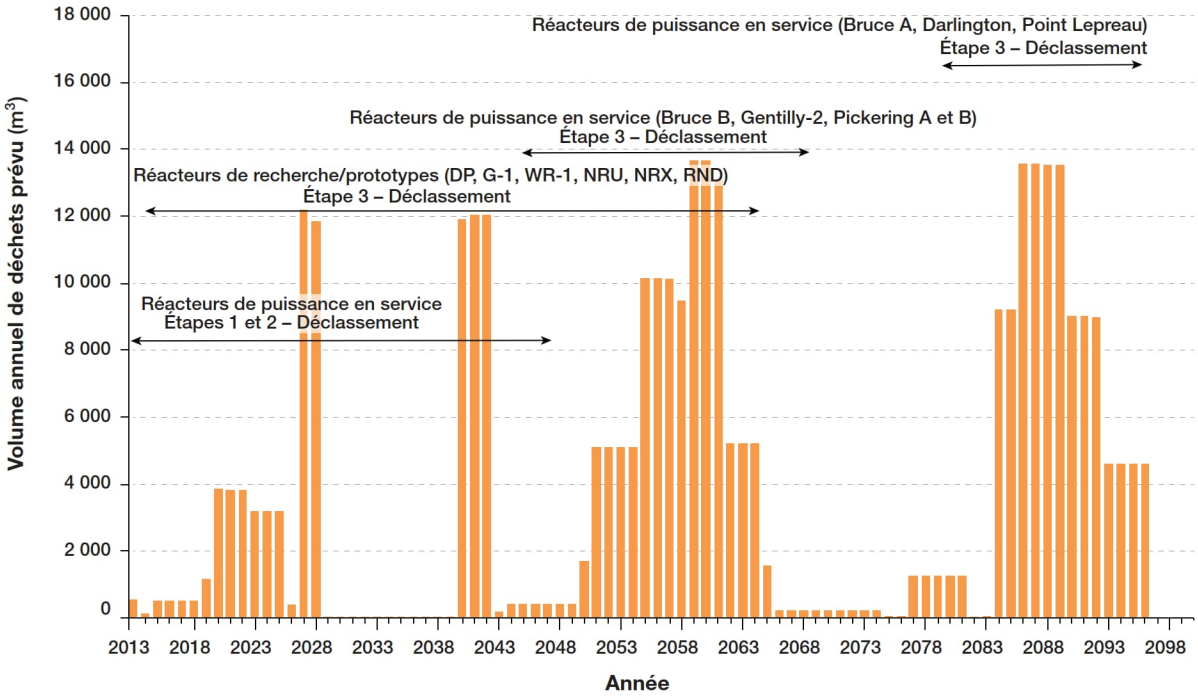


5.0 CALENDRIER DE DÉCLASSEMENT ET PRODUCTION DE DRFMA CONNEXES

Conformément aux sections 3.4 et 4.4, les projections quant aux stocks de DRFA et de DRMA découlant du déclassement ont été fournies par les propriétaires de déchets et reposent sur les plans de déclassement soumis à la CCSN.

Le diagramme suivant montre les volumes de déchets annuels projetés du déclassement de réacteurs de puissance, prototypes/de démonstration et des installations des Laboratoires de Whiteshell et des Laboratoires de Chalk River jusqu'en 2100. Ce calendrier a été choisi pour inclure le déclassement (étape 3) complet de tous les réacteurs de puissance actuellement en service. Il donne également un aperçu des activités de déclassement prévues qui produiront de grands volumes de DRFA et DRMA. Diverses hypothèses, y compris les incertitudes concernant le calendrier et les volumes de déchets, ont été prises en compte dans ces estimations.

Figure 16. Volume annuel de déchets radioactifs provenant du déclassement d'installations nucléaires (jusqu'en 2100)




1407
967
1363
1364
1393

6.0 GESTION À LONG TERME

Les volumes de déchets radioactifs figurant dans cet inventaire permettent de comprendre le calendrier de production des divers types de déchets radioactifs ainsi que la nécessité d'avoir en place des installations de gestion à long terme des déchets radioactifs à l'échelle nationale. Les sections ci-dessous donnent un aperçu des installations de gestion à long terme prévues au Canada pour la gestion des DRHA et des DRFMA.

6.1 Projets proposés de gestion des déchets radioactifs à long terme

6.1.1 Dépôt géologique en profondeur proposé par la SGDN

La SGDN est actuellement en train de choisir un site qui est à la fois disposé à accueillir un dépôt géologique en profondeur et qui possède les caractéristiques techniques nécessaires à cet effet. Ce dépôt, qui devrait être construit à environ 500 m sous le sol, confinerait et isolerait tous les déchets de combustible nucléaire du Canada, conformément aux prévisions actuelles. Pour obtenir de plus amples renseignements, visitez https://www.nwmo.ca/fr.

6.1.2 Installation de gestion des déchets près de la surface (IGDPS) proposée par les LNC

Les LNC ont soumis une proposition à la CCSN pour une IGDPS aux Laboratoires de Chalk River pour les DRFA actuels et futurs d'EACL. Le projet consisterait en un monticule de confinement artificiel comportant dix cellules distinctes. La capacité totale de cette installation devrait être de 1 000 000 m^3.
Pour obtenir de plus amples renseignements, visitez http://www.cnl.ca/

6.1.3 Installation de gestion à long terme des déchets historiques

L'Initiative dans la région de Port Hope vise à construire deux installations de gestion des déchets à long terme à Clarington et à Port Hope dans le sud-est de l'Ontario. Il s'agit de deux installations près de la surface consistant en des monticules de confinement artificiel pour les déchets historiques de faible activité. L'une des installations, située à Port Hope, devrait contenir environ 1 300 000 m^3. L'autre installation, située dans la ville voisine de Clarington, en Ontario, devrait contenir 810 000 m^3 de matériaux. La majorité des déchets proviennent de sols contaminés par des pratiques de gestion des déchets découlant des activités industrielles de raffinage de l'uranium menées dans les années 1930 à Port Hope. Pour obtenir de plus amples renseignements, visitez http://www.phai.ca/fr.

6.1.4 Déclassement sur place des réacteurs WR-1 et RND

Les LNC ont soumis une proposition à la CCSN pour le déclassement sur place (gestion sur place) des réacteurs d'EACL, à savoir le réacteur WR-1 aux Laboratoires de Whiteshell à Pinawa, au Manitoba, et le réacteur RND à Rolphton, en Ontario. Ces projets consisteraient à démanteler la structure au-dessus du sol et à effectuer ensuite une injection de remplissage dans la section souterraine avec une couverture artificielle pour empêcher l'infiltration d'eau. Une fois le déclassement terminé, ces sites seraient envisagés pour devenir des installations d'évacuation autorisées en vertu de la LSRN, destinées à gérer les stocks de déchets (radionucléides et autres) de manière responsable.

Les propriétaires des déchets réalisent des progrès dans la gestion à long terme de leurs DRFA et DRMA. Une solution à long terme est prévue pour plus de 75 % du volume total de DRFA projeté en 2100. En ce qui concerne les DRMA, les propriétaires de déchets continueront à élaborer des solutions à long terme pour leurs DRMA. Quant au combustible nucléaire usé, il sera entièrement géré dans le cadre du plan GAP de la SGDN consistant à trouver un site et à construire un dépôt géologique en profondeur.

6.2 Projections pour le stockage des déchets aux installations de gestion à long terme

Le tableau suivant présente un aperçu des volumes de déchets à stocker dans des installations de gestion à long terme d'ici 2030, 2050 et 2100. Si l'on tient compte des installations actuellement proposées (sujettes à une évaluation environnementale et un examen réglementaire), d'ici 2050, le Canada aura fait de grands progrès à l'égard de la gestion à long terme de la vaste majorité des DRFA et des DRHA projetés.

Tableau 12. Projections des sites de stockage en vue de la gestion à long terme en 2100

Installation	Stockage en 2022		Stockage en 2030		Stockage en 2050		Stockage en 2100	
DÉCHETS ET EMBALLAGE	**Nombre de grappes de combustible**	**Volume incluant l'emballage** (m^3)	**Nombre de grappes de combustible**	**Volume incluant l'emballage** (m^3)	**Nombre de grappes de combustible**	**Volume incluant l'emballage** (m^3)	**Nombre de grappes de combustible**	**Volume incluant l'emballage** (m^3)
Dépôt géologique en profondeur de la SGDN	0	0	0	0	840 000	51 100 [1]	5 565 000	338 600 [1]
DÉCHETS D'EXPLOITATION ET DE DÉCLASSEMENT	**Volume (m^3)**		**Volume (m^3)**		**Volume (m^3)**		**Volume (m^3)**	
Installation de gestion des déchets près de la surface d'EACL	0		497 546		727 826		876 935	
Déclassement sur place du réacteur WR-1	0		2 248		2 248		2 248	
Déclassement sur place du RND	0		2 678		2 678		2 678	
DÉCHETS HISTORIQUES	**Volume (m^3)**		**Volume (m^3)**		**Volume (m^3)**		**Volume (m^3)**	
Installation de gestion des déchets à long terme de Port Hope	982 000		1 270 000		1 270 000		1 270 000	
Installation de gestion des déchets à long terme de Port Granby	802 800		802 800		802 800		802 800	

[1] Reposant sur l'utilisation présumée d'un contenant de 48 grappes dans une boîte tampon en bentonite de 1 m sur 1 m sur 2,92 m.

7.0 RÉSIDUS D'EXTRACTION MINIÈRE ET DE CONCENTRATION DE L'URANIUM

7.1 Définition des résidus d'extraction minière et de concentration de l'uranium

Les résidus d'extraction minière et de concentration de l'uranium sont des sous-produits provenant des activités d'extraction minière et de concentration de l'uranium et comprennent les déchets de traitement et les stériles, comme décrit ci-dessous.

Résidus issus du traitement de l'uranium

Les résidus de traitement de l'uranium découlent de la concentration (traitement) du minerai d'uranium pour produire le concentré d'uranium. Une fois raffiné et converti, le concentré d'uranium sert à fabriquer du combustible pour les réacteurs de puissance canadiens et étrangers. De nos jours, les résidus sont déposés dans des mines à ciel ouvert épuisées converties en installations de gestion. Toutefois, il n'en a pas toujours été ainsi. Autrefois, les résidus étaient placés dans des aires de confinement naturelles, comme des lacs ou des vallées, servaient de remblai dans les mines souterraines, ou étaient placés dans des aires aménagées de confinement en surface.

Pour toutes les plus récentes activités d'exploitation en Saskatchewan, les résidus sont gérés dans des installations où ils sont confinés hydrauliquement pendant les activités (de sorte que l'écoulement souterrain se fait en direction de l'installation de gestion des résidus) et passivement à long terme après le déclassement. On trouvera des renseignements détaillés sur chacune de ces installations dans les rapports annuels remis à la CCSN par les propriétaires des déchets.

Stériles

Les stériles sont les matières retirées pendant l'extraction minière pour obtenir le minerai. Aujourd'hui, les stériles sont séparés en déchets minéralisés et non minéralisés, selon la concentration relative d'uranium se trouvant dans la matière. Autrefois, les stériles étaient stockés en surface ou utilisés comme remblai dans les mines souterraines. Un inventaire régulier des stocks de stériles n'était toutefois pas toujours réalisé et les déchets minéralisés et non minéralisés étaient souvent stockés ensemble.

Les stériles minéralisés peuvent renfermer des concentrations subéconomiques d'uranium ainsi que des niveaux élevés d'autres éléments, comme le soufre, l'arsenic ou le nickel, lesquels pourraient avoir des effets néfastes sur l'environnement. Les stériles non minéralisés ont de très faibles concentrations d'uranium et niveaux d'autres éléments qui sont inférieurs aux normes applicables.

En raison de la migration possible des contaminants, les stériles minéralisés étant exposés à la surface sont habituellement utilisés comme remblai de mine ou stockés dans des puits épuisés convertis en installations de gestion. Toutefois, il n'y a pas d'exigences particulières pour le stockage à long terme des stériles non minéralisés.

Figure 17. Comment les résidus de l'extraction minière et du traitement de l'uranium sont-ils produits?



7.2 Emplacement des résidus d'extraction minière et du traitement de l'uranium



7.3 Inventaire des résidus d'extraction minière et de traitement de l'uranium

Les résidus de traitement de l'uranium sont exprimés en tonnes puisque c'est la façon dont l'industrie minière comptabilise habituellement ses matières et en rend compte. Les quantités de déchets peuvent être converties en volume (m^3) en utilisant des densités hypothétiques ou mesurées. Une densité sèche type pour les résidus serait de 1,0 à 1,5 tonne/m^3. Toutefois, la densité des résidus peut varier grandement d'un site à l'autre et selon l'endroit ou la profondeur à un site particulier.

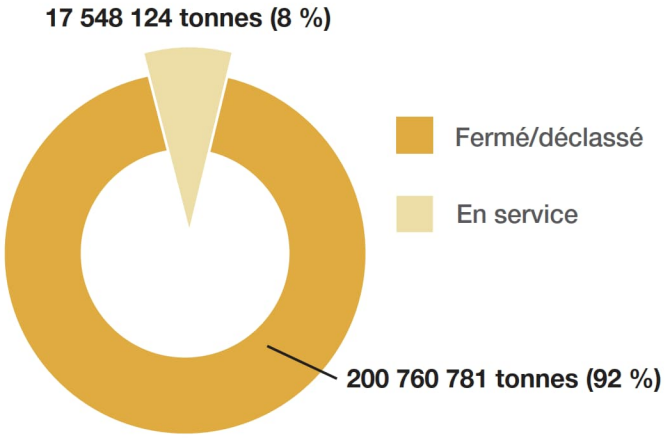
Tableau 13. Taux d'accumulation et inventaire des résidus d'extraction minière et de traitement de l'uranium - 2019

Catégorie de mine ou d'usine	Taux d'accumulation (résidus) en 2019 (tonnes/an)	Masse totale des résidus au 31 déc. 2019 (tonnes)
En service	75 286	17 548 124
Fermé/déclassé	0	200 760 781
Totaux	**75 286**	**218 308 905**

Résidus issus du traitement de l'uranium

L'inventaire total des résidus s'élève à 218 308 905 tonnes. Au 31 décembre 2019, les stocks de résidus provenant de sites fermés ou déclassés s'élevaient à environ 201 millions de tonnes alors que près de 17,5 millions de tonnes provenaient de sites en service. Environ 0,075 million de tonnes de résidus ont été produites en 2019.

Figure 18. Inventaire des résidus de traitement de l'uranium – 2019



Stériles

Au 31 décembre 2019, l'inventaire total des stériles minéralisés s'élevait à 36 454 876 tonnes, alors que celui des stériles non minéralisés était de 130 696 484 tonnes.

L'état des amas de stériles est dynamique par nature en raison des fluctuations du prix de l'uranium, qui déterminent le rapport du minerai aux stériles. Par conséquent, le taux de production annuel peut être trompeur. On utilise donc les stocks totaux de stériles pour obtenir une valeur reflétant plus fidèlement la réalité.

Le tableau ci-dessous présente un résumé de la masse de l'inventaire des stériles et l'état de différents sites en service, fermés ou déclassés, ainsi que de sites en préparation au Canada en date du 31 décembre 2019. L'inventaire des stériles accumulés en 2019 a été arrondi à 100 tonnes près. Pour l'inventaire des stériles par propriétaire, voir l'annexe 1, tableau A.12.

Tableau 14. Inventaire des stériles - 2019

Catégorie de mine ou d'usine	Waste rock inventory	
	Stériles minéralisés (tonnes)	**Stériles non minéralisés** (tonnes)
En service	13 473 595	130 696 484
Fermé/déclassé	23 200 000	0
Totaux	**36 673 876**	**130 696 484**

7.3.1 Déchets de déclassement (résidus d'extraction minière et de traitement de l'uranium)

En raison des grands volumes de résidus produits et des faibles niveaux de radioactivité, les sites des mines d'uranium sont habituellement déclassés sur place. Le déclassement des sites de résidus de surface inclut habituellement des améliorations ou la construction de barrages pour assurer un confinement à long terme; la submersion ou le recouvrement des résidus pour réduire la production d'acide et l'émission de rayons gamma et de radon; et la gestion/surveillance des résidus et des effluents.

On trouve des stériles et des résidus de traitement de l'uranium aux mines et aux usines de traitement de l'uranium dans le nord de la Saskatchewan ainsi qu'à des sites fermés ou déclassés en Saskatchewan, en Ontario et aux Territoires du Nord-Ouest.

7.4 Projections des résidus d'extraction minière et du traitement de l'uranium

Les ressources connues de minerai d'uranium des mines actuellement en service seront épuisées avant 2050. Aucune projection de résidus de traitement de l'uranium ou de stériles n'est procurée en raison des incertitudes liées à l'estimation du volume de déchets des projets éventuels. Les sections suivantes fournissent une brève évaluation qualitative des facteurs influant sur les résidus d'extraction et de traitement de l'uranium.

Projections des résidus d'extraction et de traitement de l'uranium dans l'avenir

Sites en service

Les taux de production de l'uranium dans l'avenir pourraient augmenter selon le calendrier et les conditions du marché. La qualité du minerai provenant de Cigar Lake est très élevée (15 % d'uranium) et, par conséquent, a réduit les taux de production de résidus à l'usine de concentration de McClean Lake par rapport à la production précédente d'uranium à la mine de McClean Lake. La société Cameco continuera de mélanger des stériles particuliers de la mine Key Lake au minerai à grande teneur en uranium de McArthur River afin de produire une charge d'alimentation contenant 4 % d'uranium. À Rabbit Lake, qui fait l'objet de travaux d'entretien et de maintenance depuis 2016, on envisage également de mélanger des résidus à des stériles ou à du till avant la mise en pile en cas de reprise des activités. En raison de ces possibilités, il est difficile de prévoir la masse finale des résidus provenant des sites de traitement en service.

Sites fermés ou déclassés

Le déclassement des résidus de traitement de l'uranium prévoit habituellement une gestion sur place. La masse actuelle des résidus à tous les sites inactifs ou déclassés est d'approximativement 201 millions de tonnes et devrait demeurer la même jusqu'en 2050.

ANNEXE 1 – Tableaux détaillés de l'inventaire et des projections de déchets radioactifs

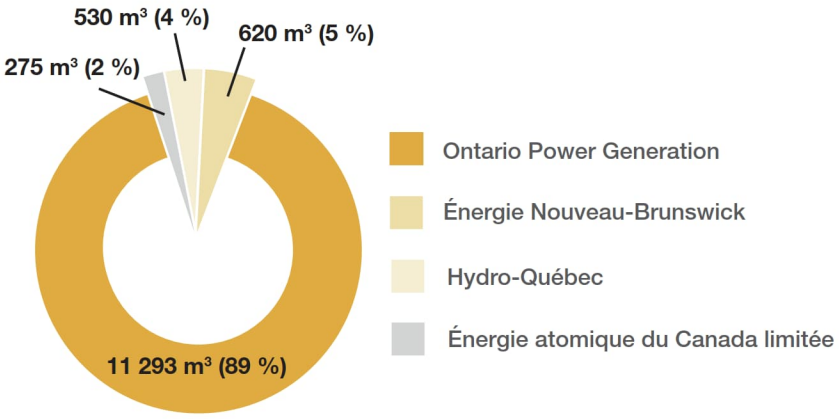
Tableau A.1 Inventaire des déchets radioactifs de haute activité (par propriétaire) - 2019

Entreprise – Nom du site	État du réacteur en décembre 2019	Déchets de combustible nucléaire produits en 2019 (taux d'accumulation en 2019) Stockage en piscine		Stocks des déchets de combustible nucléaire sur place au 31 décembre 2019[1]				
				Stockage en piscine	Stockage à sec	Inventaire total		
		Nombre de grappes de combustible	Vol. est. (m^3)	Nombre de grappes de combustible	Nombre de grappes de combustible	Nombre de grappes de combustible	Vol. est. (m^3)	Masse d'uranium[1] (kg)
RÉACTEURS DE PUISSANCE								
OPG – Bruce A	En service	19 032	76	365 480	0	365 480	1 492	6 896 750
OPG – Bruce B	En service	22 762	91	370 810	0	370 810	1 514	7 045 710
Installation de gestion des déchets de Western	En service			0	615 542	615 542	2 512	11 710 238
OPG – Darlington	En service	22 886	92	340 392	0	340 392	1 389	6 518 918
IGD Darlington	En service			0	260 649	260 649	1 064	4 974 978
OPG – Pickering A	2/4 unités en service	6 772	27	271 533	0	271 533	1 108	5 342 043
OPG – Pickering B	En service	12 886	52	157 276	0	157 276	642	3 116 651
IGD Darlington	En service			0	385 230	385 230	1 572	7 652 154
Hydro-Québec – Gentilly-2	Arrêt/ déclassement	0	0	5 725	124 200	129 925	530	2 469 204
Énergie NB – Point Lepreau	En service	5 252	21	33 460	121 498	154 958	620	2 942 632
Sous-total – Réacteurs de puissance		**89 590**	**359**	**1 544 676**	**1 507 119**	**3 051 795**	**12 443**	**58 669 278**
RÉACTEURS PROTOTYPES/DE DÉMONSTRATION/DE RECHERCHE								
EACL – Douglas Point	Arrêt et déclassement partiel	0	0	0	22 256	22 256	89	299 827
EACL – Gentilly-1	Arrêt et déclassement partiel	0	0	0	3 213	3 213	13	67 596
EACL – Réacteur national de recherche universe[2]	Arrêt	0	0	804	0	804	3	2 646
EACL – Zone de gestion des déchets B (combustible usé provenant du réacteur de recherche)[2][3]	En service	280	5	0	9 334	9 334	120	22 646

EACL – Zone de gestion des déchets G	Arrêt et déclassement partiel	0	0	0	4 886	4 886	20	65 385
EACL – Laboratoires de Whiteshell	Arrêt et déclassement partiel	0	0	0	2 290	2 290	29	23 834
Université McMaster – Réacteur nucléaire[3]	En service	5	1	13	0	13	1	13
Sous-total – Réacteurs de recherche		**285**	**6**	**817**	**41 979**	**42 796**	**275**	**481 947**
TOTAL DES DÉCHETS RADIOACTIFS DE HAUTE ACTIVITÉ		**89 875**	**365**	**1 545 493**	**1 549 098**	**3 094 591**	**12 718**	**59 151 225**

[1] L'inventaire comprend l'uranium appauvri, l'uranium enrichi, l'uranium naturel, le plutonium et le thorium contenus dans le combustible usé.
[2] L'inventaire comprend les grappes, barres, assemblages et autres articles de combustible.
[3] Données en date du 31 juillet 2019.

Figure 19. Inventaire des DRHA par producteur – 2019



Les DRHA déclarés pour Bruce Power dans le tableau A.1 sont comptabilisés dans la catégorie Ontario Power Generation aux fins du présent tableau.



Tableau A.2 Projections pour les déchets radioactifs de haute activité (par propriétaire) – 2022, 2030, 2050, 2100

Entreprise – nom du site	Stocks de DRHA en 2022			Stocks de DRHA en 2030		
	Nombre de grappes de combustible	Vol. est. (m^3)	Masse (kg d'uranium)	Nombre de grappes de combustible	Vol. est. (m^3)	Masse (kg d'uranium)
RÉACTEURS DE PUISSANCE						
OPG – Bruce A[1]	644 844	2,631	12 213 990	784 179	3 199	14 853 134
OPG – Bruce B[1]	815 106	3,326	15 573 415	970 920	3 961	18 550 398
OPG – Darlington[1]	643 229	2,624	12 339 062	804 781	3 284	15 438 114
OPG – Pickering A[1]	380 844	1,554	7 566 989	391 901	1 599	7 786 681
OPG – Pickering B[1]	480 309	1,960	9 543 260	518 764	2 117	10 307 322
Hydro-Québec – Gentilly-2[1][6]	129 925	530	2 471 173	129 925	530	2 471 173
Énergie NB – Point Lepreau[1]	169 931	680	3 237 186	209 931	840	3 999 186
Sous-total Réacteurs de puissance	**3 264 188**	**13 305**	**62 945 075**	**3 810 401**	**15 530**	**73 406 008**
RÉACTEURS PROTOTYPES/DE DÉMONSTRATION/DE RECHERCHE						
EACL – Douglas Point	22 256	89	299 827	22,256	89	299,827
EACL – Gentilly-1	3 213	13	67 596	3,213	13	67,596
EACL – Laboratoires de Chalk River (articles)[2]	9 334	120	22 646	9,334	120	22,646
EACL – Laboratoires de Chalk River	804	3	2646	804	3	2,646
EACL – Laboratoires de Chalk River (grappes)[3]	4 886	20	65 395	4,886	20	65,395
EACL – Laboratoires de Whiteshell	2 301	29	21 540	2,301	29	21,540
Université McMaster – Réacteur nucléaire[2][4]	65	1	72	105	1	116
Sous-total – Réacteurs de recherche	**42 859**	**275**	**479 722**	**42 899**	**275**	**479 766**
TOTAL DES DÉCHETS RADIOACTIFS DE HAUTE ACTIVITÉ	**3 307 047**	**13 580**	**63 424 797**	**3 853 300**	**15 805**	**73 885 774**

Entreprise – nom du site	Stocks de DRHA en 2050			Stocks de DRHA en 2100		
	Nombre de grappes de combustible	Vol. est. (m^3)	Masse (kg d'uranium)	Nombre de grappes de combustible	Vol. est. (m^3)	Masse (kg d'uranium)
RÉACTEURS DE PUISSANCE (SUITE)						
OPG – Bruce A[1]	1 109 734	4 528	21 019 472	1 217 833	4 969	23 066 975
OPG – Bruce B[1]	1 426 954	5 822	27 263 383	1 693 051	6 908	32 347 432
OPG – Darlington[1]	1 245 488	5 082	23 892 196	1 322 614	5 396	25 371 704
OPG – Pickering A[1]	391 901	1 599	7 786 681	391 901	1 599	7 786 681
OPG – Pickering B[1]	518 764	2 117	10 307 322	518 764	2 117	10 307 322
Hydro-Québec – Gentilly-2[1][6]	129 925	530	2 471 173	129 925	530	2 471 173
Énergie NB – Point Lepreau[1][5]	265 741	1 063	5 062 366	265 741	1 063	5 062 366
Sous-total – Réacteurs de puissance	**5 088 507**	**20 741**	**97 802 593**	**5 539 829**	**22 582**	**106 413 653**
RÉACTEURS PROTOTYPES/DE DÉMONSTRATION/DE RECHERCHE (SUITE)						
EACL – Douglas Point	22 256	89	299 827	22,256	89	299 827
EACL – Gentilly-1	3 213	13	67 596	3,213	13	67 596
EACL – Laboratoires de Chalk River (articles)[2]	9 334	120	22 646	9,334	120	22 646
EACL – Laboratoires de Chalk River	804	3	2 646	804	3	2 646
EACL – Laboratoires de Chalk River (grappes)[3]	4 886	20	65 395	4,886	20	65 395
EACL – Laboratoires de Whiteshell	2 301	29	21 540	2,301	29	21 540
Université McMaster – Réacteur nucléaire[2][4]	0	0	0	0	0	0
Sous-total – Réacteurs de recherche	**42 794**	**274**	**479 650**	**42 794**	**274**	**479 650**
TOTAL DES DÉCHETS RADIOACTIFS DE HAUTE ACTIVITÉ	**5 131 301**	**21 015**	**98 282 243**	**5 582 623**	**22 856**	**106 893 303**

[1] La masse de l'uranium indiquée pour les exploitants de réacteurs de puissance est d'approximativement 19 kg par grappe, mais varie selon les propriétaires et les installations.
[2] L'inventaire comprend les barres, assemblages, unités et autres articles de combustible irradiés.
[3] Le nombre de grappes inclut 4 825 grappes du RND ainsi que des grappes partielles de Pickering, Bruce et Douglas Point.
[4] Les grappes de combustible du réacteur de l'Université de McMaster devraient être rapatriées aux États-Unis et les projections ne tiennent pas compte des déchets étrangers.
[5] Par souci de cohérence avec l'industrie et avec le plan préliminaire de déclassement de 2020 et l'étude des coûts, les stocks actuels et prévus de DRHA (déchets radioactifs dont la dose au contact est supérieure à 125 mSv/h) d'Énergie NB ont été inclus dans les tableaux en tant que DRMA.
[6] Les projections de DRHA d'Hydro-Québec pour 2100 peuvent comprendre les DRHA non combustibles.


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Tableau A.3 Inventaire des déchets radioactifs de haute activité non combustibles – 2019

Installation	Description des déchets stockés	Méthode de stockage	Stocks des déchets sur place au 19 décembre 2019 (m^3)
OPG – Centrales d'énergie nucléaire de Bruce	Sources scellées de cobalt-60 retiré du service	Stockage en piscine	3

Tableau A.4 Projections pour les déchets radioactifs de haute activité non combustibles (par propriétaire – 2022, 2030, 2050, 2100

Installation	Stocks de DRHA non combustibles en 2021	Stocks de DRHA non combustibles en 2030	Stocks de DRHA non combustibles en 2050	Stocks de DRHA non combustibles en 2100
OPG – Centrales d'énergie nucléaire de Bruce	n.d.	n.d.	n.d.	n.d.
EACL	0	0	2	2

n.d. – non disponible.

Tableau A.5 Inventaire des déchets radioactifs de moyenne activité d'exploitation (par propriétaire) – 2019

Nom du site	Partie responsable	Taux d'accumulation des DRMA en 2019 (m^3)	Stocks de DRMA au 31 décembre 2019 (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE ET PRODUCTION D'ISOTOPES			
Installation de gestion des déchets Western	OPG	125	11 293[2]
Installation de gestion des déchets Darlington	OPG	9	628
Installation de gestion des déchets Pickering	OPG	0	1 012
Aire de stockage des déchets radioactifs-1	OPG	0	5
Gentilly-2	Hydro-Québec	3	358
Point Lepreau[3]	Énergie NB	7	362
Nordion Kanata	Nordion	0	5
Best Theratronics Kanata	Best Theratronics	0	1
Sous-total (cycle du combustible nucléaire)		**144**	**13 664**
RECHERCHE-DÉVELOPPEMENT			
Laboratoires de Chalk River[4]	EACL	25	1 050[1]
Sous-total (recherche-développement nucléaire)		**25**	**1 050**
Sous-total (exploitation)		**169**	**14 714**

[1] Les estimations antérieures étaient fondées sur une hypothèse prudente selon laquelle tous les déchets stockés dans une structure qui pourrait contenir des DRMA seraient classés comme des DRMA jusqu'à ce que de meilleures données de caractérisation soient disponibles. Entre 2016 et 2019, des opérations de récupération et de traitement ont été menées sur certains déchets historiques stockés, et les registres ont été vérifiés pour extrapoler les volumes actuels

[2] Comprend les volumes de résine épuisée dans les réservoirs de la centrale, que l'on suppose seront éventuellement transférés à l'Installation de gestion des déchets de Western et stockés à long terme.

[3] La diminution des volumes de DRMA d'Énergie NB entre le 31 décembre 2016 et le 31 décembre 2019 peut être attribuée à la stratégie de réduction à long terme des volumes de DRFA et de DRMA d'Énergie NB qui comprend l'incinération, le recyclage des métaux fondus, ou le compactage par l'intermédiaire de l'installation de traitement des déchets radioactifs Bear Creek d'Energy Solutions à Oak Ridge (Tennessee).

[4] Les DRFA qui ne sont pas destinés à l'installation de gestion des déchets près de la surface proposée sont inclus dans les DRMA.

Tableau A.6 Inventaire des déchets radioactifs de moyenne activité découlant du déclassement (par propriétaire) – 2019

Nom du site	Partie responsable	Taux d'accumulation des DRMA en 2019 (m^3)	Inventaire des DRMA au 31 décembre 2019 (m^3)
RECHERCHE-DÉVELOPPEMENT			
Douglas Point[1][2]	EACL	0	6
RND[1][2]	EACL	0	389
Laboratoires de Chalk River[1]	EACL	13	332
Laboratoires de Whiteshell[1][2]	EACL	0	240
Sous-total (déclassement)		**13**	**967**
Sous-total (exploitation)		**169**	**14 714**
TOTAL DES DÉCHETS RADIOACTIFS DE MOYENNE ACTIVITÉ		**182**	**15 681**

[1] Les DRFA qui ne sont pas destinés à l'installation de gestion des déchets près de la surface proposée sont inclus dans les DRMA.
[2] Les volumes ont diminué en raison de l'utilisation de services hors site de traitement ou de transfert aux LCR.

Figure 20. Inventaire des DRMA par producteur - 2019

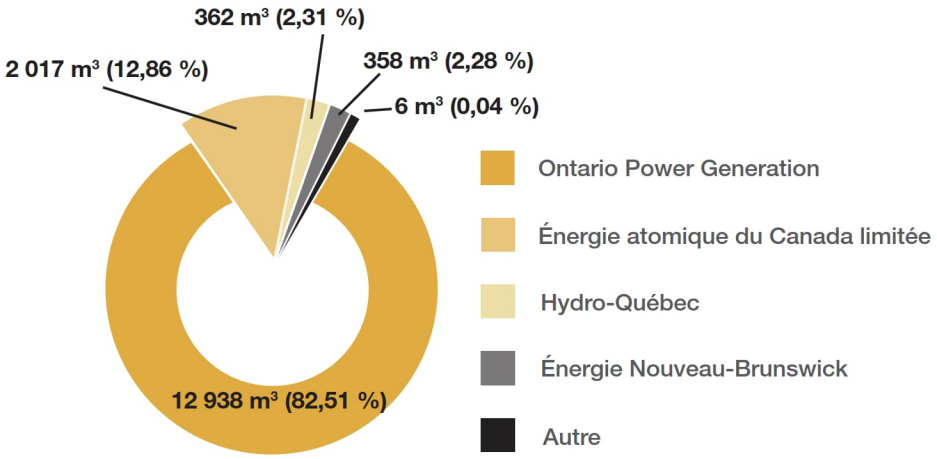


Tableau A.7 Projections pour les déchets radioactifs de moyenne activité d'exploitation (par propriétaire) – 2022, 2030, 2050, 2100

Nom du site	Partie responsable	Stocks de DRMA en 2022 (m^3)	Stocks de DRMA en 2030 (m^3)	Stocks de DRMA en 2050 (m^3)	Stocks de DRMA en 2100 (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE ET PRODUCTION D'ISOTOPES					
Installation de gestion des déchets Western	OPG	12 463	15 226	17 166	17 702
Installation de gestion des déchets Darlington	OPG	1 523	2 653	2 653	2 653
Installation de gestion des déchets Pickering	OPG	1 012	1 012	1 012	1 012
Aire de stockage des déchets radioactifs-1	OPG	5	5	5	5
Gentilly-2	Hydro-Québec	358	358	358	358
Point Lepreau	Énergie NB	382	435	210[1]	210[1]
Best Theratronics Kanata	Best Theratronics	1	1	0	0
Sous-total (cycle du combustible nucléaire)		**15 744**	**19 690**	**21 404**	**21 940**
RECHERCHE-DÉVELOPPEMENT					
Laboratoires de Chalk River[2]	EACL	1 400	1 538	1 598	1 748
Subtotal (Nuclear R&D)		**1 400**	**1 538**	**1 598**	**1 748**
Subtotal (Operations)		**17 144**	**21 228**	**23 002**	**23 688**

[1] L'importante réduction du volume projeté est attribuable à l'incinération (taux de réduction de 80:1) et à un retour de cendres connexes/déchets ne pouvant être traités.
[2] Les DRFA qui ne sont pas destinés à l'installation de gestion des déchets près de la surface proposée sont inclus dans les DRMA.

Tableau A.8 Projections pour les déchets radioactifs de moyenne activité de déclassement (par propriétaire) – 2022, 2030, 2050, 2100

Nom du site	Partie responsable	Stocks de DRMA en 2022 (m^3)	Stocks de DRMA en 2030 (m^3)	Stocks de DRMA en 2050 (m^3)	Stocks de DRMA en 2100 (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE					
Installation de gestion des déchets Western	OPG	0	158	258	358
Gentilly-2	Hydro-Québec	0	0	0	620
Point Lepreau	Énergie NB	0	0	0	567
Sous-total (cycle du combustible nucléaire)		0	158	258	1 545
RECHERCHE-DÉVELOPPEMENT					
Douglas Point	EACL	6	6	6	264
Gentilly-1	EACL	0	0	319	319
RND	EACL	389	389	389	389
Laboratoires de Chalk River[1][2]	EACL	548	1 711	4 678	4 684
Laboratoires de Whiteshell	EACL	274	1 435	1 435	1 435
Sous-total (recherche-développement nucléaire)		1 217	3 541	6 827	7 091
Sous-total (déclassement)		**1 217**	**3 699**	**7 085**	**8 636**
Sous-total (exploitation)		**17 144**	**21 228**	**23 002**	**23 688**
TOTAL DES DÉCHETS RADIOACTIFS DE MOYENNE ACTIVITÉ		**18 361**	**24 927**	**30 087**	**32 324**

[1] Au 31 décembre 2019, les données sur la production et l'utilisation de radio-isotopes des LCR ont été intégrées aux volumes des Laboratoires de Chalk River.
Dans les rapports d'inventaire antérieurs, celles-ci étaient indiquées sur une ligne distincte.
[2] Les DRFA qui ne sont pas destinés à l'installation de gestion des déchets près de la surface proposée sont inclus dans les DRMA.

Tableau A.9 Inventaire des déchets radioactifs de faible activité historiques et de Deloro – 2019

Nom du site		Partie responsable	Total (m^3)
DÉCHETS HISTORIQUES ET DE DELORO	Port Hope (PHAI)	EACL	720 000
	Welcome (PHAI)	EACL	550 000
	Port Granby (PHAI)	EACL	765 622
	Région du Grand Toronto	EACL	4 900
	Deloro	Ministère de l'Environnement de l'Ontario	34 500
		TOTAL	**2 075 022**


1665
375
375


SITE TRANSITION

Tableau A.10 Inventaire des déchets radioactifs de faible activité d'exploitation (par propriétaire) – 2019

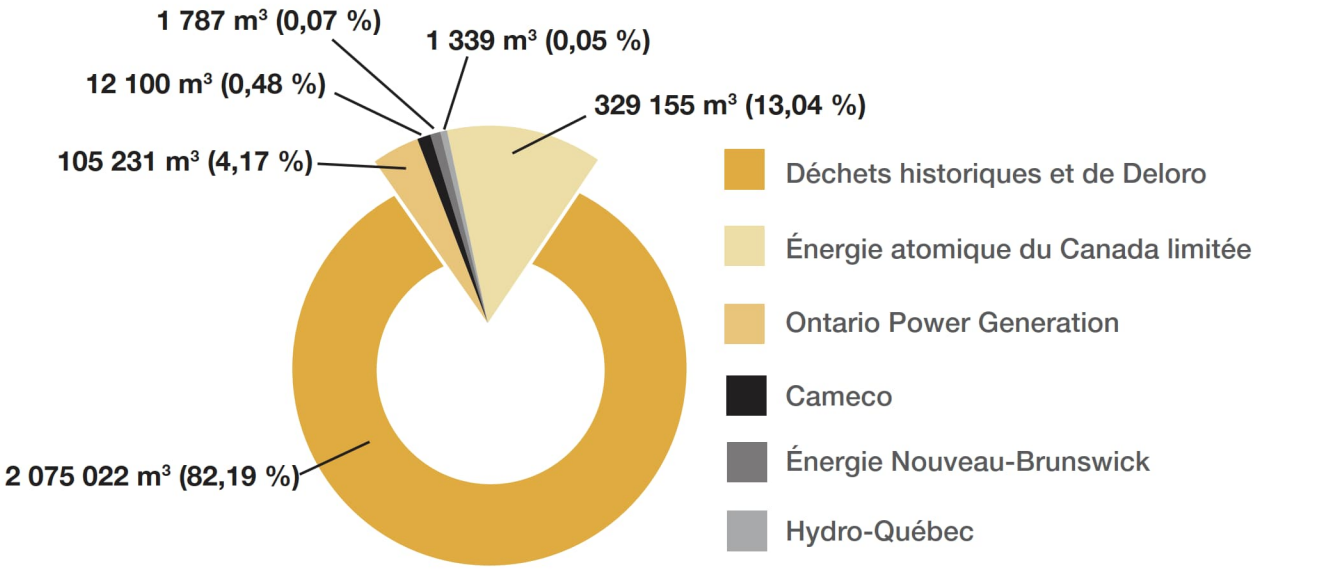
Nom du site	Partie responsable	Taux d'accumulation des DRFA en 2019 (m^3)	Stocks de DRFA au 31 décembre 2019		
			Déchets (m^3)	Sol cont. (m^3)	Total (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE ET PRODUCTION D'ISOTOPES					
Installation de gestion des déchets Western	OPG	665	104 906[2]	0	104 906
Aire de stockage des déchets radioactifs-1	OPG	0	325	0	325
Gentilly-2	Hydro-Québec	0	1 339	0	1 339
Point Lepreau[3]	Énergie NB	71	1 787	0	1 787
Installation de conversion de Port Hope	Cameco Corp.	S. O.	4 000	0	4 000
Raffinerie de Blind River	Cameco Corp.	S. O.	4 400	0	4 400
Cameco Fuel Manufacturing	Cameco Corp.	S. O.	2 000	0	2 000
BWXT Toronto	BWXT	34	33	0	33
BWXT Peterborough	BWXT	9	2	0	2
Best Theratronics Kanata	Best Theratronics	S. O.	1	0	1
Sous-total (cycle du combustible nucléaire)		**779**	**118 793**	**0**	**118 793**
RECHERCHE-DÉVELOPPEMENT					
Laboratoires de Chalk River	EACL	2 655	136 582	156 276[1]	292 858
Sous-total (recherche-développement nucléaire)		**2 655**	**136 582**	**156 276**	**292 858**
Sous-total (exploitation)		**3 434**	**255 375**	**156 276**	**411 651**

[1] Le volume a diminué depuis 2016, puisque certains matériaux ont été classés dans la catégorie des déchets emballés et comprenaient des déchets qui devaient être produits à l'avenir.
[2] Comprend les volumes de DRFA actuellement stockés hors site à EnergySolutions Canada, mais qui sont censés revenir éventuellement et être stockés à long terme à l'Installation de gestion des déchets de Western.
[3] La diminution des volumes de DRMA d'Énergie NB entre le 31 décembre 2016 et le 31 décembre 2019 peut être attribuée à la stratégie de réduction à long terme des volumes de DRFA et de DRMA d'Énergie NB qui comprend l'incinération, le recyclage des métaux fondus, ou le compactage par l'intermédiaire de l'installation de traitement des déchets radioactifs Bear Creek d'Energy Solutions à Oak Ridge (Tennessee).

Tableau A.11 Inventaire des déchets radioactifs de faible activité découlant du déclassement (par propriétaire) – 2019

Nom du site	Partie responsable	Taux d'accumulation des DRFA en 2019 (m^3)	Stocks de DRFA au 31 décembre 2019		
			Déchets (m^3)	Sol cont. (m^3)	Déchets (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE					
Installation de conversion de Port Hope	Cameco Corp.	0	1 500	200	1 700
Sous-total (cycle du combustible nucléaire)		0	1 500	200	1 700
RECHERCHE-DÉVELOPPEMENT					
Douglas Point	EACL	0	92	0	92
Gentilly-1	EACL	0	161	0	161
RND	EACL	0	2 289	0	2 289
Laboratoires de Chalk River	EACL	4 588	12 692	4 202	16 894
Laboratoires de Whiteshell	EACL	929	16 861	0	16 861
Sous-total (recherche-développement nucléaire)		**5 517**	**32 095**	**4 202**	**36 297**
Sous-total (déclassement)		**5 517**	**33 595**	**4 402**	**37 997**
Sous-total (exploitation)		**3 434**	**255 375**	**156 276**	**411 651**
STOCK TOTAL DES DÉCHETS RADIOACTIFS DE FAIBLE ACTIVITÉ		**8 951**	**288 970**	**160 678**	**449 648**

Figure 21. Inventaire des DRFA par producteur - 2019



* Ne comprend pas 36 mètres cubes de déchets de faible activité provenant d'autres producteurs de déchets.

Tableau A.12 Projections pour les déchets radioactifs de faible activité d'exploitation (par propriétaire) – 2022, 2030, 2050, 2100

Nom du site	Partie responsable	Stocks de DRFA en 2022 (m^3)	Stocks de DRFA en 2030 (m^3)	Stocks de DRFA en 2050 (m^3)	Stocks de DRFA en 2100 (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE ET PRODUCTION D'ISOTOPES					
Installation de gestion des déchets Western	OPG	105 026	111 399	110 939	108 252
Aire de stockage des déchets radioactifs-1	OPG	325	325	325	325
Gentilly-2	Hydro-Québec	593[1]	593	593	593
Point Lepreau	NB Power	1 571	983	849	831
Installation de conversion de Port Hope	Cameco Corp.	500	350	0	0
Raffinerie de Blind River	Cameco Corp.	700	500	0	0
Cameco Fuel Manufacturing	Cameco Corp.	100	50	0	0
BWXT Toronto	BWXT	33	0	0	0
BWXT Peterborough	BWXT	2	0	0	0
Best Theratronics Kanata	Best Theratronics	1	1	0	0
Sous-total (cycle du combustible nucléaire)		**108 851**	**114 201**	**112 706**	**110 001**
RECHERCHE-DÉVELOPPEMENT					
Laboratoires de Chalk River	EACL	294 994	299 281	308 641	332 041
Sous-total (recherche-développement nucléaire)		**294 994**	**299 281**	**308 641**	**332 041**
Sous-total (exploitation)		**403 845**	**413 482**	**421 347**	**442 042**

[1] La projection tient compte du programme de réduction des déchets en cours selon un ratio de 80:1

Tableau A.13 Projections pour les déchets radioactifs de faible activité de déclassement (par propriétaire) – 2022, 2030, 2050, 2100

Nom du site	Partie responsable	Stocks de DRFA en 2022 (m^3)	Stocks de DRFA en 2030 (m^3)	Stocks de DRFA en 2050 (m^3)	Stocks de DRFA en 2100 (m^3)
CYCLE DU COMBUSTIBLE NUCLÉAIRE					
Installation de gestion des déchets Western	OPG	0	6 638	7 734	172 163
Gentilly-2	Hydro-Québec	0	0	0	17 033
Point Lepreau	Énergie NB	0	0	92	14
Installation de conversion de Port Hope	Cameco Corp.	1 000	0	0	0
Raffinerie de Blind River	Cameco Corp.	0	0	120 000	120 000
Sous-total (cycle du combustible nucléaire)		**1 000**	**6 638**	**127 826**	**309 210**
RECHERCHE-DÉVELOPPEMENT					
Douglas Point	EACL	92	422	422	731
Gentilly-1	EACL	208	741	908	908
RND	EACL	2 289	2 289	2 289	2 289
Laboratoires de Chalk River	EACL	79 425	151 728	372 481	497 881
Laboratoires de Whiteshell	EACL	17 028	45 217	45 217	45 217
Sous-total (recherche-développement nucléaire)		**99 042**	**200 397**	**421 317**	**547 026**
Sous-total (déclassement)		**100 042**	**207 035**	**549 143**	**856 236**
Sous-total (exploitation)		**403 845**	**413 482**	**421 347**	**442 042**
STOCK TOTAL DES DÉCHETS RADIOACTIFS DE FAIBLE ACTIVITÉ		**503 887**	**620 517**	**970 490**	**1 298 278**

Tableau A.14 Taux d'accumulation et inventaire des résidus d'extraction minière et de traitement de l'uranium (par propriétaire) – 2019

Nom de mine ou d'usine	Nom de la principale entreprise source ou partie responsable	Territoire ou province	Résidus Installation	Taux d'accumulation (résidus) en 2019 (tonnes/an)	Masse totale des résidus au 31 déc. 2019 (tonnes)	État de l'installation de gestion
SITES EN SERVICE						
Key Lake	Cameco Corp.	Saskatchewan	Installation de gestion des résidus Deilmann	907	6 177 572	En service depuis 1995
Rabbit Lake	Cameco Corp.	Saskatchewan	Installation de gestion des résidus en puits de Rabbit	542	9 126 693	En service depuis 1985
McClean Lake	Orano Canada Inc.	Saskatchewan	Installation de gestion des résidus JEB	73 837	2 243 859	En service depuis 1999
			Sous-total des sites en service	**75 286**	**17 548 124**	
SITES FERMÉS OU DÉCLASSÉS						
Cluff Lake	Orano Canada Inc.	Saskatchewan	Aire de gestion des résidus	0	3 230 000	Déclassé depuis 2006/ surveillance continue
Key Lake	Cameco Corp.	Saskatchewan	Résidus de surface (anciens bassins de résidus)	0	3 579 781[2]	Fermé depuis 1996/ surveillance continue
Rabbit Lake	Cameco Corp.	Saskatchewan	Résidus de surface	0	6 500 000	Fermé depuis 1985/ surveillance continue
Beaverlodge	Cameco Corp.	Saskatchewan	Résidus de surface, subaréaux et subaquatiques	0	5 700 000[1]	Déclassé depuis 1982/surveillance continue
Gunnar	Saskatchewan Research Council	Saskatchewan	Résidus de surface	0	4 400 000	Fermé depuis 1964
Lorado	Saskatchewan Research Council	Saskatchewan	Résidus de surface	0	360 000	Déclassé en 2015/ surveillance continue
Port Radium	Relations Couronne-Autochtones et Affaires du Nord Canada	Territoires du Nord-Ouest	Résidus de surface – quatre aires	0	907 000	Déclassé depuis 1984/ surveillance continue
Rayrock	Relations Couronne-Autochtones et Affaires du Nord Canada	Territoires du Nord-Ouest	Amas de résidus nord et sud	0	71 000	Fermé depuis 1959/ surveillance continue
Quirke 1 and 2 - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des résidus Quirke Mine	0	46 000 000	Déclassé/surveillance continue
Panel - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des résidus Panel Mine, bassin principal et bassin sud	0	16 000 000	Déclassé/surveillance continue
Denison - Elliot Lake	Denison Mines Corp.	Ontario	Aire de gestion des résidus Denison (1 et 2)	0	63 800 000	Déclassé/surveillance continue

Nom de mine ou d'usine	Nom de la principale entreprise source ou partie responsable	Territoire ou province	Résidus Installation	Taux d'accumulation (résidus) en 2019 (tonnes/an)	Masse totale des résidus au 31 déc. 2019 (tonnes)	État de l'installation de gestion
CLOSED/DECOMMISSIONED SITES						
Spanish-American - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des résidus Spanish American	0	450 000	Déclassé/surveillance continue
Stanrock/Can-Met - Elliot Lake	Denison Mines Corp.	Ontario	Aire de gestion des résidus Stanrock	0	5 750 000	Déclassé/surveillance continue
Stanleigh - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des résidus Stanleigh	0	19 953 000	Déclassé/surveillance continue
Lacnor - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des déchets Lacnor	0	2 700 000	Déclassé/surveillance continue
Nordic - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des déchets Nordic	0	12 000 000	Déclassé/surveillance continue
Milliken - Elliot Lake	Rio Algom Ltd.	Ontario	Milliken	0	150 000	Déclassé/surveillance continue
Pronto - Elliot Lake	Rio Algom Ltd.	Ontario	Aire de gestion des déchets Pronto	0	2 100 000	Déclassé/surveillance continue
Agnew Lake Mines - Espanola	Ministère du Développement du Nord, des Mines, des Richesses naturelles et des Forêts de l'Ontario	Ontario	Aire sèche de gestion des résidus	0	510 000	Déclassé depuis 1990/surveillance continue
Dyno - Bancroft	EnCana West Ltd.	Ontario	Résidus de surface	0	600 000	Fermé depuis 1960/ surveillance continue
Bicroft - Bancroft	Barrick Gold Corp.	Ontario	Aire de gestion des résidus Bicroft	0	2 000 000	Fermé depuis 1964/ surveillance continue
Madawaska - Bancroft	EnCana West Ltd.	Ontario	Résidus en surface – deux aires	0	4 000 000	Déclassé/surveillance continue
			Sous-total des sites déclassés	**0**	**200 760 781**	
			TOTAL	**75 286**	**218 308 905**	

[1] Le volume des résidus n'inclut pas les 4 300 000 tonnes utilisées comme remblai.
[2] Reposant sur des rapports de production mensuels entre 1983 et 1996. En 1996, le stockage des résidus a été transféré à l'aire de gestion des résidus Deilmann.

Tableau A.15 Inventaire des stériles d'uranium (par propriétaire) – 2019

Nom de mine ou d'usine	Nom de la principale entreprise source ou partie responsable	Province de l'entreprise source	Stocks de stériles		État du site des stériles en décembre 2019
			Stériles minéralisés (tonnes)	Stériles non minéralisés (tonnes)	
Key Lake	Cameco Corp.	Saskatchewan	1 123 058	68 028 327	En service depuis 1995
Rabbit Lake	Cameco Corp.	Saskatchewan	1 348 389	11 157 174	Suspendu en juillet 2016
McClean Lake	Orano Canada Inc.	Saskatchewan	10 200 000	51 200 000	En service depuis 1999
McArthur River	Cameco Corp.	Saskatchewan	116 501	226 811	En service depuis 1999
Cigar Lake	Cameco Corp.	Saskatchewan	685 647	84 172	En service depuis 2014
Sous-total des sites en service			**13 473 595**	**130 696 484**	
Cluff Lake	Orano Canada Inc.	Saskatchewan	18 400 000[1]		Déclassé depuis 2006, surveillance continue
Beaverlodge	Cameco Corp.	Saskatchewan	4 800 000[1]		Déclassé depuis 1982, surveillance continue
Totaux			**36 673 595**	**130 696 484**	

[1] Stocks ajoutés au total des stériles minéralisés.

Leadership & Democracy Lab

Political Risk Assessment

Mitigating Risk to the NWMO's Proposed Deep Storage Repository in Ignace and Teeswater

Prepared by the Leadership & Democracy Lab, University of Western Ontario

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Executive Summary

The Nuclear Waste Management Organization (NWMO) of Canada was established under the Nuclear Fuel Waste Act (NFWA) of 2002 to investigate approaches for managing Canada's used nuclear fuel. Presently, the NWMO is the sole organization that oversees the management of spent nuclear fuel in Canada. On January 24th, 2020, the NWMO announced Teeswater and Ignace as the two remaining potential host areas in the site selection process for the construction of a deep geological repository location for spent nuclear fuel from reactors in Ontario and New Brunswick. The deep geological repository project is projected to cost $23 billion dollars and take 40 years to complete, hence the significant discussion, research, and time spent in considering sites. Moreover, the NWMO is committed to only developing the repository in an area where the hosts are 'informed and willing.'

This report compiles research from various primary and secondary sources to identify potential risks to the proposed deep geological repository. Additionally, this report provides mitigation strategies to neutralize the risks and allow for improvement.

This document features four sections:

1. **Economic and Financial Risks**

A broad overview of the operations of the NWMO and how it might impact the repository project.

2. **Technological Risks**

An investigation into the technological trends relating to the transfer and storage of spent nuclear fuel which may present security concerns

3. **Health Risks**

An examination of the risks that the spent nuclear waste might pose to the health of the communities involved through passive and acute exposure to radiation, including the use of the Hanford Site as a case study.

4. **Social Risks**

An analysis of how the outlook regarding the repository and nuclear fuel might generate social trends in surrounding communities.



Figure 1: Opposition to the proposed location for disposing of spent nuclear fuel.

Economic and Financial Risks

Operational Risks

For any company like the *Nuclear Waste Management Organization (NWMO)* dealing with a used nuclear fuel project and long-term time frame, the costs of long-term waste management approaches will be high. Considering the perplexity of developing and implementing a waste management system, the many indirect factors, including the court of public opinion, and the exceptionally grand time frame for completion, a complete specification of all relevant cost issues is very challenging. In other terms, any cost estimate will be subject to a great deal of uncertainty.

The *NWMO* has provided a gross simplification of a life-cycle cost approach that includes:

- "processing and packaging costs of spent fuel before shipment to retrievable storage permanent disposal facilities;
- development and construction costs of storage/disposal facilities;
- transportation costs, from the reactor facility through to the ultimate disposal location, including any interim storage stops in between;
- interim storage costs between current on-site storage and eventual disposal, as applicable;
- costs of depositing the waste in the disposal site;
- monitoring and security; and,
- costs of ultimately closing and decommissioning the disposal site."[1]

The *NWMO* believes that the eight-bullet list is critical to achieving the "polluter-pays" principle, which ensures that future generations are not faced with the unfair financial burden of managing nuclear waste whose electricity production benefits were enjoyed by previous generations.

The *NWMO* Board comprises nine Directors, including Wayne Robbins as Chair, Laurie Swami as President and CEO, and Glenn Jager acting as Vice-Chair. The remaining seven directors are Jason Nouwens, Lesley Gallinger, Sean Granville, Ronald L. Jamieson, Josée Pilon, and Beth Summers. The Board is responsible for overseeing the corporate management and leading the strategic direction. Fiscal responsibility is of utmost importance, especially given the size and duration of the project.

In March 2021, *NWMO* (the "Organization") released its annual report for 2020. The independent auditor's report conducted by Deloitte LLP on February 16, 2021, concluded that the accompanying consolidated financial statements as of December 31, 2020, present fairly, in all material respects, the financial position of the Organization and the results of its operations and its cash flows for the year then ended in accordance with Canadian accounting standards for not-for-profit organizations.[2]

Ensuring Funding is in Place

Generally speaking, financial risk refers to the possibility of losing money on an investment or business venture. Funding risks are associated with a project's cash flow from higher costs or lack of funds. In the case of *NWMO*, Canadians have high expectations that the money necessary to pay for the long-term care of Canada's used nuclear fuel will be available when needed.

The *Nuclear Fuel Waste Act (NFWA)* requires the major owners of used nuclear fuel in Canada to fund the planning, development, and implementation of the project. The major owners are Ontario Power Generation, NB Power, Hydro-Québec, and Atomic Energy of Canada Limited. These companies are required to establish independently managed trust funds and make annual deposits to ensure the money to fund this project will be available when needed.[3] In 2002, these funds were established and annual contributions have been made by each waste owner since. At the end of 2020, the total value of these funds, including investment income, was approximately $5.4 billion (balance estimates are rounded to the nearest $ million). This grand sum is in addition to other segregated funds and financial guarantees the companies have set aside for nuclear waste management and decommissioning.

The *Act* also requires the *NWMO* to maintain a funding formula and define the number of deposits to trust funds required by each company on an annual basis. The *NFWA* explicitly addresses the future financial obligations expected for managing used fuel over the long term. The box below describes the requirements of the *Act*.

"Requirements of the *NFWA* (2002)

The NWMO is required to provide a range of financial information in each of our annual reports following the government's decision, as defined in subsection 16(2) of the *NFWA*.

16(2) Each annual report after the date of the decision of the Governor in Council under section 15 must include:

(a) the form and amount of any financial guarantees that have been provided during that fiscal year by the nuclear energy corporations and Atomic Energy of Canada Limited under the *Nuclear Safety and Control Act* and relate to implementing the approach that the Governor in Council selects under section 15 or approves under subsection 20(5);

(b) the updated estimated total cost of the management of nuclear fuel waste;

(c) the budget forecast for the next fiscal year;

(d) the proposed formula for the next fiscal year to calculate the amount required to finance the management of nuclear fuel waste and an explanation of the assumptions behind each term of the formula; and

(e) the amount of the deposit required to be paid during the next fiscal year by each of the nuclear energy corporations and Atomic Energy of Canada Limited, and the rationale by which those respective amounts were arrived at."[4]

In addition to trust fund contributions, the major owners are also responsible for funding the *NWMO*'s annual operating budget and are required to provide financial guarantees that are dedicated to nuclear waste management and decommissioning to the *Canadian Nuclear Safety Commission (CNSC)* as per the *Nuclear Safety and Control Act (NSCA)*.

Ensuring adequacy and sustainability of funding mechanisms

From a political stakeholder standpoint, the nuclear repository project presents some significant but manageable risks regarding the stability of agreements with political stakeholders in the community and any surrounding nearby indigenous communities. It cannot be emphasized enough to ensure political stakeholder

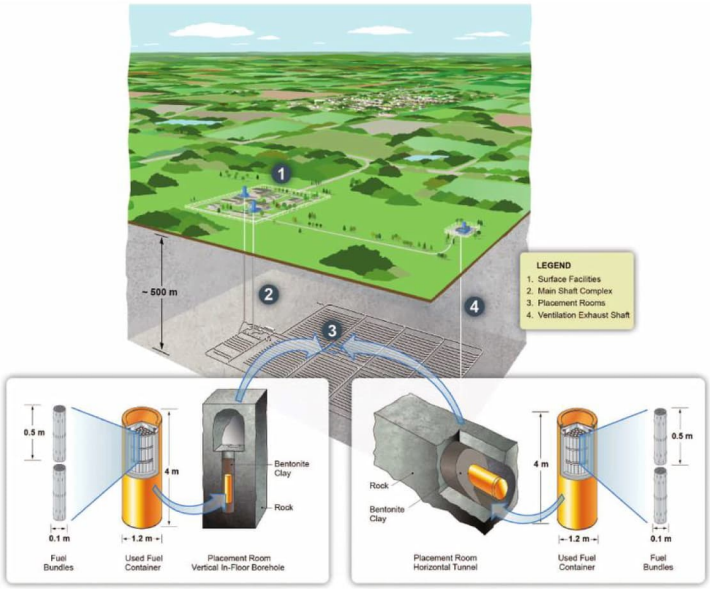


Figure 2: Options for spent nuclear fuel disposal in Canada

relationships are in good standing with the community and any indigenous peoples before this project begins.[5]

A major risk associated with this project is the absence of contingency plans to get all people living in the vicinity of this repository to get to safety without becoming displaced persons. To mitigate this risk, the *Nuclear Liability and Compensation Act* has provisions to protect those who are involved if there is a nuclear incident. The 16th provision of the act under the liabilities section protects people from economic, physical, and psychological harm.[6] This will mitigate the risk by making sure community stakeholders feel protected. This law will also prove to give these people peace of mind. The other mitigation strategy employed by the NWMO is ensuring the hosting community and nearby indigenous communities undertake host-ships voluntarily. This means that these people know what they have agreed to and understand the risks of this. It is extremely important to make sure they have all the information and the decision is made in a democratic

way using a referendum due to the small population size of each municipality.[7] This risk could be mitigated by making this an official community decision and making a stern request that all community members aged 18+ vote, which can be promoted through promotional campaigns.

.

Technological Risks

Waste Transportation and Security

Spent nuclear fuel has a long half-life and thus remains radioactive for thousands of years. Consequently, the waste that is intended to be stored in the deep geological repositories would be of interest to bad actors - within Canada and outside. The nuclear material being stored in most deep geological repositories are high or intermediate-level waste.[8] Intermediary nuclear material is less radioactive than high-level waste, however, it is still hazardous and requires safety precautions.[9] High-level nuclear waste is the material that has been processed in nuclear reactors. This material is highly radioactive and requires extreme caution in handling and storing.[10] In addition to containing radioactive material, used nuclear fuel also contains mercury, which is chemically hazardous and used in weapons systems.[11]

Although the material being stored in the DGR would need to undergo significant reprocessing in order to be used by hostile actors, it does not entirely neutralize the threat these actors pose. Hostile actors may take action if they think gaining access to the materials stored in the DGR would benefit them in any way. Whether the risk of attack from hostile actors is significant or not, concern from the public will remain present. Therefore, the security of the DGR plants, and the security of the used fuel containers (UFC) during the transportation is a top priority. Historically, transportation of spent nuclear fuel in countries heavily reliant on nuclear energy, like France, has been successful. This is due to the safety systems and technology in place. In the case of France, safe transport is ensured by confirming all equipment used in the process undergoes rigorous testing to ensure all standards and requirements are met. Additionally, emergency management plans are in place to deal with any unexpected situation that arises. Finally, all operators undergo education and training to ensure their ability to safely handle the radioactive material and implement all security planning.[12] Due to the success of France's nuclear transport, the model should be implemented in the transport of UFCs to DGR sites in Canada. This would entail implementing a strict verification regime to regulate and monitor the entire process from the nuclear plant to repository. Equipment must be tested and maintained properly, emergency contingency plans must be in place and operators must have the proper training. In regards to the security of the UFCs, once they are being stored at the DGR, the plant must be adequately equipped to deal with actors who may want to gain access to the facility or compromise the security of the UFCs. This should include physical barriers such as walls and fencing, in addition to technological barriers restricting access and surveilling the facilities. Access to the facility should be highly regulated and monitored.



Figure 3: Options for spent nuclear fuel disposal in Canada

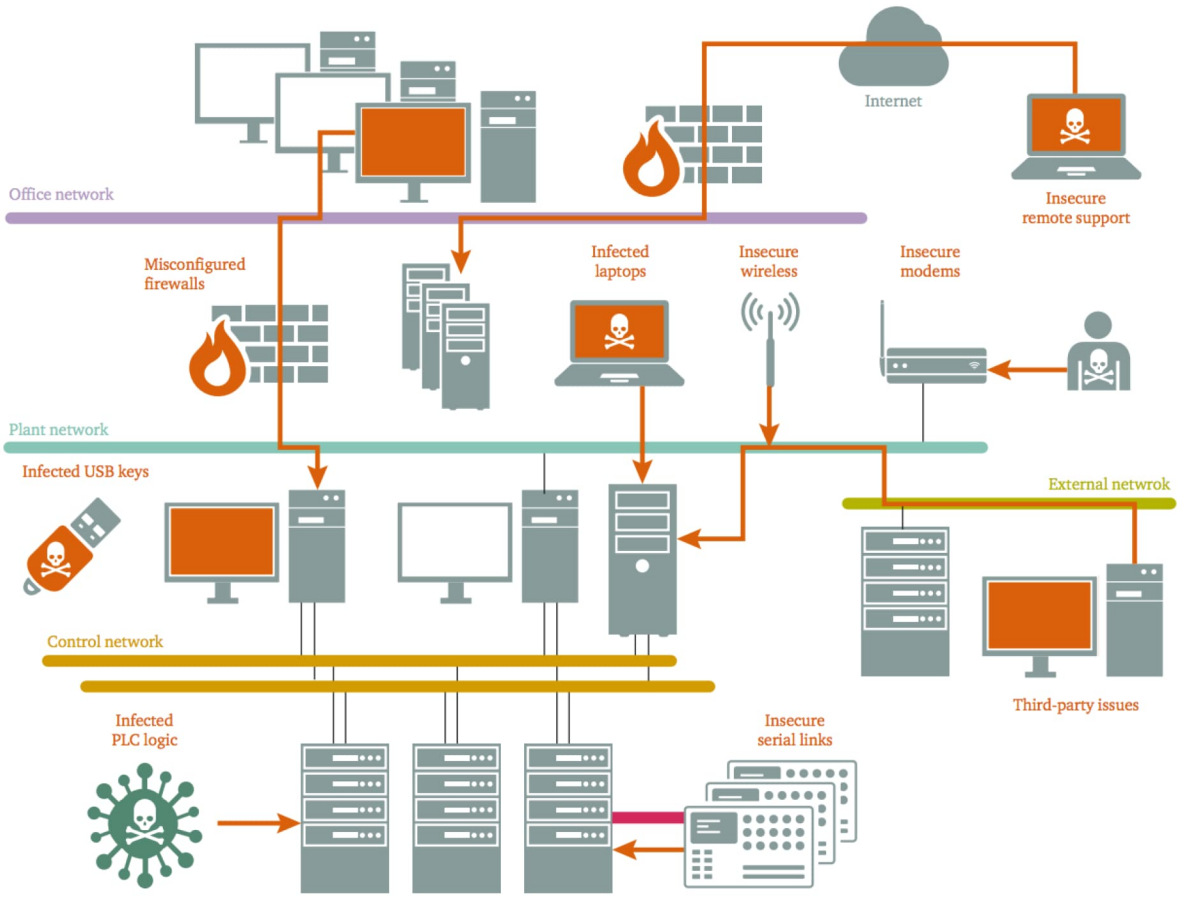
Susceptibility to Cyber Influence

In ensuring an adequately secured facility in the modern age, it is necessary that the DGR plant relies on computer technologies to maintain and protect the nuclear waste stored within. However, in the use of such information and communication technology, the facility becomes vulnerable to cyberattacks. In the past, cyberattacks on other nuclear facilities have come from bad actors within and outside the state.[13] These actors have successfully compromised the safety systems, leaving facilities vulnerable. This is increasing the

concern that extremists could turn individuals working in the facilities who could help them to gain access to the cyber systems.[14] Due to the hazardous nature of the material being stored in the DGR, the safety and security implications should the facility experience a cyberattack are severe.

One way to safeguard against individual workers' choices is to ensure that all processes require two operators rather than one. Additionally, to reduce the risk of a cyberattack on the DGR, the NWMO should ensure that they are hiring qualified candidates to maintain and update the technology used in the facility. This could help ensure that security features are regularly updated and developed to be more advanced. In hiring, the NWMO should utilize the creativity and innovation of new graduates from related fields and draw applicants from top programs. The facility should also invest in hackathons, where participants try to find weaknesses in the defenses of the DGR systems. The employment of 'white hat' ethical hackers would help identify areas of weakness and ensure that they are updated to maximize security. Moreover, the facility should have thorough emergency response plans, including but not limited to safeguards built in that rely on brick and mortar defenses in case cyber protections were compromised. Physical defenses, such as additional barriers and gates that automatically lockdown at signs of attacks should be implemented.

Figure 1: Potential control system vulnerabilities



Source: Eric Byres, Byres Security.

Figure 4: System vulnerabilities in nuclear controls

Public Health Risks

Similarly to other energy sources, nuclear energy and its radioactive waste pose health risks to the people in the area. This section will be a risk assessment of the health of the inhabiting Teeswater and Ignace populations. Radioactivity has the potential to contaminate food and water resources which could negatively impact consumers. Excess passive radioactive emissions over a long period of time from nuclear waste can increase the risks of radiation-related diseases such as cancers. If there is a malfunction of storage then acute risks to local populations may be present. While nuclear energy has appealing impacts, nuclear waste stored improperly poses significant adverse impacts to the local populations.

Hanford Case Study

Hanford is a nuclear production and waste storage site that was constructed during the second world war as a part of the Manhattan Project. It is located on a desert plateau near the Columbia River, one of Washington's main waterways, in the southern area of Washington State. Over its lifetime, the facility produced 70 million gallons of high-level radioactive waste that was evaporated into solid states and placed into steel tanks.[15] These tanks were then placed underground beneath relatively loose soil. Due to the lack of safety measures at the site, high-level nuclear waste and other chemicals have leaked into the surrounding soil and the Columbia River. "Other high-level waste tanks have also leaked. Between August 1958, and this June [1973], an estimated 422,000 gallons containing more than half a million curies seeped out of 15 other tanks, all of which have since been "retired".[16] According to Washington state's Environmental agency, over one million gallons of nuclear waste have leaked into the soil with tank B-109 being the latest tank to deteriorate.[17] With Hanford housing about 60% of the United State's nuclear waste, it is one of the most contaminated sites in the world.[18] Hanford demonstrates that improperly stored nuclear waste can cause immense damage to the surrounding environment and its inhabiting populations

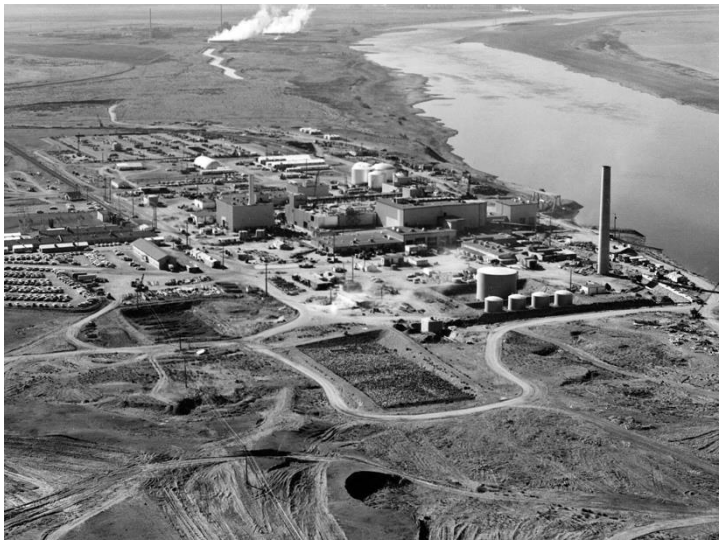


Figure 5: The Hanford nuclear prooduction and waste storage site

Passive Radiation Exposure

The human body is accustomed to low levels of passive radiation and can withstand periodic incidents of elevated radiation exposure, though not without long-term impacts at higher doses. Different types of radiation exposure have varying levels of danger due to the broad spectrum in emission energy and distribution.[19] For example, Gamma radiation poses more risk than alpha or beta radiation.[20] The proposed nuclear waste site would house spent nuclear fuel rods which are considered High-Level Waste (HLW). These rods emit more radiation than less radiative low or intermediate-level waste. Due to the higher

radioactivity, HLW poses more risk to public health newly spent nuclear fuel spends years in wet pools located in on-site storage facilities as the most dangerous radiation depletes.[21] The old fuel that would be placed in permanent underground storage would not be as unstable as newly spent fuel. This means that the risk to the local communities from passive radiation would be lessened. Natural background radiation varies from 1.5 to 50 millisieverts (mSv/yr) and these levels do not pose a heightened risk to populations.[22] However, even low doses of radiation can increase risks to vulnerable groups such as pregnant women, older people, and children, as well as the immunocompromised.[23] To compound the impact of passive radiation, the location of the nuclear storage site being underground presents a risk of radiation leaking into the surrounding rock and local water sources. radioactive soil or rock leaks into the food supply. Consumption of irradiated food or water can lead to detrimental health effects relating to radiation ingestion. This is an especially crucial variable to consider for the proposed Ignace site due to its proximity to lake George. While passive radiation in the environment does not pose a major public health risk, added radiation from an improperly constructed nuclear waste site can increase rates of cancer and other health issues. This causes a health domino effect that can impact the health of the local population.

There are ways to mitigate the risks of passive radiation. To prevent excess radiation, steps can be taken before and during the construction of the nuclear waste deposit to ensure that the materials used to shield the radiation, such as the steel and concrete cube, is well constructed and effective at blocking radiation. This requires at least 510 millimeters of high-density concrete lined with 12.7 millimeters thick steel plate in accordance with CSA standards.[24] [25] To prevent destabilization or degradation of the deposit tunnel, inspections should take place every 7 years by nuclear engineering specialists. The location of the deposit is also crucial to containing radiation. The nuclear deposit site should be constructed in dense and non-porous rocks that do not contain much water. This will lower the amount of radiation that leaks into the local water system. Construction of residential neighborhoods should be prohibited in an area of 2.5 kilometers surrounding the nuclear deposit site. In addition, updated radiation measurement systems should monitor the amount of environmental radiation to ensure that it does not reach a concerning level. Measures must be taken in order to ensure that passive radiation levels do not elevate to mitigate the risks of cancer later in life. If properly constructed, a nuclear waste deposit site, such as the geographic deposit reservoir proposed, should not significantly add to the already present environmental radiation levels.

Acute Exposure Risk

While much more uncommon, the risk of an acute radiation leak occurring from a storage site malfunction is still present. Vulnerable areas of the reservoir such as the disposal tunnel, may pose a potential for structural instability and result in leakage.[26] If leakage does occur due to negligence or structural instability, large amounts of radiation could be released which would have an immediate impact on the surrounding populations. When exposed to radiation, the radioactive particles impact the body's cells causing damage to structures such as DNA. This can increase the risk of developing cancers later on in life. If enough radiation impacts the cells, they will die, causing the affected person to experience symptoms of radiation sickness. Symptoms of radiation sickness can include burns, nausea, intestinal and bone damage, and eventful death.[27] If a leak occurs in the nuclear waste site, it is paramount that actions be taken to reduce the amount of radiation affected populations are exposed to.

In the event of a radiation leak, an early warning system with preset evacuation and decontamination protocols should be implemented and reviewed every 10 years. Areas should be evacuated by sections with those living downwind of the nuclear site being evacuated first. At least more than one evacuation route should be available to facilitate swift evacuations and avoid backups. This will decrease the amount of time people are exposed to radiation, thus lowering the health impact. Hospitals nearest to the nuclear waste site should have updated equipment and staff training to treat radiation poisoning. Along with evacuation protocols, all residents within 5km of the nuclear waste site and all nuclear site staff should have access to potassium iodide pills in case of exposure.[28] Due to the location of the nuclear waste site being underground with standard construction, the risk of radiation exposure to residents and staff is very low, and there are easy solutions to prevent or counteract the impacts of radiation.

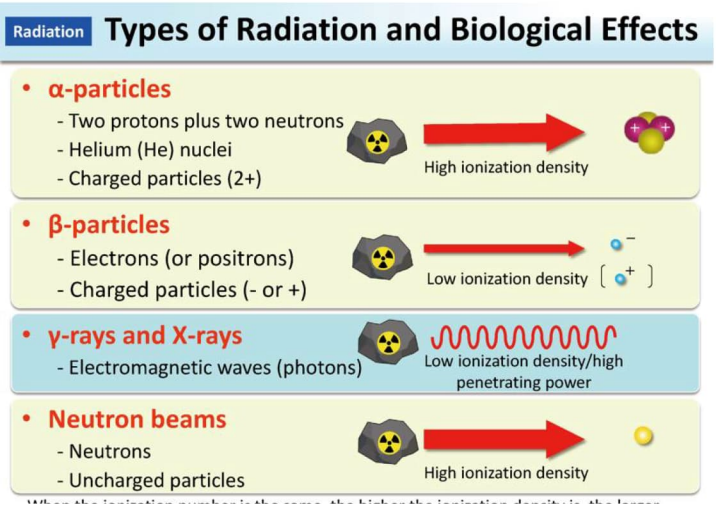


Figure 6: Biological effects due to different forms of radiation exposure

Social Risks

Demographic Risks

In terms of demographics, both villages have a small population of working-class individuals. In Teeswater, the population in 2016 was 995 people with an average age of 42.7 years old.[29] Whereas the 2016 population of Ignace is slightly larger at 1,202 with an average age of 46.8 years.[30] Most families in both communities live in single-family detached homes, small apartments, or motorhomes with an average household size of 2.3 and 2.1 for Teeswater and Ignace respectively.[31] Data suggests that both towns are composed of mostly married couples with some families having children. The average annual income for Teeswater is 38,000 CDN while Ignace is 30,000CDN a year which is within the range of the national average for 2016. Most people in Teeswater speak English primarily with a small percentage speaking French and a few others speaking languages such as German or Spanish. In Ignace, the primary language is English with the nearby reservation leading to some indigenous languages being spoken. From evaluating Teeswater, apart from the remoteness of the town limiting access to public goods, the population does not seem to be at elevated risk due to marginalization. Ignace has some demographic complications due to the Wabigoon Lake Ojibway Nation reserve with a population of 184 people located 35km away from the proposed nuclear storage site.[32] The marginalization of First Nations in Canada has resulted in a lack of accessible resources for reservations, placing the local population in the reserve at higher risk. Considering the demographic data of both of the drilling sites in Teeswater and Ignace, the smaller population size and non-reserve status of lands around Teeswater suggest that the site of Teeswater would pose a less immediate base risk to the population.

Unwillingness of Local Community to Accept Nuclear Repository

One of the guiding principles of the NWMO regarding its implementation plan for the long-term storage of nuclear waste requires that the management facility is located in an "informed and willing host community."[33] Hence, the population residing at the proposed deep geological repository site must have enough of an understanding of the project and its likely impacts to be well-informed and to demonstrate a

willingness to accept.[34] This has been a source of conflict for the NWMO in its proposed repository sites, Teeswater and Ignace. Despite attempts to present the safety protocols taken, many members of the proposed host communities and other localities and groups continue to display resistance. For example, a resident of Ignace was cited expressing their abhorrence towards the NWMO proposal, saying, "no matter how safe the project is [...] the very idea of Ignace as a nuclear waste 'dump' will sully its name."[35] Rejection is widespread due to large coalitions of protest groups, such as Nuclear Free North - who demand that the proposal to 'abandon' nuclear waste in Northern Ontario be done away with as a whole.[36] The NWMO has made appeal attempts by demonstrating the technical success of the project; however, opposition persists due to the lack of communication between the experts involved and the community that will be impacted.[37]

One way to reduce the disconnect between the NWMO and local community members is to facilitate more open communication forums. These would be similar to a 'town hall' for residents of the township wherein the repository is located, where they are able to express their concerns and feedback in a direct fashion, and on a regular basis. By ensuring that public input is consistently included in the NWMO project, community members will feel less isolated, and thus be more open to acceptance.

Population Loss in the Community

In ensuring a successful implementation plan, it is necessary that the proposed repository site contributes to the continued socioeconomic success of the surrounding community. Residents of the proposed repository sites fear that they will face a decrease in investment and economic development from new industries, due to investors not wanting their products and services to be tainted by being associated with nuclear waste. Members of these communities also express similar fears of property devaluation, increased costs of living, decreased livelihoods, and an increase in crime as a result of being a host for nuclear waste. Both fears could lead to population loss to neighboring municipalities.[38]

One way to mitigate potential population loss due to the perceived negative socioeconomic consequences of the repository site is to increase public awareness of employment and development opportunities that this project will bring to the community. As shown, the project expects to create jobs for many decades; the construction, operations, extended monitoring, and decommissioning phases are projected to create approximately 900, 1000, 260, and 420 jobs per year, respectively, in both skilled and semi-skilled areas.[39] To better amplify these opportunities to the public, the NWMO can mirror the American National Nuclear Security Administration (NNSA). Their job fair was marketed as a networking opportunity, wherein the 'next generation' of nuclear experts were to meet with hiring managers across all areas of the nuclear sector. It successfully demonstrated the future of nuclear energy as innovative and contributive to socioeconomic development nationwide.[40]

Persistence of Nuclear Stigma

The stigma surrounding nuclear energy significantly contributes to the difficulty in finding a location for any new developments - whether it be a power plant, a waste management facility, or even sites for nuclear research and development.[41] The negative connotation of nuclear energy as being 'dangerous' can persist due to a lack of public understanding of nuclear energy and a lack of transparency within the industry. More needs to be done to break down the secrecy barriers and increase the level of available information for public use to prevent public mistrust from contributing to a slowing of decision-making in the case of the NWMO.[42]

The Fukushima nuclear disaster is a relevant example that reveals how mismanagement and secrecy in the nuclear energy industry contribute to the continued existence of nuclear stigma. Although a natural disaster brought about the 2011 nuclear accident, poor risk management and a lack of proper communication between the Tokyo Electric Power Company (TEPCO), the government, and the public contributed to the magnitude of the catastrophe and the inadequate crisis response. This was a breeding ground for mistrust among Japanese citizens, facilitating widespread misinformation on nuclear energy.[43] A decade later, nuclear stigma is still prevalent, primarily maintained by misinformation and sensationalization -

particularly surrounding the health risks of radiation exposure from Fukushima. For example, in 2018, a pamphlet was distributed in Minamisoma city, one of the regions most impacted by Fukushima, wrongly claimed that the prevalence of thyroid cancer and leukemia had increased by approximately 30 and 10 percent, respectively. Despite the information contained in this brochure being proven inaccurate, it was still widely received, even reaching national attention via social media. Due to the mishandling of the crisis, there is a lack of valuable epidemiological data on the incidence rate of cancers post-Fukushima, which allows for false information and consequently, public mistrust of nuclear energy to continue to spread.[44]

To mitigate the consequences of nuclear stigma in the NWMO project, it is crucial to ensure that all steps are communicated fully to the public. The NWMO can mirror the French transparency framework for nuclear energy to do so. This framework includes The ASN which is an independent administrative authority that publishes relevant information on inspection results, reactor outages, incident and accident reports, and much more. There are also local information committees, which monitor the impact of nuclear facilities and report their findings to the surrounding population. In addition, they implemented a High Committee for Transparency and Information on Nuclear Security, a think tank that produces opinion pieces that facilitates debate on issues in France's nuclear energy sector. Finally, any person in France is entitled to obtain any documents held by the ASN and information about the environmental impacts of nuclear energy held by authorities.[45] By increasing transparency in the NWMO through this framework, public mistrust in nuclear energy that upholds stigmatizing beliefs would reduce.

Figures

Figure 1. Miller, Scott. "South Bruce Residents 'Push Back' against Nuclear Waste Opposition." London. CTV News, July 2, 2020. https://london.ctvnews.ca/south-bruce-residents-push-back-against-nuclear-waste-opposition-1.5008497.

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PASSONS À L'ÉTAPE SUIVANTE

Dans le cadre de la revue des déchets radioactifs du Canada

STRATÉGIE INTÉGRÉE POUR LES DÉCHETS RADIOACTIFS

Rapport présenté au ministre des Ressources naturelles du Canada

Juin 2023



nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Déclaration de reconnaissance du territoire

La Société de gestion des déchets nucléaires (SGDN) reconnaît que, depuis notre création, nous avons travaillé au sein de plusieurs territoires autochtones. Nous sommes reconnaissants envers les collectivités autochtones et municipales qui ont travaillé avec nous au cours des 20 dernières années.

Nous reconnaissons également qu'actuellement, nous travaillons dans le nord-ouest de l'Ontario, au sein du territoire traditionnel de la Nation ojibwée de Wabigoon Lake, avec la collectivité de la Nation ojibwée de Wabigoon Lake et le canton d'Ignace.

Dans le sud de l'Ontario, nous travaillons au sein du territoire traditionnel de la Nation ojibwée de Saugeen (NOS), avec ses deux collectivités – les Chippewas de la Première Nation non cédée de Nawash et les Chippewas de la Première Nation de Saugeen – ainsi qu'avec la municipalité de South Bruce.

Nous reconnaissons en outre que, tant dans le nord-ouest que dans le sud, nous avons le privilège de travailler avec d'autres Premières Nations et organisations autochtones, avec des collectivités métisses et la Nation métisse de l'Ontario, de même qu'avec plusieurs collectivités municipales qui ont toutes manifesté leur intérêt à en apprendre davantage sur notre travail.

Dans le cadre de notre engagement envers la réconciliation, nous reconnaissons les injustices historiques et actuelles subies par beaucoup trop de collectivités autochtones. Nous nous engageons à faire tout ce que nous pouvons pour favoriser le bien-être des collectivités avec lesquelles nous travaillons.

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Résumé

Le Canada peut être très fier de la position de chef de file mondial qu'il occupe dans le domaine du développement et du déploiement des technologies nucléaires, une position qu'il a établie au fil de plusieurs décennies d'efforts et qui fournit une base solide d'excellence technique et de savoir-faire opérationnel sur laquelle nous pouvons nous appuyer. Aujourd'hui, plus que jamais, l'énergie nucléaire est reconnue comme un outil essentiel pour atteindre les objectifs climatiques, parvenir à une économie carboneutre d'ici à 2050 et garantir la continuité d'un système énergétique sûr et sécuritaire dans le contexte des défis mondiaux qui se présentent à nous. Pour réussir à atteindre de tels objectifs, il ne suffit pas de disposer de la bonne technologie et des bonnes ressources; les Canadiens et les peuples autochtones veulent aussi avoir l'assurance qu'une stratégie à long terme encadrera la gestion des déchets radioactifs résultants.

Le gouvernement du Canada a déjà fait l'important pas de moderniser le cadre canadien de gestion des déchets radioactifs en publiant, en mars 2023, une version révisée de la Politique en matière de gestion des déchets radioactifs et de déclassement (ci-après dénommée « la Politique »).[1] Au cours de l'automne 2020, dans le contexte de l'examen entrepris de la politique gouvernementale de gestion des déchets radioactifs, le ministre canadien des Ressources naturelles a confié à la Société de gestion des déchets nucléaires (SGDN) le mandat de diriger un processus distinct de concertation avec les Canadiens, les peuples autochtones et des représentants de l'industrie qui aurait pour but d'éclairer l'élaboration d'une stratégie de gestion à long terme intégrée de tous les déchets radioactifs au Canada, en particulier les déchets de faible et moyenne activité qui ne sont actuellement visés par aucun plan de gestion à long terme.[2] Ce mandat a été confié à la SGDN en reconnaissance de la vingtaine d'années d'expertise que nous avons acquise dans la concertation avec les Canadiens et les peuples autochtones pour la planification de la gestion à long terme sûre du combustible nucléaire irradié. Le gouvernement a demandé à la SGDN de fournir dans le cadre de ce mandat :

- Une description de la situation actuelle de la gestion des déchets au Canada, qui rendrait compte des volumes actuels et de ceux qui seront générés dans le futur, notamment par d'éventuels petits réacteurs modulaires, ainsi que des caractéristiques, de l'emplacement et de la propriété des déchets;
- Une mise à jour sur les plans et le degré d'avancement des solutions de gestion et de stockage à long terme des déchets canadiens, ainsi que sur les lacunes qui devraient être comblées;
- Des approches conceptuelles qui permettraient d'assurer la gestion de notre inventaire actuel et futur de déchets radioactifs, y compris des options techniques pour la gestion ou le stockage à long terme des divers types de déchets et des options relatives au nombre d'installations de gestion à long terme qui seraient déployées au Canada;
- Les facteurs à considérer lors de la prise de décisions concernant la préparation, l'intégration, l'établissement et l'exploitation des installations de gestion à long terme de déchets.

Cette Stratégie intégrée pour les déchets radioactifs (SIDR) canadienne lance le début d'une nouvelle ère pour la gestion des déchets au Canada. Il s'agit d'une autre étape, une évolution dans le domaine de la gestion des déchets au Canada. Cette stratégie représente une première pour le Canada et comble les lacunes qui existent dans la gestion de tous les déchets radioactifs au Canada qui ont été générés jusqu'à maintenant pour produire de l'électricité et des isotopes médicaux essentiels, avec un regard vers l'avenir.[3]

Depuis que ce mandat a été initialement confié à la SGDN, cette stratégie a pris de l'importance, considérant que la réalisation de certains projets liés à de nouvelles technologies telles que les petits réacteurs modulaires a commencé à prendre de l'élan. Ces réacteurs produiraient aussi des déchets qui devraient être gérés de manière sûre. La présente stratégie s'est vu attribuer toute la flexibilité nécessaire pour intégrer ces déchets dans le flux de déchets qui leur conviendrait, selon la classification adoptée pour les déchets au Canada : les déchets de haute activité, qui incluent le combustible nucléaire irradié, les déchets de moyenne activité, les déchets de faible activité et les déchets des mines et usines de concentration d'uranium. De plus, en vertu de cette stratégie, le respect des droits et des traités des Autochtones constituera un élément fondamental pour les activités futures.

L’élaboration de cette stratégie intégrée s’est appuyée sur la Politique, sur ce que nous avons entendu lors des activités de concertation menées avec des participants canadiens et autochtones, ainsi que sur les avis d’experts recueillis dans le cadre des diverses études commandées au cours de ce processus. La Politique a établi des orientations, et la stratégie intégrée ne doit pas faire double emploi avec le mandat de la Politique, ni l’élargir. En conséquence, les recommandations de l’ébauche de la SIDR publiée à des fins d’examen public en août 2022 ont été modifiées en tenant compte des orientations fournies par la Politique.

La stratégie formule deux recommandations fondamentales et énonce quatre principes de mise en oeuvre qui ont pour but de garantir que le Canada dispose d’installations de stockage à long terme pour tous ses déchets radioactifs. Voici les recommandations et principes de mise en oeuvre établis. Ils seront définis plus en détail plus loin dans le présent document :

Recommendation 1	Stocker les déchets de moyenne activité et les déchets de haute activité autres que le combustible dans un dépôt géologique en profondeur, dont la mise en oeuvre serait assurée par la SGDN
Recommendation 2	Stocker les déchets de faible activité au sein de plusieurs installations près de la surface, dont la mise en oeuvre serait assurée par les producteurs et les propriétaires des déchets
Principe de mise en oeuvre 1	Le consentement des collectivités locales et des peuples autochtones sur le territoire desquels les futures installations seront planifiées devra être obtenu au cours du processus de sélection d’un site.
Principe de mise en oeuvre 2	Lors de la conception des installations, la protection de l’eau constituera une priorité absolue.
Principe de mise en oeuvre 3	Les installations de stockage feront l’objet d’un suivi à long terme.
Principe de mise en oeuvre 4	Il est essentiel d’agir dès maintenant et de ne pas abandonner cette tâche aux générations futures.

Les déchets radioactifs au Canada

Le Canada est depuis plus d'un demi-siècle un chef de file dans le développement et le déploiement des technologies nucléaires, sur lesquelles il compte pour alimenter en électricité ses collectivités et fournir des radioisotopes pour la médecine nucléaire et d'autres recherches novatrices, ainsi que pour de précieuses applications industrielles. Ces activités génèrent des déchets radioactifs, qui sont classés en fonction du degré de confinement et d'isolement dont ils doivent faire l'objet pour que soit assurée la protection des personnes et de l'environnement. Au Canada, il existe quatre grandes catégories de déchets radioactifs :

- Les déchets de haute activité (DHA);
- Les déchets de moyenne activité (DMA);
- Les déchets de faible activité (DFA);
- Les déchets des mines et usines de concentration d'uranium.

Chaque catégorie de déchets nécessite ses propres méthodes d'entreposage et de stockage, qui sont déterminées par le risque à court et à long terme que posent leur radioactivité et/ou la chaleur qu'ils dégagent. Tous les déchets radioactifs au Canada sont gérés de manière sûre, en conformité avec les normes internationales, dans des installations autorisées par la Commission canadienne de sûreté nucléaire (CCSN). Cependant, les déchets radioactifs au Canada ne sont pas tous visés par un plan de stockage à long terme.

Lacunes dans les plans de gestion à long terme des déchets radioactifs canadiens

Le tableau ci-dessous représente les volumes et les pourcentages approximatifs des déchets radioactifs non visés par un plan de gestion à long terme qui ont été identifiés lors de l'élaboration de cette stratégie intégrée. Ces déchets englobent à la fois les déchets déjà produits et les déchets qui devraient être produits dans l'avenir par les installations nucléaires existantes. Il est important de noter qu'environ 84 pour cent des déchets radioactifs au Canada étaient déjà visés par un plan de gestion à long terme. Sur les 16 pour cent de déchets radioactifs qui ne sont pas visés par un plan de gestion à long terme, 14 pour cent sont des déchets de faible activité, seulement approximativement deux pour cent sont des déchets de moyenne activité et moins de 0,01 pour cent du volume total sont des déchets radioactifs de haute activité autres que du combustible.

Tableau 1 : Déchets non visés par un plan de gestion à long terme

Type de déchets	Volume (m^3)	Pourcentage du total des déchets radioactifs au Canada
Déchets de haute activité (autres que du combustible)[4]	<10	< 0,01
Déchets de moyenne activité	51 000	2
Déchets de faible activité	294 000	14
Déchets des mines et usines de concentration d'uranium	Pas de lacunes – Plans déjà en place	–
Approximativement 84 pour cent du volume total des déchets radioactifs au Canada sont déjà visés par un plan de stockage à long terme.		

Options techniques et inventaires

Une étude comparative de portée internationale a permis de dégager les options qui permettraient de combler les lacunes qui existent dans la planification à long terme des déchets radioactifs au Canada, en particulier pour ce qui concerne les déchets radioactifs de faible et moyenne activité. L'intendance perpétuelle ne constitue pas une option de stockage ni une pratique exemplaire internationale. Cependant, elle a été examinée dans le cadre du processus de concertation afin de fournir aux participants un éventail de solutions de gestion à long terme (entreposage et stockage) pour éclairer au mieux la stratégie.

Options d'installations de stockage près de la surface :

1. Monticule ouvragé de confinement
2. Enceinte de béton
3. Caverne rocheuse peu profonde

Options de stockage en profondeur :

4. Dépôt géologique en profondeur
5. Forage profond

Entreposage à long terme :

6. Intendance perpétuelle

Les options ci-dessus ont été évaluées d'un point de vue technique, en s'appuyant sur le volume et les caractéristiques des inventaires de déchets de faible et moyenne activité fournis par les producteurs et les propriétaires de déchets. Le volume inclut les inventaires qui devraient être produits au total par le parc actuel de réacteurs CANDU (Canada Deutérium Uranium), en tenant compte de certaines hypothèses liées à leur cycle de vie, mais non l'inventaire des déchets qui pourraient être générés par les technologies futures, comme les petits réacteurs modulaires (PRM). Une étude complémentaire d'estimations du coût de mise en oeuvre des différentes options techniques a également été réalisée pour faciliter l'évaluation des différentes options.[5]

En se fondant sur cette évaluation technique, les déchets de faible activité au Canada devraient être stockés dans les types d'installations de stockage près de la surface mentionnés ci-dessus. Toutefois, le monticule ouvragé de confinement conviendrait et serait le plus économique pour les déchets de faible activité en vrac tels que les sols, étant donné leur faible concentration en radionucléides et l'important volume de ces déchets. L'enceinte de béton conviendrait à tous les déchets de faible activité, considérant le niveau accru de confinement et d'intégrité structurelle qu'elle offre; toutefois, si l'on tient compte de l'aspect économique, elle conviendrait plus particulièrement aux déchets radioactifs non volumineux.

Selon l'évaluation technique, les options de stockage pour les déchets de moyenne activité seraient le dépôt géologique en profondeur et les forages profonds. Toutefois, le dépôt géologique en profondeur constituerait la meilleure option, puisque l'option des forages profonds coûterait, selon les estimations, approximativement 10 fois plus par mètre cube de déchets que celle du dépôt géologique en profondeur. En outre, l'option des forages profonds ne permettrait de stocker qu'une partie de l'inventaire des déchets de moyenne activité en raison de ses contraintes de taille.

Stratégie intégrée

Au cours de la période de deux ans pendant laquelle nous avons travaillé en concertation avec les Canadiens, les peuples autochtones et des représentants de l'industrie, et avons réalisé un examen des meilleures pratiques utilisées dans le monde afin de dégager les solutions techniques optimales à proposer, à la SGDN, nous avons élaboré la stratégie intégrée suivante pour les différents flux de déchets radioactifs au Canada. Trois lacunes ont été identifiées : certains déchets radioactifs de faible activité, certains déchets de moyenne activité et les déchets radioactifs de haute activité autres que le combustible n'étaient pas visés par un plan de stockage.

Pour combler ces lacunes en tenant compte de ce que les parties prenantes et les peuples autochtones ont dit à la SGDN ainsi que des orientations fournies par la Politique, deux recommandations fondamentales et quatre principes de mise en oeuvre ont été formulés pour garantir que le Canada dispose d'installations de stockage pour tous ses déchets radioactifs. La stratégie est résumée dans le tableau et l'illustration qui suivent; elle ne vise pas à remplacer les projets de stockage à long terme déjà en cours, mais les intègre.

Tableau 2 : Stratégie intégrée pour tous les déchets radioactifs actuels et prévus

Classification des déchets	Type de déchets	Plan de gestion à long terme existant	Responsabilité de la mise en oeuvre actuellement	Stratégie intégrée
Déchets de haute activité (DHA)	Combustible irradié	Oui	SGDN	Aucun changement – Dépôt géologique en profondeur
	DHA autres que le combustible	Non	–	Dépôt géologique en profondeur Responsabilité de la mise en oeuvre du plan de stockage à long terme des déchets : SGDN
Déchets de moyenne activité (DMA)	DMA produits par diverses installations nucléaires	Non	–	Dépôt géologique en profondeur Responsabilité de la mise en oeuvre du plan de stockage à long terme des déchets : SGDN
	DMA produits par l'installation nucléaire de démonstration et le réacteur Whiteshell-1	Oui	Laboratoires nucléaires canadiens	Aucun changement – Déclassement in situ
Déchets de faible activité (DFA)	DFA historiques de Port Hope	Oui	Laboratoires nucléaires canadiens	Aucun changement – Initiative de la région de Port Hope
	DFA propriété d'Énergie atomique du Canada limitée à Chalk River	Oui	Laboratoires nucléaires canadiens	Aucun changement – Installation de stockage près de la surface
	DFA produits par l'installation nucléaire de démonstration et le réacteur Whiteshell-1	Oui	Laboratoires nucléaires canadiens	Aucun changement – Déclassement in situ
	DFA produits par diverses installations nucléaires	Non	–	Plusieurs installations de stockage près de la surface Responsabilité de la mise en oeuvre du plan de stockage à long terme des déchets : Producteurs/propriétaires des déchets
Déchets des mines et usines de concentration d'uranium[6]	Installation de gestion des résidus près du lieu de production	Oui	Compagnies d'extraction d'uranium et de gestion des résidus d'uranium, gouvernement fédéral et gouvernements provinciaux concernés	Aucun changement – Installations de stockage près du lieu de production

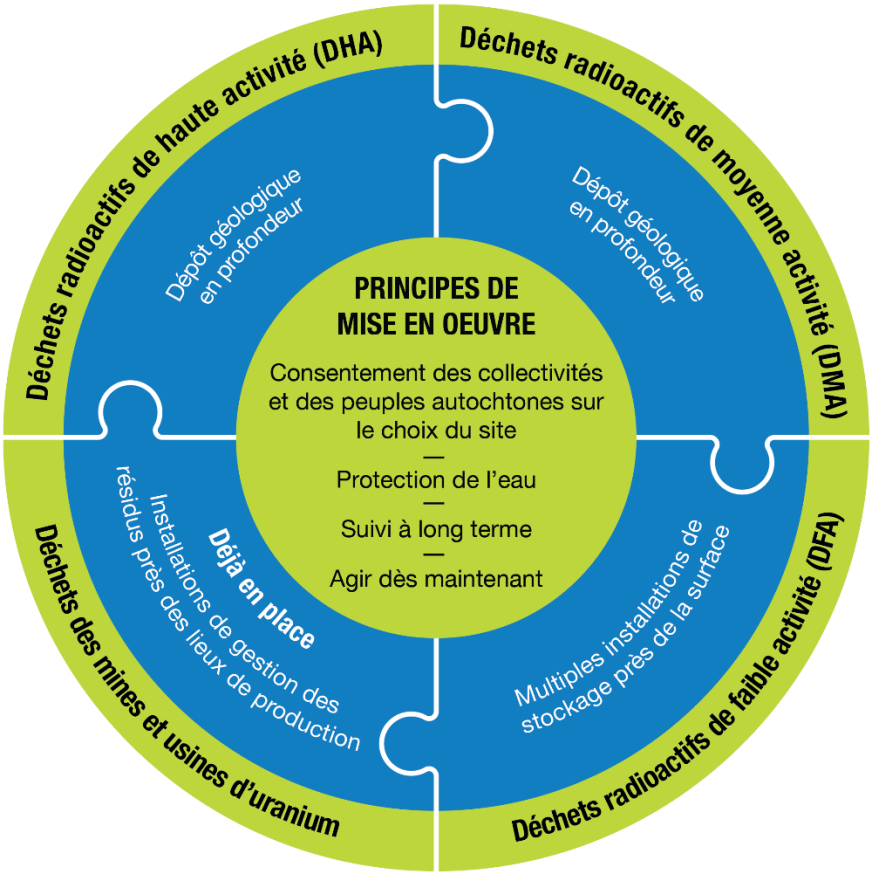


Figure 1 : Stratégie intégrée pour les déchets radioactifs du Canada

Recommandations et principes pour la mise en oeuvre de la Stratégie intégrée pour les déchets radioactifs du Canada

Recommandations

RECOMMANDATION 1 : STOCKER LES DÉCHETS DE MOYENNE ACTIVITÉ ET LES DÉCHETS DE HAUTE ACTIVITÉ AUTRES QUE LE COMBUSTIBLE DANS UN DÉPÔT GÉOLOGIQUE EN PROFONDEUR, DONT LA MISE EN OEUVRE SERAIT ASSURÉE PAR LA SGDN

- La SGDN, la principale organisation de stockage en couche géologique profonde au Canada, serait chargée de choisir un site et de construire un dépôt géologique en profondeur pour les déchets de moyenne activité (DMA) et les déchets de haute activité (DHA) autres que le combustible, avec le financement des producteurs et des propriétaires de déchets.
- La SGDN préparerait un plan détaillé définissant le processus de sélection d'un site pour le dépôt, y compris la stratégie de concertation et l'approche de financement, en tenant compte de notre expérience et de ce que nous avons appris au fil de la mise en oeuvre d'autres processus de sélection d'un site pour des installations nucléaires. Ce processus de sélection d'un site est distinct des travaux de la SGDN pour choisir un site pour la mise en oeuvre du plan canadien de gestion du combustible nucléaire irradié.

- Le plan engloberait le processus qui permettra de déterminer, conformément à la Politique et aux principes de mise en oeuvre décrits ci-après, les exigences d'acceptabilité technique et sociale du dépôt.
- Le plan comprendrait également les délais prévus pour la sélection d'un site et la construction du dépôt.
- La préparation du processus de sélection d'un site se ferait sur une période de 12 à 18 mois, après quoi la SGDN présenterait à Ressources naturelles Canada un rapport sur l'approche adoptée.

RECOMMANDATION 2 : STOCKER LES DÉCHETS DE FAIBLE ACTIVITÉ AU SEIN DE PLUSIEURS INSTALLATIONS PRÈS DE LA SURFACE, DONT LA MISE EN OEUVRE SERAIT ASSURÉE PAR LES PRODUCTEURS ET LES PROPRIÉTAIRES DES DÉCHETS

- Les producteurs et les propriétaires des déchets seraient chargés de choisir les sites et de construire les installations de stockage près de la surface pour les déchets de faible activité qui ne sont actuellement visés par aucun plan de stockage à long terme, en conformité avec les meilleures pratiques internationales et en tenant compte des caractéristiques et du volume des déchets, de la proximité des installations d'entreposage provisoires existantes, de l'acceptation des collectivités et des considérations techniques.
- La possibilité de mettre en oeuvre des installations appartenant à plusieurs producteurs de déchets ou des installations régionales centralisées devrait également être étudiée afin de trouver le juste équilibre entre le nombre d'installations et la distance de transport des déchets. Des installations régionales centralisées pourraient permettre de réaliser des économies d'échelle et garantir aux petits producteurs de déchets un accès équitable. Les installations régionales pourraient être provinciales, elles pourraient être associées à plusieurs provinces et il pourrait y en avoir plus d'une dans une même province, suivant plusieurs facteurs tels que le volume de déchets, les distances de transport et les coûts.
- Les producteurs et les propriétaires de déchets seraient chargés d'élaborer des plans plus détaillés de mise en oeuvre, de manière ouverte et transparente, et en s'appuyant dès le départ et de façon continue sur un programme de concertation, conformément à la Politique.

Principes de mise en oeuvre

Quatre principes de mise en oeuvre ont été élaborés en s'appuyant sur les nombreux commentaires fournis par les Canadiens et les peuples autochtones et ont été soulignés comme une priorité pour toute nouvelle installation de stockage; ils sont présentés ci-dessous et décrits plus en détail au chapitre 4.

PRINCIPE DE MISE EN OEUVRE 1 : LE CONSENTEMENT DES COLLECTIVITÉS LOCALES ET DES PEUPLES AUTOCHTONES SUR LE TERRITOIRE DESQUELS LES FUTURES INSTALLATIONS SERONT PLANIFIÉES DEVRA ÊTRE OBTENU AU COURS DU PROCESSUS DE SÉLECTION D'UN SITE.

Cette considération a été jugée prioritaire par la majorité des participants aux séances de concertation. Le consentement des collectivités autochtones touchées est également conforme aux mesures prises par le Canada pour la mise en oeuvre de la *Loi sur la Déclaration des Nations Unies sur les droits des peuples autochtones*. Cette considération cruciale s'étend à toute installation future de stockage de déchets radioactifs. Les collectivités autochtones des régions hôtes potentielles devront faire dès le départ l'objet d'une concertation et devront participer de manière continue à toutes les phases de tout projet de gestion de déchets radioactifs, quelle qu'en soit l'envergure. Ce processus de concertation devra être fondé sur le renforcement des capacités des peuples autochtones, le partage de l'information et la collaboration.[7] De plus, les lois, les processus réglementaires et les protocoles de consultation avec les peuples autochtones élaborés et mis en oeuvre dans les régions où des installations seront planifiées doivent être respectés.

PRINCIPE DE MISE EN OEUVRE 2 : LORS DE LA CONCEPTION DES INSTALLATIONS, LA PROTECTION DE L'EAU CONSTITUERA UNE PRIORITÉ ABSOLUE.

La Politique exige que la gestion des déchets radioactifs, y compris leur stockage, soit effectuée d'une manière intégrée, qui accorde la priorité à la santé, à la sûreté et à la sécurité des gens et de l'environnement, y compris de l'eau.[8] Bien que la sûreté puisse être démontrée d'un point de vue technique quel que soit l'emplacement, il pourrait être difficile d'obtenir un appui sociétal pour des installations situées à proximité de sources importantes d'eau potable. La protection de l'eau était une priorité pour la plupart des participants aux processus de concertation de la SGDN, qui estimaient fortement que les sites de stockage des déchets ne devraient pas être construits près de sources d'eau potable, craignant qu'ils puissent les contaminer et affecter le mode de vie des résidents. Bien que plusieurs participants aient recommandé que les installations soient situées loin de toute source importante d'approvisionnement en eau, la réalité du paysage canadien est telle que cela ne serait pas possible. La protection de l'eau est primordiale et, par conséquent, toute installation de stockage devra respecter les normes les plus rigoureuses en matière de protection de l'environnement et de l'eau.

PRINCIPE DE MISE EN OEUVRE 3 : LES INSTALLATIONS DE STOCKAGE FERONT L'OBJET D'UN SUIVI À LONG TERME.

Les déchets et les installations devront être surveillés aussi longtemps que les générations futures le jugeront nécessaire pour s'assurer que l'environnement reste protégé. Cela signifie que les connaissances sur les types de déchets, leur emplacement et les plans de surveillance associés devront être transmises aux générations futures afin que ces dernières soient en mesure de déterminer si ces plans demeurent adéquats ou utiles. Cela est conforme à la Politique, d'après laquelle le gouvernement « reconnaît les délais liés à la gestion des déchets radioactifs et les obligations afférentes pour garantir une responsabilité permanente des installations, emplacements et sites d'élimination des déchets radioactifs après leur fermeture, afin qu'ils demeurent à perpétuité sécuritaires et sûrs pour les personnes et l'environnement ».[9] De plus, les collectivités autochtones ayant des installations de gestion des déchets nucléaires devraient faire partie des conversations sur l'intendance des terres. Cela est conforme aux attentes des producteurs et des propriétaires de déchets dans la Politique de travailler en partenariat avec les peuples autochtones pour mieux comprendre leur savoir autochtone et obtenir des conseils concernant la gestion des déchets radioactifs et les projets de déclassement.

PRINCIPE DE MISE EN OEUVRE 4 : IL EST ESSENTIEL D'AGIR DÈS MAINTENANT ET DE NE PAS ABANDONNER CETTE TÂCHE AUX GÉNÉRATIONS FUTURES.

Il est essentiel d'élaborer et de mettre en oeuvre, avec un sentiment d'urgence, une stratégie intégrée pour l'ensemble des déchets radioactifs du Canada, plutôt que de léguer cette responsabilité aux générations futures. Cet impératif est conforme à l'exigence imposée par la Politique aux propriétaires et producteurs de déchets de collaborer avec les autres propriétaires ou producteurs de déchets dans le cadre de leurs plans pour l'avancement, l'élaboration et la mise en oeuvre, sur le plan national, de solutions exhaustives et intégrées de gestion des déchets radioactifs dans les meilleurs délais et de déclasser les installations, les emplacements et les sites dans les meilleurs délais afin de réduire le fardeau sur les générations futures.[10] La mise en oeuvre de la SIDR exigera un engagement et un soutien permanents de la part du gouvernement, ainsi qu'une structure qui sera habilitée à assurer l'atteinte des objectifs de la stratégie, quels que soient les changements de gouvernements qui surviendront. Cette urgence d'agir doit être équilibrée de manière appropriée avec l'engagement du Canada envers la réconciliation avec les peuples autochtones.

Résumé des activités de concertation

En 2021, à la SGDN, nous avons commencé à nous concerter avec les producteurs et les propriétaires de déchets ainsi qu'avec les Canadiens et les peuples autochtones intéressés en entreprenant des recherches sur l'opinion publique, en tenant un sommet pour entendre divers points de vue, en écoutant les citoyens au cours d'une série de séances de concertation organisées dans les collectivités où des déchets sont actuellement entreposés, en animant des discussions en table ronde et en organisant des ateliers techniques. La SGDN a mené en tout plus de 75 activités diverses de concertation (voir la figure 2 plus bas) de janvier 2021 à avril 2023. Près de 4000 personnes au total y ont participé. À la SGDN, nous nous sommes engagés à régulièrement faire état du processus de concertation et avons créé un site pour le projet afin que les participants aient accès aux informations tout au long du processus – plandechetsradioactifs.ca.

Concertation avec les Autochtones

À la SGDN, nous sommes résolus à favoriser de manière tangible la réconciliation et l'établissement de relations avec les collectivités autochtones.

Au cours des activités de concertation sur cette stratégie intégrée, nous nous sommes efforcés à la SGDN de recueillir les points de vue et les recommandations des peuples autochtones, de renforcer les relations établies et d'en créer de nouvelles afin qu'il y ait un partage de réflexions, de priorités et de préoccupations. La SGDN reconnaît humblement que, bien que des efforts aient été faits pour établir une large concertation avec les collectivités autochtones, cette concertation a connu certaines limites, notamment l'absence de participants inuits. Le terme « Autochtones » utilisé dans ce rapport n'englobe que les participants des Premières Nations et métis énumérés dans le rapport Ce que nous avons entendu – Concertation avec les Autochtones, et les commentaires exprimés ne sont pas censés représenter l'ensemble de ces groupes[11].



Figure 2 : Activités de concertation sur la SIDR

Thèmes clés dégagés des activités de concertation de la SGDN

Voici un résumé des principaux thèmes qui sont ressortis de la concertation menée sur la Stratégie intégrée pour les déchets radioactifs du Canada.

THÈME CLÉ 1 – LA SÛRETÉ EST D'UNE IMPORTANCE PRIMORDIALE

Le thème le plus marquant qui s'est dégagé de l'ensemble des activités de concertation est l'importance que doit jouer la sûreté dans tous les aspects de l'élaboration et de la mise en oeuvre de la Stratégie intégrée pour les déchets radioactifs. Les participants ont accordé une plus grande priorité à la sûreté qu'aux considérations de coûts. En tant que priorité, la sûreté doit être envisagée dans une perspective à long terme afin que la stratégie tienne compte des risques futurs et garantisse la protection des personnes dans des conditions environnementales, gouvernementales, sociétales et technologiques futures qui seront imprévisibles et potentiellement instables.

THÈME CLÉ 2 – AGIR DÈS MAINTENANT

Il est essentiel que nous adoptions une stratégie intégrée et nous devons déterminer l'approche à suivre pour assurer la gestion à long terme des déchets de faible et moyenne activité. Il a été généralement convenu lors des activités de concertation que la bonne chose à faire serait de mettre en oeuvre un plan qui engloberait tous les déchets radioactifs canadiens et de le faire avec un sentiment d'urgence, plutôt que de le léguer aux générations futures.

THÈME CLÉ 3 – COMMUNICATION ET TRANSPARENCE

Les participants ont insisté sur le fait qu'une communication claire, factuelle et inclusive, qui fournit un contexte de manière pertinente, accessible et impartiale, est absolument essentielle. La transparence, assurée notamment en communiquant les décisions et les processus de manière claire, ouverte et continue, est très importante. Une transparence sur les déchets et les risques qui y sont associés est également essentielle, tout comme une communication efficace qui fournit des informations contextuelles lorsque c'est utile. Certains participants ont mentionné qu'il sera important de donner une plus grande visibilité aux inventaires de déchets existants et anticipés.

THÈME CLÉ 4 – RELATION DE CONFIANCE AVEC LES COLLECTIVITÉS AUTOCHTONES

Une concertation approfondie et l'établissement de relations suivies avec les collectivités autochtones doivent être au coeur de l'élaboration et de la mise en oeuvre du plan. Il est essentiel d'écouter les peuples autochtones pour restaurer leur confiance, établir des relations avec eux et affirmer l'importance de la réconciliation. La prise en compte du savoir autochtone, au même titre que la science occidentale, a également été jugée importante pour une stratégie qui doit répondre tant à des considérations éloignées dans le temps qu'à des considérations plus immédiates. Les participants souhaitaient que la stratégie reflète le droit des collectivités autochtones à un consentement libre, préalable et éclairé et empêche que la participation des peuples autochtones soit exploitée par des pratiques déloyales.

THÈME CLÉ 5 – ÉDUCATION ET CONCERTATION

Une concertation exhaustive est nécessaire pour obtenir une réelle adhésion à une stratégie adaptée au public canadien et l'importance de la concertation avec les jeunes a aussi été soulignée. L'éducation est essentielle pour permettre aux personnes et aux collectivités potentiellement touchées d'être bien informées et doit être davantage intégrée aux discussions pour que les Canadiens et les peuples autochtones puissent bien comprendre les défis uniques que posent les déchets radioactifs et la façon dont la sûreté sera assurée. Tirer des enseignements des meilleures pratiques scientifiques établies dans le monde a également été identifié comme une voie importante à suivre pour protéger le public et

optimiser l'aspect économique de la stratégie, deux éléments importants, aujourd'hui comme pour le long terme. Les jeunes participants ont souligné l'importance de mettre en oeuvre une stratégie d'éducation intergénérationnelle pour cultiver chez les jeunes un sentiment de responsabilité à l'égard de la mise en oeuvre de la stratégie à long terme.

THÈME CLÉ 6 – DURABILITÉ ET ENVIRONNEMENT

En plus de protéger la collectivité et les résidents, la stratégie doit faire en sorte de limiter le plus possible l'empreinte carbone et protéger à long terme l'environnement, en particulier l'eau. Des participants ont insisté sur le fait que nous devons être attentifs à l'urgence climatique et faire en sorte que chaque aspect de la stratégie soit viable, tienne compte des risques posés par les changements climatiques, respecte l'environnement et protège les sources d'eau pour toutes les générations futures. Les objectifs en matière de réduction de l'impact environnemental doivent être envisagés dans le cadre d'une approche fondée sur le cycle de vie et englober les volets de la construction des installations et du transport des déchets radioactifs. Les participants étaient parfaitement conscients du racisme environnemental subi historiquement par les collectivités autochtones et ont plaidé pour que l'aspect de la justice environnementale soit pris en considération lorsque viendra le temps de déterminer le nombre d'installations à construire et les endroits où elles devraient être construites.

THÈME CLÉ 7 – TRANSPORT

Les participants ont fréquemment posé des questions sur les risques associés au transport et sur les conséquences que pourraient avoir les accidents de transport sur la sûreté des déchets radioactifs transportés. Ils préféraient en général que les distances parcourues pour transporter les déchets radioactifs soient limitées afin de réduire les risques associés. Parmi les autres préoccupations soulevées relativement au transport, citons le coût, l'augmentation potentielle des émissions de gaz à effet de serre et les impacts environnementaux que pourrait avoir la construction de nouvelles routes d'accès. Les points de vue des participants sur les risques relatifs du transport ont influencé leur préférence pour l'option de construire un seul dépôt centralisé pour les déchets de faible et de moyenne activité ou celle de construire plusieurs installations de stockage plus près des lieux où les déchets sont produits. Les participants des territoires traditionnels ont exprimé le souhait d'être inclus dans les discussions sur la planification du transport.

THÈME CLÉ 8 – CADRE DE RESPONSABILITÉ PARTAGÉE/INDÉPENDANCE DE L'ENTITÉ RESPONSABLE

Les points de vue variaient quant à savoir qui devrait être responsable de la surveillance de la stratégie. Les participants ont eu des divergences d'opinions sur le rôle que devrait jouer de l'industrie, mais ils s'entendaient généralement pour dire que la gestion des déchets devrait être assurée par une seule entité, qui posséderait l'expertise appropriée, serait indépendante des responsables de la mise en oeuvre et serait assujettie à une surveillance réglementée en matière de sûreté et d'environnement. La gouvernance d'une telle entité a fait l'objet d'idées différentes, certains suggérant que la gouvernance chargée de la surveillance devrait être assurée par des représentants de l'industrie, d'organisations de la société civile et des peuples autochtones, et d'autres accordant la priorité à ce que l'entité de surveillance soit indépendante et qu'elle dispose de l'expertise appropriée. Un large appui a été accordé à l'option d'une stratégie financée par les propriétaires de déchets.

THÈME CLÉ 9 – INTENDANCE PERPÉTUELLE ET STOCKAGE DES DÉCHETS

Une majorité des participants ont appuyé le principe qu'il faille trouver dès maintenant des solutions pour stocker à perpétuité les déchets, plutôt que de léguer cette responsabilité aux générations futures. L'incertitude liée aux changements climatiques et la possibilité que les futurs changements de gouvernements ou l'évolution de la société rendent les déchets vulnérables si une option d'entreposage de durée indéfinie est adoptée figurent parmi les préoccupations exprimées lors des activités de concertation. Des participants souhaitaient que les déchets de moyenne activité soient gérés de la même manière que les déchets de haute activité, c'est-à-dire qu'ils soient stockés dans un dépôt géologique en

profondeur. Cependant, d'autres considéraient que l'intendance perpétuelle serait la meilleure stratégie à adopter, en particulier pour les déchets de faible activité, elle qui permettrait de tirer avantage des éventuelles innovations technologiques, de garder à l'esprit l'existence des déchets et d'assurer une surveillance constante des installations pour que tout impact environnemental soit identifié et corrigé avant qu'il ne cause des dommages importants, en particulier à la nappe phréatique.

THÈME CLÉ 10 – REGROUPEMENT ET CENTRALISATION

Les avis à ce sujet variaient, certains participants estimant que réduire le nombre d'installations pourrait présenter des avantages. Des participants ont reconnu qu'il était difficile de trouver des collectivités hôtes consentantes et informées, et que l'obligation d'obtenir le consentement libre, préalable et éclairé des peuples autochtones réduisait la probabilité de trouver plusieurs sites pour des installations. Cependant, ils étaient inquiets de l'impact que pourrait avoir la mise en oeuvre d'un site unique sur le transport des déchets. Certains participants ont souligné qu'il faudrait prévoir des dispositions techniques distinctes pour les différents types de déchets stockés dans la même installation, tandis que d'autres ont souligné les avantages économiques qui pourraient être tirés du fait de regrouper l'expertise et les installations en un seul endroit.

La majorité des participants préféraient l'option d'une installation centralisée pour les déchets de moyenne activité, estimant que cela permettrait d'assurer un meilleur contrôle et une meilleure surveillance des déchets pendant leur longue durée de vie et, potentiellement, de réaliser des économies de coûts et de temps. La centralisation des déchets de moyenne activité a été jugée préférable parce qu'elle restreindrait à un seul endroit les risques encourus et éviterait de mettre à risque plusieurs zones écologiques. L'idée du regroupement et de la centralisation a été plus largement appuyée pour les déchets de moyenne et haute activité que pour les déchets de faible et moyenne activité. Les volumes de déchets de faible activité sont plus importants et les participants ont généralement estimé qu'il serait préférable de les laisser plus près des sites où ils ont été produits ou entreposés plutôt que de les transporter sur de grandes distances. Quelle que soit l'option choisie, le consentement de la collectivité a été identifié comme un impératif pour toute installation de stockage.

THÈME CLÉ 11 – UNE STRATÉGIE PAR ET POUR LES CANADIENS ET LES PEUPLES AUTOCHTONES

Les participants ont clairement exprimé qu'ils souhaitaient que cette stratégie soit créée par et pour les Canadiens et les peuples autochtones, et que cela serait essentiel pour obtenir l'adhésion de ces derniers. Une stratégie inclusive est une stratégie qui reflète les points de vue du public. De plus, la SIDR devra tenir compte des conditions et de l'environnement qui sont uniques au Canada, notamment la taille du pays, la diversité des Canadiens et des peuples autochtones et les effets particuliers que pourraient y avoir les changements climatiques.

Chapitre 1 : Élaboration de la stratégie intégrée

Contexte : Le gouvernement fédéral a demandé à la SGDN de faire participer les Canadiens, les peuples autochtones et les producteurs et propriétaires de déchets à l'élaboration d'une Stratégie intégrée pour les déchets radioactifs (SIDR) du Canada, reconnaissant que les décisions prises aujourd'hui auront un impact sur les générations futures.

Introduction

Au cours de l'automne 2020, dans le cadre de l'examen de la politique gouvernementale de gestion des déchets radioactifs, le ministre canadien des Ressources naturelles a confié[12] à la SGDN le mandat de diriger un processus distinct de concertation avec les Canadiens, les peuples autochtones et des représentants de l'industrie qui aurait pour but d'éclairer l'élaboration d'une stratégie de gestion à long terme intégrée de tous les déchets radioactifs au Canada, en particulier les déchets de faible et moyenne activité qui ne sont actuellement visés par aucun plan de gestion à long terme. Cette tâche a été confiée à la SGDN, en reconnaissance de la vingtaine d'années d'expertise que nous avons acquise dans la concertation avec les Canadiens et les peuples autochtones pour la planification de la gestion à long terme sûre du combustible nucléaire irradié.

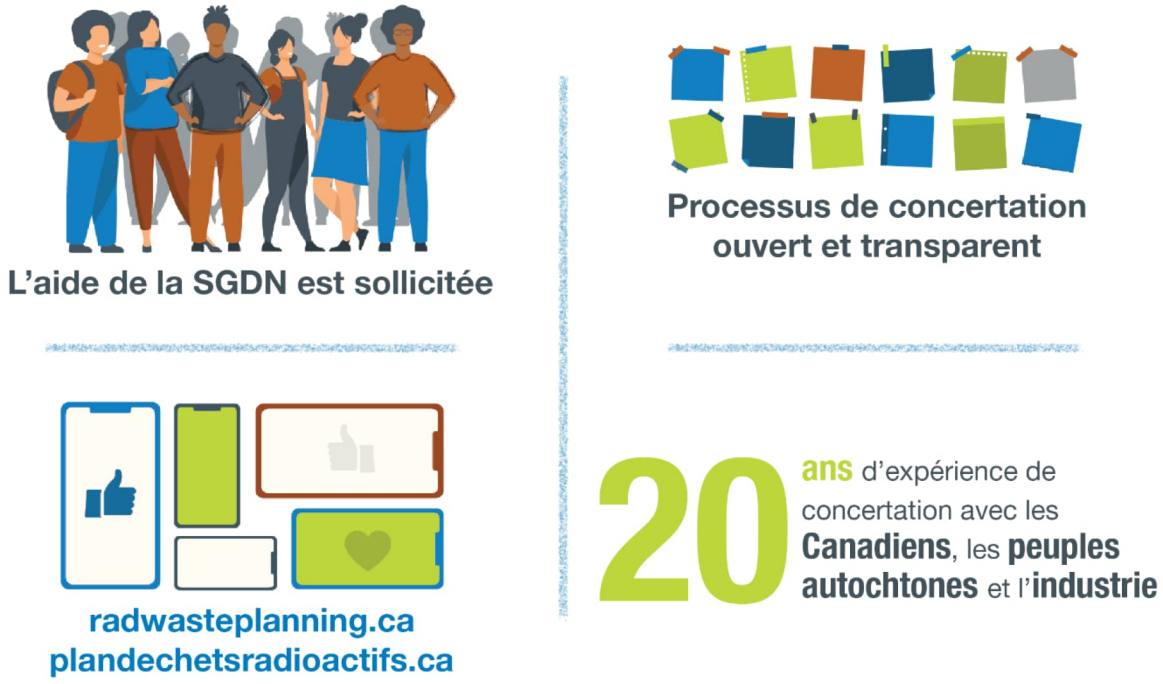


Figure 3 : Contexte sur la SIDR

Cette stratégie marque une nouvelle étape – qui consiste à identifier et à combler les lacunes, en vue de préparer l'avenir. Bien que tous les déchets radioactifs du Canada soient actuellement gérés de façon sûre, ils ne sont pas tous visés par un plan de gestion à long terme qui permettra d'assurer la protection des gens et de l'environnement jusque dans un avenir très lointain. Les plans de gestion à long terme des déchets de faible et de moyenne activité ont des lacunes et le Canada ne s'est pas doté d'une stratégie intégrée dans ce domaine. La présente stratégie intégrée a été élaborée de manière à ce qu'elle reflète les commentaires reçus, le consensus scientifique international ainsi que les meilleures pratiques dans le monde, et que soit garantie la protection à très long terme des gens et de l'environnement. En collaboration avec les producteurs et propriétaires de déchets, le gouvernement, les peuples autochtones, des organisations de la société civile et les Canadiens intéressés, nous nous sommes employés à la SGDN à fournir :

1. Une description de la situation actuelle de la gestion des déchets au Canada, qui rend compte des volumes actuels et de ceux qui seront générés dans le futur, par exemple par d'éventuels petits réacteurs modulaires, ainsi que des caractéristiques, de l'emplacement et de la propriété des déchets;
2. Une mise à jour sur les plans et le degré d'avancement des solutions de gestion et de stockage à long terme des déchets canadiens, et sur les lacunes qui devraient être comblées;
3. Des approches conceptuelles pour la gestion de notre inventaire actuel et futur de déchets radioactifs, y compris des options techniques pour la gestion ou le stockage à long terme des divers types de déchets et des options relatives au nombre d'installations de gestion à long terme qui seraient déployées au Canada;
4. Les facteurs à considérer concernant les étapes de mise en oeuvre, l'intégration, l'établissement et l'exploitation des installations de gestion à long terme de déchets.

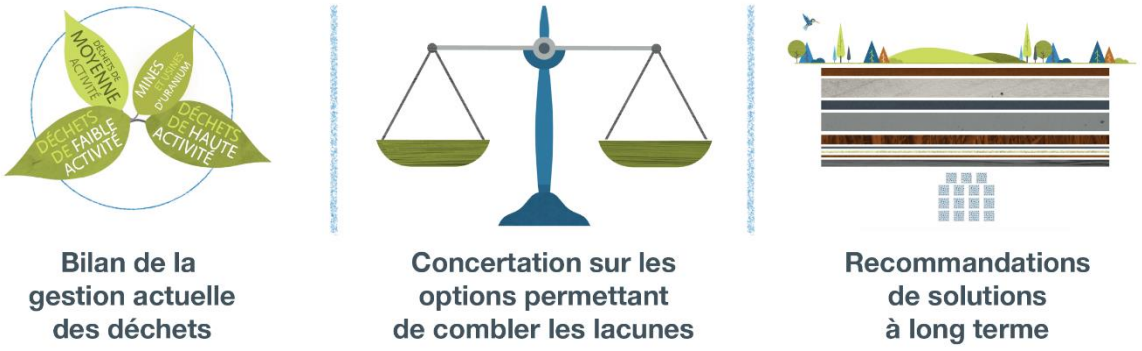


Figure 4 : Approche suivie par la SGDN pour l'élaboration de la SIDR

Nous avons toujours été profondément résolu à la SGDN à mener notre processus de concertation de manière transparente et inclusive, et tenu à souligner qu'aucun résultat n'était prédéterminé. Nous nous sommes engagés à régulièrement faire état du processus de concertation et avons créé un site pour le projet pour faire en sorte que les participants aient accès aux informations tout au long du processus : plandechetsradioactifs.ca.

Contexte – Les déchets radioactifs au Canada

Un déchet radioactif est défini comme toute matière (liquide, gazeuse ou solide) contenant une substance nucléaire radioactive et pour laquelle on ne prévoit pas d'usage ultérieur. Ce type de déchet provient principalement de la production d'énergie nucléaire et de l'utilisation d'autres types de fission ou de technologie nucléaire, notamment pour la recherche et la médecine. Comme les déchets radioactifs sont dangereux pour la plupart des formes de vie et pour l'environnement en général, ils doivent être gérés avec précaution et rigoureusement réglementés par des organismes gouvernementaux.

Au Canada, des déchets radioactifs sont générés lors de l'extraction et du traitement de l'uranium, des activités de médecine nucléaire, de la fabrication du combustible nucléaire, de l'exploitation des réacteurs nucléaires, des activités de recherche-développement, de la fabrication et de l'utilisation des radioisotopes, et des activités de déclassement des installations nucléaires.

Classification des déchets radioactifs

Les déchets radioactifs sont classés en fonction du degré de confinement et d'isolation qui est nécessaire pour garantir la sûreté, du risque que posent les différentes catégories de déchets et de la durée de ce risque. Au Canada, il existe quatre grandes catégories de déchets radioactifs :

- Les déchets de haute activité (DHA);
- Les déchets de moyenne activité (DMA);
- Les déchets de faible activité (DFA);
- Les déchets des mines et usines de concentration d'uranium.

Chaque catégorie de déchets nécessite ses propres méthodes d'entreposage et de stockage, qui sont déterminés par le risque à court et à long terme que posent leur radioactivité et/ou la chaleur qu'ils dégagent. Une gestion prudente des déchets, y compris en ce qui concerne leur entreposage et leur stockage à long terme, permettra de protéger les gens et l'environnement contre des niveaux nocifs de rayonnements et d'autres dangers.

Les déchets contenant une quantité de matières radioactives trop faible pour poser un danger ne sont pas considérés comme des déchets radioactifs. Par conséquent, les déchets dont la teneur en radionucléides est en deçà des seuils de libération et d'exemption (établis dans le Règlement sur les substances nucléaires et les appareils à rayonnement) peuvent être éliminés à l'aide des méthodes conventionnelles, par exemple en les envoyant dans une décharge locale[13].

Déchets de haute activité

Les déchets radioactifs de haute activité désignent principalement le combustible nucléaire irradié ou les déchets qui produisent beaucoup de chaleur par désintégration radioactive. Les déchets de haute activité émettent des rayonnements pénétrants et nécessitent par conséquent un blindage. Ils contiennent aussi d'importantes quantités de radionucléides à longue période radioactive, d'où la nécessité d'un isolement à long terme. Le stockage dans des formations géologiques profondes et stables, à des profondeurs de plusieurs centaines de mètres ou davantage sous la surface est recommandé pour la gestion à long terme des déchets de haute activité.

Déchets de moyenne activité

Les déchets radioactifs de moyenne activité sont principalement générés par les centrales nucléaires, les réacteurs prototypes et de recherche, les installations d'essai ainsi que les fabricants et les utilisateurs de radioisotopes, y compris pour certaines applications médicales. Les déchets de moyenne activité contiennent habituellement des radionucléides à longue période radioactive qui doivent être isolés et confinés pendant plus de quelques centaines d'années. Les déchets de moyenne activité ne nécessitent aucune disposition particulière, ou alors, des dispositions limitées pour la dissipation de la chaleur pendant leur entreposage et leur stockage. En raison de leur contenu en radionucléides à longue

période, les déchets de moyenne activité exigent généralement un degré de confinement et d'isolement supérieur à celui qui peut être assuré par les dépôts près de la surface. Les déchets de cette catégorie peuvent devoir être enfouis à de plus grandes profondeurs intermédiaires allant de quelques dizaines à quelques centaines de mètres, voire plus.

Déchets de faible activité

Les déchets radioactifs de faible activité sont produits par les réacteurs en exploitation et dans le cadre d'utilisations médicales, universitaires, industrielles et commerciales de substances radioactives. Les déchets de faible activité contiennent des matières renfermant des radionucléides en quantités supérieures aux seuils de libération et d'exemption (tels que définis dans le Règlement sur les substances nucléaires et les appareils à rayonnement), mais ils sont généralement caractérisés par une quantité limitée de radionucléides à longue période. Les déchets de faible activité doivent être confinés et isolés pour des périodes pouvant atteindre quelques centaines d'années. Une installation de stockage ouvragée près de la surface convient généralement aux déchets de faible activité.

Résidus des mines et usines de concentration d'uranium

Les résidus des mines et des usines de concentration d'uranium sont un type particulier de déchets radioactifs générés lors de l'extraction et du traitement du minerai d'uranium et de la production de concentré d'uranium. Outre les résidus, les activités minières produisent généralement de grandes quantités de déchets rocheux lors de l'excavation des galeries pour accéder au corps minéralisé. Ces déchets contiennent une radioactivité à vie longue qui ne diminue pas substantiellement pendant une longue période. En général, la gestion à long terme dans des installations près de la surface, adjacentes aux mines et aux usines, est la seule option pratique pour ces déchets, considérant les grands volumes de déchets produits lors des opérations d'extraction et de concentration. Le tableau ci-dessous présente quelques exemples de déchets radioactifs associés à chaque catégorie.

Tableau 3 : Classification des déchets radioactifs au Canada

Déchets de haute activité	Déchets de moyenne activité	Déchets de faible activité	Déchets des mines et usines de concentration d'uranium
Principalement le combustible nucléaire irradié	Filtres, résines et composants de réacteurs usés Sources médicales/industrielles	Têtes de vadrouilles, chiffons et serviettes en papier Isotopes médicaux	Résidus et stériles générés par l'extraction et le traitement du minerai d'uranium
Production importante de chaleur	Pas ou peu de chaleur générée	Aucune chaleur générée	Aucune chaleur générée
Confinement et isolement pendant des centaines de milliers d'années	Confinement et isolement pour des périodes supérieures à plusieurs centaines d'années	Confinement et isolement pour des périodes allant jusqu'à quelques centaines d'années (moins de 300 ans)	La radioactivité à vie longue ne diminue pas considérablement pendant une longue période
Dépôt géologique en profondeur	Dépôt géologique en profondeur	Dépôt près de la surface	Dépôt près de la surface
Importantes quantités de radionucléides à longue vie nécessitant un isolement à long terme	Exigent généralement un degré de confinement et d'isolement supérieur à celui qui peut être assuré par les dépôts près de la surface	Quantités de radionucléides supérieures aux seuils de libération et d'exemption	Seule option pratique pour ces déchets, vu les volumes importants de déchets produits

Surveillance

Au Canada, les questions relatives aux activités et aux substances nucléaires relèvent du gouvernement du Canada. Ressources naturelles Canada (RNCan) a comme responsabilité de définir les politiques du Canada en matière d'énergie nucléaire, y compris celles qui concernent les déchets radioactifs. La Politique canadienne en matière de gestion des déchets radioactifs et de déclassement définit les rôles et les responsabilités du gouvernement du Canada ainsi que des producteurs et propriétaires de déchets.[14] Cette Politique repose sur les quatre priorités suivantes :

1. Protection de la santé, de la sûreté et de la sécurité des gens et de l'environnement, et mesures garantissant la non-prolifération nucléaire;
2. Engagement inclusif, ouverture et transparence sur les questions touchant la gestion des déchets radioactifs et le déclassement;
3. Reconnaissance de l'engagement profond du Canada à établir des partenariats et à servir la réconciliation avec les peuples autochtones concernant la gestion des déchets radioactifs et le déclassement, sur la base d'une reconnaissance des droits, du respect, de la collaboration et du partenariat;
4. Excellence mondiale dans les domaines de la gestion des déchets radioactifs et du déclassement.

La Politique exige que le gouvernement fédéral « [maintienne] et actualise au besoin un régime législatif et réglementaire national axé sur un organisme indépendant de réglementation nucléaire rendant ses décisions à l'aide d'audiences inclusives, ouvertes et transparentes pour superviser et régir la gestion des déchets radioactifs et le déclassement, y compris les besoins de financement, conformément aux plans de gestion des déchets et de déclassement ».[15]

De plus, la Politique exige que le gouvernement fédéral supervise l'élaboration, la tenue à jour et la mise en oeuvre, par les producteurs et les propriétaires de déchets, d'une stratégie intégrée pour les déchets radioactifs du Canada afin de répondre aux plans à long terme de gestion des déchets, stratégie qui sera revue et actualisée au besoin sur demande du ministre des Ressources naturelles.

Processus d'élaboration de la SIDR et des recommandations

En 2020, RNCan a confié à la SGDN la tâche d'élaborer une Stratégie intégrée pour les déchets radioactifs. Dans le cadre de l'élaboration de cette SIDR, la SGDN a entrepris un certain nombre d'activités et d'évaluations, notamment des analyses comparatives internationales, des évaluations techniques et un programme de concertation avec le public, les peuples autochtones et diverses parties prenantes.

La SGDN a commencé en 2020 par commander un rapport d'analyse comparative internationale sur la gestion à long terme des déchets de faible et moyenne activité.[16] Ce rapport, préparé à partir d'une enquête sur les méthodes de plus de 22 pays, a fourni un aperçu des options techniques mises en oeuvre ou envisagées dans le monde. De cette analyse comparative internationale, la SGDN a retenu cinq options possibles pour la gestion des déchets de faible et moyenne activité canadiens. L'intendance perpétuelle ne constitue pas une option de stockage ni une pratique exemplaire internationale. Cependant, elle a été examinée dans le cadre du processus de concertation afin de fournir aux participants un éventail de solutions de gestion à long terme (entreposage et stockage) pour éclairer au mieux la stratégie.

Cette étape a été suivie d'une compilation des données sur les inventaires de déchets à gérer et de la commande, en 2021, d'une évaluation des options possibles d'un point de vue technique.[17] Plus tard en 2021, un rapport d'estimation des coûts complémentaire a été commandé pour évaluer le coût relatif de chacune des options techniques possibles.[18]

La SGDN a défini un ensemble de principes en se fondant sur ce que l'organisation avait entendu antérieurement de la part des Canadiens et des peuples autochtones. Ces principes initiaux ont été inclus dans la recherche sur l'opinion publique et affinés par les participants lors du Sommet canadien sur les déchets radioactifs, le premier des événements de concertation organisés pour l'élaboration de la Stratégie intégrée pour les déchets radioactifs. Le Sommet a eu lieu les 30 mars et 1er avril 2021. Les principes dégagés ont servi de base aux séances de concertation avec les collectivités. Tous les travaux entrepris par la SGDN étaient ancrés sur ces principes. Le texte intégral des principes est fourni à l'annexe A.



Figure 5 : Principes directeurs

Des données d'opinion quantitatives ont été recueillies au moyen de deux sondages : un sondage mené auprès d'un groupe représentatif de Canadiens et un sondage ouvert à tous. Nos sondages en ligne ont donné l'occasion aux Canadiens et aux peuples autochtones d'identifier les priorités, les principes et les considérations qui devraient, selon eux, guider l'élaboration d'une stratégie complète. Ils nous ont également permis de recueillir un précieux éventail de points de vue, d'opinions et de commentaires qui nous aideront à nous assurer que les options les plus judicieuses sont en place pour gérer les déchets radioactifs canadiens. Les deux sondages ont porté sur le même ensemble de sujets et comportaient pour la plupart les mêmes questions. Ils ont également fourni aux répondants essentiellement les mêmes informations factuelles de base (par exemple, les niveaux de radioactivité des déchets, les pratiques actuelles de gestion des déchets, les pratiques internationales).

Au début de 2021, la SGDN a commandé le premier sondage, un sondage délibératif auprès d'un échantillon représentatif de Canadiens (sondage représentatif) sur l'élaboration d'une stratégie intégrée de gestion à long terme des déchets radioactifs.[19] Cette enquête a été réalisée au cours des deux dernières semaines du mois de janvier 2021. Un échantillon aléatoire de 1625 résidents adultes canadiens a répondu à ce sondage représentatif en ligne. Avant de recueillir les commentaires des

répondants, le questionnaire donnait de l'information contextuelle factuelle sur les différentes questions (p. ex., les types de déchets radioactifs, les pratiques actuelles de gestion des déchets, les pratiques des autres pays).

Une formule similaire a été utilisée pour le deuxième sondage (sondage ouvert), mené celui-là de mai à décembre 2021.[20] L'une des caractéristiques distinctives de ce sondage ouvert en ligne est qu'il était ouvert à tous, afin de permettre à toutes les personnes intéressées de contribuer. En tout, 345 personnes ont participé au sondage ouvert. Il convient de noter que le sondage ouvert comprenait une vidéo d'information sur le transport et une autre sur la réglementation des déchets radioactifs au Canada, ce qui n'était pas le cas pour le sondage représentatif initial.

En matière de concertation, la SGDN a mené une multitude d'activités de différents formats sur une période de 18 mois allant de janvier 2021 à juin 2022. Près de 4000 personnes au total ont participé à ces activités. La concertation avec certaines collectivités autochtones s'est poursuivie après la clôture de la période de consultation publique, soit jusqu'à ce que soit publiée la Politique révisée de RNCan.

En janvier 2021, la SGDN a lancé un site Web sur la SIDR, tout à fait distinct et indépendant du site Web de la SGDN. Ce site Web constitue le principal point d'accès pour toutes les informations relatives à la SIDR. Les présentations et les rapports préparés y ont été fournis afin d'assurer le degré de transparence le plus élevé possible. L'inscription à la plupart des activités de concertation se faisait également par le biais de ce site Web. Les médias sociaux, qui ont été utilisés pour promouvoir les activités de concertation, ont permis de rejoindre approximativement un million de personnes.

Le Sommet canadien sur les déchets radioactifs, qui s'est tenu les 30 mars et 1er avril 2021, a marqué le coup d'envoi du processus de concertation sur l'élaboration de la SIDR.[21] Il a été conçu pour offrir un espace sûr et commun permettant à de multiples voix de se faire entendre, de mettre les participants en contact de façon nouvelle et approfondie, et de présenter diverses voix et perspectives sur les questions importantes associées à l'élaboration d'une stratégie intégrée pour les déchets radioactifs canadiens.

Des conférenciers ont représenté les points de vue des peuples autochtones, des organisations de la société civile, de l'industrie, du secteur municipal, des jeunes et de plusieurs autres pays. L'événement de trois jours était gratuit et ouvert à toute personne intéressée. Il ne s'agissait pas d'un événement technique, mais plutôt d'une occasion pour les participants pour qui les sujets n'étaient peut-être pas tous familiers d'entendre une pluralité de voix exprimant différentes considérations, et de pouvoir poser des questions et participer à des séances en petits groupes pour explorer ces sujets et faire part de leurs idées.

Les autres activités de concertation peuvent être classées dans les catégories suivantes : séances de concertation locales ouvertes à tous; tables rondes avec des représentants de l'industrie, du milieu universitaire et d'organisations de la société civile et avec des fonctionnaires fédéraux et provinciaux; concertation avec les jeunes; et concertation avec les Autochtones.



Figure 6 : Séances de concertation avec de multiples groupes de participants

Lors de ces activités de concertation, les participants ont été invités à prendre part à une discussion sur trois sujets clés afin de contribuer à éclairer l'élaboration d'une Stratégie intégrée pour les déchets radioactifs du Canada :

1. Le premier visait à déterminer ce qu'il sera le plus important de faire correctement lors de l'élaboration d'une Stratégie intégrée pour les déchets radioactifs du Canada.
2. Le deuxième visait à déterminer la meilleure chose à faire pour le long terme avec les déchets radioactifs de faible et moyenne activité du Canada (considérés séparément).
3. Le troisième portait sur la question de savoir qui devrait être responsable de la mise en oeuvre de la stratégie.

Ces sujets de discussion ont permis d'identifier les considérations que les participants estimaient être essentielles à une stratégie intégrée.

De plus, la SGDN a organisé six ateliers techniques pour des experts et des profanes : trois sur les déchets de faible activité et trois sur les déchets de moyenne activité. Au cours de ces ateliers, les participants ont été invités à commenter le rapport et à dire si les options recommandées étaient classées selon l'ordre de priorité qu'ils souhaiteraient. Les participants ont été encouragés à se concentrer sur les options techniques sans tenir compte des autres facteurs qui seront pris en compte dans les recommandations finales de la stratégie.

La SGDN a publié une série de rapports Ce que nous avons entendu afin de présenter les commentaires reçus au cours des diverses activités de concertation.[22] Voir l'annexe B : *Matrice des commentaires reçus lors des activités de concertation, classés par groupe de participants*, pour en savoir plus sur les contributions apportées par les différents groupes de participants à l'élaboration des thèmes et des idées figurant dans les recommandations.

Il convient de noter que plusieurs organisations de la société civile ont refusé de participer à l'élaboration de la SIDR. Les organisations de la société civile qui ont participé ont apporté une contribution précieuse au dialogue et leurs commentaires ont été recueillis et sont pris en compte dans le présent rapport.

Il est décevant que certains groupes aient refusé de participer, car nous voulions faire en sorte que tous les points de vue puissent être entendus. Nous avons continué à leur tendre la main tout au long du processus et nous les avons invités à nous faire part de leurs commentaires sur les mesures que nous pourrions prendre pour répondre à leurs préoccupations relatives à leur participation, afin que leurs points de vue soient pris en compte. Ils ont cependant choisi de ne pas engager de dialogue avec la SGDN.

L'organisation de la société civile Nuclear Waste Watch a réuni le Radioactive Waste Review Group en 2019 et a publié en avril 2022 un document intitulé *An Alternative Policy for Canada on Radioactive Waste Management and Decommissioning*. La SGDN a examiné ce document et pris en compte les contributions pertinentes qu'il contenait pour l'élaboration de la stratégie.

La SGDN a publié en août 2022 une version préliminaire de la SIDR qui a été soumise à une période de commentaires publics de 90 jours.[23] Les commentaires sur cette ébauche de la SIDR, la concertation continue avec les peuples autochtones intéressés et la publication de la Politique ont éclairé ce document final de SIDR.

Calendrier

La SGDN a été chargée en novembre 2020 de diriger la concertation sur la SIDR. Nous avons amorcé notre processus de concertation en janvier 2021 avec un sondage représentatif, conclu notre programme de concertation publique en avril 2022 et publié l'ébauche de la SIDR pour une période de consultation publique de 90 jours en août 2022. La concertation avec les Autochtones s'est toutefois poursuivie jusqu'au moment de la publication de la présente stratégie intégrée.



Figure 7 : Calendrier de la SIDR

Options techniques considérées dans le cadre de l'élaboration de la SIDR

À partir du rapport portant sur l'analyse comparative internationale commandée en 2020, la SGDN a dégagé six options possibles pour une discussion et une évaluation plus approfondies, qui sont définies dans le tableau suivant.

Tableau 4 : Résumé des options techniques retenues pour l'évaluation

Monticule ouvragé de confinement Des monticules ouvragés de confinement sont utilisés au Canada pour certains déchets de faible activité, notamment près de Port Hope, en Ont., et des installations similaires existent aussi ailleurs dans le monde.	• Convient aux déchets de faible activité qui ne diminueront pas en volume et ne se comprimeront pas avec le temps, comme les sols ou le béton contaminés; • Il emploie des couches de matériaux naturels en combinaison avec des matériaux synthétiques; • Il peut se construire dans divers types de sols; • De conception semblable à un site d'enfouissement de déchets ménagers; • Technologie exploitée actuellement au Canada, en France, en Suède et aux États-Unis.

Enceinte de béton Les enceintes de béton sont largement utilisées dans le monde pour le stockage des déchets radioactifs de faible activité. Les dépôts à enceintes de béton sont faciles à construire et à exploiter. Ils sont de conception modulaire, c'est-à-dire que des enceintes peuvent être ajoutées pour augmenter la capacité du dépôt.	• Conception simple, modulaire; • Expansible selon les besoins; • Convient aux déchets de faible activité contenus dans divers types de colis, y compris les déchets qui peuvent se comprimer avec le temps, comme les vêtements et les produits de papier; • Peut se construire dans divers types de sols; • En exploitation en République tchèque, en France, au Japon, en Slovaquie, en Espagne et au Royaume-Uni.
Caverne rocheuse peu profonde Les cavernes rocheuses peu profondes pourraient possiblement convenir au stockage des déchets de faible activité. Une série de cavernes rocheuses sont excavées à une profondeur nominale de 50 à 100 mètres sous la surface, dans une roche de faible perméabilité. On y accède depuis la surface par un petit système de rampes et de tunnels.	• Convient aux déchets de faible activité, y compris les déchets qui peuvent diminuer en volume ou se comprimer avec le temps, comme les produits de papier; • Exige une géologie appropriée; • Tire avantage des barrières naturelles; • Les bâtiments en surface sont relativement petits; • En exploitation en Finlande et en Suède.
Dépôt géologique en profondeur Les dépôts géologiques en profondeur sont reconnus comme une pratique exemplaire pour le stockage des déchets qui doivent être isolés pendant plus que quelques centaines d'années, tels que les déchets de moyenne ou de haute activité.	• Pratique considérée comme exemplaire dans le monde pour les déchets de moyenne activité et les déchets de haute activité, qui doivent être isolés pendant plus que quelques centaines d'années; • Exige une géologie appropriée; • Tire avantage des barrières naturelles et de barrières ouvragées; • Technologie exploitée actuellement en Hongrie et aux États-Unis.
Forage profond Cette technologie émergente pourrait être utile pour de plus petites quantités de déchets de moyenne activité. Cette méthode consiste à forer une série de puits étroits à des profondeurs de 500 à 1000 mètres approximativement sous la surface et à y empiler des colis de déchets à grande profondeur.	• Relativement simple à construire et à exploiter comparativement aux installations plus importantes; • Peut convenir aux faibles volumes de déchets de moyenne activité; • Exige une géologie appropriée; • Tire avantage des barrières naturelles; • Taille limitée; • Aucun n'est en exploitation au moment de la publication de ce document.
Intendance perpétuelle L'intendance perpétuelle pour le stockage à long terme des déchets de faible et moyenne activité exigerait une intervention multigénérationnelle. Bien que cette approche ait ses défenseurs pour la gestion à long terme des déchets nucléaires, l'intendance perpétuelle n'est pas reconnue internationalement comme une méthode optimale pour la gestion des déchets nucléaires.	• Une façon de gérer les déchets de manière indéfinie, non une solution de stockage. Laisse la porte ouverte à toutes sortes de solutions; • Présume qu'une technologie future offrira une solution de stockage permanente; • Exige une surveillance continue, des inspections perpétuelles et le renouvellement périodique des colis et des installations de stockage pendant de nombreuses années; • Imposerait un investissement en travail et en argent aux générations futures; • Méthode non reconnue internationalement pour le stockage des déchets radioactifs; • En usage aux Pays-Bas.



Chapitre 2 : Inventaire des déchets et lacunes dans les plans de stockage à long terme

Contexte : Près de 84 pour cent de tous les déchets radioactifs au Canada sont actuellement visés par un plan de stockage à long terme. La présente Stratégie intégrée pour les déchets radioactifs du Canada marque un point dans le temps à partir duquel nous pouvons commencer, dans une perspective à long terme, à prendre les mesures qui s'imposent pour combler les lacunes qui existent dans la planification du stockage de tous les déchets radioactifs canadiens qui ont été générés jusqu'à maintenant pour produire de l'électricité et des isotopes médicaux essentiels, avec un regard vers l'avenir.

Tous les déchets radioactifs au Canada sont gérés de manière sûre, en conformité avec les normes internationales, dans des installations autorisées par la Commission canadienne de sûreté nucléaire. Cependant, les déchets radioactifs au Canada ne sont pas tous visés par un plan de gestion à long terme. Dans le cadre de l'élaboration de cette SIDR, la SGDN a commandé une étude pour évaluer à un niveau sommaire les lacunes des plans à long terme prévus pour l'inventaire des déchets radioactifs de faible et moyenne activité canadiens, pour catégoriser et regrouper les déchets radioactifs et pour déterminer les options de gestion à long terme qui conviendraient le mieux à chaque catégorie de déchets radioactifs.

Les six options retenues pour la gestion à long terme des déchets radioactifs de faible et moyenne activité canadiens sur la base d'une analyse comparative internationale ont été évaluées par rapport à l'inventaire des déchets radioactifs qui ne sont pas visés par un plan de gestion à long terme, et le rapport intitulé *Société de gestion des déchets nucléaires – Stratégie intégrée pour les déchets radioactifs (SIDR) – Élaboration d'un plan initial – Caractérisation et options – Rapport de projet* (appelé ci-après le Rapport sur les options techniques), a été préparé.[24]

Le combustible irradié n'a pas été inclus dans cette étude, puisqu'il est visé par le projet de la Gestion adaptative progressive de la SGDN, comme le prévoit la *Loi sur les déchets de combustible nucléaire*. De même, les déchets des mines et des usines de concentration d'uranium ont été exclus de l'évaluation, étant déjà gérés dans des installations de gestion à long terme existantes.

Aux fins de ce Rapport sur les options techniques, des détails sommaires ont été recueillis sur l'inventaire actuel et l'inventaire futur prévu de déchets auprès des principaux producteurs et propriétaires de déchets canadiens actuels. Le Rapport sur les options techniques a identifié les déchets radioactifs de faible et moyenne activité actuels et futurs au Canada qui n'étaient visés par aucun plan de gestion à long terme et a présenté une évaluation intégrée de la gestion à long terme de ces déchets. Ces déchets comprennent les déchets générés lors des activités de médecine nucléaire, de la fabrication du combustible nucléaire, de l'exploitation des réacteurs nucléaires, des activités de recherche-développement, de la fabrication et de l'utilisation des radioisotopes, et du déclassement des installations nucléaires.

Les déchets ont été regroupés en catégories de matières de nature similaire pour ce qui concerne la gestion à long terme. En général, les déchets ont été regroupés en fonction de leur classification radiologique (p. ex., déchets de faible activité, déchets de moyenne activité) et de leur configuration physique (p. ex., matériau en vrac, emballage, taille, etc.).

Le tableau ci-après montre l'état d'avancement des plans de stockage à long terme pour les différents types de déchets radioactifs au Canada.

Tableau 5 : Plans actuellement établis pour le stockage à long terme des déchets au Canada

Classification des déchets	Type de déchets	Plan de stockage à long terme existant	Responsabilité actuelle de la mise en oeuvre du plan à long terme	Pourcentage du volume total de déchets non visé par un plan de stockage à long terme
Déchets de haute activité (DHA)	Combustible irradié	Oui	SGDN	0
	DHA autres que le combustible	Non	–	< 0,01
Déchets de moyenne activité (DMA)	DMA produits dans diverses installations nucléaires	Non	–	2
	DMA produits par l'installation nucléaire de démonstration et le réacteur Whiteshell-1	Oui	LNC	0
Déchets de faible activité (DFA)	DFA historiques de Port Hope	Oui	LNC	0
	DFA propriété d'Énergie atomique du Canada limitée à Chalk River	Oui	LNC	0
	DFA produits par l'installation nucléaire de démonstration et le réacteur Whiteshell-1	Oui	LNC	0
	DFA produits dans diverses installations nucléaires	Non	–	14
Déchets des mines et usines de concentration d'uranium[25]	Installations de gestion des résidus près du lieu de production	Oui	Compagnies d'extraction d'uranium et de gestion des résidus d'uranium, gouvernement fédéral et gouvernements provinciaux concernés	0
	84 pour cent des déchets radioactifs sont actuellement visés par un plan de stockage à long terme 16 pour cent des déchets radioactifs ne sont actuellement visés par aucun plan de stockage à long terme			

Lacunes dans les plans de stockage à long terme des déchets radioactifs au Canada

Près de 84 pour cent de tous les déchets radioactifs au Canada sont actuellement visés par un plan de gestion à long terme. Les volumes de déchets non visés par un plan de gestion à long terme (visés par la SIDR) comprennent les déchets radioactifs de faible et moyenne activité actuels et futurs au Canada pour lesquels aucun plan de gestion à long terme n'est actuellement en place. Ils s'élèvent à approximativement 294 000 m^3 de déchets de faible activité, 51 000 m^3 de déchets de moyenne activité et moins de 10 m^3 de déchets de haute activité autres que du combustible (voir ci-dessous).

Tableau 6 : Déchets non visés par un plan de stockage à long terme

Type de déchets	Volume (m^3)	Pourcentage du total des déchets radioactifs au Canada
Déchets de haute activité (autres que du combustible)[26]	<10	< 0,01
Déchets de moyenne activité	51 000	2
Déchets de faible activité	294 000	14
Déchets des mines et usines de concentration d'uranium	Pas de lacunes – Plans déjà en place	S/O
Approximativement 84 pour cent du total des déchets radioactifs au Canada sont déjà visés par un plan de stockage à long terme.		

Il convient de noter que les options pour le reste de l'inventaire total (déchets de haute activité, déchets des mines et usines de concentration d'uranium, déchets de faible activité sous la responsabilité d'Énergie atomique du Canada limitée) ne sont pas abordées dans le présent rapport, étant donné qu'il existe déjà des installations ou des plans pour les traiter. Voir l'annexe C : *État d'avancement des projets de gestion à long terme des déchets au Canada*, pour l'état d'avancement des plans actuels et de la mise en oeuvre des solutions d'entreposage et de stockage à long terme des déchets radioactifs canadiens.

La figure ci-après montre la proportion en pourcentage du volume total de déchets des différents types de déchets radioactifs non visés par un plan à long terme. La quantité de déchets non visés par un plan de gestion à long terme représente approximativement 16 pour cent de l'ensemble des déchets radioactifs au Canada. Sur cette quantité, le Rapport sur les options techniques a révélé que 15 pour cent des déchets sont des déchets de moyenne activité (DMA) et 85 pour cent des déchets de faible activité (DFA).

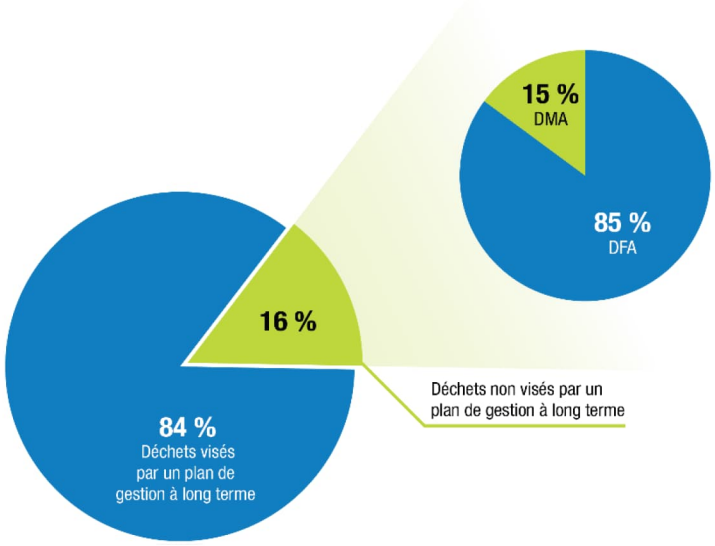


Figure 8 : Pourcentage de déchets non visés par un plan à long terme par rapport au volume total de déchets

À titre de référence, l'inventaire total actuel des déchets radioactifs au Canada présenté ci-dessous indique que la majeure partie du volume actuel de déchets radioactifs au Canada est constituée de déchets de faible activité.

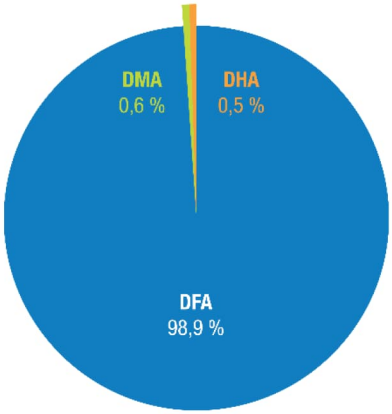


Figure 9 : Inventaire total des déchets radioactifs canadiens en 2019

PROPRIÉTAIRES DES DÉCHETS RADIOACTIFS NON VISÉS PAR UN PLAN DE STOCKAGE À LONG TERME

Le tableau ci-dessous identifie les propriétaires des déchets de faible et moyenne activité qui ne sont pas actuellement visés par un plan de stockage à long terme. Des détails supplémentaires sont fournis dans le Rapport sur les options techniques.[27]

Tableau 7 : Volume de DFA et de DMA non visés par un plan de stockage à long, par propriétaire de déchets

Propriétaire de déchets	Volume de DHA autres que le combustible (m^3)[28]	Volume de DMA (m^3)	Volume de DFA (m^3)
Ontario Power Generation	<6	40 000	270 000
Hydro-Québec	S/O	1 000	18 000
Énergie NB	S/O	780	2 270
Cameco	S/O	S/O	2 000
Autres	S/O	1 000	1 740
Énergie atomique du Canada limitée/Laboratoires nucléaires canadiens (à l'exclusion des projets existants prévus pour les DFA/DMA)	<4	8 200	S/O

INVENTAIRE DES DÉCHETS RADIOACTIFS QUI SERONT GÉNÉRÉS DANS L'AVENIR PAR DES TECHNOLOGIES ÉMERGENTES

Investir dans de nouveaux projets d'énergie nucléaire pour produire de l'électricité et ouvrir la voie à des applications industrielles qui permettront d'atténuer les changements climatiques suscite actuellement un grand intérêt au Canada et ailleurs dans le monde. Une partie de ces nouveaux projets pourrait s'appuyer sur la technologie CANDU; une autre partie pourrait s'appuyer sur d'autres technologies, notamment les petits réacteurs modulaires, basés sur la technologie des réacteurs à eau pressurisée ou à eau bouillante, ainsi que sur les réacteurs avancés. Ces nouvelles technologies pourraient générer des déchets présentant des caractéristiques différentes de celles qui sont en cours d'évaluation. La présente stratégie s'est vu attribuer toute la flexibilité nécessaire pour intégrer ces déchets dans le flux de déchets qui leur conviendrait, selon la classification adoptée pour les déchets au Canada : les déchets de haute activité, qui incluent le combustible nucléaire irradié, les déchets de moyenne activité et les déchets de faible activité.

Au fil du temps, la gestion des déchets évoluera : les installations de stockage de déchets identifiées dans la stratégie seront mises en oeuvre, de nouvelles technologies telles que les petits réacteurs modulaires pourraient être déployées, le recours innovateur des technologies nucléaires pourrait ouvrir la voir la voie à de nouveaux procédés médicaux avancés à base d'isotopes radioactifs et les exigences de la société pourraient changer. La SIDR du Canada exigera que des rapports soient fournis à intervalles réguliers pour rendre compte de la progression de sa mise en oeuvre et pour s'assurer que tous les flux de déchets qui pourraient être générés seront pris en charge. L'état d'avancement de la mise en oeuvre de cette stratégie intégrée devra être examiné à intervalles réguliers afin de s'assurer que la stratégie est mise en oeuvre de manière efficace et qu'elle intègre tous les flux de déchets qui pourraient être générés dans le futur.



Chapitre 3 : Ce que nous avons entendu

Contexte : En 2021, la SGDN a entrepris avec les Canadiens et les peuples autochtones un processus de concertation en menant des recherches sur l'opinion publique, en organisant un sommet pour entendre divers points de vue sur la question, en écoutant les citoyens dans le cadre d'une série de séances de concertation tenues dans les collectivités où des déchets sont actuellement entreposés, et en organisant des discussions en table ronde et des ateliers techniques.

Promotion numérique des occasions de concertation

Le programme de concertation sur la SIDR avait été conçu pour offrir des espaces de partage sûrs, où de multiples voix pouvaient se faire entendre et où les participants pouvaient échanger de manières nouvelles et approfondies. Les occasions de concertation offertes étaient gratuites et ouvertes à toute personne intéressée.

Comme il était important d'encourager une large participation, la SGDN a utilisé divers outils de communication et de promotion, y compris les médias sociaux (lui appartenant et payés), des courriels, ainsi que la sensibilisation des collectivités partenaires pour joindre un plus large éventail de publics pertinents afin de les informer et de les encourager à s'inscrire et à participer à des activités telles que le Sommet sur les déchets radioactifs canadiens, le sondage ouvert sur la SIDR et les séances de concertation locales.

Pour susciter une large participation, la SGDN a lancé une campagne de publicités payantes sur les chaînes de médias sociaux de la SIDR, recherchant ce faisant un juste équilibre dans l'utilisation de ses différentes chaînes propres au projet (Facebook et Twitter) et des deux langues officielles (anglais/français).

Les publicités déployées sur Facebook et Twitter pour annoncer le Sommet canadien sur les déchets radioactifs, le sondage délibératif ouvert sur la SIDR et les séances de concertation locales ont été diffusées et vues plus de 1,91 million de fois à travers le Canada, joignant au total 1 153 878 personnes et les invitant à participer aux diverses possibilités de concertation.

Thèmes clés dégagés des activités de concertation

Cette section présente les thèmes les plus fréquemment soulevés lors des activités de concertation tenues à travers le pays, mais ne relate pas tous les commentaires individuels qui y ont été faits. La SGDN a publié une série de rapports « Ce que nous avons entendu » afin de présenter les commentaires fournis au cours des diverses activités de concertation. Des détails supplémentaires sur ces activités sont fournis à l'annexe B : *Matrice des commentaires reçus lors des activités de concertation, classés par groupe de participants*.

Thème clé 1 – La sûreté est d'une importance primordiale

Le thème le plus marquant qui s'est dégagé de l'ensemble du programme de concertation est l'importance de la sûreté dans tous les aspects de l'élaboration et de la mise en oeuvre de la Stratégie intégrée pour les déchets radioactifs. Les participants nous ont dit que la sûreté était importante pour tous les aspects de la stratégie de gestion des déchets nucléaires; la protection de l'environnement a été une considération essentielle pour tous les secteurs participants.

Nous avons entendu qu'en tant que priorité fondamentale, la sûreté devait être considérée dans une optique à long terme. Cela était important aux yeux des participants pour que la stratégie tienne compte des risques futurs et garantisse la sécurité des personnes dans des conditions environnementales, gouvernementales, sociétales et technologiques futures qui seront imprévisibles et potentiellement instables. Pour les jeunes participants, cela signifiait qu'il faudrait choisir des solutions qui offrent le plus haut niveau de protection en matière de stockage et d'isolement des déchets; intégrer la modélisation des changements climatiques et sociaux dans la gestion des risques; favoriser une stratégie flexible et adaptative; et opter pour des approches de gouvernance qui assurent un bon niveau de cohérence et de reddition de comptes. Les participants ont accordé une plus grande priorité à la sûreté qu'aux considérations de coûts.

La sûreté a également été le thème principal de toutes les discussions avec les peuples autochtones. Les conditions pourraient changer à long terme et nous devons anticiper les risques futurs, notamment les catastrophes environnementales, les changements climatiques et les perturbations sociales. Les participants ont indiqué qu'il sera important que la stratégie soit flexible et adaptative et que les diverses parties prenantes partagent la responsabilité de sa mise en oeuvre en prévision des défaillances possibles et de changements qui pourraient survenir dans le futur.

Les participants ont soulevé des préoccupations concernant l'emplacement, l'entreposage, le confinement et le transport des déchets, qui sont tous des facteurs clés à prendre en compte pour la décision finale. Les participants nous ont dit qu'à l'avenir, lorsqu'un projet de stockage de déchets sera entrepris, sa conception devra être adaptée dès le départ à l'emplacement ainsi qu'aux volumes et aux caractéristiques des déchets, et répondre aux exigences réglementaires.

Thème clé 2 – Agir dès maintenant

Nous avons entendu qu'une stratégie intégrée était nécessaire et qu'il fallait déterminer l'approche à adopter pour la gestion à long terme des déchets de faible et moyenne activité. Nous avons entendu que l'absence d'installations de stockage pour les déchets de moyenne activité accroissait les risques encourus du fait que les déchets sont conservés en surface, dans des installations d'entreposage provisoires, et que ce problème devait être traité en priorité. Les participants convenaient en général que la bonne chose à faire serait de mettre en place et en oeuvre un plan pour tous les déchets radioactifs canadiens et de le faire avec un sentiment d'urgence, plutôt que de laisser aux générations futures la tâche de résoudre ce problème.

Thème clé 3 – Communication et transparence

Les thèmes de la transparence et de la communication ont été soulevés par l'ensemble des participants. Des participants à toutes les activités de concertation ont insisté sur l'importance d'une communication qui soit claire, factuelle, transparente et inclusive, et qui fournisse un contexte lorsque cela est utile. Nous avons entendu que nous devons être totalement transparents au sujet des déchets et des risques qui leur sont associés. Certains participants ont mentionné qu'il sera important de donner une plus grande visibilité aux inventaires de déchets, tels qu'ils existent aujourd'hui et tels qu'ils devraient évoluer dans le futur.

Les participants ont défini la transparence dans les communications comme étant le fait de fournir toutes les informations importantes, de manière pertinente, accessible et impartiale. La transparence suppose également que soient fournies aux collectivités et aux parties prenantes touchées des possibilités de vérifier les informations ainsi que des mises à jour régulières et fréquentes. Comme pour le thème de l'éducation, les participants ont souligné que la transparence des informations et des communications était essentielle pour une concertation approfondie et l'établissement de relations de confiance.

Les participants ont déclaré que les producteurs de déchets et les propriétaires de déchets doivent communiquer clairement les rôles et les responsabilités attribués aux différentes parties prenantes du domaine de l'énergie nucléaire. En outre, de nombreux participants ont souligné qu'il sera important d'avertir les collectivités lorsque des marchandises dangereuses seront transportées sur leurs territoires traditionnels et de leur communiquer les plans d'urgence de l'industrie.

Nous avons entendu que la SIDR doit tenir compte de la dimension sociale et mettre l'accent sur la recherche de consensus, la transparence et le consentement éclairé. Nous avons entendu que les questions techniques liées aux déchets semblent avoir été abondamment discutées, mais que les aspects sociaux ou politiques ne l'ont pas suffisamment été.

Thème clé 4 – Relation de confiance avec les collectivités autochtones

Les participants ont appuyé l'idée qu'il faille mériter la confiance des collectivités autochtones et bâtir avec elles des relations pour réussir l'élaboration et la mise en oeuvre du plan. La prise en compte du savoir autochtone, au même titre que la science occidentale, a également été jugée importante pour une stratégie qui doit répondre tant à des considérations éloignées dans le temps qu'à des considérations plus immédiates. Les participants autochtones ont insisté sur le fait que ce type d'information doit provenir des détenteurs du savoir, qui doivent participer et être inclus à toutes les étapes de l'élaboration, de la mise en oeuvre et de l'exploitation du projet. Le savoir autochtone ne devrait pas servir aux promoteurs d'instrument permettant de passer outre l'inclusion ou la contribution de la collectivité.

Nous avons entendu qu'une concertation approfondie et l'établissement de relations soutenues avec les collectivités autochtones étaient une priorité pour les jeunes. Les participants souhaitaient que la stratégie comprenne l'obligation de respecter le droit des collectivités autochtones à un consentement préalable libre et éclairé et de veiller à ce que la participation des Autochtones ne soit pas entachée par des pratiques destinées à les exploiter. Ils ont indiqué que la stratégie devait être centrée sur les perspectives, l'expertise et les visions du monde des Autochtones et contribuer à la souveraineté autochtone en créant des structures qui permettent aux collectivités autochtones d'assumer de nouveau le contrôle de la gestion à long terme de leurs terres. Il faudrait notamment que les collectivités et les dirigeants autochtones participent à la gestion et à la supervision de la stratégie; il faudrait aussi renforcer la capacité des collectivités autochtones à prendre part à ces processus.

L'importance de s'engager véritablement à favoriser la réconciliation avec les collectivités autochtones a été l'un des principaux constats dégagés des séances de concertation avec les Autochtones. Des partenariats larges, diversifiés et exhaustifs, en particulier avec les collectivités susceptibles d'être directement touchées, seront essentiels pour prendre des décisions judicieuses sur cette question. L'obligation de rendre compte des problèmes hérités et l'ouverture à l'inclusion et à la collaboration avec

les collectivités autochtones seront des éléments essentiels pour établir des partenariats et favoriser la réconciliation.

Les droits et titres issus des traités, y compris l'obligation de consulter et d'obtenir un consentement libre, préalable et éclairé, ont été au premier plan de la plupart des séances de concertation avec les Autochtones. La plupart des participants ont souligné qu'il était important pour eux de participer, dans le cadre d'une concertation ou d'une consultation approfondie, à l'élaboration et à la mise en oeuvre de toute stratégie ou de tout projet lié à l'énergie nucléaire.

Thème clé 5 – Éducation et concertation

De nombreux participants aux séances ont souligné l'importance d'éduquer les gens, par le biais d'un programme de concertation publique, au cours de l'élaboration de la stratégie et ont indiqué que l'éducation était essentielle à la réussite du projet.

Nous avons également entendu dire que l'éducation doit être davantage intégrée à nos discussions. Des participants ont indiqué qu'ils souhaitaient contribuer à la stratégie, mais qu'ils avaient parfois besoin de plus d'informations. Certains participants ont indiqué qu'ils ne disposaient pas de suffisamment d'informations pour porter un jugement adéquat dans le cadre de ces discussions. Cela a mis en évidence la nécessité de poursuivre l'éducation du public afin que les Canadiens et les Autochtones comprennent les défis uniques que posent les déchets radioactifs. Certains trouvaient qu'il était difficile d'envisager les options techniques sans tenir compte des coûts, des facteurs environnementaux et de sûreté, tels que la description et la composition des déchets, ainsi que de la hiérarchisation des déchets (ce qui se passe avant le stockage, y compris les autres utilisations).

Des participants reconnaissaient l'importance de l'expertise, mais souhaitaient vivement eux-mêmes en apprendre davantage pour contribuer à la stratégie et ont noté que les experts doivent éduquer et proposer des options. Cette éducation est essentielle pour aider les Canadiens et les Autochtones à comprendre les défis uniques que posent les déchets radioactifs et la façon dont la sûreté sera maintenue. Les participants ont également indiqué que l'éducation était essentielle pour contrer la désinformation sur les déchets radioactifs.

L'éducation est ressortie comme un facteur clé pour la concertation avec les collectivités et les peuples autochtones dans le cadre du processus décisionnel. Les participants ont reconnu que leur niveau d'éducation sur les déchets radioactifs, sur les options de stockage, sur la comparaison avec ce qui se fait ailleurs dans le monde et sur l'utilisation de l'énergie nucléaire au Canada était faible. Certains groupes situés dans des régions hôtes avaient un niveau de connaissance plus élevé, mais dans l'ensemble, les différents niveaux de connaissance peuvent avoir une incidence sur la préférence accordée aux types d'installations.

Nous avons entendu que les participants souhaitaient en savoir plus sur tous les aspects de la stratégie afin de prendre des décisions plus éclairées et contribuer davantage à la stratégie globale. Nous avons entendu que tirer des enseignements des meilleures pratiques scientifiques internationales était une voie importante à suivre pour à la fois protéger le public et optimaliser l'aspect économique de la stratégie, deux éléments qui sont importants, aujourd'hui comme pour le long terme, et qui fournissent des données et de l'expertise très précieuses. Toutefois, les participants, et en particulier les jeunes, ont généralement appuyé l'idée d'une solution proprement canadienne, qui tiendrait compte des conditions et de l'environnement qui sont uniques au Canada, notamment la taille du pays, la diversité des Canadiens et des peuples autochtones et les effets particuliers que pourraient avoir les changements climatiques.

Nous avons entendu qu'une éducation pertinente et accessible sur la gestion des déchets radioactifs était essentielle pour créer des occasions de concertation approfondies pour tous les groupes. Certains participants ont fait remarquer que la concertation avec le public n'a d'habitude pas lieu avant qu'une solution de gestion soit présentée dans leur collectivité. Ils ont exprimé le souhait d'être consultés dès le début de l'élaboration de tout plan envisagé. La concertation doit rester un aspect important de cette stratégie et de tous les plans à venir.

Les jeunes participants souhaitaient qu'un vaste programme de concertation soit établi avec les divers groupes de parties prenantes, et qu'une concertation soutenue et l'établissement de relations soient engagés avec les collectivités et les peuples autochtones touchés. Les participants ont estimé que les points de vue des jeunes devaient faire partie intégrante de toute éventuelle stratégie de planification et de gestion. Ils ont exprimé la nécessité d'appliquer une stratégie d'éducation intergénérationnelle pour cultiver chez les jeunes un sentiment de responsabilité envers la mise en oeuvre de la stratégie à long terme.

Thème clé 6 – Durabilité et environnement

En plus d'assurer la protection de la collectivité et de ses résidents, on nous a dit qu'il était important de limiter le plus possible l'empreinte carbone et de protéger l'environnement à long terme, en particulier l'eau. Des participants ont insisté sur le fait que nous devons être attentifs à l'urgence climatique et faire en sorte que chaque aspect de cette stratégie soit durable, tienne compte des risques posés par les changements climatiques, respecte l'environnement et protège les sources d'eau pour toutes les générations futures.

Nous avons entendu des jeunes que la protection de la terre, de l'eau et de l'environnement devait se voir attribuer la plus haute des priorités. Les participants ont indiqué que les sites de stockage de déchets ne devraient pas être construits près de l'eau, afin d'éviter qu'ils la contaminent et affectent le mode de vie des résidents. Ils ont également fait remarquer que l'objectif de réduire au minimum les incidences sur l'environnement devrait être envisagé dans le cadre d'une approche fondée sur le cycle de vie, et devrait englober les volets de la construction des installations et du transport des déchets radioactifs.

Protéger les terres et limiter le plus possible l'impact sur les terres et l'environnement naturel, y compris les perturbations sur la faune et les terres utilisées à des fins cérémonielles et traditionnelles, constituaient une priorité pour les peuples autochtones. Les participants ont exprimé une préférence pour les options techniques qui auraient le moins d'impact sur l'environnement. Ils estimaient que les options où les déchets seraient placés sous terre ou dont les sites peuvent être restaurés ou recouverts de végétation semblaient répondre à cette priorité. Limiter l'impact visuel a également été perçu comme une considération importante, en particulier par les participants qui vivent près d'autres types d'installations industrielles.

De nombreux participants autochtones ont également indiqué que la protection des sources d'eau et la réduction au minimum des impacts sur les sources d'eau étaient des priorités. La recommandation qu'aucune installation et qu'aucun site de stockage ne soient situés près d'une source d'eau était un thème commun.

Nous avons constaté un consensus large et fréquent entre les participants sur le fait que la réduction à la source des déchets devait être encouragée. Les organisations de l'industrie et de la société civile ont toutes fait valoir le principe de réduire au minimum les déchets générés. De plus, il a été soulevé que le Canada pourrait investir dans des technologies qui permettraient de soutenir des initiatives de réduction des déchets. Caractériser de manière précise les déchets a également été jugé important pour garantir que les déchets seront gérés et stockés en conformité avec le risque qu'ils posent.

Les jeunes participants étaient très conscients du racisme environnemental exercé historiquement au Canada, notamment envers les collectivités autochtones, et ont plaidé pour que l'aspect de la justice environnementale soit pris en considération lorsque viendra le temps de déterminer le nombre d'installations à construire et les endroits où elles devraient être construites. Les participants voulaient s'assurer que la stratégie n'impose pas de façon disproportionnée à certaines collectivités les responsabilités et les risques associés à la gestion des déchets radioactifs.

Thème clé 7 – Le transport

Les participants nous ont dit que le transport est un aspect particulièrement important du plan à long terme et que lorsque des déchets radioactifs sont transportés, cela doit se faire en toute sûreté. Les participants ont fréquemment posé des questions sur les risques associés au transport et sur les conséquences que pourraient avoir les accidents de transport sur la sûreté des déchets radioactifs transportés. Ils préféraient en général que les distances parcourues pour transporter les déchets radioactifs soient limitées afin de réduire les risques associés. Les points de vue des participants sur les risques relatifs du transport ont influencé leur préférence pour l'option de construire un seul dépôt centralisé pour les déchets de faible et de moyenne activité ou celle de construire plusieurs installations de stockage plus près des lieux où les déchets sont produits.

Même si les participants étaient conscients que le transport des déchets radioactifs est fortement réglementé, ils étaient préoccupés par les risques que pose le transport des déchets sur de grandes distances et à proximité de zones bâties. Les participants voulaient s'assurer que des plans d'atténuation des risques et d'intervention en cas d'incident seront en place. Parmi les autres préoccupations soulevées au regard du transport, citons le coût, l'augmentation potentielle des émissions de gaz à effet de serre et les impacts environnementaux potentiels de la construction de nouvelles routes d'accès.

Le transport possible de déchets dangereux à travers des territoires traditionnels, sans consultation, concertation ou notification préalable, a été soulevé comme sujet de préoccupation pour les peuples autochtones. La présence de déchets à l'intérieur de zones vulnérables en l'absence de plans de communication et de gestion des urgences inquiétait beaucoup. L'impact potentiel du transport des déchets dans ou à travers les collectivités et les territoires traditionnels a été un thème commun à toutes les séances de concertation avec les Autochtones.

Thème clé 8 – Cadre de responsabilité partagée/indépendance de l'entité responsable

Les points de vue variaient quant à savoir qui devrait être responsable de la mise en oeuvre de la SIDR. Les participants ont eu des divergences d'opinions sur le rôle que devrait jouer l'industrie, mais ils s'entendaient généralement pour dire que la gestion des déchets devait être assurée par une seule entité qui posséderait l'expertise appropriée, qui serait indépendante du gouvernement et de l'industrie, mais qui serait assujettie à une surveillance réglementée en matière de sûreté et d'environnement.

La gouvernance d'une telle entité a fait l'objet d'idées différentes, certaines personnes suggérant que la gouvernance de l'organisation soit composée de représentants de l'industrie, d'organisations de la société civile et des peuples autochtones, et d'autres accordant la priorité à ce que l'organisation reste indépendante et dispose de l'expertise appropriée. Certains considéraient que cette organisation devait être un organisme gouvernemental ou dirigé par le gouvernement, tandis que d'autres souhaitaient que cette organisation soit plus indépendante. Un point de vue partagé par plusieurs était qu'un éventail de parties prenantes devrait être représenté au sein de cette organisation et que les collectivités autochtones devraient jouer un rôle clé, voire de premier plan.

Les réponses concernant le rôle des producteurs et propriétaires de déchets dans la mise en oeuvre de la stratégie étaient variées. Certains participants souhaitaient que les producteurs et les propriétaires de déchets jouent un rôle plus important, mais encadré par le gouvernement. D'autres ont estimé que le rôle des producteurs et propriétaires de déchets devait se limiter à leur responsabilité financière et à leur participation à un processus de concertation multipartite. Le principe du pollueur-payeur pour le financement de la stratégie a reçu un large appui.

Les participants autochtones ont noté l'importance de la collaboration entre les multiples parties prenantes et ont souligné les rôles importants que doivent jouer le gouvernement, les collectivités autochtones et l'industrie en ce qui a trait à la responsabilité du stockage des déchets radioactifs et de la mise en oeuvre de la stratégie.

Thème clé 9 – Intendance perpétuelle et stockage des déchets

Nous avons reçu des points de vue divergents sur l'intendance perpétuelle et le stockage définitif des déchets radioactifs. La plupart des participants ont appuyé l'idée qu'il faille dès maintenant trouver des solutions pour stocker les déchets, éviter d'abandonner la décision aux générations futures et stocker les déchets de moyenne activité dans un dépôt géologique en profondeur. Cependant, certaines personnes ont exprimé leur préférence pour l'intendance perpétuelle, une solution qui consiste à conserver les déchets en surface, à l'endroit où ils se trouvent actuellement, et qui permettrait de les surveiller à long terme et de toujours se souvenir de l'endroit où ils sont conservés. De nombreux participants, dont des jeunes, se sont montrés ouverts à l'une ou l'autre approche, à condition que la sûreté soit garantie.

Un nombre considérable de participants ont souligné la nécessité d'assurer une surveillance perpétuelle, tant et aussi longtemps que les déchets resteront dangereux, peu importe l'option choisie. Ces participants ont rappelé l'importance de veiller à ce qu'une entité surveille les déchets et tienne les producteurs et les propriétaires de déchets responsables de leurs produits.

Les personnes qui considéraient que l'intendance perpétuelle serait la meilleure stratégie à adopter ont cité comme justification qu'elle permettrait de tirer avantage des éventuelles innovations technologiques, de garder à l'esprit l'existence des déchets et d'assurer une surveillance constante des installations pour que tout impact environnemental soit identifié et corrigé avant qu'il ne cause des dommages importants, en particulier à la nappe phréatique. Certains participants ont trouvé que l'intendance perpétuelle serait une bonne solution pour les déchets de faible activité. Ils estimaient qu'elle permettrait d'assurer une meilleure surveillance et qu'elle offrait la possibilité d'utiliser d'éventuelles innovations technologiques pour recycler ou réutiliser ces déchets.

L'incertitude liée aux changements climatiques et la possibilité que les futurs changements de gouvernement ou de société rendent les déchets vulnérables si une option d'entreposage de durée indéfinie est adoptée figurent parmi les préoccupations qui ont été exprimées. D'autres préoccupations étaient liées à la possibilité de léguer aux générations futures la responsabilité de la gestion des déchets radioactifs et les risques associés à l'oubli de ces installations, à leur défaillance ou à leur mauvaise gestion.

Nous avons lu que l'industrie privilégiait un cadre large et flexible qui permettrait aux producteurs et propriétaires de déchets d'envisager toutes les stratégies, les méthodes et les technologies qui seraient acceptables pour assurer la sûreté des déchets.

Thème clé 10 – Regroupement et centralisation

Les participants ont dit de diverses manières que la centralisation des déchets pouvait présenter des avantages. Des participants ont reconnu qu'il est difficile de trouver des collectivités hôtes consentantes et informées, et que l'obligation d'obtenir le consentement préalable, libre et éclairé des Autochtones diminuait la probabilité de trouver plusieurs sites pour des installations. Cependant, ils étaient inquiets de l'impact que pourrait avoir la mise en oeuvre d'un site unique sur le transport des déchets. Certains participants ont souligné qu'il faudrait prévoir des dispositions techniques distinctes pour les différents types de déchets stockés dans une même installation, tandis que d'autres ont souligné les avantages économiques qui pourraient être tirés du fait de regrouper l'expertise et les installations en un seul endroit.

L'idée du regroupement et de la centralisation a été plus largement appuyée pour les déchets de moyenne et haute activité que pour les déchets de faible et moyenne activité. Les volumes de déchets de faible activité sont plus importants et les participants ont généralement estimé qu'il serait préférable de les laisser plus près des sites où ils ont été produits ou entreposés plutôt que de les transporter sur de grandes distances.

Les jeunes participants étaient généralement ouverts aux stratégies de regroupement de tous les types de déchets. Toutefois, des participants ont indiqué qu'ils auraient besoin de plus d'informations sur la façon dont les différents types de déchets sont gérés et sur ce que leur regroupement impliquerait.

Les réactions démontraient que la plupart des participants considéraient que le recours à des installations spécialisées et plus décentralisées constituerait une stratégie appropriée pour les déchets de faible activité, considérant les risques plus faibles associés à ces déchets. La recommandation d'explorer la possibilité de construire plusieurs installations au pays (de multiples installations, mais en nombre limité) a recueilli un large appui. Les participants ont exprimé une plus grande préférence pour l'utilisation d'installations centralisées pour les déchets de moyenne activité.

Les participants ont indiqué que la meilleure option pour les déchets de moyenne activité serait le stockage en profondeur. Certains participants se sont dits favorables à ce que les déchets de moyenne activité à plus longue durée de vie soient placés avec les déchets de haute activité.

Les participants étaient en majorité d'avis que la centralisation présente des avantages sur le plan des coûts, notamment des coûts liés au remballage, à la surveillance et au contrôle. Certains participants ont soulevé des préoccupations relatives aux caractéristiques des déchets, comme la production de chaleur et de gaz, qui pourraient avoir une incidence sur la faisabilité de la centralisation des déchets de moyenne et de haute activité.

Certains participants ont discuté de la possibilité de centraliser les déchets de faible et moyenne activité. Toutefois, la plupart des participants étaient d'avis que toute installation de stockage des déchets de faible activité devrait être construite séparément de celle des déchets de moyenne activité.

Thème clé 11 – Une stratégie par et pour les Canadiens et les peuples autochtones

Il est clairement ressorti de l'ensemble des séances que les participants souhaitaient que la stratégie soit créée par et pour les gens et qu'une telle approche constituerait un élément clé pour obtenir l'adhésion du public au projet. Il est important que divers groupes, tels que les collectivités autochtones, les experts techniques et scientifiques, les universitaires, les collectivités hôtes et les municipalités environnantes, puissent se faire entendre au cours du processus de concertation. Une stratégie inclusive est une stratégie qui reflète les points de vue du public.

De plus, les jeunes appuyaient généralement l'idée d'une solution proprement canadienne, qui tiendrait compte des conditions et de l'environnement qui sont uniques au Canada, notamment la taille du pays, la diversité des Canadiens et des peuples autochtones et les effets particuliers que pourraient y avoir les changements climatiques.

Ce que nous ont dit les sondages

Un des moyens que nous avons pris pour déterminer ce qui compte le plus pour les gens en ce qui concerne la gestion à long terme des déchets radioactifs canadiens fut notre sondage ouvert en ligne. Ce sondage ouvert en ligne a permis au public canadien et aux peuples autochtones d'identifier les priorités, les principes et les considérations qui devraient guider l'élaboration d'une stratégie complète. Il nous a également permis de recueillir un précieux éventail de points de vue, d'opinions et de commentaires qui nous aideront à mettre en place les options les plus judicieuses pour gérer les déchets radioactifs canadiens.

L'une des caractéristiques distinctives de ce sondage ouvert en ligne est qu'il était ouvert à tous. C'est pourquoi, tout au long de ce rapport, nous l'appelons le « sondage ouvert ». Ce sondage ouvert complétait celui qui avait mené au cours des deux dernières semaines de janvier 2021, dans le cadre duquel un échantillon aléatoire de n = 1 625 résidents adultes canadiens avaient donné leur avis en ligne. En tout, 345 personnes ont participé au sondage ouvert.

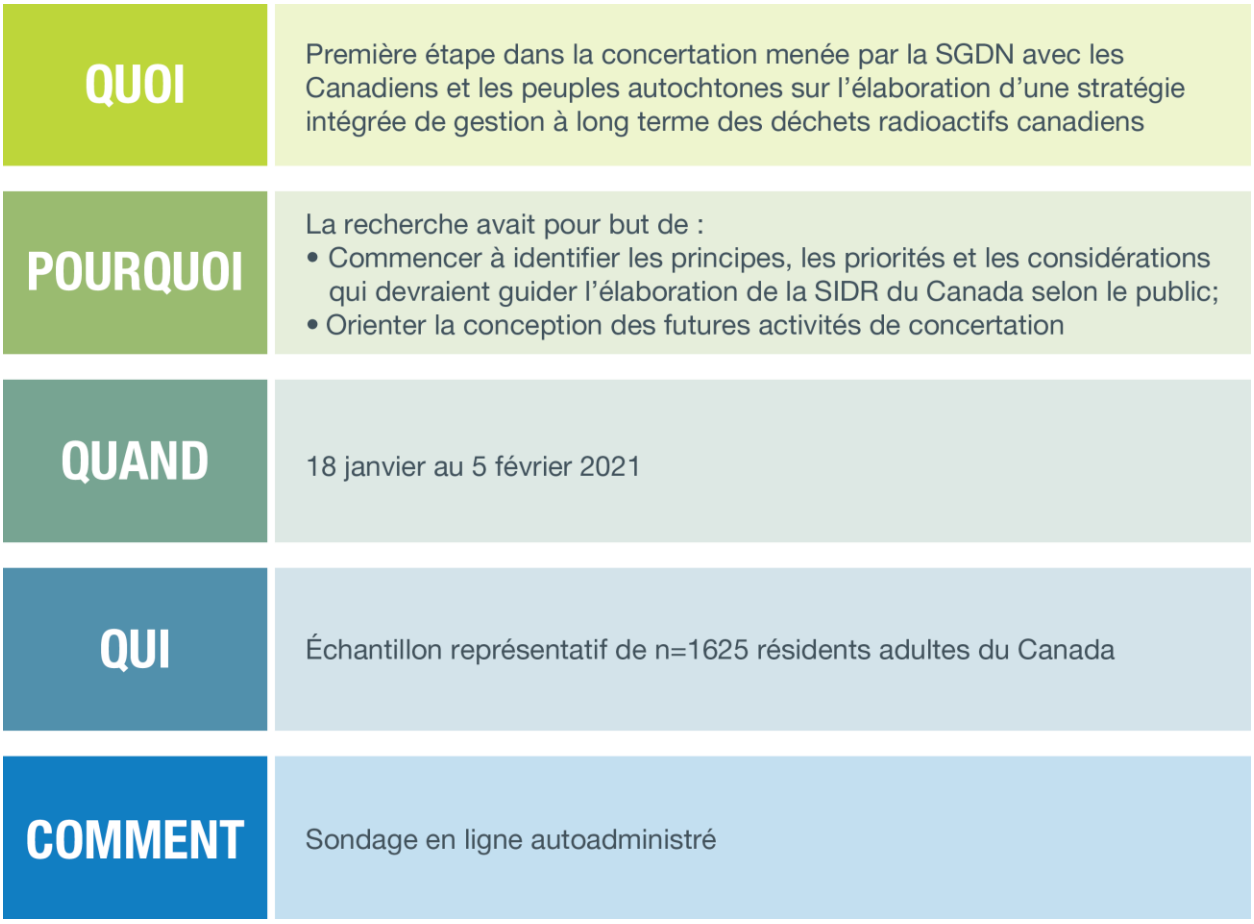


Figure 10 : Aperçu de la méthodologie du sondage

Les deux sondages ont porté sur le même ensemble de sujets et comportaient pour la plupart les mêmes questions. Ils ont également fourni aux répondants essentiellement les mêmes informations factuelles de base (par exemple, les niveaux de radioactivité des déchets, les pratiques actuelles de gestion des déchets, les pratiques internationales). Il convient de noter que le sondage ouvert comprenait une vidéo d'information sur le transport et une autre sur la réglementation des déchets radioactifs au Canada, ce qui n'était pas le cas pour le sondage représentatif.

Dans l'ensemble, les résultats des deux sondages concordaient. Par ailleurs, les répondants au sondage ouvert étaient mieux renseignés sur la gestion des déchets radioactifs (18 pour cent étaient employés par l'industrie nucléaire et 10 pour cent par le secteur public). Les opinions des membres de l'industrie nucléaire étaient beaucoup plus homogènes et claires, mais leurs points de vue correspondaient généralement à ceux des autres répondants du sondage ouvert.

Priorités

Les priorités ont été examinées au moyen d'un exercice de choix entre deux propositions comprenant au total 10 éléments différents (c'est-à-dire que chacune des propositions a été comparée au hasard aux neuf autres un nombre à peu près égal de fois). L'obtention d'un « appui actif » des collectivités autochtones et non autochtones situées à proximité des installations a été considérée comme une priorité absolue, de même que la création d'une « organisation sans but lucratif distincte » qui serait chargée de mettre en oeuvre la stratégie canadienne. Au bas de l'échelle, on trouvait « réduire au minimum le transport » et « réduire les coûts pour les consommateurs d'électricité ».

En comparaison, les répondants au sondage représentatif ont accordé une priorité relativement plus élevée à la nécessité de construire les installations de stockage de déchets loin des Grands Lacs et des régions habitées. Ils ont également accordé une plus grande priorité à la réduction des distances de transport.

AVANTAGES ET INCONVÉNIENTS PERÇUS DES APPROCHES POTENTIELLES DE GESTION DES DÉCHETS RADIOACTIFS

Les sondages sont ensuite passés de l'examen des principes et des priorités à la collecte d'informations sur des considérations plus tangibles (par exemple, l'utilisation d'une ou de plusieurs installations de stockage). Conformément aux conclusions du sondage représentatif, les répondants ont en général préféré que les déchets radioactifs ne soient pas conservés en surface, en particulier les déchets de moyenne activité. Ce choix était considéré comme plus sûr et plus responsable vis-à-vis des générations futures.

Les avis étaient relativement partagés sur les avantages de l'option d'une installation centralisée unique par rapport à une approche décentralisée misant sur plusieurs installations. Une majorité relative de répondants appuyaient la décentralisation pour les déchets de faible activité et la centralisation pour les déchets de moyenne activité. Le choix entre les deux variait selon que les participants préféraient réduire les risques perçus du transport ou privilégiaient les avantages en matière de conception, de construction, de la surveillance et de reddition de comptes qui découleraient du fait de concentrer tous les efforts sur une seule installation. Dans le sondage représentatif, une approche décentralisée avait été quelque peu préférée pour les déchets des deux niveaux d'activité.

Conformément aux autres résultats du sondage, la plupart des répondants ont exprimé une préférence pour la création d'une organisation distincte chargée de mettre en oeuvre la stratégie canadienne, estimant que cette approche serait plus susceptible de protéger l'intérêt public (p. ex. par une plus grande participation du gouvernement, une plus grande visibilité). Le sondage comprenait six questions d'opinion sur le niveau d'aise et de confiance qu'avaient les gens à l'égard des organisations qui gèrent les déchets et qui s'occupent de leur réglementation.

Plus de la moitié des personnes interrogées (56 pour cent) ont déclaré avoir « une confiance totale » dans la réglementation encadrant la gestion des déchets radioactifs, ce qui représente dix points de pourcentage de plus que le résultat du sondage représentatif.

Les répondants étaient divisés sur la question de savoir si les propriétaires de déchets radioactifs seraient en mesure de mettre en oeuvre une stratégie « sûre et sécuritaire » pour la gestion à long terme des déchets de faible activité et des déchets de moyenne activité canadiens : 44 pour cent pensaient qu'ils en seraient capables, tandis que 42 pour cent pensent le contraire.

Conformément aux résultats du sondage représentatif, les répondants au sondage ouvert étaient plus à l'aise avec l'idée que le gouvernement fédéral dirige la mise en oeuvre d'une stratégie de gestion à long terme des déchets de faible et moyenne activité qu'avec celle d'une mise en oeuvre dirigée par les propriétaires de déchets (59 pour cent contre 38 pour cent).

De même, la plupart (61 pour cent) convenaient que la gestion à long terme de tous les déchets radioactifs canadiens devait être assumée par une organisation sans but lucratif distincte. Dans l'enquête représentative, le chiffre correspondant était de 70 pour cent.

Nous constatons également que, par rapport à ceux qui ont participé au sondage représentatif, les répondants au sondage ouvert étaient plus susceptibles de considérer les déchets de faible et moyenne activité comme moins préoccupants. Ce constat peut également être tiré de leurs commentaires écrits.

Contributions à la version finale de la SIDR

La SGDN a publié une ébauche de stratégie intégrée en août 2022. Celle-ci a été mise à la disposition du public pour une période de commentaires de 90 jours, et les recommandations ont également été mises à la disposition du public sur le site Web plandechetsradioactifs du projet de SIDR. Dans le cadre du processus lié à la période de commentaires, la SGDN a également fait réaliser un suivi auprès de certains des jeunes qui avaient précédemment participé au processus de concertation afin qu'ils examinent les recommandations. Les commentaires du public transmis sur le site Web ainsi que les mémoires écrits officiels fournis ont permis de finaliser la stratégie intégrée. De plus, cette stratégie intégrée s'est appuyée sur un dialogue mené de manière continue avec les peuples autochtones, dialogue qui a été plus poussé que celui engagé avec le public canadien et les parties prenantes. Enfin, la publication de la politique du gouvernement du Canada en mars 2023 a fourni des données essentielles pour orienter la stratégie intégrée. Voir l'annexe D pour un résumé des changements apportés aux recommandations de l'ébauche de la SIDR pour produire cette version finale de la SIDR.



Chapitre 4 : Évaluation des options techniques

Contexte : En 2021, la SGDN a commandé une évaluation des options. Cette étude avait pour but d'évaluer sommairement l'inventaire des déchets radioactifs de faible et moyenne activité au Canada, de classer et de regrouper les déchets radioactifs, et de déterminer les options de gestion à long terme qui conviendraient le mieux à chacune des catégories de déchets radioactifs.

Options techniques

Les six options potentielles retenues pour la gestion à long terme des déchets radioactifs canadiens de faible et moyenne activité sur la base de l'analyse comparative internationale ont été évaluées. Les six options sont décrites ci-dessous.

Monticule ouvragé de confinement

Un monticule ouvragé de confinement est un type d'installation de stockage près de la surface où les colis de déchets sont placés sur une base étanche, puis recouverts d'épaisses couches de matériaux naturels tels que l'argile et la terre. Des couches de matériaux synthétiques comme du polyéthylène haute densité sont également incorporés pour empêcher que des rayonnements soient libérés dans l'environnement. Ce type d'installation comprend habituellement des systèmes de collecte et de traitement des eaux usées. Le monticule ouvragé de confinement convient généralement aux déchets de faible activité qui ne diminueront pas en volume et ne se comprimeront pas avec le temps.

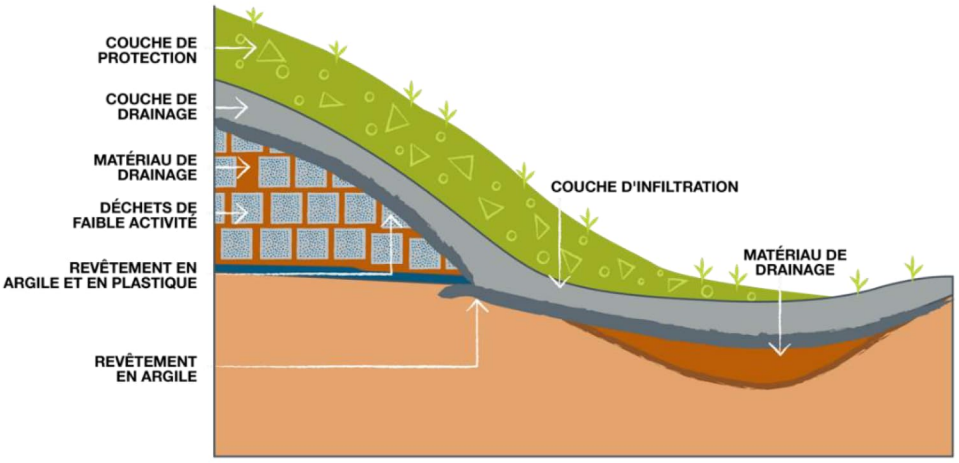


Figure 11 : Monticule ouvragé de confinement

Enceinte de béton

L'enceinte de béton est un type d'installation de stockage près de la surface qui est largement utilisé dans le monde pour stocker les déchets radioactifs de faible activité. Une enceinte de béton a l'apparence d'une grande boîte en béton. Un dépôt de ce type comprendrait plusieurs de ces enceintes. Chaque enceinte aurait son propre système de drainage et un « système de recouvrement » composé de diverses couches de sol et d'une couche supérieure d'herbe ou d'autres plantes. Cette méthode de stockage peut être utilisée pour un large éventail de types de sols. Un dépôt à enceintes de béton est de conception modulaire, c'est-à-dire qu'on peut ajouter graduellement des enceintes pour augmenter la capacité de stockage.

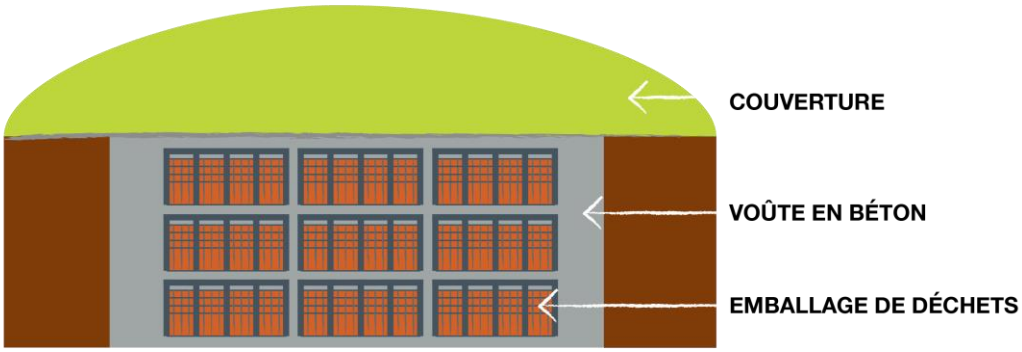


Figure 12 : Enceinte de béton

Caverne rocheuse peu profonde

La méthode de stockage en caverne rocheuse peu profonde est parfois utilisée pour le stockage des déchets de faible activité ou pour les déchets de faible et moyenne activité. Une série de cavernes rocheuses sont excavées à une profondeur nominale de 50 à 100 mètres sous la surface, dans une roche de faible perméabilité. On y accède depuis la surface par un petit système de rampes et de tunnels.

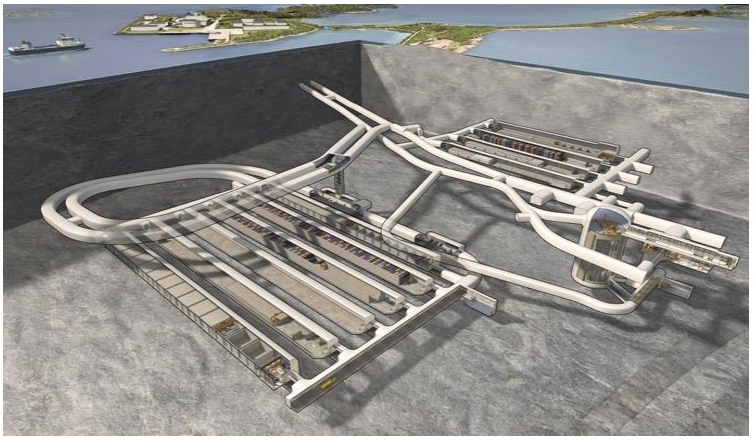


Figure 13 : Caverne rocheuse peu profonde (dépôt SFR, Suède)

Dépôt géologique en profondeur

Un dépôt géologique en profondeur consiste généralement en un réseau de tunnels et de salles de stockage de déchets radioactifs construit à plusieurs centaines de mètres sous la surface du sol. Ces dépôts misent sur un système à barrières multiples de protection : des barrières ouvragées, comme les conteneurs de déchets, et des barrières naturelles, comme la roche elle-même, se conjuguent pour confiner les déchets et les isoler des gens et de l'environnement.

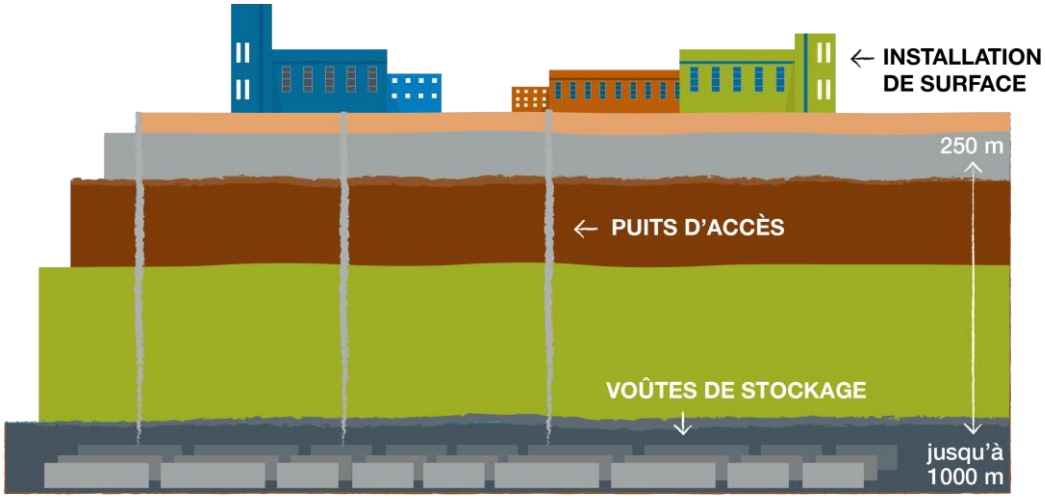


Figure 14 : Dépôt géologique en profondeur

Forage profond

Le stockage en forage profond est une technologie en émergence qui convient aux déchets qui doivent être isolés pendant quelques centaines d'années. Il peut être approprié pour de faibles volumes de déchets de moyenne activité. Une série de forages étroits sont réalisés à une profondeur d'environ 500 à 1 000 mètres. On y descend des colis de déchets, créant ainsi une pile de déchets à grande profondeur dans le sol.

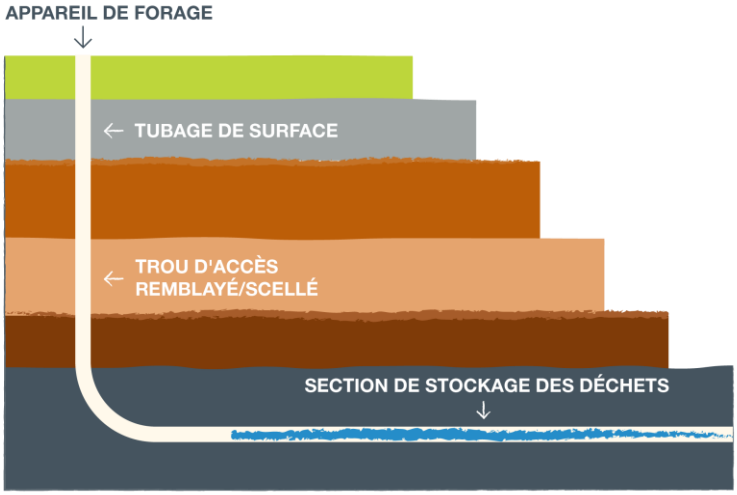


Figure 15 : Stockage en forages profonds

Intendance perpétuelle (pas une option de stockage)

L'intendance perpétuelle est une approche de gestion des matières radioactives pour lesquelles il n'existe pas à court terme de solution de stockage. Dans l'option de l'intendance perpétuelle, les déchets radioactifs sont entreposés à la surface, où des mesures de contrôle humaines permettent de confiner, d'isoler, de surveiller et de sécuriser les déchets de manière sûre et indéfinie, c'est-à-dire en passant le relai de l'intendance d'une génération à la suivante, et à la suivante encore, et ainsi de suite (succession d'intendants) indéfiniment. Ce concept présume que de nouvelles technologies résoudront un jour le problème de la gestion à long terme des déchets, possiblement en les détruisant ou les neutralisant.

Évaluation technique des options

Aux fins de ce plan initial, des détails sommaires ont été recueillis sur l'inventaire actuel et l'inventaire futur anticipé auprès des principaux producteurs et propriétaires de déchets canadiens actuels. Cette étude a identifié les déchets radioactifs de faible et moyenne activité actuels et futurs au Canada pour lesquels il n'y a actuellement aucun plan de gestion à long terme et a fourni une évaluation intégrée de la gestion à long terme de ces déchets. Les déchets ont été regroupés en catégories de matières de nature similaire pour ce qui concerne leur gestion à long terme. En général, les déchets ont été regroupés en fonction de leur classification radiologique (p. ex., les déchets de faible activité [DFA] et les déchets de moyenne activité [DMA]) et de leur configuration physique (p. ex., matériau en vrac, emballage, taille, etc.).

L'étude s'est appuyée sur les hypothèses suivantes pour déterminer l'inventaire de déchets radioactifs de chaque propriétaire de déchets en vue de l'analyse :

- Tous les déchets liquides sont présumés être solidifiés (p. ex. par incinération, vitrification, enrobage dans un coulis, un agent de solidification, selon les besoins).
- À moins qu'elles aient été quantifiées par le propriétaire des déchets, les pratiques supplémentaires de décontamination et de réduction du volume n'ont pas été prises en compte dans cette étude.
- Il a été présumé que les déchets d'exploitation prévus seraient emballés selon la même configuration physique que les déchets d'exploitation de même source. Par exemple, les déchets de faible activité non traitables d'Ontario Power Generation sont actuellement entreposés dans des conteneurs en acier; il est donc présumé que toute production future de déchets de faible activité non traitables sera également confinée dans des conteneurs en acier.
- Il est présumé que toutes les options de gestion à long terme peuvent accepter des déchets nucléaires ayant des propriétés dangereuses autres que nucléaires, car les installations de stockage de déchets dangereux autres que nucléaires emploient des mesures techniques de confinement semblables à celles qui sont présentes dans les installations de stockage de déchets nucléaires à faible profondeur, notamment l'imperméabilisation, le contrôle des lixiviats et la surveillance. Des considérations de conception supplémentaires pourraient être nécessaires pour prendre en compte tous les dangers autres que nucléaires au stade de la conception détaillée.
- Les inventaires des propriétaires de déchets ont été arrondis pour tenir compte du niveau d'incertitude actuel. Cette simplification est considérée comme raisonnable, vu le niveau de détail requis pour cette étude.

Les catégories de déchets radioactifs ont été évaluées en fonction de chaque option de gestion à long terme en prenant en considération la faisabilité technique et les aspects pratiques. À chaque groupe de déchets a été attribué un degré d'applicabilité parmi quatre, comme le présente le tableau 8 : *Résultats de l'évaluation des options par type de déchets*.

Tableau 8 : Résultats de l'évaluation des options par type de déchets.

Type de dépôt	DFA (matériaux en vrac)	DFA (autres)	DMA (généraux)	DMA (petits)
Monticule ouvragé de confinement	O Convient surtout aux grands volumes de DFA en vrac	O2	N	N
Enceinte de béton	O2	O Pratique acceptée internationalement pour le stockage des DFA	N	N
Caverne rocheuse peu profonde	O2	O Pratique reconnue internationalement comme exemplaire pour le stockage des DFA; les objets de grande taille peuvent nécessiter une segmentation ou une réduction du volume	N	N
Dépôt géologique en profondeur	O3	O2	O Pratique reconnue internationalement comme exemplaire pour le stockage des DMA; les objets de grande taille peuvent nécessiter une segmentation ou une réduction du volume	O Pratique reconnue internationalement comme exemplaire pour le stockage des DMA
Forage profond	N	N	N	O2
Intendance perpétuelle	O3	O3	N	N

Matrice d'applicabilité	
O	Applicable et recommandée pour le groupe de déchets visé
O2	Peut être applicable au groupe de déchets visé, mais nécessiterait une étude plus approfondie
O3	Pratique conceptuellement faisable, mais non jugée pratique après considération des facteurs de risque
N	L'approche ne convient pas au groupe de déchets visé

Il a été établi que tous les déchets de faible activité peuvent être stockés dans une installation proche de la surface (monticule ouvragé de confinement, enceinte de béton ou caverne rocheuse peu profonde), tandis que tous les déchets de moyenne activité doivent être stockés dans un dépôt géologique en profondeur ou un forage profond. En général, les déchets de faible activité peuvent faire l'objet d'un confinement de niveau supérieur (c'est-à-dire en profondeur), mais les déchets de moyenne activité ne peuvent pas être stockés dans une installation de niveau de confinement inférieur (c'est-à-dire une installation près de la surface). L'option du dépôt géologique en profondeur, par exemple, serait techniquement réalisable pour l'ensemble des déchets de faible et moyenne activité.

Le monticule ouvragé de confinement a été considéré comme l'option la plus appropriée pour les déchets de faible activité en vrac, comme les sols et le béton démoli, compte tenu de leurs faibles concentrations en radionucléides et de leur important volume. D'autres déchets de faible activité pourraient convenir au monticule ouvragé de confinement, selon le dossier de sûreté de l'installation de stockage envisagée.

L'enceinte de béton et la caverne rocheuse peu profonde ont été considérées comme les options les plus appropriées pour les déchets de faible activité non en vrac, à cause du niveau accru de confinement et d'intégrité structurelle qu'elles offrent (barrière en béton ou masse rocheuse) en comparaison avec le monticule de confinement ouvragé. Ces options de gestion à long terme peuvent également convenir aux déchets de faible activité en vrac, puisque le niveau de confinement et d'isolement offert par ces options dépasse ce qui est requis pour les matériaux en vrac. De plus, le stockage regroupé de tous les déchets de faible activité non en vrac dans un dépôt géologique en profondeur a été envisagé comme option de gestion.

D'après l'Agence internationale de l'énergie atomique (AIEA), les déchets radioactifs de moyenne activité peuvent être stockés dans différents types d'installations, selon leurs caractéristiques. Alors que le stockage pourrait se faire dans une installation construite dans des cavernes, des enceintes ou des silos à quelques dizaines de mètres de profondeur, cette option n'a pas été retenue pour les déchets de moyenne activité de l'inventaire visé par la SIDR en raison de leur longue vie. De l'analyse comparative internationale réalisée, le dépôt géologique en profondeur est ressorti comme l'approche à privilégier pour la gestion à long terme des déchets de moyenne activité et a donc été considéré comme l'option la plus appropriée pour l'ensemble des déchets de moyenne activité. L'Organisation de coopération et de développement économiques adhère au solide consensus scientifique établi sur l'utilisation de dépôts géologiques en profondeur pour le stockage des déchets nucléaires. Ce consensus est le fruit de plusieurs décennies d'analyses scientifiques, d'essais techniques, de développement et d'exploitation de laboratoires de recherche souterrains.

Les forages profonds sont considérés comme une autre option de gestion à long terme des déchets de moyenne activité de petite dimension, tels que les sources scellées désaffectées et les résines échangeuses d'ions usées. Les forages profonds conviennent particulièrement à une approche de stockage décentralisée (c.-à-d. de multiples sites de forages à travers le Canada) qui serait adoptée pour réduire la nécessité de transporter les déchets radioactifs. Des recherches plus poussées sur la faisabilité de cette option devront être effectuées à mesure que la technologie évolue.

L'intendance perpétuelle est une solution possible pour la gestion à court terme des déchets, mais elle n'est pas considérée comme une solution pratique à long terme pour tous les déchets de faible ou moyenne activité, compte tenu des incertitudes associées aux coûts, aux changements climatiques et à l'évolution de la société.

L'intendance perpétuelle pourrait être réalisable pour certains types de déchets de faible activité qui se désintègrent rapidement et qui pourraient donc être libérés ou stockés de manière conventionnelle au terme de quelques décennies, mais pas pour les déchets qui resteront radioactifs pendant plusieurs centaines d'années ou plus. Des données de caractérisation détaillées permettraient d'évaluer la période radioactive de l'inventaire des déchets et d'identifier les déchets de faible activité à vie courte qui pourraient se prêter à une intendance perpétuelle. Cependant, l'intendance perpétuelle n'est pas conforme aux meilleures pratiques internationales de gestion à long terme des déchets radioactifs. D'autres considérations de coût comprennent l'éventuelle nécessité de remballer les déchets, vu que les

conteneurs de déchets se dégraderont au fil des siècles, ainsi que celle de disposer de nouvelles installations à long terme spécialisées.

Compte tenu du niveau sommaire des informations recueillies pour ce plan initial, il serait indiqué de poursuivre les efforts de concertation entrepris avec chaque propriétaire de déchets et d'examiner la caractérisation des déchets dans le cadre de futures études.

Des ateliers techniques ont été organisés pour discuter des résultats de l'évaluation technique. Des ateliers distincts ont aussi été tenus pour discuter des déchets de faible et moyenne activité. Mentionnons que des ateliers différents ont été offerts aux experts techniques et aux profanes, les participants ayant choisi eux-mêmes le cadre qu'ils préféraient. Au cours des ateliers, un animateur bilingue indépendant guidait les participants à travers une série de questions destinées à obtenir leurs points de vue sur le sujet suivant : « L'ordre de classement des recommandations pour le stockage des déchets de faible ou moyenne activité est-il valable? ».

Sur la base uniquement des facteurs techniques associés à la gestion à long terme des déchets de faible et de moyenne activité, les participants ont convenu du classement des options recommandées reproduit dans la figure suivante.



Figure 16 : Classement des options techniques convenu au terme des ateliers

Les participants ont souligné l'importance d'autres facteurs de décision tels que la sûreté, l'environnement, le transport et le coût.

Analyse des coûts

Pour étayer davantage l'analyse, la SGDN a commandé un rapport d'estimation des coûts des six options techniques[29]. Cette estimation des coûts a été préparée en même temps que l'étude d'évaluation technique. L'objectif de cette estimation des coûts était d'établir, à titre indicatif, le coût par unité de volume de déchets de chaque option de gestion à long terme.

L'estimation des coûts a été préparée en conformité avec les lignes directrices et les pratiques recommandées par l'Association for the Advancement of Cost Engineering pour une estimation des coûts de catégorie 5. Une base de conception préliminaire et une base de coûts ont été établies pour chaque option d'après les informations publiquement accessibles et l'avis de spécialistes des secteurs nucléaire et autres que nucléaire. Il convient de souligner que ce rapport a été préparé pour comparer le coût relatif par unité de volume de chaque option de stockage des déchets et qu'il ne doit pas être utilisé pour établir l'estimation absolue du coût global de chaque option. L'intendance perpétuelle est présentée comme trois sous-options (300, 500 et 1 000 ans) pour une comparaison relative avec les autres options.

Pour chaque option, le coût du cycle de vie a été déterminé suivant une approche ascendante d'estimation des coûts pour chaque phase de développement (sélection du site, autorisations réglementaires, conception et construction, exploitation, déclassement et fermeture, et surveillance). Des infrastructures et installations communes ont été identifiées pour chaque option de gestion à long terme (par exemple, les bureaux, les services publics, la sécurité, etc.) et leurs coûts ont été estimés sur une base générale. Les coûts reliés à une installation en particulier sont également identifiés et estimés pour chaque option de gestion à long terme. Les coûts qui dépendent de la taille de l'installation (c'est-à-dire le volume total de déchets) ont été examinés de façon distincte pour identifier les coûts variables. Les coûts fixes et variables ont été estimés séparément pour déterminer l'économie d'échelle qui serait réalisée avec chaque type d'installation si l'inventaire de conception de l'installation devait changer par rapport au scénario de référence.

L'étude présume que de nouvelles installations de gestion des déchets seront construites. Pour tous les types d'installations, à l'exception des forages profonds, l'estimation des coûts suppose que l'aménagement du site se fera dans un nouvel environnement vierge, à un emplacement indéterminé offrant un bon accès aux infrastructures et à des gens de métier, et situé à une distance raisonnable des zones urbaines aménagées. Comme les forages profonds sont censés être construits sur des sites de gestion de déchets existants dotés d'une infrastructure, de services publics et d'équipements de soutien, les coûts de développement d'un site ne sont pas pris en compte dans les estimations relatives aux forages profonds.

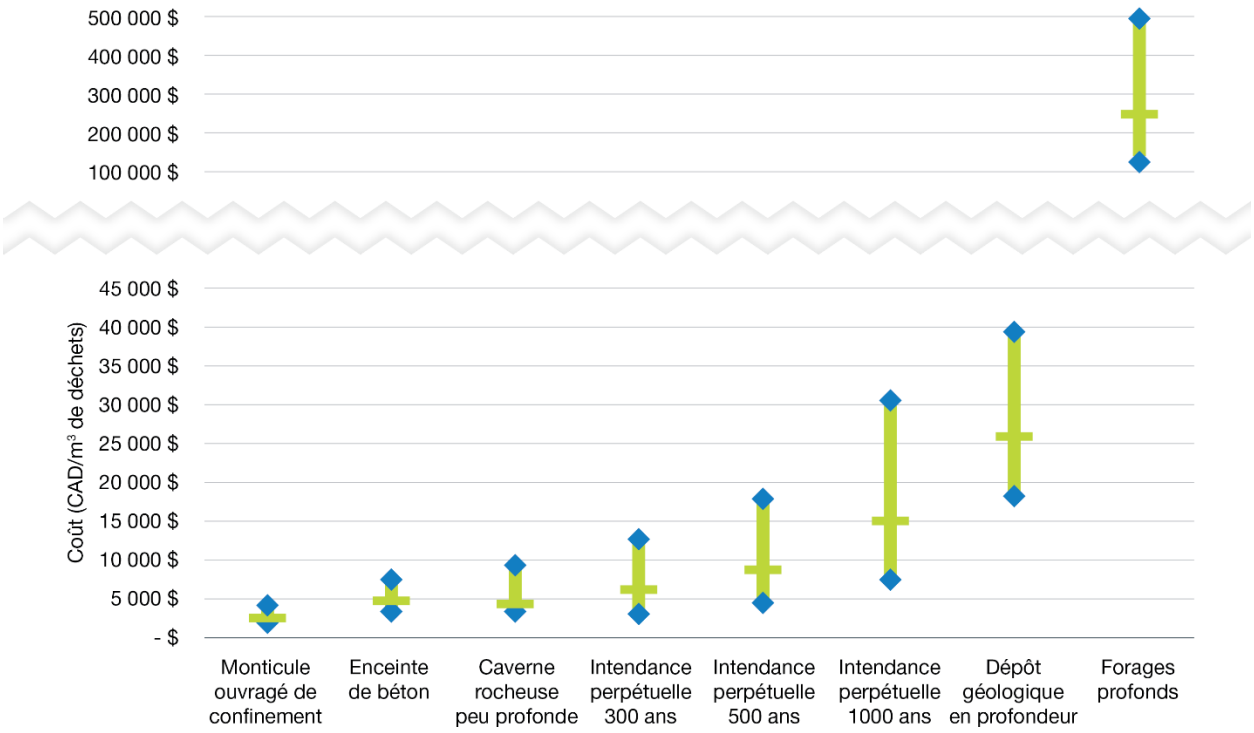


Figure 17 : Résumé du coût de chaque option de gestion à long terme, plage de précision comprise

Les déchets visés par la SIDR comprennent les déchets de faible et moyenne activité canadiens actuels et futurs pour lesquels il n'y a actuellement aucun plan de gestion à long terme. Ces déchets englobent au total approximativement 294 000 m³ de déchets de faible activité et 51 000 m³ de déchets de moyenne activité. L'étude technique a démontré que l'intendance perpétuelle, le monticule ouvragé de confinement, l'enceinte de béton et la caverne rocheuse peu profonde ne conviendraient pas pour la gestion à long terme des déchets de moyenne activité. Nous présumons par conséquent que la taille des installations de référence pour l'intendance perpétuelle, le monticule ouvragé de confinement, l'enceinte de béton et la caverne rocheuse peu profonde permettrait de gérer l'inventaire des DFA, et que la taille des installations de référence pour un dépôt géologique en profondeur et un dépôt à forages profonds permettrait de gérer l'inventaire des déchets de moyenne activité.

L'estimation des coûts s'appuie sur les scénarios de gestion et de tailles d'installations de référence réalisés conformément aux recommandations formulées dans l'évaluation technique. Il convient de noter que le coût par unité de volume de chaque installation de gestion à long terme bénéficiera d'économies d'échelle et que les résultats présentés dans ce rapport pourraient varier si le volume de déchets de référence change. L'influence des économies d'échelle est présentée ci-dessous (pour plus de clarté, notez que la plage de précision et l'option des forages profonds ne sont pas présentées).

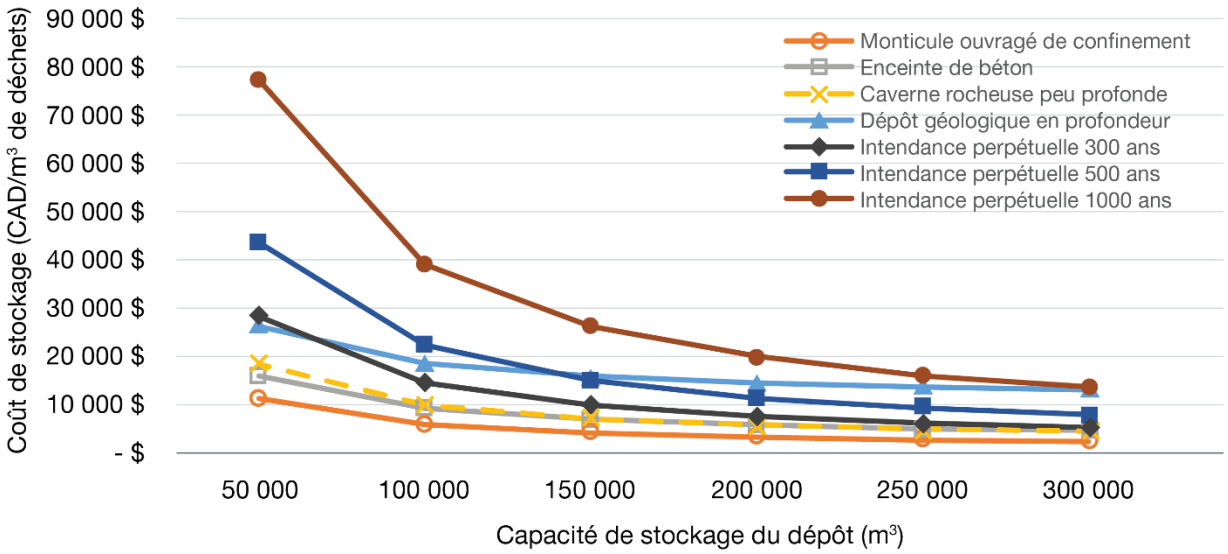


Figure 18 : Effet de la modification de la taille de l'installation sur le coût unitaire à titre indicatif

Comme nous l'avons vu précédemment, les quatre options les moins coûteuses (monticule ouvragé de confinement, enceinte de béton, caverne rocheuse peu profonde et intendance perpétuelle sur 300 ans) ne conviendraient que pour les déchets de faible activité. Le monticule ouvragé de confinement s'est révélé être l'option la moins coûteuse, en moyenne, mais comme le relève l'évaluation technique, il pourrait ne pas convenir à l'ensemble de l'inventaire des déchets de faible activité. Toutefois, les plages de précision des quatre options se chevauchent, de sorte qu'il serait opportun de poursuivre les recherches et de définir plus précisément quelle serait la meilleure option sur le plan économique, parmi plusieurs autres critères d'évaluation.

En ce qui concerne le stockage des déchets de moyenne activité, il a été établi qu'une installation à forages profonds serait approximativement 10 fois plus coûteuse qu'un dépôt géologique en profondeur par unité de volume de déchets. En outre, l'option des forages profonds ne permettrait d'éliminer qu'une partie de l'inventaire des déchets de moyenne activité visés par la SIDR. Un dépôt géologique en profondeur serait nécessaire pour le stockage des déchets de moyenne activité restants. Par conséquent, les coûts élevés supplémentaires associés à l'exploitation de forages profonds pourraient ne pas convenir au stockage des déchets de moyenne activité dans le cadre de la SIDR.

Les coûts de transport et la mise en oeuvre d'une approche décentralisée (c.-à-d. plusieurs installations dispersées) ou d'une approche centralisée (c.-à-d., une seule installation avec une ou plusieurs options de gestion à long terme) n'ont pas été pris en compte dans cette estimation des coûts. Les coûts associés au traitement et/ou à l'emballage (conditionnement) des déchets radioactifs ne sont pas pris en compte dans cette estimation. Cependant, un centre de remballage pour le stockage en forages profonds est considéré comme faisant partie de cette estimation, puisque le remballage est nécessaire pour que les forages profonds soient réalisables pour l'inventaire actuel des déchets visés par la SIDR.



Chapitre 5 : Stratégie intégrée et recommandations associées

Contexte : En collaboration avec les producteurs et propriétaires de déchets, le gouvernement, les peuples autochtones et les Canadiens intéressés, la SGDN s'est appliquée à cerner les lacunes des plans actuels de gestion à long terme des déchets radioactifs et à proposer des solutions techniques qui permettront de pallier ces lacunes.

Stratégie intégrée

Cette Stratégie intégrée pour les déchets radioactifs (SIDR) lance le début d'une nouvelle ère dans la gestion des déchets au Canada. Il s'agit d'une première. Elle marque un point dans le temps à partir duquel nous pouvons commencer, dans une perspective à long terme, à prendre les mesures qui s'imposent pour combler les lacunes qui existent dans la planification du stockage à long terme de tous les déchets radioactifs qui ont été générés jusqu'à maintenant pour produire de l'électricité et des isotopes médicaux essentiels.

Au cours de la période de deux ans pendant laquelle elle a travaillé en concertation avec les Canadiens, les peuples autochtones et des représentants de l'industrie, et a réalisé un examen des meilleures pratiques utilisées dans le monde afin de dégager les solutions techniques optimales à proposer, la SGDN a élaboré la stratégie intégrée suivante pour les différents flux de déchets radioactifs au Canada. Trois lacunes ont été identifiées : certains déchets radioactifs de faible activité, certains déchets de moyenne activité et les déchets radioactifs de haute activité autres que le combustible n'étaient pas visés par un plan de stockage.

Pour combler ces lacunes en tenant compte de ce que les parties prenantes et les peuples autochtones ont dit à la SGDN ainsi que des orientations fournies par la Politique, deux recommandations fondamentales et quatre principes de mise en oeuvre ont été formulés pour garantir que le Canada dispose d'installations de stockage pour tous ses déchets radioactifs. Nous recommandons également que la progression de la mise en oeuvre de cette stratégie fasse l'objet de rapports à intervalles réguliers. La stratégie est résumée dans le tableau et l'illustration qui suivent; elle ne vise pas à remplacer les projets de stockage à long terme déjà en cours, mais les intègre.

Avec l'émergence des nouvelles technologies comme les petits réacteurs modulaires, ces applications nucléaires produiront également des déchets qui devront être gérés de manière sûre. La présente stratégie s'est vu attribuer toute la flexibilité nécessaire pour intégrer ces déchets dans le flux de déchets qui leur conviendrait, selon la classification adoptée pour les déchets au Canada : les déchets de haute activité, qui incluent le combustible nucléaire irradié, les déchets de moyenne activité, et les déchets de faible activité.

Au fil du temps, à mesure que progressera la gestion des déchets par le biais de la mise en oeuvre des installations de stockage des déchets identifiées dans la présente stratégie ou du déploiement de nouvelles technologies pour répondre aux exigences de la société ou aux changements climatiques, la SIDR canadienne devra être révisée afin d'assurer que tous les flux de déchets qui pourraient être générés seront pris en charge.

La stratégie intégrée est illustrée ci-dessous.

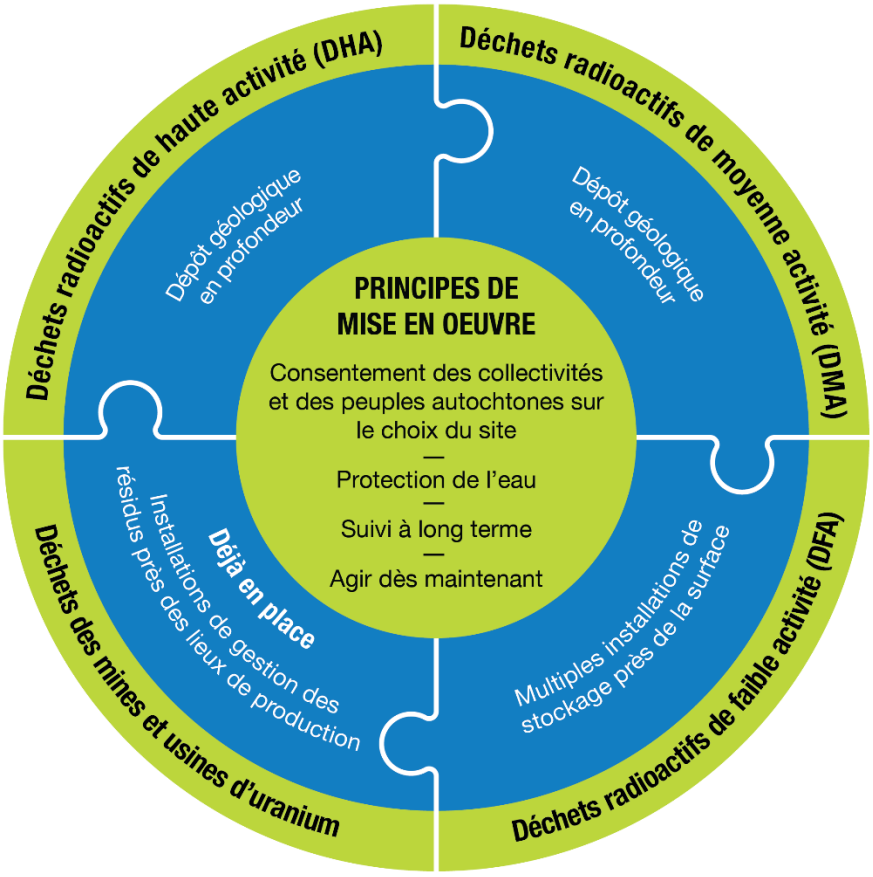


Figure 19 : Stratégie intégrée pour les déchets radioactifs

Tableau 9 : Stratégie intégrée pour tous les déchets radioactifs actuels et prévus

Classification des déchets	Type de déchets	Plan de gestion à long terme existant	Responsabilité de la mise en oeuvre actuellement	Stratégie intégrée
Déchets de haute activité (DHA)	Combustible irradié	Oui	SGDN	Aucun changement – Dépôt géologique en profondeur
	DHA autres que le combustible	Non	–	Dépôt géologique en profondeur Responsabilité de la mise en oeuvre du plan de stockage à long terme des déchets : SGDN
Déchets de moyenne activité (DMA)	DMA produits par diverses installations nucléaires	Non	–	Dépôt géologique en profondeur Responsabilité de la mise en oeuvre du plan de stockage à long terme des déchets : SGDN
	DMA produits par l'installation nucléaire de démonstration et le réacteur Whiteshell-1	Oui	Laboratoires nucléaires canadiens	Aucun changement – Déclassement in situ
Déchets de faible activité (DFA)	DFA historiques de Port Hope	Oui	Laboratoires nucléaires canadiens	Aucun changement – Initiative de la région de Port Hope
	DFA propriété d'Énergie atomique du Canada limitée à Chalk River	Oui	Laboratoires nucléaires canadiens	Aucun changement – Installation de stockage près de la surface
	DFA produits par l'installation nucléaire de démonstration et le réacteur Whiteshell-1	Oui	Laboratoires nucléaires canadiens	Aucun changement – Déclassement in situ
	DFA produits par diverses installations nucléaires	Non	–	Plusieurs installations de stockage près de la surface Responsabilité de la mise en oeuvre du plan de stockage à long terme des déchets : Producteurs/propriétaires des déchets
Déchets des mines et usines de concentration d'uranium[30]	Installation de gestion des résidus près du lieu de production	Oui	Compagnies d'extraction d'uranium et de gestion des résidus d'uranium, gouvernement fédéral et gouvernements provinciaux concernés	Aucun changement – Installations de stockage près du lieu de production

Déchets de haute activité

Les déchets radioactifs de haute activité sont principalement constitués de combustible nucléaire irradié. La SGDN est chargée, en vertu de la *Loi sur les déchets de combustible nucléaire*, d'élaborer et de mettre en oeuvre une solution pour la gestion à long terme du combustible nucléaire irradié généré par les réacteurs canadiens. La Gestion adaptative progressive est le nom qui a été donné au plan de gestion à long terme du combustible nucléaire irradié canadien. Elle prévoit le confinement et l'isolement centralisés du combustible nucléaire irradié dans un dépôt géologique en profondeur construit dans une région présentant une géologie appropriée et comptant des hôtes informés et consentants.

Cependant, il y a aussi de petites quantités de déchets radioactifs de haute activité au Canada qui ne sont pas du combustible nucléaire. Pour traiter les déchets de haute activité autres que le combustible dans le cadre de la stratégie intégrée, il est recommandé de les stocker dans un dépôt géologique en profondeur avec les déchets de moyenne activité.

Déchets de moyenne activité

La gestion à long terme d'un très faible volume de déchets de moyenne activité au Canada est actuellement assurée par des installations existantes ou des projets en cours d'examen réglementaire. Toutefois, la plupart des déchets de moyenne activité ne sont visés par aucun plan de gestion à long terme. Pour y remédier, la stratégie intégrée recommande que ces déchets soient stockés dans un dépôt géologique en profondeur.

Déchets de faible activité

La gestion à long terme de certains déchets de faible activité au Canada est assurée par des installations existantes ou des projets en cours d'examen réglementaire. Par le biais de l'Initiative de la région de Port Hope, les Laboratoires nucléaires canadiens (LNC) gèrent 1,7 million de m^3 de déchets de faible activité historiques dans des monticules ouvragés en surface. En plus de l'Initiative de la région de Port Hope, les LNC ont présenté une demande de permis pour la construction et l'exploitation d'une installation de stockage près de la surface sur le site des laboratoires de Chalk River. L'installation de stockage proposée serait un monticule ouvragé de confinement pouvant contenir jusqu'à 1 million de m^3 de déchets de faible activité. Pour s'occuper du reste des déchets faiblement radioactifs du Canada, il serait recommandé de construire plusieurs installations de stockage près de la surface dans le cadre de la stratégie intégrée.

Déchets des mines et usines de concentration d'uranium

Plus de 200 millions de tonnes de résidus de mines et d'usines de concentration d'uranium ont été générées au Canada depuis le milieu des années 1950. Il existe 25 sites de résidus en Ontario, en Saskatchewan et dans les Territoires du Nord-Ouest, dont 22 ne reçoivent plus de déchets. Les trois autres installations de gestion de résidus sont situées en Saskatchewan, près du lieu où les déchets sont produits. À l'heure actuelle, aucune lacune n'a été relevée dans ce domaine et aucune installation supplémentaire n'est recommandée dans le cadre de la stratégie intégrée.

Pour plus d'informations sur les projets de stockage des déchets existants voir l'annexe C : *État d'avancement des projets de gestion à long terme des déchets au Canada*.

Mise en oeuvre de la stratégie intégrée

Outre les options techniques recommandées pour la gestion à long terme des déchets, la stratégie intégrée énonce pour sa mise en oeuvre quatre principes qui s'appuient sur ce que nous ont dit les différents participants. Ces principes sont également conformes à la Politique. Les recommandations de la stratégie intégrée et les principes de mise en oeuvre sont examinés plus en détail ci-dessous.

Recommandations pour la mise en oeuvre de la stratégie

Les recommandations suivantes tiennent compte des données qui ont été obtenues à partir de l'analyse comparative internationale, de l'inventaire des déchets, des évaluations techniques et des estimations de coûts, ainsi que de toutes les activités de concertation. Ces recommandations et les projets de stockage en cours ou faisant l'objet d'évaluations réglementaires au moment de la rédaction du présent document composent ensemble une stratégie complète pour la gestion de tous les déchets radioactifs canadiens actuels et futurs.

Voir l'annexe B : *Matrice des commentaires reçus lors des activités de concertation, par groupe de participants*, pour voir la contribution des différents groupes de participants à l'élaboration des thèmes et des idées figurant dans les recommandations.

RECOMMANDATION 1 : STOCKER LES DÉCHETS DE MOYENNE ACTIVITÉ ET LES DÉCHETS DE HAUTE ACTIVITÉ AUTRES QUE LE COMBUSTIBLE DANS UN DÉPÔT GÉOLOGIQUE EN PROFONDEUR MIS EN OEUVRE, DONT LA MISE EN OEUVRE SERAIT ASSURÉE PAR LA SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

La SGDN, la principale organisation de stockage en couche géologique profonde au Canada, serait chargée de choisir un site et de construire un dépôt géologique en profondeur pour les déchets de moyenne activité (DMA) et les déchets de haute activité (DHA) autres que le combustible. Elle serait financée pour ce faire par les producteurs et les propriétaires de déchets.

La SGDN préparerait un plan détaillé définissant le processus de sélection d'un site, y compris la stratégie de concertation et l'approche de financement, en tenant compte de l'expérience et des enseignements tirés de la mise en oeuvre d'autres processus de sélection de sites pour les installations nucléaires. Ce processus de sélection d'un site serait distinct des travaux de la SGDN visant à sélectionner un site pour le plan canadien pour le combustible nucléaire irradié.

Le plan engloberait le processus qui permettra de déterminer, conformément à la Politique et aux principes de mise en oeuvre décrits ci-dessous, les exigences d'acceptabilité technique et sociale du dépôt.

Le plan doit également inclure les délais prévus pour la sélection du site et la construction de l'installation.

La préparation de cette phase de la planification du programme se ferait sur une période de 12 à 18 mois, après quoi la SGDN présenterait à Ressources naturelles Canada un rapport sur l'approche adoptée.

Informations générales

L'option du stockage à long terme des déchets de moyenne activité est conforme aux meilleures pratiques internationales et a été préférée par la majorité des participants à l'option de l'intendance perpétuelle. D'un point de vue technique et sociétal, le stockage des déchets de moyenne activité dans un dépôt géologique en profondeur a été établi comme la meilleure option pour isoler ces déchets de

l'environnement. Cette approche permettrait également d'accueillir les déchets de haute activité autres que le combustible.

Les participants ont exprimé une préférence pour les options techniques qui auraient le moins d'impact sur l'environnement. Ils estimaient que les options où les déchets seraient placés sous terre ou dont les sites peuvent être restaurés ou recouverts de végétation semblaient répondre à cette priorité. Limiter l'impact visuel a également été perçu comme une considération importante, en particulier par les participants qui vivent près d'autres types d'installations industrielles.

Sur le plan quantitatif, une forte majorité des répondants, 60 pour cent dans le cas du sondage ouvert et 63 pour cent dans le cas du sondage représentatif, préféraient que les déchets de faible activité soient gérés à long terme dans une installation de stockage spécialement conçue pour eux. En revanche, seuls 13 pour cent des répondants au sondage ouvert (10 pour cent de l'échantillon représentatif) ont opté pour le maintien du stockage en surface. Douze pour cent des répondants au sondage ouvert (20 pour cent de l'échantillon représentatif) ont jugé l'une ou l'autre de ces approches acceptables, pour autant que tous les règlements fédéraux et internationaux en matière de sûreté soient respectés.

Maintien de l'entreposage en surface ou utilisation d'un DGP ou d'un autre type d'installation (p. ex. en forages profonds) pour les DMA

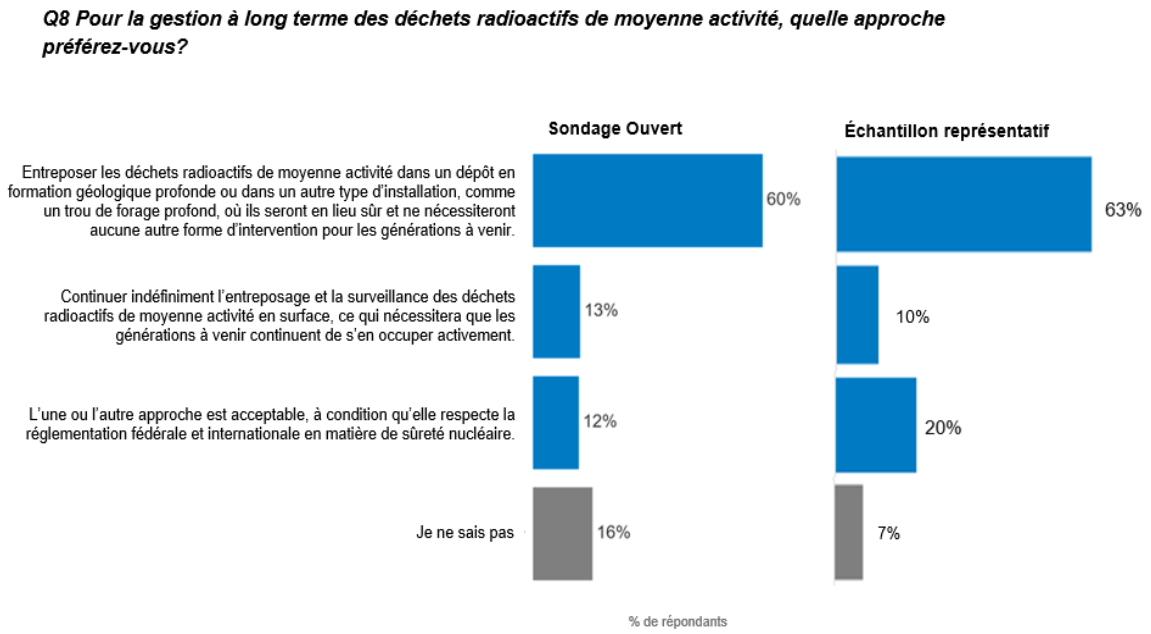


Figure 20 : Maintien de l'entreposage en surface ou utilisation d'un DGP ou d'une autre installation pour les DMA

Nous avons entendu qu'il serait préférable d'opter pour un endroit centralisé au pays pour stocker les déchets de moyenne activité plutôt que pour plusieurs installations régionales. Sur le plan sociétal, le stockage de ces déchets avec les déchets de haute activité sur un site techniquement approprié et associé à des collectivités hôtes consentantes recueille le même niveau d'appui que l'option d'un dépôt géologique en profondeur distinct pour les déchets de moyenne activité. D'un point de vue financier, le regroupement avec les déchets de haute activité permettrait de réaliser des économies d'échelle, notamment grâce à l'utilisation des mêmes ressources et infrastructures. Toutefois, une analyse plus approfondie, qui prendrait en compte les différentes considérations sociales et techniques, serait nécessaire pour trancher la question.

Lors des activités de concertation, certains participants ont dit qu'il pourrait être acceptable qu'une partie des déchets de moyenne activité soit placée dans le même dépôt géologique en profondeur que les déchets de haute activité (regroupement). Ces participants ont dit que ce regroupement avec les déchets hautement radioactifs serait logique d'un point de vue financier et que cette pratique est actuellement utilisée ailleurs dans le monde. On nous a également dit qu'en raison du faible volume de déchets de moyenne activité au Canada (moins d'un pour cent du volume total des déchets), ceux-ci devraient être combinés dans une même installation de stockage permanent avec les déchets hautement radioactifs plutôt que d'être placés dans une installation de stockage distincte.

D'autres participants ont dit préférer qu'une seule collectivité accueille un site pour les déchets de faible activité et qu'une seule autre collectivité accueille un site pour les déchets de moyenne activité. On nous a également dit qu'une seule installation distincte de stockage des déchets de moyenne activité pourrait être plus acceptable sur le plan social pour les déchets de moyenne activité qu'une installation combinée ou plusieurs installations. Certains participants étaient d'avis qu'un site distinct de stockage en profondeur constituerait la meilleure solution pour les déchets de haute activité et les déchets de moyenne activité. Certains s'interrogeaient sur la viabilité technique du regroupement des déchets de moyenne activité et de haute activité. Dans tous les cas, les participants ont indiqué que le consentement de la collectivité serait nécessaire.

D'un point de vue quantitatif, une majorité relative de 36 pour cent des répondants au sondage ouvert ont dit préférer une option de stockage centralisé, où les déchets de moyenne activité seraient transportés vers une seule installation de stockage qui accueillerait également le combustible nucléaire irradié et les déchets de moyenne activité. En revanche, 25 pour cent ont opté pour une installation distincte de celle du combustible nucléaire irradié. Presque un quart des répondants pensaient que l'une ou l'autre approche serait acceptable, pour autant que tous les règlements fédéraux et internationaux en matière de sûreté soient respectés. C'est l'un des rares cas où les résultats du sondage ouvert différaient de ceux du sondage représentatif. Dans ce dernier, l'option de la construction d'installations distinctes sur différents sites a été la plus populaire (choisie par 34 pour cent), le regroupement des déchets de moyenne activité avec le combustible nucléaire irradié n'ayant été préféré que par 25 pour cent des répondants. On constate également qu'une plus grande proportion de ces répondants étaient ambivalents quant à l'orientation à prendre (33 pour cent).

Une approche centralisée ou une approche décentralisée pour la gestion à long terme des DMA

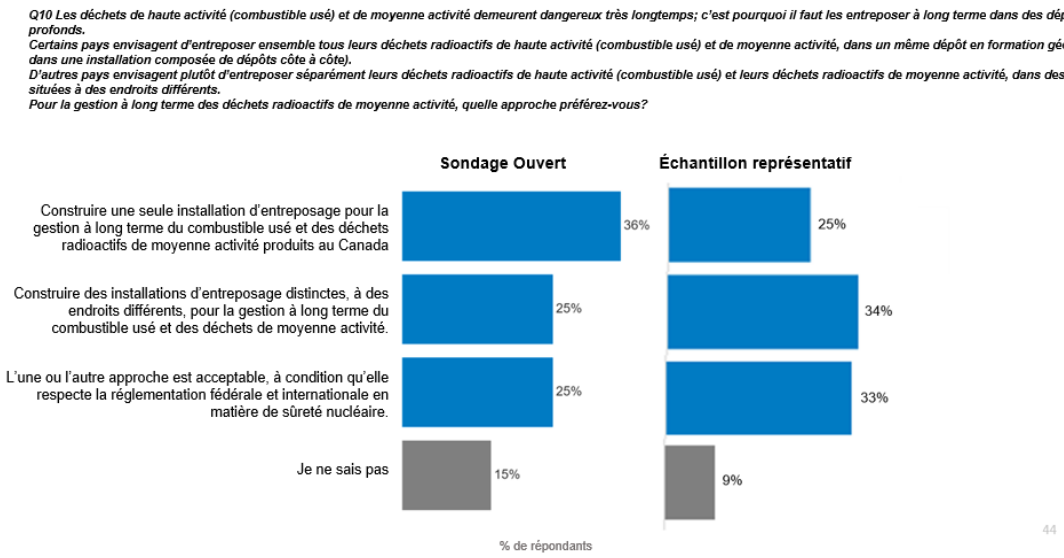


Figure 21 : Une approche centralisée ou une approche décentralisée pour la gestion à long terme des DMA

Comme tous les déchets de moyenne activité seraient stockés dans une seule installation, une seule entité spécialisée chargée de la mise en oeuvre du projet, comme c'est le cas pour le combustible nucléaire irradié, serait l'option la plus efficace. Considérant notre structure et notre expertise en matière de dépôts géologiques en profondeur, il serait recommandé que la SGDN assume la responsabilité de la mise en oeuvre de la gestion des déchets de moyenne activité. Les propriétaires des déchets demeureraient responsables du financement de la gestion à long terme des déchets de moyenne activité, conformément à la Politique.

Certains participants se sont dits favorables à ce que la SGDN joue ce rôle, soulignant qu'il est important que la responsabilité soit partagée entre un organisme indépendant mandaté par le gouvernement fédéral pour la mise en oeuvre, d'une part, et les propriétaires de déchets sur le plan financier, d'autre part. Ils ont dit qu'il faudrait que cette entité suive les meilleures pratiques canadiennes et internationales et qu'elle soit à l'abri des soubresauts que peuvent causer les cycles électoraux et le processus politique. Nous avons entendu qu'un organisme central réglementé par le gouvernement apaiserait les préoccupations du public. Nous avons également entendu que pour une mise en oeuvre efficace de la stratégie, l'organisme responsable devrait être indépendant de l'organisme de réglementation et du gouvernement, et à l'abri de toute interférence gouvernementale, mais qu'il devrait respecter les politiques et les règlements en vigueur.

Les participants se sont dits à l'aise avec l'idée d'une entité centrale indépendante, de préférence sans but lucratif, qui serait chargée de s'occuper des déchets, une entité unique qui jouirait de la confiance de la collectivité et du soutien du gouvernement fédéral, et dont le conseil d'administration serait composé de représentants de diverses parties prenantes.

RECOMMANDATION 2 : STOCKER LES DÉCHETS DE FAIBLE ACTIVITÉ AU SEIN DE PLUSIEURS INSTALLATIONS PRÈS DE LA SURFACE, DONT LA MISE EN OEUVRE SERAIT ASSURÉE PAR LES PROPRIÉTAIRES DES DÉCHETS

Les producteurs et les propriétaires des déchets seraient chargés de choisir les sites et de construire les installations de stockage près de la surface pour les déchets de faible activité qui ne sont actuellement visés par aucun plan de stockage à long terme, en conformité avec les meilleures pratiques internationales et en tenant compte des caractéristiques et du volume des déchets, de la proximité des installations d'entreposage provisoires existantes, de l'acceptation des collectivités et des considérations techniques pertinentes.

La possibilité de mettre en oeuvre des installations appartenant à plusieurs producteurs de déchets ou des installations régionales centralisées devrait également être étudiée afin de trouver le juste équilibre entre le nombre d'installations et la distance de transport des déchets. Des installations régionales centralisées pourraient permettre de réaliser des économies d'échelle et garantir aux petits producteurs de déchets un accès équitable. Les installations régionales pourraient être provinciales, elles pourraient être associées à plusieurs provinces et il pourrait y en avoir plus d'une dans une même province, suivant plusieurs facteurs tels que le volume de déchets, les distances de transport et les coûts.

Les producteurs et les propriétaires de déchets seraient chargés d'élaborer des plans plus détaillés de mise en oeuvre, de manière ouverte et transparente, et en s'appuyant dès le départ et de façon continue sur un programme de concertation, conformément à la Politique.

Informations générales

Le stockage à long terme des déchets de faible activité est conforme aux meilleures pratiques internationales et a été préféré par la majorité des participants à l'intendance perpétuelle. D'un point de vue technique, financier et sociétal, le stockage à faible profondeur représenterait la meilleure option pour confiner ces déchets jusqu'à ce qu'ils ne présentent plus de danger. Les options de stockage près de la surface ont été considérées comme propices pour les déchets de faible activité sur le plan technique. Elles sont également les options les plus abordables sur le plan économique.

Lors des activités de concertation, les participants ont indiqué que le stockage près de la surface des déchets de faible activité serait une approche acceptable parce que ces déchets présentent un moindre risque et que la période pendant laquelle ils demeurent dangereux est plus courte. Certains participants ont indiqué que placer les déchets de faible activité en profondeur ne correspondrait pas au faible niveau de risque de ces déchets, ni aux exigences techniques et aux pratiques internationales en la matière. Ils étaient également d'avis qu'il ne serait pas responsable sur le plan financier de construire des installations trop complexes techniquement et qu'il serait difficile de justifier le coût d'un stockage en dépôt géologique en profondeur pour les déchets de faible activité. Certains ont estimé qu'il y avait des leçons à tirer de la gestion des déchets conventionnels et que l'expertise canadienne en matière de décharges pour déchets à faible risque est reconnue. Les participants étaient également à l'aise avec l'idée d'entreposer les déchets de faible activité aussi bien en surface qu'à faible profondeur dans des installations spécialement construites à cet effet.

D'un point de vue quantitatif, une forte pluralité de répondants, 48 pour cent dans le cas du sondage ouvert et 41 pour cent dans celui du sondage représentatif, ont préféré que les déchets de faible activité soient gérés à long terme dans une installation de stockage spécialement conçue pour eux. En revanche, seulement 14 pour cent des répondants au sondage ouvert (huit pour cent de l'échantillon représentatif) ont opté pour le maintien de l'entreposage en surface. Vingt-six pour cent estimaient que l'une ou l'autre approche serait acceptable, pour autant que tous les règlements fédéraux et internationaux en matière de sûreté soient respectés. Ce chiffre était toutefois beaucoup plus élevé dans le cas de l'échantillon représentatif (46 pour cent).

Maintien de l'entreposage en surface ou utilisation d'installations spécialement conçues pour les DFA

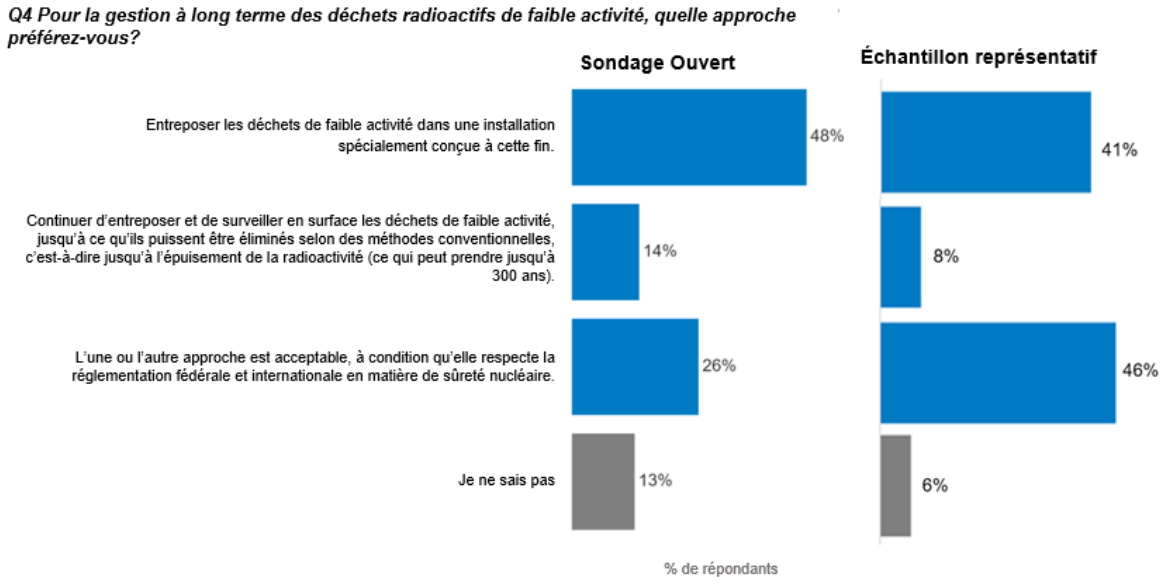


Figure 22 : Maintien de l'entreposage en surface ou utilisation d'installations spécialement conçues pour les DFA

L’enceinte de béton et la caverne rocheuse peu profonde ont été vues comme des approches techniques appropriées pour traiter tous les déchets de faible activité visés par la SIDR. L’une ou l’autre de ces options conviendrait d’un point de vue technique au stockage de tous les déchets de faible activité et offrirait la plus grande souplesse possible au regard des déchets futurs, mais le site d’une caverne rocheuse peu profonde devrait répondre à davantage d’exigences.

Le monticule ouvragé de confinement a été l’option la plus souvent privilégiée d’un point de vue sociétal et financier; toutefois, il a été estimé, d’après certaines évaluations techniques préliminaires et hypothèses prudentes, qu’il ne conviendrait qu’à une partie seulement de l’inventaire des DFA non visés par un plan de gestion à long terme. Il pourrait peut-être convenir à une plus grande partie des déchets de faible activité, mais il faudrait réaliser une analyse plus détaillée des déchets et de leur emballage pour le confirmer. À l’heure actuelle, le monticule ouvragé de confinement pourrait être envisagé en combinaison avec l’une ou les deux autres options d’installations de stockage près de la surface pour gérer l’inventaire des déchets de la SIDR.

D’un point de vue sociétal, il serait préférable d’opter pour un nombre multiple d’installations, compte tenu des grands volumes de déchets et des considérations liées au transport. La centralisation a également recueilli un appui important et, sur le plan financier, les économies d’échelle associées pourraient favoriser cette approche. Une analyse plus détaillée, y compris des coûts de transport, devrait être réalisée à ce sujet.

Le concept des installations régionales devrait être étudié plus avant afin de réduire au minimum le nombre d’installations et les distances à parcourir pour le transport des déchets. Le concept régional pourrait également être important pour garantir que les petits producteurs de déchets aient accès à des installations de stockage. Les installations régionales pourraient être provinciales, elles pourraient être associées à plusieurs provinces et il pourrait y en avoir plus d’une dans une même province, suivant plusieurs facteurs tels que le volume de déchets, les distances de transport et les coûts. Nous avons entendu dire que la question des coûts de transport ne devrait pas être la seule à considérer pour déterminer si une installation centralisée devrait être construite ou non. Les considérations relatives au transport devraient être mises en balance avec les effets que pourraient subir les collectivités autochtones sur le territoire desquelles se trouve déjà une partie des déchets radioactifs, ainsi qu’avec la question de savoir si ces collectivités consentiraient ou non à accueillir une installation de gestion de déchets. Une étude plus approfondie serait nécessaire pour étayer une telle décision.

Lors des discussions sur la centralisation ou la décentralisation des installations d’entreposage et de stockage à long terme, de nombreux participants ont exprimé leur préoccupation quant à la répartition équitable de la responsabilité et des risques liés à ces installations. Ils voulaient s’assurer que certaines collectivités n’auraient pas à subir un trop grand fardeau par rapport aux autres et estimaient que l’option d’un plus grand nombre de sites de déchets répondrait à des exigences de justice sociale, puisque les déchets seraient entreposés près de l’endroit où ils ont été produits. Certains participants ont indiqué que la construction d’une installation unique augmenterait les coûts et les risques associés au transport et que la construction de plusieurs installations serait une approche plus équitable pour les collectivités hôtes, qui se partageraient ainsi le fardeau d’accueillir les déchets. D’autres participants ont parlé du risque qu’un incident se produise dans le cas où tous les déchets radioactifs au Canada seraient gérés dans un seul dépôt. Leur préoccupation était que si tous les déchets étaient réunis au même endroit, l’impact d’un incident pourrait être plus important. Ils estimaient donc qu’il serait préférable de créer plusieurs sites.

D’autres préféraient l’option d’un nombre multiple de sites parce que cela permettrait d’éviter de transporter les déchets sur de longues distances. Certains participants nous ont dit qu’en raison du volume beaucoup plus élevé de déchets de faible activité que de déchets de moyenne activité, il devrait y avoir un plus grand nombre d’installations pour les déchets de faible activité. Certains participants estimaient que plus les déchets seront transportés sur de longues distances, plus les risques d’accident de transport seront élevés. Certains jeunes étaient favorables à la stratégie consistant à construire plusieurs installations réparties au Canada pour aider à réduire ces risques. De plus, les participants ont

fait remarquer que, compte tenu de la taille du Canada, le transport des déchets de faible activité à travers le pays ne serait pas considéré comme responsable sur le plan environnemental.

D'un point de vue quantitatif, 38 pour cent des répondants au sondage ouvert et 43 pour cent de l'échantillon représentatif ont opté pour une approche décentralisée pour la gestion à long terme des déchets de faible activité, soit pour la construction de plusieurs installations de stockage de déchets de faible activité, chacune à proximité du lieu où une quantité importante de déchets a été produite et entreposée. La centralisation a recueilli l'appui de 23 pour cent des répondants au sondage ouvert (20 pour cent de l'échantillon représentatif). Vingt-six pour cent estimaient que l'une ou l'autre approche serait acceptable, pour autant que tous les règlements de sûreté fédéraux et internationaux soient respectés. Ce chiffre était légèrement plus élevé dans le cas de l'échantillon représentatif (32 pour cent).

Une approche centralisée ou une approche décentralisée pour la gestion à long terme des DFA

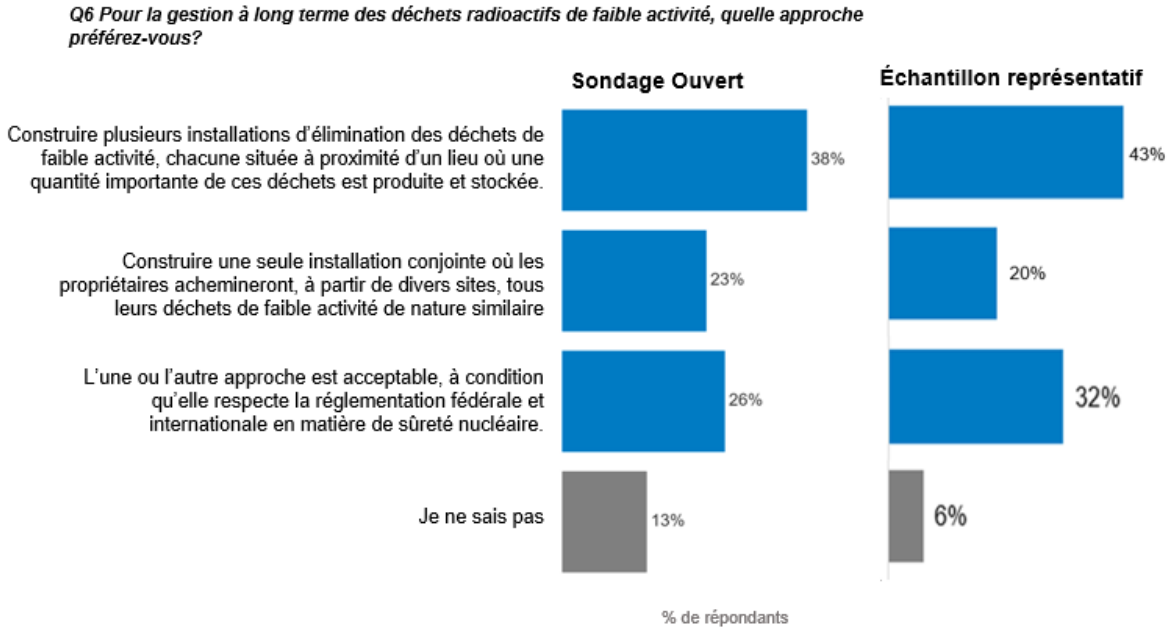


Figure 23 : Une approche centralisée ou une approche décentralisée pour la gestion à long terme des DFA

En ce qui concerne la mise en oeuvre, la responsabilité des déchets faiblement radioactifs devrait continuer d'incomber aux propriétaires des déchets, qui devraient s'assurer, ensemble, à ce qu'il y ait des installations de stockage pour tous les déchets de faible activité, quels que soient leurs propriétaires ou leur quantité. La collaboration sera essentielle pour la mise en oeuvre du concept régional et pour faire en sorte que les petits producteurs de déchets aient accès à des installations de stockage, par exemple grâce à des accords commerciaux et à un partage juste et raisonnable des coûts.

Au cours des activités de concertation, plusieurs participants ont dit que les organisations qui produisent actuellement les déchets seraient peut-être les mieux placées pour assumer une plus grande responsabilité au regard de la mise en oeuvre de la SIDR, puisqu'ils connaissent bien le type de déchets qu'ils produisent. Certains participants ont indiqué qu'ils seraient ouverts à ce que les producteurs de déchets mettent en oeuvre la stratégie sous la supervision et la surveillance du gouvernement. Les producteurs et propriétaires de déchets seraient dans ce cas responsables de leur stratégie et choisiraient la technologie de stockage qui conviendrait le mieux à leurs déchets, en tenant compte de l'inventaire, du site, de la géologie et des caractéristiques des déchets. La mise en place d'un organisme

de surveillance chargé de veiller à ce que les déchets soient gérés de manière sûre, de résoudre les problèmes et de faire appliquer les règlements appropriés a été considérée comme souhaitable. Toutefois, des participants ont également déclaré que dans le passé, il est arrivé que certains propriétaires de déchets ne se soucient que de leurs propres intérêts et qu'ils n'acceptent pas d'autres déchets, quelle que soit leur proximité. Nous avons entendu que les principaux producteurs de volumes faibles à modestes de déchets n'auront probablement pas la capacité voulue pour mettre en place les installations requises et qu'il serait donc essentiel que l'entité chargée de la mise en oeuvre de la stratégie donne aux petits producteurs de déchets accès à des sites.

Certains participants ont soutenu qu'il sera nécessaire que tout le monde collabore à la mise en oeuvre de la stratégie, mais qu'il ne serait peut-être pas idéal qu'une seule entité en soit responsable. Ils ont estimé que le partage des responsabilités serait important et que ce partage devrait être coordonné au niveau national, les différentes entreprises travaillant dans un esprit de collaboration. L'industrie resterait alors responsable de la mise en oeuvre de la stratégie, tout en étant assujettie aux approbations et à la supervision requises d'un organisme indépendant de confiance.

D'un point de vue quantitatif, même si nous avons constaté une nette préférence parmi les répondants au sondage ouvert (dans un rapport de 5:1) et au sondage représentatif pour la création d'un organisme indépendant des propriétaires de déchets pour assurer la mise en oeuvre de la stratégie de gestion à long terme des déchets de faible et moyenne activité du Canada, la formulation de la question ne permettait pas aux répondants de donner des réponses différentes à ce sujet pour les différents types de déchets. En fait, certaines personnes pensaient que des approches différentes pourraient et devraient être utilisées pour les déchets de faible activité et les déchets de moyenne activité, puisque ces derniers nécessitent une plus longue période de confinement. Ainsi, les propriétaires de déchets pourraient continuer à gérer les déchets de faible activité, mais une approche plus collective pourrait être utilisée pour les déchets de moyenne activité (comme c'est le cas pour le combustible nucléaire irradié, pour lequel une seule entité est chargée de mettre en oeuvre le plan canadien).

Principes de mise en oeuvre

Sur la base des nombreux commentaires fournis par les Canadiens et les peuples autochtones, quatre principes de mise en oeuvre ont été élaborés. Ces principes sont conformes à la Politique.

PRINCIPE DE MISE EN OEUVRE 1 : LE CONSENTEMENT DES COLLECTIVITÉS LOCALES ET DES PEUPLES AUTOCHTONES SUR LE TERRITOIRE DESQUELS LES FUTURES INSTALLATIONS SERONT PLANIFIÉES DEVRA ÊTRE OBTENU AU COURS DU PROCESSUS DE SÉLECTION DU SITE

Cette considération a été jugée prioritaire par la majorité des participants aux séances de concertation. Ce principe est également conforme à ce que prescrit la Politique concernant les mesures à prendre pour assurer la mise en oeuvre de la *Loi sur la déclaration des Nations unies sur les droits des peuples autochtones (DNUDPA)*. Cette considération cruciale s'étend à toutes les futures installations de stockage de déchets radioactifs, y compris l'éventuel regroupement des déchets de moyenne activité avec le combustible irradié. Il sera donc nécessaire de discuter avec les principales collectivités des régions hôtes potentielles des différentes installations de gestion à long terme de déchets radioactifs afin de comprendre leurs attentes en matière de consentement.

Conformément à la Politique, les collectivités autochtones des régions d'accueil actuelles et potentielles devront participer de manière précoce, continue et significative à toutes les phases de tout projet de gestion de déchets radioactifs, quelle qu'en soit l'envergure. Cette participation devra être facilitée par le renforcement des capacités des peuples autochtones, le partage de l'information et la collaboration[31]. En outre, les lois, les processus réglementaires et les protocoles de consultation autochtones élaborés et mis en oeuvre dans les régions où de futures installations seront planifiées devront être respectés.

PRINCIPE DE MISE EN OEUVRE 2 : LORS DE LA CONCEPTION DES INSTALLATIONS, LA PROTECTION DE L'EAU CONSTITUERA UNE PRIORITÉ ABSOLUE

Bien que la sûreté puisse être démontrée d'un point de vue technique quel que soit l'emplacement, il pourrait être difficile d'obtenir un appui sociétal pour des installations situées à proximité de sources importantes d'eau potable. Des inquiétudes ont été soulevées concernant le danger perçu des déchets radioactifs pour les humains et le risque lié au transport et au stockage des déchets à proximité des cours d'eau. Les jeunes participants autochtones, en particulier, ont souligné l'importance de protéger l'eau, y compris les eaux souterraines. Bien que plusieurs participants aient recommandé que les installations soient situées loin de toute source importante d'approvisionnement en eau, la réalité du paysage canadien est telle que cela ne serait pas possible.

La Politique exige que les activités de gestion des déchets radioactifs et de déclassement, y compris les activités de transport et de stockage, soient effectuées d'une manière exhaustive et intégrée, qui accorde la priorité à la santé, à la sûreté et à la sécurité des personnes et de l'environnement et qui offre des garanties de non-prolifération. Dans cette optique, la protection de l'eau est primordiale et, par conséquent, toute installation de stockage devra respecter les normes les plus rigoureuses en matière de protection de l'environnement et de l'eau. Les sources d'eau potable devront être protégées et l'océan ne devra pas être considéré comme une option valable pour la mise en oeuvre de projets nucléaires ou pour l'entreposage ou le stockage de matières nucléaires, aujourd'hui ou dans le futur[32].

PRINCIPE DE MISE EN OEUVRE 3 : LES INSTALLATIONS DE STOCKAGE FERONT L'OBJET D'UN SUIVI À LONG TERME

Les déchets et les installations devront être surveillés aussi longtemps que les générations futures le jugeront nécessaire pour garantir que l'environnement reste protégé. Ce concept signifie également que les connaissances sur les déchets et leur emplacement devront être transmises aux générations futures afin qu'elles ne tombent pas dans l'oubli. Des tâches devront être créées et confiées aux générations futures afin d'assurer la continuité des projets et la surveillance des déchets. Ces tâches devront comprendre l'examen périodique des plans de surveillance, afin de déterminer s'ils demeurent adéquats ou nécessaires. Quelle que soit l'option choisie, la plupart des participants ont appuyé la mise en oeuvre d'une surveillance environnementale à long terme. Ils estimaient qu'il faudra assurer l'intendance et la surveillance de l'environnement et des déchets pendant des générations et des générations.

Puisque certaines centrales nucléaires et installations de gestion de déchets existantes sont situées sur des territoires autochtones, les collectivités autochtones devront diriger les discussions sur l'intendance des terres, conformément à l'exigence de la Politique voulant que les propriétaires de déchets travaillent en partenariat avec les peuples autochtones pour mieux comprendre leur savoir autochtone et les conseils qu'ils peuvent avoir en ce qui concerne les projets de gestion des déchets radioactifs et de déclassement. Les collectivités autochtones possèdent un savoir traditionnel et devraient être au coeur des discussions entourant toute construction qui pourrait perturber la terre, menacer l'eau et avoir un impact sur les usages traditionnels. Il conviendra également de veiller à ce que les retombées économiques soient partagées avec les collectivités locales consentantes.[33]

PRINCIPE DE MISE EN OEUVRE 4 : IL EST ESSENTIEL D'AGIR DÈS MAINTENANT ET DE NE PAS ABANDONNER CETTE TÂCHE AUX GÉNÉRATIONS FUTURES

Un des objectifs de la Politique est que soient mis en place les éléments clés de l'infrastructure de stockage des déchets radioactifs canadiens et que soient bien planifiées les autres installations qui seront nécessaires pour assurer la gestion de tous les déchets radioactifs canadiens actuels et futurs d'ici 2050. Concernant l'élaboration de la stratégie, les participants nous ont dit qu'une stratégie intégrée était essentielle et qu'il fallait déterminer l'approche à adopter pour la gestion à long terme des déchets de faible et de moyenne activité. Il a été généralement convenu, lors des activités de concertation, que la bonne chose à faire serait de mettre en oeuvre un plan pour tous les déchets radioactifs canadiens et de le faire avec un sentiment d'urgence, plutôt que d'abandonner ce problème aux générations futures. Cela

correspond aux avis reçus il y a 20 ans par la SGDN dans le cadre de son étude sur la gestion à long terme du combustible irradié.

Cela est également conforme à l'exigence imposée par la Politique aux propriétaires et producteurs de déchets de collaborer avec les autres propriétaires ou producteurs de déchets dans le cadre de leurs plans pour l'avancement, l'élaboration et la mise en oeuvre, sur le plan national, de solutions exhaustives et intégrées de gestion des déchets radioactifs dans les meilleurs délais, et de déclasser les installations, les emplacements et les sites dans un délai approprié, afin de réduire le fardeau de gestion des déchets sur les générations futures[34]. La mise en oeuvre de la SIDR exigera un engagement et un soutien permanents de la part du gouvernement, ainsi qu'une entité qui sera habilitée à assurer l'atteinte des objectifs de la stratégie, quels que soient les changements de gouvernements qui surviendront. Cette urgence d'agir doit être équilibrée de manière appropriée avec l'engagement du Canada envers la réconciliation avec les peuples autochtones.

Recommandations supplémentaires qui débordent du cadre immédiat de la SIDR

La stratégie intégrée ne prend pas en considération la question du retraitement du combustible nucléaire irradié. Le retraitement, qui a pour objectif d'extraire des matières fissiles des déchets de combustible irradié en vue d'une utilisation ultérieure, n'est pas encore pratiqué au Canada et n'entre donc pas pour le moment dans le champ d'application de la Politique ni, par conséquent, de la SIDR. Si le retraitement est un jour pratiqué, les déchets radioactifs issus d'un projet de ce type relèveraient du champ d'application de la Politique et seraient alors pris en compte dans les futures mises à jour de la SIDR.

Dans le cadre de la stratégie intégrée, aucune option de réduction des déchets, y compris de leur volume, n'est considérée au-delà de celles prévues et quantifiées par les propriétaires des déchets. La stratégie intégrée pourrait bénéficier d'une approche holistique de réduction à la source des déchets avant leur stockage, mais cela devra être confirmé par des études futures. De plus, une approche intégrée pourrait ouvrir des avenues de traitement des déchets qui découleraient des nouvelles économies d'échelle rendues accessibles aux petits propriétaires de déchets.

La stratégie intégrée ne prend pas en considération la question des déchets et problèmes hérités, ni ne propose de solutions dans ce domaine.

Annexes et glossaire

Annexe A : Principes directeurs

La SGDN a défini un ensemble de principes fondés sur ce que l'organisation a entendu antérieurement de la part des Canadiens et des peuples autochtones. Ces principes initiaux ont été inclus dans la recherche sur l'opinion publique et affinés par les participants lors du Sommet canadien sur les déchets radioactifs, le premier des événements de concertation organisés pour l'élaboration de la Stratégie intégrée pour les déchets radioactifs. Le Sommet a eu lieu les 30 mars et 1er avril 2021.

Les principes dégagés ont servi de base de discussion lors des séances de concertation avec les collectivités. Tous les travaux entrepris par la SGDN étaient ancrés sur ces principes.

Une illustration et le texte intégral des principes sont fournis ci-dessous.



Figure 24 : Principes directeurs

La sûreté doit être le principe cardinal guidant l'élaboration et la mise en oeuvre de la stratégie. Aucune autre considération ne doit compromettre la sûreté ni la santé humaine.

La stratégie doit assurer la sûreté des installations, des matériaux, des infrastructures et des informations.

La stratégie doit assurer la protection de l'environnement, qui englobe l'air, l'eau, le sol, la faune et les habitats.

La stratégie doit être élaborée et mise en oeuvre de manière à satisfaire, voire à surpasser, les exigences réglementaires en matière de santé, de sûreté et de protection des personnes et de l'environnement.

La stratégie doit s'appuyer sur les meilleures connaissances disponibles, ce qui comprend le savoir traditionnel autochtone, les sciences fondamentales, les sciences sociales, le savoir collectif local et les bonnes pratiques internationales. Pour être robuste, elle doit en effet intégrer les connaissances traditionnelles et les modes de vie des Premières Nations, y compris la connaissance du territoire et de l'environnement. Elle doit également intégrer les valeurs et les principes qui favorisent le développement et le maintien de relations fructueuses et significatives.

La stratégie doit respecter les droits des autochtones et leurs traités et prendre en considération toute revendication formulée par les peuples autochtones au gouvernement fédéral qui n'a pas encore été résolue.

La stratégie doit être élaborée d'une manière transparente qui informe le public, notamment les jeunes et les Autochtones, et suscite sa participation. Il sera important, dès le début du processus, de donner des informations faciles à comprendre aux personnes les plus susceptibles d'être touchées par la mise en oeuvre de la stratégie. Il faudra écouter les questions et les préoccupations des gens, en prendre acte et fournir des réponses. Les informations utilisées pour élaborer la stratégie devront être facilement accessibles au public.

La stratégie doit être élaborée et mise en oeuvre sur la base d'un plan financier responsable afin d'éviter que le coût des projets n'alourdisse le fardeau financier des consommateurs d'électricité, des contribuables ou des générations futures.

Dans la mesure du possible, la stratégie doit mettre à contribution les projets existants de gestion à long terme des déchets nucléaires canadiens.

Annexe B : Matrice des commentaires reçus lors des activités de concertation, classés par groupe de participants

Les tableaux de cette annexe présentent les contributions des différents groupes de participants à l'élaboration des thèmes et des idées énoncés dans les recommandations. Chaque tableau présente les principaux thèmes ressortis des domaines clés des discussions tenues au cours des différentes séances de concertation :

1. Stockage ou intendance perpétuelle;
2. Regroupement ou centralisation;
3. Responsabilité de la mise en oeuvre.

Chaque tableau présente dans la rangée supérieure les différents groupes avec lesquels nous avons mené nos activités de concertation et, dans la colonne de gauche, un résumé des principales idées dégagées des discussions. Un chevron indique que le thème a été identifié par un groupe.

Les thèmes à gauche sont classés par fréquence relative, les thèmes les plus hauts dans le tableau ayant été soulevés plus fréquemment que les thèmes les plus bas.

Toutes les déclarations sommaires tirées de ce que nous avons entendu au cours de nos séances de concertation ont été regroupées en idées similaires et le groupe de participants d'origine de chacune de ces idées est identifié. Une valeur subjective a été attribuée pour indiquer l'intensité des commentaires associés, et une valeur subjective a été attribuée pour indiquer le nombre de personnes à l'origine du commentaire.

Tableau 10 : Stockage ou intendance perpétuelle

Catégorie	Peuples autochtones	Collectivités	Organisations de la société civile	Secteur universitaire	Industrie	Municipalités	Gouvernement	Ouvert	Jeunes
Stockage préféré	»	»	»	»	»		»	»	»
Stockage – DMA + regroupement			»	»	»	»			»
Surveillance continue + intendance	»	»	»		»			»	
Intendance perpétuelle	»	»	»	»				»	»
Intendance perpétuelle – DFA		»		»	»	»			»
Stockage – DFA				»	»				»
Intendance perpétuelle – DMA		»		»				»	
Défense en profondeur			»						
Stockage – évolution des considérations sociétales				»			»		
Stockage – considérations technologiques + flexibilité					»				
Aucune préférence									»
Autre – urgence			»		»				
Stockage – DFA (multiples options techniques)					»				
Autre – récupérabilité			»						
Autre – réduction des déchets		»							

» Entendu de ce groupe au cours de nos diverses activités de concertation

Tableau 11 : Regroupement et centralisation

Catégorie	Peuples autochtones	Collectivités	Organisations de la société civile	Secteur universitaire	Industrie	Municipalités	Gouvernement	Ouvert	Jeunes
Multiples installations		»	»	»	»	»			»
Sélection d'un site – loin de l'eau	»	»	»					»	»
DMA – regroupement avec les DHA	»	»	»	»	»		»	»	
DFA – multiples sites		»			»			»	»
DFA – stockage près de la surface		»		»	»		»		
Multiples sites – près du lieu de production		»	»	»	»	»		»	
DMA – site unique – emplacement distinct		»		»		»	»		
DFA – regroupement avec les DMA		»	»	»		»		»	
DFA – multiples sites – près du lieu de production	»			»		»			
DFA – site unique	»			»	»	»			
DFA – multiples sites – régionaux	»			»					»
Multiples sites – régionaux					»		»	»	
Installations distinctes pour les DFA et les DMA		»		»	»				
Site loin des foyers de population	»						»		»
Regroupement					»				
DMA – peu de sites								»	»
DMA – multiples options techniques					»				
Stratégie adaptable				»					
Environnemental			»						

DMA – DGP					»				
DMA – près de la surface			»						
DFA – sites de déchets dangereux				»					
Traitement – stabilisation et solidification		»							

» Entendu de ce groupe au cours de nos diverses activités de concertation

Tableau 12 : Responsabilité de la mise en oeuvre

Catégorie	Peuples autochtones	Collectivités	Organisations de la société civile	Secteur universitaire	Industrie	Municipalités	Gouvernement	Ouvert	Jeunes
Gouvernance – représentation diversifiée	»	»	»	»				»	»
Multiples organisations – collaboration – industrie et peuples autochtones	»	»		»	»				
Organisation unique – fournisseur de service	»	»	»			»		»	»
Organisation unique – agence fédérale indépendante	»	»		»	»		»	»	
Organisation unique – indépendante de l'industrie		»	»					»	»
Multiples organisations – dirigées par l'industrie		»		»	»		»		»
Responsabilité financière – propriétaires de déchets		»			»		»		»
Autre – intégration et coordination de la mise en oeuvre				»	»	»	»		
Organisation unique – dirigée par le gouvernement			»		»				»
Organisation unique – SGDN ou équivalente	»				»				»
Responsabilité financière					»				
Responsabilité financière – financement indépendant							»		
Gouvernance – CCSN ou ANC						»			
Gouvernance – indépendante de l'industrie			»						
Gouvernance – peuples autochtones									»
Gouvernance – modèle de la SGDN							»		
Multiples organisations – par type de déchets				»					
Autre – processus		»							
Autre – abolir le rôle de l'ACN et suivre l'AIEA			»						

Organisation unique – fournisseur de service				»					
Organisation unique – DHA				»					
Organisation unique – DMA				»					
Organisation unique – OGEE				»					

» Entendu de ce groupe au cours de nos diverses activités de concertation

Annexe C : État d’avancement des projets de gestion à long terme des déchets au Canada

Gestion adaptative progressive

En 2002, le gouvernement canadien a ordonné, conformément à la *Loi sur les déchets de combustible nucléaire*, la création de la SGDN. La SGDN est une organisation indépendante, sans but lucratif, qui est financée par les propriétaires de déchets au Canada : Ontario Power Generation, Énergie Nouveau-Brunswick, Hydro-Québec et Énergie atomique du Canada limitée. La SGDN progresse dans la mise en oeuvre de sa stratégie de gestion à long terme du combustible nucléaire irradié provenant des réacteurs nucléaires canadiens; par conséquent, aucune recommandation ni aucune solution à long terme supplémentaire n’ont été fournies dans cette SIDR pour le combustible nucléaire irradié.

À l’heure actuelle, le combustible nucléaire irradié canadien Canada est entreposé dans des installations de surface autorisées. Bien que cette approche soit sûre, il est largement reconnu qu’elle ne convient pas à long terme. Les Canadiens et les peuples autochtones ont clairement exprimé qu’ils reconnaissaient l’importance d’agir dès maintenant pour trouver une solution à long terme et de ne pas laisser cette tâche aux générations futures.

Le plan de gestion du combustible nucléaire irradié canadien, appelé la Gestion adaptative progressive, est le fruit d’un dialogue mené pendant trois ans avec des spécialistes et le public. Il est fondé sur les valeurs et les objectifs qu’ils avaient identifiés ensemble. En 2007, le gouvernement du Canada a fait de la Gestion adaptative progressive le plan national et a chargé la SGDN de la mettre en oeuvre.

Une étape importante se profile maintenant à l’horizon pour la SGDN, alors que nous prévoyons de choisir le site du dépôt géologique en profondeur en 2024. Vingt-deux collectivités avaient initialement exprimé l’intention d’en apprendre davantage sur le projet et d’explorer leur aptitude à l’accueillir. Au cours de la dernière décennie, la SGDN a progressivement réduit le nombre de régions hôtes potentielles à deux seulement, toutes deux situées en Ontario – la région de la Nation ojibwée de Wabigoon Lake (NOWL)-Ignace, dans le nord-ouest, et la région de la Nation ojibwée de Saugeen (NOS)-South Bruce, dans le sud.

La Gestion adaptative progressive comprend un plan technique, ainsi qu’un plan de mise en oeuvre progressif et adaptatif.

C’est à la fois une méthode technique (ce que nous envisageons de construire) et une approche de gestion (comment nous entendons travailler avec les gens pour y parvenir). La méthode technique consiste à construire un dépôt géologique en profondeur au sein d’une formation rocheuse appropriée pour confiner et isoler en toute sûreté le combustible nucléaire irradié. L’approche de gestion a comme élément central un processus de décision progressif et adaptatif qui est soutenu par la concertation publique et l’apprentissage continu.

Le projet n’ira de l’avant que dans une région associée à des hôtes informés et consentants. Avec les régions hôtes potentielles, nous continuons d’explorer les possibilités de nouer des partenariats et d’examiner comment le projet pourrait améliorer le bien-être de leurs résidents.

Les travaux que la SGDN mène actuellement serviront de base à une transition vers une nouvelle série d’activités qui seront menées une fois le site optimal choisi. Nous lancerons des processus réglementaires, construirons un Centre d’expertise et amorcerons le déménagement de nos opérations vers le site.

Le dépôt géologique en profondeur comprend un système à barrières multiples conçu pour confiner et isoler de manière sûre et à très long terme le combustible nucléaire irradié. Construit à plus de 500 mètres sous terre, le dépôt consistera en un réseau de salles de stockage où sera stocké le combustible nucléaire irradié.

En surface, le dépôt comprendra des installations où le combustible irradié sera reçu, inspecté, puis remballé dans des conteneurs de conception spéciale enchâssés dans une boîte tampon, avant d'être transféré au puits principal en vue de son stockage sous terre. Il y aura aussi des bâtiments servant à assurer les fonctions d'administration, d'assurance de la qualité, de sécurité, de traitement des matériaux de scellement et d'exploitation du site.

Le dépôt comprendra une zone de services centralisée, où sera assurée la ventilation souterraine par la voie de trois puits situés dans une zone sécurisée unique. Le dépôt comprendra aussi de multiples tunnels d'accès qui permettront aux spécialistes techniques de trouver les endroits les plus propices sur le plan géologique pour aménager les salles de stockage. Les boîtes tampons seront placées dans des salles de stockage horizontales et tous les espaces vides seront remblayés avec des pastilles de bentonite.

Pour se préparer au processus de décision réglementaire et à la construction des installations, la SGDN a commencé à réaliser des dessins conceptuels de l'aménagement du dépôt en se basant sur les informations tirées des évaluations géoscientifiques et des premiers forages réalisés dans les régions hôtes potentielles. Ce processus est de nature itérative – la SGDN continuera d'affiner la conception du dépôt à mesure qu'elle recueillera des renseignements propres à chacun des sites. Le site proposé dans la région de la NOWL-Ignace reposerait sur une formation de roche cristalline; le site dans la région de la NOS-South Bruce reposerait sur une formation de roche sédimentaire.

Des normes de sûreté rigoureuses encadrent le projet. La SGDN s'est engagée à respecter ou à surpasser toutes les exigences réglementaires fédérales et provinciales applicables afin de protéger la santé, la sûreté et la sécurité des personnes et de l'environnement pour les générations à venir.

Un ensemble de barrières ouvragées et naturelles se conjugueront pour confiner et isoler de manière sûre le combustible nucléaire irradié dans le dépôt. Chaque barrière fournira un niveau de protection unique et autonome, tout en servant de filet de sécurité à la barrière précédente. En cas de défaillance de l'une de ces barrières, une autre garantira que toutes les matières dangereuses resteront confinées et isolées.

La première barrière est la pastille de combustible. Les pastilles de combustible sont faites d'une céramique solide et très stable constituée d'une poudre de dioxyde d'uranium cuite très durable. Elles sont insérées bout à bout dans de longs tubes métalliques solides et résistants à la corrosion.

La seconde barrière est la grappe de combustible, qui est composée d'un matériau très résistant à la corrosion appelé zircaloy. Chaque grappe contient plusieurs de ces tubes.

La troisième barrière est le conteneur en acier revêtu de cuivre. Ce conteneur est conçu pour résister à la corrosion et est suffisamment résistant pour complètement confiner le combustible nucléaire irradié jusqu'à ce que sa radioactivité ait diminué à un niveau sécuritaire. Il est conçu pour résister à la pression exercée par 3 000 mètres de neige, de glace et d'eau de fonte, 800 mètres de roche, de terre et d'eaux souterraines ainsi que l'argile environnante.

La quatrième barrière est une boîte tampon faite d'une argile bentonitique hautement comprimée. Chaque conteneur sera inséré dans une telle boîte. L'argile bentonitique est une matière naturelle qui, selon les études, constitue une puissante barrière contre l'écoulement de l'eau. Elle est très stable, comme le confirment les observations faites dans des formations naturelles vieilles de centaines de millions d'années. Elle empêche aussi naturellement la croissance microbienne, ce qui contribuera à maintenir l'intégrité du conteneur sur une longue période.

La cinquième barrière est la roche elle-même, qui protégera le dépôt contre les perturbations naturelles, l'écoulement de l'eau et l'intrusion humaine.

L’installation de stockage près de la surface, l’installation de démonstration nucléaire, le réacteur WR-1 (Whiteshell) et l’Initiative de la région de Port Hope des Laboratoires nucléaires canadiens

Les déchets de faible activité constituent le plus grand volume de déchets radioactifs gérés par les Laboratoires nucléaires canadiens (LNC). Les LNC ont progressé dans la mise en oeuvre de leur stratégie de gestion à long terme des déchets de faible activité provenant des activités d’exploitation, de déclassement et de restauration environnementale; par conséquent, aucune recommandation ni aucune solution à long terme ne sont fournies dans cette SIDR pour les déchets de faible activité que les LNC gèrent au nom d’Énergie atomique du Canada limitée (EACL).

Les LNC ont présenté une demande de permis pour la construction et l’exploitation d’une installation de gestion de déchets près de la surface sur le site des laboratoires de Chalk River. L’installation de stockage proposée sera un monticule ouvragé de confinement qui pourra contenir jusqu’à 1 million de m^3 de déchets de faible activité et soutenir la mission de nettoyage environnemental en cours sur les sites appartenant à EACL.

En plus de l’installation de gestion de déchets près de la surface, les LNC ont proposé le stockage in situ des déchets du réacteur nucléaire de démonstration et du réacteur Whiteshell-1, ce qui permettra d’achever le déclassement de ces deux réacteurs souterrains et d’assurer la sûreté à long terme du public et de l’environnement. La validité de la gestion des déchets de faible et moyenne activité de ces deux réacteurs par cette approche proposée a été démontrée par un solide dossier de sûreté et est conforme à toutes les exigences réglementaires concernées.

Installation de stockage près de la surface

L’installation de stockage de déchets près de la surface est une installation nécessaire pour permettre aux LNC de procéder à la restauration environnementale des sols et des matériaux contaminés déjà présents sur le site des Laboratoires de Chalk River afin de protéger l’environnement, y compris la rivière des Outaouais. L’installation de stockage près de la surface a été spécialement conçue comme solution permanente pour réduire les risques environnementaux et isoler les déchets radioactifs de faible activité conformément aux lignes directrices internationales et aux exigences réglementaires.

L’installation de stockage près de la surface ne contiendra que des déchets radioactifs de faible activité. Ces déchets incluent des matériaux de construction (provenant principalement du projet de revitalisation en cours des Laboratoires de Chalk River) des sols contaminés et des articles généraux tels que des vadrouilles, des vêtements de protection et des chiffons jetés qui ont été légèrement contaminés. Quatre-vingt-dix pour cent des déchets proposés pour l’installation de stockage près de la surface se trouvent déjà aux Laboratoires de Chalk River, cinq pour cent proviendront d’hôpitaux et d’universités, et cinq pour cent d’autres sites appartenant à EACL.

Le principal élément de l’installation proposée sera un monticule ouvragé de confinement comportant des barrières naturelles et ouvragées qui se conjugueront pour isoler les déchets de l’environnement pendant plus de 550 ans, des centaines d’années de plus que ce qu’il faut à la radioactivité des déchets pour se désintégrer jusqu’aux niveaux trouvés naturellement dans l’environnement.

L’installation de stockage près de la surface sera également dotée d’un système de collecte et de traitement des eaux usées qui éliminera les contaminants radiologiques et chimiques afin que les effluents traités soient sûrs pour l’homme et l’environnement. Les eaux usées traitées seront échantillonnées avant d’être rejetées dans l’environnement afin de s’assurer que les objectifs de rejet sont bien atteints.

Les LNC élargiront leur programme déjà très poussé de surveillance environnementale des Laboratoires de Chalk River et d’échantillonnage de l’air, de l’eau et des eaux souterraines, pour y inclure l’installation de stockage près de la surface. L’évaluation environnementale du projet de l’installation de stockage près

de la surface ne prévoit aucune incidence substantielle sur les humains ou l'environnement, compte tenu des mesures d'atténuation prévues. La surveillance continue de l'installation de stockage près de la surface et du milieu environnant confirmera ces prévisions et l'utilisation efficace des mesures d'atténuation.

L'installation proposée devra être autorisée en vertu de la *Loi sur la sûreté et la réglementation nucléaires*, et assujettie à la réglementation associée et à la surveillance réglementaire indépendante de la Commission canadienne de sûreté nucléaire. Une audience publique en deux parties sur l'évaluation environnementale et la demande d'autorisation de construction de l'installation de stockage près de la surface a eu lieu au cours du premier semestre 2022. Au moment de la rédaction de ce rapport, une décision était en attente.

Installation nucléaire de démonstration

Les LNC proposent de procéder à la fermeture de l'installation nucléaire de démonstration, ce qui assurera la protection à long terme des personnes et de l'environnement. Cette technique, appelée « stockage in situ », achèvera le déclassement de l'installation et permettra de confiner et d'isoler les systèmes et composants vides restants sous le niveau du sol, dans le substratum rocheux. L'approche consiste à démolir la structure en surface, à placer les débris résultants dans des zones ouvertes de la structure souterraine, puis à mettre en place des barrières ouvragées, notamment par l'injection souterraine de coulis et la construction d'un système de fermeture et de couverture pour garantir l'isolement et le confinement des déchets. Le résultat est une installation de stockage définitif. Les déchets restent sur place, ce qui évite d'avoir à les manipuler, à les expédier et à construire une autre installation de stockage ailleurs.

Ce projet fait actuellement l'objet d'une évaluation environnementale fédérale, et les LNC ont fourni l'ébauche révisée de l'Énoncé des incidences environnementales à la Commission canadienne de sûreté nucléaire en décembre 2021. La Commission canadienne de sûreté nucléaire a demandé aux LNC de fournir des révisions supplémentaires aux informations fournies dans l'ébauche révisée de l'Énoncé des incidences environnementales pour le projet de fermeture de l'installation nucléaire de démonstration.

Les LNC continueront de travailler avec les collectivités autochtones et les parties prenantes publiques pour faire en sorte que leurs intérêts et préoccupations soient pris en compte dans la version révisée de l'Énoncé des incidences environnementales et que le projet y réponde.

Une fois la vérification de l'exhaustivité effectuée, la prochaine étape du processus d'évaluation environnementale consistera en un examen technique réalisé par des représentants autochtones, fédéraux et provinciaux. Les LNC travaillent en ce moment en vue de présenter, à la fin de 2024, une version finale de leur Énoncé des incidences environnementales, qui donnera suite à tous les commentaires fournis depuis 2015 par le public, les collectivités autochtones, les groupes d'intérêt et les organismes fédéraux et provinciaux.

Réacteur Whiteshell-1

Le déclassement des Laboratoires de Whiteshell a commencé en 2003, après que la Commission canadienne de sûreté nucléaire a approuvé un cadre général de déclassement et a ensuite délivré un permis de déclassement du site. Depuis, les bâtiments redondants ont été démolis et de nouvelles installations de traitement des déchets ont été construites. La prochaine étape majeure du plan est le déclassement du réacteur Whiteshell-1 (WR-1) lui-même, l'une des installations les plus grandes et les plus complexes du site.

Les LNC proposent de déclasser le réacteur et de le laisser en place sur le site de Whiteshell. Tout le combustible et tous les liquides ont été retirés et il ne reste que les composants structurels du réacteur, comme la cuve et la tuyauterie.

L’approche proposée par les LNC – le déclassement in situ – réduit au minimum les risques pour la santé, la sûreté et la sécurité du public, des travailleurs et de l’environnement. Elle évite d’avoir à transporter des composants contaminés et à trouver un autre endroit et une autre installation pour le stockage.

La proposition relative à ce projet a été soumise à l’approbation de la Commission canadienne de sûreté nucléaire en 2017. Les LNC ont présenté à la Commission canadienne de sûreté nucléaire une mise à jour de l’énoncé des incidences environnementales pour le projet du WR-1. Un examen technique fédéral, provincial et autochtone a été réalisé, et les LNC s’affairent actuellement à répondre aux demandes de renseignements reçues. Les LNC prévoient organiser une audience en vue de l’autorisation du projet à la fin de 2024.

Initiative de la région de Port Hope

Les LNC ont également réalisé des progrès importants relativement à l’Initiative de la région de Port Hope, qui prévoit le nettoyage d’environ 1,7 million de m^3 de déchets accumulés de faible activité provenant de divers sites de Port Hope et de Port Granby. Ces déchets historiques de faible activité sont en train d’être stockés dans des monticules ouvragés en surface, où ils seront confinés en toute sûreté. Les nouvelles installations feront l’objet d’une surveillance et d’un entretien à long terme.

L’Initiative de la région de Port Hope (IRPH) découle de l’engagement pris par le gouvernement du Canada de nettoyer et de gérer en toute sûreté, localement et à long terme, les déchets radioactifs de faible activité de deux municipalités du sud de l’Ontario, Port Hope et Clarington. Ces déchets proviennent des activités de transformation du radium et de l’uranium qui ont été menées à Port Hope entre 1933 et 1988 par l’ancienne société d’État Eldorado Nuclear Limited et ses prédécesseurs du secteur privé.

L’Initiative de la région de Port Hope repose sur des solutions recommandées par la collectivité pour le nettoyage et la gestion à long terme d’environ 1,7 million de mètres cubes de déchets de faible activité. Il s’agit actuellement de l’un des plus importants projets d’assainissement de l’environnement au Canada.

L’Initiative de la région de Port Hope est réalisée sous forme de deux projets : le projet de Port Hope et le projet de Port Granby. Chaque projet comporte trois phases : la phase 1 – planification/approbation réglementaire; la phase 2 – mise en oeuvre et la phase 3 – surveillance et entretien à long terme. La phase 2 du projet de Port Granby s’est achevée en 2022 avec l’enlèvement de plus de 1,3 million de tonnes de déchets historiques d’un ancien site sur la rive du lac Ontario et leur transfert à la nouvelle installation de stockage, où ils resteront désormais confinés à long terme et en toute sûreté. Le projet de Port Hope en est rendu à la phase 2.

Par l’intermédiaire de leur Bureau de gestion du Programme des déchets historiques, les LNC travaillent à la mise en oeuvre de l’Initiative de la région de Port Hope pour le compte d’EACL, une société d’État fédérale. Le Bureau de gestion du Programme des déchets historiques rassemble du personnel diversifié du gouvernement, de l’industrie privée et de cabinets de services-conseils oeuvrant dans des domaines comme le génie, les sciences environnementales, la sûreté industrielle, la gestion financière, l’administration des contrats, les communications et l’ordonnancement pour mettre en oeuvre les projets.

L’Installation de gestion à long terme des déchets de Port Hope est située dans la municipalité de Port Hope. Elle offre une capacité de stockage à long terme sûr pour approximativement 1,2 million de mètres cubes de déchets radioactifs historiques de faible activité en cours de récupération dans le cadre du projet de Port Hope. L’Installation de gestion à long terme des déchets de Port Granby est située à Port Granby, au sud-est de Clarington.

Chacune de ces installations de gestion à long terme des déchets comprend un monticule en surface conçu pour isoler les déchets radioactifs historiques de faible activité en les enveloppant de manière sûre sur le dessus, le dessous et les côtés avec des couches épaisses et multiples de matériaux naturels et de fabrication spécialisée.

Ces couches forment la couverture et le revêtement de base et, indépendamment les unes des autres, sont suffisamment robustes pour empêcher les matières contaminantes de pénétrer dans l'environnement. Ensemble, elles constituent un système de sécurité à multiples barrières.

Le système de couverture à plusieurs composants réduira l'infiltration des eaux de surface à travers les déchets, protégera le monticule contre toute intrusion accidentelle dans les déchets et réduira au niveau des rayonnements de fond les niveaux de rayonnement gamma à la surface du monticule.

Des systèmes de surveillance sont installés à l'intérieur du monticule et autour du périmètre du site de l'installation de gestion à long terme des déchets.

Mines et usines de concentration d'uranium

(Adapté de l'annexe 6 du *Septième Rapport national du Canada pour la Convention commune sur la sûreté de la gestion du combustible usé et sur la sûreté de la gestion des déchets radioactifs*)[35]

Les propriétaires de déchets exploitent déjà des installations de gestion à long terme pour les déchets des mines et des usines de concentration d'uranium canadiennes; par conséquent, aucune solution ni aucune recommandation supplémentaire n'ont été fournies dans cette SIDR pour la gestion à long terme des déchets des mines et des usines de concentration d'uranium.

KEY LAKE

Le minerai de la mine de McArthur River est traité à l'usine de concentration de Key Lake. La mine de McArthur River et l'usine de concentration de Key Lake ont suspendu leur production pour une période indéterminée et sont en mode d'entretien et surveillance depuis janvier 2018. Il y a des usines de concentration d'uranium et des installations de gestion des résidus à Key Lake. Il y a également des zones de gestion des résidus qui ne sont pas en exploitation à Key Lake.

Gestion des résidus

Les activités de gestion des résidus à Key Lake visent à isoler et à stocker les résidus produits par le procédé de concentration de manière à protéger la population et l'environnement de toute incidence future. D'un point de vue conceptuel, cela consiste à confiner les solides et à traiter l'eau selon des normes de qualité acceptables en vue de son rejet dans l'environnement. Les précipités de métaux résiduels qui sont extraits de l'eau sont envoyés sous forme de solides dans l'installation de gestion des résidus.

De 1983 à 1996, les déchets de l'usine de Key Lake ont été déposés dans une installation de gestion des résidus en surface qui couvrait une zone de 600 mètres sur 600 (36 hectares) et de 15 mètres de profondeur. L'installation de gestion des résidus a été construite cinq mètres au-dessus de la nappe phréatique au moyen de digues artificielles, qui forment un périmètre de confinement, et d'un revêtement en bentonite modifiée pour sceller le fond et isoler les résidus des sols environnants.

Depuis 1996, la fosse de la mine à ciel ouvert désaffectée Deilmann est utilisée comme installation de gestion de résidus. Mise en service en janvier 1996, elle sert au stockage des résidus produits lors de la concentration du minerai de la mine de McArthur River ainsi que des déchets spéciaux de la mine de McArthur River et de l'usine de Key Lake. Cette installation de gestion des résidus comporte une couche de drainage inférieure aménagée sur le socle rocheux de la fosse épuisée. Les résidus sont déposés sur cette couche de drainage et l'eau est continuellement siphonnée pour favoriser leur consolidation.

Les résidus étaient initialement placés dans la fosse par dépôt subaérien, l'eau étant extraite de la masse des résidus par la couche de drainage sous-jacente et le système de pompage de puits d'élévation. On a par la suite transformé l'installation en dépôt subaquatique en inondant partiellement la fosse.

Les résidus sont déposés sous la couverture aqueuse au moyen d'un système de conduites à trémie, ce qui offre des avantages du point de vue de la mise en place des résidus et de l'atténuation des émissions de radon. Dans ce système, les résidus sont déposés dans la fosse de la mine épuisée au moyen d'une stratégie de confinement dite de « ceinture naturelle ». L'eau résiduelle extraite de la masse de résidus est recueillie en vue de son traitement. Les résidus consolidés forment une masse de faible perméabilité par rapport à la zone à perméabilité plus élevée qui les entoure.

Après le déclassement, les eaux souterraines suivront la voie offrant la moindre résistance (c.-à-d. qu'elles s'écouleront de part et d'autre des résidus plutôt qu'au travers), minimisant ainsi les incidences environnementales. À la fin de 2019, l'installation de gestion des résidus Deilmann contenait 6,18 millions de tonnes de résidus.

Gestion des stériles

Les installations de gestion des stériles incluent deux installations de stockage des déchets spéciaux et trois zones de stockage des stériles. Ces dernières contiennent surtout des roches bénignes et ne sont donc pas dotées de systèmes de confinement ou de collecte des eaux d'infiltration. Les déchets spéciaux ont de faibles teneurs (non rentables) d'uranium, de sorte que ces matières sont confinées dans des installations spécialisées pourvues de doublures et de systèmes de collecte des eaux d'infiltration. Pendant les activités d'exploitation, les matières des zones de déchets spéciaux sont récupérées et mélangées au minerai à teneur élevée de McArthur River pour alimenter l'usine de concentration de Key Lake. Toutes les autres zones de stériles sont inactives.

De façon à diminuer les obligations en matière de déclassement associées à l'amas de stériles Deilmann North, environ 1,3 million de mètres cubes de stériles riches en nickel ont été excavés et placés dans la fosse Gaertner en 1998. En outre, 300 000 m^3 supplémentaires ont été traités et utilisés pour le projet de stabilisation du mur ouest de l'installation de gestion de déchets Deilmann en 2013. De la même manière, en 2017, 57 320 m^3 de stériles riches en nickel ont été retirés de l'amas de stériles Gaertner et placés dans le banc sud de l'installation de gestion de déchets Deilmann.

RABBIT LAKE

Rabbit Lake est entrée dans une période indéfinie d'entretien et de surveillance, suspendant ses activités d'extraction et de concentration du minerai vers la moitié de 2016. Il y a des usines de concentration d'uranium et des installations de gestion des résidus (IGR) en exploitation à Rabbit Lake. Il existe également des zones de gestion des résidus qui ne sont pas en exploitation à Rabbit Lake.

Gestion des résidus

L'IGR de Rabbit Lake a une superficie d'environ 53 hectares et contient environ 6,5 millions de tonnes de résidus déposés entre 1975 et 1985. Ces résidus proviennent tous du traitement du gisement minéralisé initial de Rabbit Lake. Les résidus contenus dans l'IGR sont confinés par des digues de terre aux extrémités nord et sud et par des crêtes de substrat rocheux naturel le long des côtés est et ouest. L'IGR fait actuellement l'objet de travaux de stabilisation à long terme et de restauration progressive.

En 1986, la mine à ciel ouvert de Rabbit Lake a été convertie en IGR au moyen de la technique dite de ceinture perméable. Depuis son entrée en service, l'installation de gestion des résidus en fosse de Rabbit Lake sert de dépôt de résidus pour le minerai des mines de Rabbit Lake, de la zone B, de la zone D, de la zone A et d'Eagle Point (voir les figures 6.2 et 6.3). À la fin de 2019, cette installation de gestion des résidus contenait 9,13 millions de tonnes (poids sec) de résidus.

La ceinture perméable, qui est composée de sable et de roche concassée, est placée au fond et contre les parois de la fosse avant le dépôt des résidus. Cette matière perméable permet de drainer l'excès d'eau dans les résidus vers un système de collecte des eaux d'infiltration, de recueillir l'eau contenue dans la roche hôte environnante et de maintenir ainsi un gradient hydraulique vers l'installation pendant l'exploitation. L'eau recueillie est traitée avant son rejet dans l'environnement. Au moment du déclassement final et du retour à des conditions hydrogéologiques normales, les eaux souterraines

s'écouleront de préférence au travers de la ceinture perméable plutôt qu'au travers des résidus de faible perméabilité. Le rejet des contaminants se limitera à la diffusion au travers de l'interface résidus-ceinture perméable.

Gestion des stériles

Le site minier de Rabbit Lake comprend un certain nombre d'amas de stériles propres et minéralisés produits au cours de l'exploitation de différents gisements depuis 1974. Une partie des stériles a été utilisée comme matériau de construction. Par exemple, des stériles ont été utilisés pour construire la route et la ceinture perméable de l'installation de gestion des résidus en fosse de Rabbit Lake Les déchets spéciaux d'Eagle Point sont entassés sur une plateforme d'entreposage dotée d'un revêtement, jusqu'à leur retour sous terre comme remblai. Certains amas de stériles ont été utilisés comme remblai et matériau de couverture dans leurs fosses respectives. Un amas de stériles principalement composé de sédiments de Rabbit Lake a été nivelé et sa végétation a été rétablie.

Selon les prévisions actuelles, il ne restera pas de stériles en surface à Eagle Point lorsque les activités d'extraction et de remblayage dans les gradins épuisés auront pris fin. Les amas de stériles de la zone A (28 307 m³ de déchets propres) et de la zone D (200 000 m3 constitués principalement de sédiments de fond de lac) ont été aplanis et nivelés et leur végétation a été rétablie. L'amas de déchets de la zone B contient 5,6 millions de mètres cubes de déchets stockés en un amoncellement couvrant une superficie de 25 hectares. L'amas de la zone B a été nivelé et remis en état au moyen d'une couverture artificielle sur laquelle se trouve une couche de till de 1 m recouverte de végétation et il a été doté de voies de drainage afin de favoriser le contrôle du ruissellement. La totalité des déchets spéciaux des mines à ciel ouvert de la zone A (69 749 m³), de la zone B (100 000 m³) et de la zone D (131 000 m³) ont été replacés dans les fosses et recouverts de couches de stériles ou de till propre avant que les fosses épuisées ne soient inondées.

L'amas de stériles ouest nº 5 qui se trouve à proximité de l'installation de gestion des résidus en fosse de Rabbit Lake renferme 6,89 millions de mètres cubes de résidus principalement constitués de grès ainsi que d'une certaine quantité de résidus de socle rocheux et de tills superficiels. Les déchets minéralisés sont stockés dans quatre amas (630 000 m³) situés à proximité de l'usine de concentration de Rabbit Lake. Les eaux de ruissellement et d'infiltration provenant de ces zones sont recueillies par l'installation de gestion des déchets en fosse de Rabbit Lake.

MCCLEAN LAKE

Il y a des usines de concentration d'uranium et des IGR en exploitation à McClean Lake.

Gestion des résidus

McClean Lake est la seule usine de concentration d'uranium ayant été construite en Amérique du Nord au cours des 20 dernières années. L'usine de concentration et l'installation de gestion des résidus sont à la fine pointe des installations de traitement du minerai d'uranium à teneur élevée en ce qui a trait à la protection des travailleurs et de l'environnement. L'extraction à ciel ouvert du corps minéralisé initial (mine John Everett Bates ou JEB) a commencé en 1995. Une fois le minerai extrait et amassé, la fosse de la mine a été transformée en IGR (voir les figures 6.4 et 6.5). La conception de l'IGR a été optimisée en vue de son rendement, pendant l'exploitation et à long terme, au moyen de caractéristiques clés, par exemple :

- La production de résidus épaissis dans le processus de concentration (ajout de chaux, de chlorure de baryum et de sulfate ferrique) afin d'enlever les contaminants environnementaux qui pourraient être présents dans la solution et d'obtenir des résidus stables du point de vue géotechnique et géochimique;
- Le transport de résidus de l'usine de concentration à l'installation de gestion des résidus au moyen d'un système de confinement à conduites à double paroi faisant l'objet d'une surveillance continue;
- L'enfouissement final subaquatique des résidus dans la fosse JEB épuisée en vue d'un confinement à long terme sûr dans une installation souterraine;

- L’utilisation d’une ceinture naturelle comme approche optimale de déviation des eaux souterraines autour du bouchon de résidus consolidés;
- L’enfouissement des résidus épaissis sous une couverture d’eau dans la fosse (à partir d’une barge flottante); cette méthode minimise la ségrégation des matières fines et grossières, prévient le gel des résidus et améliore la protection radiologique grâce à l’atténuation des émissions de radon par la couverture d’eau;
- Un drain de fond filtrant lié à des puits d’assèchement et d’élévation pour permettre la collecte et le traitement de l’eau interstitielle provenant de la consolidation des résidus;
- Le recyclage de l’eau présente dans la fosse par une barge et un système de manutention à conduites à double paroi;
- Le remblayage complet de la fosse, à son déclassement, au moyen de stériles propres et d’une couverture de till.

À la fin de la période de référence (31 mars 2020), l’installation de gestion de résidus JEB contenait 2,244 millions de tonnes (poids sec) de résidus.

Gestion des stériles

L’extraction à ciel ouvert à McClean Lake a été réalisée par fosses successives, incluant les fosses JEB, Sue A, Sue B, Sue C et Sue E (voir les figures 6.6 et 6.7). L’exploitation minière de la fosse Sue B a pris fin le 26 novembre 2008. Depuis la fermeture de Sue B, il n’y a plus d’exploitation à ciel ouvert à McClean Lake.

La majeure partie des déchets retirés des fosses à ciel ouvert JEB et Sue C consistaient en du mort-terrain ou du grès. Les monticules de mort-terrain et de stériles propres sont situés près des fosses. Le mort-terrain a servi à construire la plateforme de l’amas de stériles. Les déchets spéciaux provenant de l’exploitation des fosses Sue C et JEB ont été enfouis dans la fosse Sue C une fois l’extraction minière terminée.

Tous les déchets (à l’exclusion du mort-terrain) de la fosse Sue A ont également été déposés dans la fosse Sue C épuisée. L’approche prudente a été adoptée en raison de l’incertitude quant à la ségrégation des déchets spéciaux en fonction de leur teneur en arsenic. Les stériles sont séparés en déchets propres et en déchets spéciaux en fonction de leur potentiel de génération d’acide (au moyen d’un test de laboratoire simple), de leur contenu radiologique (au moyen d’un scanneur de minerai) et de leur teneur en arsenic, un contaminant non radiologique prépondérant (au moyen d’un spectromètre de fluorescence X qui a été mis à l’essai avec succès pendant l’exploitation de la fosse Sue A, puis intégré à la procédure de séparation). Les déchets spéciaux de Sue E ont également été placés dans la fosse Sue C épuisée, tandis que les déchets propres ont été accumulés dans un amas de stériles distinct de la fosse Sue E.

Toute la matière enlevée de la fosse Sue B a été catégorisée comme des déchets spéciaux et placée dans la fosse Sue E épuisée à une altitude inférieure à 400 mètres au-dessus du niveau de la mer. Au 31 décembre 2019, l’inventaire total de stériles à McClean Lake atteignait 51,2 millions de tonnes de matières propres (principalement des stériles) et 10,2 millions de tonnes de stériles minéralisés (déchets spéciaux).

CIGAR LAKE

Gestion des résidus

Cigar Lake ne dispose pas d’usine de concentration et ne produit pas de résidus. Le minerai qui y est extrait est traité à l’usine de concentration de McClean Lake et les résidus produits sont déposés dans l’installation de gestion de résidus JEB. L’extraction minière de l’uranium a été suspendue à Cigar Lake en mars 2020.

Gestion des stériles

À l'établissement de Cigar Lake, il y a quatre amas de stériles (l'amas A de stériles propres; l'amas A1 de béton et stériles bénins; l'amas B de déchets contaminés de faible teneur, y compris le bois, le métal et la roche; et l'amas C de stériles potentiellement réactifs à l'acide). Les stocks actuels découlent de l'aménagement minier et de l'exploitation du site. Les stériles sont classés comme des stériles propres ou bénins, des stériles potentiellement acidogènes ou des stériles minéralisés. Ces deux derniers types de stériles (amas B et C) sont entreposés temporairement sur des plateformes avec confinement à revêtement technique. Le lixiviat de ces zones est confiné et recueilli aux fins de traitement dans l'installation de traitement des eaux de la mine. Lorsque c'est possible, les stériles propres ou bénins sont utilisés comme remblai ou matériau de construction sur le site. Certains déchets de roche potentiellement réactifs à l'acide peuvent être utilisés comme remblai dans la mine, mais il est prévu que la majorité de cette matière sera transportée au site minier de McClean Lake en vue d'une évacuation dans une fosse épuisée. À la fin de 2019, l'amas B contenait 2 373 m^3 de stériles et l'amas C en contenait 378 541 m^3. Tous les stériles potentiellement acidogènes (amas C restant) seront transportés et stockés définitivement à McClean Lake dans un dépôt en fosse ouvragé. Aucun stérile minéralisé, potentiellement acidogène ou autres déchets contaminés ou minéralisés ne demeureront en surface une fois le déclassement terminé.

MCARTHUR RIVER

Gestion des résidus

McArthur River ne dispose pas d'une usine de concentration et ne produit pas de résidus. Pendant les activités d'exploitation, le minerai de McArthur River est traité à l'usine de concentration de Key Lake. La production à la mine de McArthur River et à l'usine de concentration de Key Lake a été suspendue pour une période indéterminée et les deux installations sont en mode d'entretien et surveillance depuis janvier 2018.

Gestion des stériles

Les activités d'exploitation, d'aménagement et de forage exploratoire à l'établissement de McArthur River génèrent des stériles, qui sont classés en tant que stériles propres, stériles potentiellement acidogènes ou stériles minéralisés. Ces deux derniers types de stériles sont entreposés temporairement sur des plateformes avec confinement à revêtement technique. Les produits de lixiviation issus de ces plateformes sont confinés et pompés jusqu'aux installations de traitement des effluents. Les stériles propres sont stockés dans un amas qui n'est pas doté de systèmes de confinement et de contrôle des produits de lixiviation.

Les stériles minéralisés sont expédiés à l'établissement de Key Lake et utilisés comme matériau de mélange pour le minerai qui alimente l'usine de concentration de Key Lake. Les déchets potentiellement acidogènes sont concassés et triés, et les matières grossières sont utilisées comme granulat pour le béton servant au remblayage souterrain. Les stériles propres servent à l'entretien général des routes du site et du chemin de service entre McArthur River et Key Lake.

Annexe D : Résumé des modifications apportées à l’ébauche (août 2022) pour obtenir la version finale (juin 2023) de la SIDR

La SGDN a publié une ébauche de stratégie intégrée en août 2022. Celle-ci a été mise à la disposition du public pour une période de commentaires de 90 jours, et les recommandations ont également été soumises à l’examen du public sur le site Web plandechetsradioactifs du projet de SIDR[36]. Dans le cadre du processus de commentaires publics, la SGDN a également fait réaliser un suivi auprès de certains des jeunes qui avaient précédemment participé au processus de concertation afin qu’ils examinent les recommandations. En tout, 29 commentaires publiés sur le site Web et 33 mémoires officiels ont été reçus de membres du public, de collectivités autochtones, de l’industrie, d’une organisation de la société civile, d’administrations municipales, d’organismes provinciaux et fédéraux et d’universitaires au cours de la période de consultation publique. De plus, deux autres mémoires portant sur l’ébauche de la SIDR ont été transmises par des collectivités autochtones après la fin de la période de consultation publique. Les commentaires du public transmis sur le site Web ainsi que les mémoires officiels ont permis de finaliser la stratégie intégrée. De plus, cette stratégie intégrée s’est appuyée sur un dialogue mené en continu avec les peuples autochtones, dialogue plus poussé que celui mené avec le public canadien et les parties prenantes. Enfin, la publication de la Politique en mars 2023 a fourni des données essentielles pour orienter la stratégie intégrée.

Un résumé des modifications substantielles apportées à l’ébauche de la SIDR pour obtenir cette stratégie intégrée finale est fourni ci-dessous. Les modifications qui n’avaient pour but que d’apporter plus de clarté ou de précision ne sont pas incluses.

Tableau 13 : Résumé des modifications

Recommandation ou principe de mise en oeuvre dans la SIDR finale	Recommandation dans l'ébauche de la SIDR	Justification de la modification
Recommandation 1 : Stocker les déchets de moyenne activité et les déchets de haute activité autres que le combustible dans un dépôt géologique en profondeur, dont la mise en oeuvre serait assurée par la SGDN	Intention inchangée – nouvelle numérotation. Recommandation 2 : Les déchets de moyenne activité devraient être stockés dans un seul dépôt géologique en profondeur dont la mise en oeuvre serait confiée à une seule organisation, la SGDN.	Réorganisation de la numérotation pour l'aligner sur la classification des déchets de haute et de basse activité. Définit clairement la faible quantité de déchets de haute activité autres que le combustible qui sont visés par la recommandation. Des informations sur le processus de sélection d'un site ont été ajoutées afin de fournir un contexte pour les prochaines étapes et de garder plus de cohérence avec la Politique.
Recommandation 2 : Stocker les déchets de faible activité au sein de plusieurs installations près de la surface, dont la mise en oeuvre serait assurée par les propriétaires des déchets	Intention inchangée – nouvelle numérotation. Recommandation 1 : Les déchets de faible activité devraient être stockés dans plusieurs installations près de la surface, la mise en oeuvre étant confiée aux propriétaires des déchets.	Réorganisation de la numérotation pour l'aligner sur la classification des déchets de haute à faible activité.
S/O	Recommandation 3 : Une tierce partie, indépendante des organismes chargés de la mise en oeuvre, devrait superviser la mise en oeuvre de la stratégie.	La recommandation 3 a été supprimée parce que la question est traitée dans la Politique (article 2.1), qui stipule que le gouvernement fédéral a comme responsabilité de superviser l'élaboration, la tenue à jour et la mise en oeuvre, par les producteurs et les propriétaires de déchets, d'une stratégie intégrée pour les déchets radioactifs du Canada afin de répondre aux plans à long terme de gestion des déchets, stratégie qui sera revue et actualisée au besoin sur demande du ministre des Ressources naturelles.
Principe de mise en oeuvre 1 : Le consentement des collectivités locales et des peuples autochtones sur le territoire desquels les futures installations seront planifiées devra être obtenu au cours du processus de sélection du site.	Intention inchangée. Recommandation 4 : Le consentement des collectivités et des peuples autochtones locaux dans le territoire desquels les installations futures seront planifiées doit être obtenu lors du processus de sélection de l'emplacement des installations.	Cette recommandation est traitée dans la Politique (article 3.4).
Principe de mise en oeuvre 2 :	Intention inchangée.	Cette recommandation est traitée dans la Politique, puisqu'elle donne la

Lors de la conception des installations, la protection de l'eau constituera une priorité absolue.	Recommandation 5 : Lors de la conception des installations, la priorité doit être accordée à la protection de l'eau.	priorité à l'environnement, qui englobe l'eau (article 1).
Principe de mise en oeuvre 3 : Les installations de stockage feront l'objet d'un suivi à long terme.	Intention inchangée. Recommandation 6 : Les installations de stockage doivent faire l'objet d'un suivi à long terme.	Cette recommandation est traitée dans la Politique (article 1.4).
Principe de mise en oeuvre 4 : Il est essentiel d'agir dès maintenant et de ne pas abandonner cette tâche aux générations futures.	Intention inchangée. Recommandation 7 : Nous devons agir maintenant et ne pas abandonner cette tâche aux générations futures.	Cette recommandation s'inscrit dans le cadre de la Politique (deuxième élément de la vision et article 2.1 (ii)).

Glossaire des termes et acronymes

Caverne rocheuse peu profonde : La méthode de stockage en caverne rocheuse peu profonde est parfois utilisée pour le stockage de déchets de faible activité ou pour les déchets de faible et moyenne activité. Une série de cavernes rocheuses sont excavées à une profondeur nominale de 50 à 100 mètres sous la surface dans une roche de faible perméabilité. On y accès depuis la surface par un petit système de rampes et de tunnels.

Déchet : Dans le contexte de ce rapport, le terme « déchet » désigne un déchet radioactif, sauf indication contraire (p. ex., « déchets non nucléaires »).

Déchets de faible activité : Les déchets radioactifs de faible activité sont produits par les réacteurs en exploitation et les utilisations médicales, universitaires, industrielles et commerciales de substances radioactives. Les déchets de faible activité contiennent des matières renfermant des radionucléides en quantités supérieures aux seuils de libération et d'exemption (tels que définis dans le Règlement sur les substances nucléaires et les appareils à rayonnement), mais ils sont généralement caractérisés par une quantité limitée de radionucléides à longue période. Les déchets de faible activité doivent être confinés et isolés pour des périodes pouvant atteindre quelques centaines d'années[37]. Une installation d'évacuation artificielle près de la surface convient généralement aux déchets de faible activité.

Déchets de haute activité : Les déchets radioactifs de haute activité (DHA) désignent principalement le combustible nucléaire irradié ou les déchets qui produisent beaucoup de chaleur par désintégration radioactive. Les déchets de haute activité sont associés à des rayonnements pénétrants qui nécessitent un blindage. Ils contiennent aussi d'importantes quantités de radionucléides à longue période radioactive, d'où la nécessité d'un isolement à long terme. Le stockage dans des formations géologiques profondes et stables, à des profondeurs de plusieurs centaines de mètres ou plus sous la surface, est recommandé pour la gestion à long terme des déchets de haute activité.

Déchets de moyenne activité : Les déchets radioactifs de moyenne activité sont principalement générés par les centrales nucléaires et les réacteurs prototypes et de recherche, les installations d'essai ainsi que les fabricants et les utilisateurs de radioisotopes. Les déchets de moyenne activité contiennent habituellement des radionucléides à longue période radioactive qui doivent être isolés et confinés pendant plus de quelques centaines d'années. Les déchets de moyenne activité ne nécessitent aucune disposition particulière ou alors, des dispositions limitées, pour la dissipation de la chaleur pendant leur stockage et leur évacuation. En raison de leur contenu en radionucléides à longue période, les déchets de moyenne activité exigent généralement un degré de confinement et d'isolement plus important que celui pouvant être assuré par les dépôts près de la surface. Les déchets de cette catégorie peuvent devoir être enfouis à de plus grandes profondeurs intermédiaires allant de quelques dizaines à quelques centaines de mètres, voire plus.

Dépôt géologique en profondeur : Un dépôt géologique en profondeur consiste généralement en un réseau de tunnels et de salles de stockage de déchets radioactifs construit à plusieurs centaines de mètres sous la surface du sol. De par leur conception, les dépôts utilisent un système à barrières multiples : des barrières ouvragées, comme les conteneurs de déchets, et des barrières naturelles, comme la roche elle-même, se conjuguent pour confiner les déchets et les isoler des personnes et de l'environnement.

Enceinte de béton : L'enceinte de béton est un type d'installation de stockage près de la surface largement utilisé dans le monde pour stocker les déchets radioactifs de faible activité (déchets de faible activité). Une enceinte de béton a l'apparence d'une grande boîte en béton. Un dépôt de ce type comprendrait plusieurs de ces enceintes. Chaque enceinte aurait son propre système de drainage et un « système de recouvrement » composé de diverses couches de sol et d'une couche supérieure d'herbe ou d'autres plantes. Cette méthode de stockage peut être utilisée pour un large éventail de types de sols. Elles sont de conception modulaire, c'est-à-dire que d'autres enceintes peuvent être ajoutées pour augmenter la capacité du dépôt.

Forage profond : Le stockage en forage profond est une technologie émergente pour les déchets qui doivent être isolés pendant quelques centaines d'années. Il peut être approprié pour de faibles volumes de déchets de moyenne activité. Une série de forages étroits sont réalisés à une profondeur d'environ 500 à 1 000 mètres. On y descend des colis de déchets, créant ainsi une pile de déchets à grande profondeur dans le sol.

Gestion à long terme : La gestion à long terme des déchets nucléaires radioactifs par le biais de l'entreposage ou du stockage.

Intendance perpétuelle : L'intendance perpétuelle est une approche de gestion des matières radioactives pour lesquelles il n'existe pas à court terme de solution de stockage. Dans le cadre de la solution de l'intendance perpétuelle, les déchets radioactifs sont entreposés à la surface, où des mesures de contrôle humaines permettent de confiner, d'isoler, de surveiller et de sécuriser les déchets de manière sûre et indéfinie, c'est-à-dire en passant le relai de l'intendance d'une génération à la suivante, et à la suivante encore, et ainsi de suite indéfiniment (succession d'intendants). Ce concept présume que la technologie résoudra un jour le problème de la gestion à long terme des déchets, possiblement en les détruisant ou les neutralisant.

Matières en vrac : Matières de nature granulaire, comme de la terre, du béton démoli ou des déchets de construction/démolition.

Monticule ouvragé de confinement : Un monticule ouvragé de confinement est un type d'installation de stockage près de la surface où les colis de déchets sont placés sur une base étanche, puis recouverts d'épaisses couches de matériaux naturels tels que l'argile et la terre. Des couches de matériaux synthétiques comme du polyéthylène haute densité sont également incorporés pour empêcher que des rayonnements soient libérés dans l'environnement. Ce type d'installation comprend habituellement des systèmes de collecte et de traitement des eaux usées. Le monticule ouvragé de confinement convient généralement aux déchets de faible activité qui ne diminueront pas en volume et ne se comprimeront pas avec le temps.

Petits réacteurs modulaires : Les petits réacteurs modulaires sont des réacteurs avancés qui produisent jusqu'à 300 MW(e) d'électricité par module, soit moins que les réacteurs nucléaires actuels.

Propriétaire de déchets : Un propriétaire de déchets radioactifs est une organisation actuellement responsable de déchets radioactifs.

Producteur de déchets : Un producteur de déchets radioactifs est une organisation dont les activités génèrent des déchets radioactifs.

Radionucléide : Matière dont le noyau atomique est instable et qui se désintègre spontanément en produisant un rayonnement. Les noyaux se distinguent par leur masse et leur numéro atomique.

Stockage : L'entreposage des déchets radioactifs sans intention de récupération.

Acronymes

AACE	Association for the Advancement of Cost Engineering
ACN	Association canadienne de normalisation
CANDU	Canada Deuterium Uranium (réacteur canadien à uranium-deutérium)
CCSN	Commission canadienne de sûreté nucléaire
DFA	Déchets de faible activité
DGP	Dépôt géologique en profondeur
DHA	Déchets de haute activité
DMA	Déchets de moyenne activité
EACL	Énergie atomique du Canada limitée
GAP	Gestion adaptative progressive
HQ	Hydro-Québec
IRPH	Initiative de la région de Port Hope
ISPS	Installation de stockage près de la surface
LNC	Laboratoires nucléaires canadiens
NPD	Nuclear Power Demonstration
OPG	Ontario Power Generation
PRM	Petit réacteur modulaire
RNCan	Ressources naturelles Canada
S/O	Sans objet
SGDN	Société de gestion des déchets nucléaires
SIDR	Stratégie intégrée pour les déchets radioactifs
WR-1	Réacteur Whiteshell-1

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NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

(Mise à jour 2022)

Rapport de suivi sur les cycles de combustible avancés et les technologies de remplacement pour la gestion des déchets

La Société de gestion des déchets nucléaires (SGDN) a élaboré l'approche de la Gestion adaptative progressive (GAP) en nous appuyant sur une vaste étude et des activités de concertation menées de 2002 à 2005 auprès des Canadiens pour trouver une approche de gestion à long terme pour le combustible nucléaire irradié canadien. En considérant différentes méthodes de gestion à long terme du combustible nucléaire irradié, les Canadiens ont clairement établi leurs valeurs et priorités :

- La sûreté et la sécurité doivent constituer notre plus haute priorité;
- La génération actuelle doit assumer la responsabilité des déchets qu'elle a produits;
- Nous devons nous appuyer sur les meilleures pratiques internationales;
- Nous devons pouvoir offrir aux générations futures la latitude voulue pour qu'elles puissent prendre leurs propres décisions.

L'approche de la GAP est celle qui correspond le plus à ces valeurs et priorités. Le gouvernement du Canada en a fait le plan canadien en 2007. L'aboutissement technique de la GAP consistera à confiner et isoler de manière sûre le combustible nucléaire irradié au sein d'une formation géologique profonde. Ce concept est conforme aux politiques adoptées par tous les pays dotés de programmes d'énergie nucléaire importants – même ceux qui mettent en oeuvre ou qui préconisent actuellement diverses formes de recyclage prévoient construire des dépôts géologiques en profondeur pour gérer les déchets à vie longue qui en résulteront.

Au cours de l'étude nationale, les Canadiens avaient exprimé l'intérêt d'en savoir plus sur la possibilité de recycler ou de réutiliser le combustible nucléaire irradié et sur les solutions de rechange pour la gestion à long terme du combustible nucléaire irradié. Selon l'analyse réalisée par la SGDN, le retraitement du combustible irradié était très peu probable pour le Canada à l'époque. De plus, aucune méthode technique de remplacement n'avait été jugée préférable. Toutefois, la SGDN avait recommandé de maintenir un dossier de suivi de l'état de la technologie dans le monde et des changements qui pourraient se produire dans le cycle du combustible au Canada.

La SGDN maintient et publie régulièrement ce dossier de suivi depuis 2008. La présente édition de ce rapport de suivi décrit les plus récents travaux de recherche-développement survenus dans le monde relativement aux cycles de combustible avancés, ainsi que les derniers développements qui se sont produits concernant le concept de stockage en forages profonds. Les principales conclusions sont que :

- Les nouveaux cycles de combustible et le concept du forage à très grande profondeur continuent de susciter de l'intérêt dans le monde, mais il n'y a eu aucune percée technologique qui modifierait la précédente conclusion concernant l'approche de la GAP et la gestion de l'inventaire actuel de combustible nucléaire irradié canadien.
- L'exploitation de petits réacteurs modulaires (PRM) au Canada générera, en petites quantités, de nouveaux types de déchets de combustible nucléaire. Les répercussions de ces possibles nouveaux déchets sur le programme de la SGDN sont évaluées dans le cadre de son examen des technologies liées aux PRM.
- Les cycles de combustible avancés considérés jusqu'à maintenant produiront des déchets de combustible nucléaire à vie longue qui devront être gérés de manière sûre, socialement acceptable, techniquement rigoureuse, responsable sur le plan environnemental et économiquement viable par la SGDN.
- La SGDN continuera d'assurer un suivi des développements liés aux cycles de combustible avancés et aux méthodes techniques de remplacement qui pourraient avoir une incidence sur les exigences canadiennes futures en matière de gestion des déchets.

Introduction

La SGDN maintien un dossier de suivi sur les récents développements survenus dans le monde concernant les cycles de combustible avancés, y compris les technologies de retraitement et de recyclage, et sur les méthodes techniques de remplacement pour la gestion à long terme du combustible nucléaire irradié. Les rapports techniques détaillés précédents [Jackson, 2008-2010] et les résumés des rapports de suivi [p. ex., SGDN, 2021] peuvent être consultés sur le site Web de la SGDN.

En 2022, plusieurs pays et programmes de collaboration internationale ont poursuivi des travaux de recherche-développement pour évaluer la technologie et les conséquences de l'utilisation des cycles de combustible avancés, y compris les cycles fermés basés sur le retraitement, la séparation et la transmutation (RST) et les méthodes techniques de remplacement pour la gestion à long terme du combustible nucléaire irradié.

Cycles de combustible actuels

Il existe trois types de cycles du combustible nucléaire :

- Le cycle « ouvert », ou « à passage unique », où le combustible, qui est irradié dans le réacteur, est considéré comme un déchet au moment de son retrait.
- Le « recyclage partiel » ou le « cycle à deux passages », où le combustible irradié est réutilisé. Dans une version, le combustible irradié est retraité pour récupérer le plutonium, qui est converti en combustible d'oxyde mixte (Pu-U), ou MOX, et est utilisé une autre fois dans un type existant de réacteur (ce cycle est utilisé dans une certaine mesure en France). Dans une autre version, le combustible irradié d'un réacteur à eau légère (REL) est considéré comme étant converti en combustible pouvant être réutilisé dans un réacteur CANDU (la Chine prévoit utiliser ce cycle).
- Le cycle « fermé », ou « à recyclage complet », où le combustible irradié est retraité pour en récupérer les isotopes fissiles comme le plutonium et d'autres actinides, puis est utilisé dans des réacteurs avancés tels que les réacteurs à neutrons rapides (RNR). Le combustible irradié d'un RNR peut ensuite être

retraité et continuellement recyclé dans les RNR pour en extraire l'énergie restante. Selon le réacteur, des quantités supplémentaires d'uranium naturel ou appauvri ou de combustible irradié retraité peuvent être ajoutées pour remplacer le combustible consommé par le RNR.

D'autres variantes peuvent inclure diverses combinaisons de réacteurs thermiques conventionnels, de RNR et/ou de systèmes pilotés par accélérateur (SPA).

Les réacteurs nucléaires commerciaux actuellement exploités dans le monde sont en majorité basés sur les neutrons thermiques (« de faible énergie »). Ces réacteurs utilisent une substance modératrice pour ralentir les neutrons de haute énergie produits par les réactions de fission – les modérateurs sont habituellement de l'eau normale, ou légère (comme dans la plupart des réacteurs autres que CANDU), de l'eau lourde (les réacteurs CANDU) ou du graphite (les réacteurs refroidis au gaz). Les combustibles utilisés dans ces réacteurs contiennent soit de l'uranium naturel (0,7 pour cent d'U-235 et 99,3 pour cent d'U-238), comme dans les réacteurs CANDU par exemple, ou de l'uranium à plus forte concentration d'U-235 fissile (généralement de 3 à 5 pour cent). Le procédé employé pour obtenir cette concentration plus élevée d'U-235 est appelé « enrichissement ». L'exploitation des types de réacteurs actuels requiert un approvisionnement continu en uranium d'extraction comme source d'U-235. Un sous-produit de ce processus d'enrichissement est l'uranium appauvri, qui contient moins d'U-235, soit approximativement 0,3 pour cent, et est aujourd'hui généralement considéré comme un déchet par les pays qui exploitent des installations d'enrichissement. Toutefois, l'uranium appauvri issu du processus d'enrichissement constitue une source potentielle de combustible pour certains cycles de combustible avancés.

Un cycle de combustible fermé doit comprendre un RNR pour que le combustible soit utilisé de manière efficace. Les RNR n'utilisent pas de modérateur et leur technologie est plus complexe. Le tableau 1 énumère les RNR électrogènes actuellement exploités ou projetés. Ils peuvent extraire de l'énergie de l'U-238 ainsi que d'autres actinides (plutonium, américium, neptunium, etc.). Dans le cas de l'U-238, cela s'effectue en convertissant premièrement l'U-238 en Pu-239 par le biais de la capture neutronique et de la désintégration radioactive subséquente, puis en provoquant la fission du Pu-239 par un autre neutron. À mesure que l'U-238 est consommé, on peut ajouter de l'uranium ou d'autres actinides issus du retraitement du combustible d'un réacteur thermique, ou de l'uranium appauvri résultant des processus d'enrichissement. L'uranium appauvri est largement disponible, son taux de radioactivité spécifique est faible et il peut être manipulé plus facilement, alors que l'uranium retraité et d'autres actinides tendent à être très radioactifs.

Tableau 1 : Réacteurs à neutrons rapides actuellement en exploitation ou en construction pour la production d'électricité

Pays	Installation	Puissance (MWe)	État
Fédération de Russie	BN-600 BN-800	600 880	En exploitation depuis 1980 – type à cuve de sodium En exploitation depuis 2016 – type à cuve de sodium
Inde	Prototype de réacteur surgénérateur (PFBR)	500	En construction – type à cuve de sodium
Chine	CFR-600	2 x 600	En construction – type à cuve de sodium

Le Canada, comme la plupart des pays qui exploitent l'énergie nucléaire, utilise actuellement le cycle de combustible ouvert. Comme le montre le tableau 2, quelques pays, notamment la France, la fédération de Russie et l'Inde, retraitent une partie de leur combustible et utilisent une portion du combustible MOX résiduel dans un cycle de combustible à recyclage partiel ou l'accumulent en vue de le recycler dans d'éventuels réacteurs de types encore indéterminés. Certains pays ont retraité une partie de leur combustible dans le passé, mais ne le font plus; leur combustible retraité est traité comme un déchet. Le tableau 3 résume la capacité mondiale de retraitement du combustible commercial, qui ne comprend pas le combustible des installations plus petites et déjà fermées et celui des installations utilisées uniquement à des fins militaires. Il contient également des informations sur les stratégies de gestion du cycle du combustible nucléaire pour les pays utilisant du combustible CANDU.

Tableau 2 : Résumé de la situation actuelle concernant le retraitement pour le cycle du combustible nucléaire

Pays	Installation commerciale de retraitement		Combustible irradié actuellement retraité dans un autre pays	Une certaine quantité de combustible irradié recyclée dans le passé	Prévoit le stockage direct du combustible irradié dans un dépôt
	Existante	Prévue			
Allemagne				✓	✓
Belgique				✓	✓
Bulgarie			✓	✓ (7)	
Canada					✓
Chine(3)		✓			✓ (4)
Espagne				✓	✓
États-Unis(3)				✓	✓
Fédération de Russie	✓	✓			
Finlande				✓ (7)	✓
France(3)	✓ (2)				
Hongrie				✓ (7)	✓
Inde(3)	✓	✓			
Italie			✓		
Japon		✓ (6)	✓		
Mexique					✓
Pakistan(3)					
Pays-Bas			✓ (5)		
Rép. de Corée					✓
République tchèque				✓ (7)	✓
Roumanie					✓
Royaume-Uni(1)				✓	✓
Slovaquie				✓ (7)	✓
Slovénie					✓
Suède				✓	✓
Suisse				✓	✓
Ukraine				✓ (7)	✓

(1) Le Royaume-Uni a totalement cessé de retraiter du combustible en juillet 2022.

(2) La France a fourni des services de retraitement commercial à quelques pays européens et asiatiques.

(3) La Chine, la France, le Royaume-Uni, la fédération de Russie, les États-Unis, le Pakistan et l'Inde pratiquent actuellement ou ont pratiqué dans le passé le retraitement pour des motifs militaires et aux fins des centrales nucléaires.

(4) La Chine prévoit stocker directement son combustible irradié de type CANDU dans un dépôt. Elle prévoit réutiliser une partie de son combustible de REL dans ses réacteurs CANDU.

(5) Combustible irradié envoyé en France pour y être retraité. Le contrat a été prolongé en 2015 pour couvrir la durée de vie des réacteurs actuels.

(6) Installation d'échelle commerciale construite à Rokkasho-mura et en cours d'essai final de mise en service.

(7) Une partie du combustible irradié a été envoyée dans l'ancienne Union soviétique pour y être retraitée. Cette pratique a cessé au début des années 1990.

Tableau 3 : Résumé de la capacité mondiale actuelle de retraitement des combustibles commerciaux

Pays	Installation	Capacité (tonnes par année)	État
Chine	Gansu	200	En construction (achèvement prévu vers 2025)
France	UP1, Marcoule UP2-400, La Hague UP2-800, La Hague UP3, La Hague	600 400 800 800	Fermée/en déclassement Fermée/en déclassement En exploitation En exploitation
Inde	Tarapur Kalpakkam	100 100	En exploitation En exploitation
Japon	Tokai Rokkasho	90 800	Fermée/en déclassement En cours de mise en service (démarrage prévu vers 2024)
Fédération de Russie	RT-1, Mayak MCC-PDC RT-2, Zheleznogorsk	400 250 700	En exploitation (fermeture prévue vers 2030) En construction En construction (achèvement prévu vers 2025)
Royaume-Uni	MAGNOX, Sellafield THORP, Sellafield	1,500 900	Fermée en 2022 Fermée en 2018
États-Unis	West Valley	300	Exploitée de 1966 à 1972, déclassée

Cycles de combustible avancés

Les principaux cycles de combustible avancés qui revêtent un intérêt sont les combustibles fermés (bien que des cycles à recyclage partiel soient actuellement utilisés de manière limitée). Ces cycles de combustible avancés ont un intérêt parce qu'ils utilisent le combustible d'uranium de manière très efficace. En particulier, certains cycles de combustible avancés sont théoriquement presque auto-soutenables lorsque l'équilibre est atteint.

Réduire le besoin en uranium d'extraction est le principal avantage. Pour le Canada, qui dispose d'importantes ressources d'uranium, cela réduirait l'impact environnemental de l'exploitation minière en utilisant de manière efficiente l'uranium d'extraction.

Un second avantage potentiel serait de réduire la « radiotoxicité » des déchets. Cela pourrait être réalisé en retraitant le combustible et en recyclant une partie, voire la plus grande partie des actinides, c.-à-d. l'uranium et les transuraniens, dans un RNR. Les actinides sont généralement à vie longue; les consommer dans un RNR réduit donc la charge radioactive imposée au dépôt qui sera requis pour gérer les déchets à vie longue restantes.

Le troisième avantage est de réduire la taille requise du dépôt, étant donné que le volume de déchets à stocker est plus faible, ou, semblablement, de permettre au dépôt de desservir un plus grand parc de centrales nucléaires. L'uranium constitue la majeure partie du combustible irradié. Le séparer et le réutiliser en diminue donc le volume.

Toutefois, les cycles de combustible avancés posent des problèmes d'ordre scientifique et technique, tels que la mise au point des matériaux spécialisés nécessaires et la mise à échelle des prototypes expérimentaux pour produire des réacteurs pleine grandeur. Des défis économiques et sociopolitiques se posent également, y compris en ce qui a trait aux coûts liés à la construction et à la sélection d'un site pour les installations, ainsi

qu'aux mesures qui doivent être prises pour empêcher la prolifération. La réalisation des avantages repose sur l'hypothèse que l'énergie nucléaire continuera de représenter une bonne solution économique pour le pays en question.

Sur le plan de la taille du dépôt, recycler le combustible irradié dans des RNR peut réduire le volume de déchets de haute activité produits par mégawatt d'électricité généré. Cela peut diminuer la quantité de roche à excaver par mégawatt pour construire le dépôt, mais ne réduira pas nécessairement de manière substantielle l'empreinte totale du dépôt. La raison en est que l'empreinte est déterminée par la charge thermique totale des déchets et non pas par leur volume total ou leur volume par mégawatt généré. La charge thermique des déchets correspond principalement à la quantité d'énergie qui a été produite, quel que soit le cycle de combustible employé. Pour une réduction substantielle de l'empreinte d'un dépôt, il faudrait également séparer les produits de fission à vie plus courte et stocker préalablement les déchets en surface pendant une longue période pour laisser suffisamment décroître les radionucléides qui dégagent de la chaleur. Même dans ce cas, la diminution de l'espace de stockage requis pour les déchets de haute activité peut être neutralisée par l'augmentation de la quantité de déchets de moyenne activité à vie longue générés par ces cycles de combustible [RED-IMPACT, 2008].

De plus, la réduction des actinides ne supprime pas la nécessité d'un stockage à long terme, puisqu'il faut tout de même confiner les actinides résiduels et les produits de fission à vie longue. Bien qu'une diminution des actinides à vie longue diminue la « radiotoxicité » des déchets, ce qui est nettement avantageux, cela n'améliore pas substantiellement la sûreté globale d'un dépôt parce que les éléments actinides ont une très faible mobilité dans l'environnement d'un dépôt. Ce sont les produits de fission à vie longue, comme l'I-129, qui sont les radionucléides qui déterminent généralement la sûreté à long terme d'un dépôt [Kessler et coll., 2012; Sandia, 2012a; Posiva, 2021; EASAC, 2014; SGDN, 2017, 2018]. Ces produits de fission à vie longue ne sont généralement pas réduits dans les cycles de combustible avancés. De plus, recycler le combustible pour produire davantage d'électricité aboutit au total à une plus grande quantité de produits de fission, qui correspond approximativement à la quantité totale d'électricité produite, quel que soit le cycle de combustible employé.

Quoi qu'il en soit, la mise en oeuvre complète d'un cycle de combustible fermé nécessite le déploiement à l'échelle commerciale de réacteurs avancés comme des RNR, ainsi que l'infrastructure associée, par exemple des usines de retraitement et des installations de fabrication du combustible. Bien que les RNR existent depuis les années 50, ils ne sont pas encore largement acceptés et déployés commercialement (voir le tableau 1). Voir par exemple [AIEA, 2012, 2013, 2022d] pour une description de divers prototypes de RNR et pour un historique de leur exploitation.

Ces facteurs ont été abordés dans divers examens nationaux, qui ont continué de confirmer la nécessité d'un dépôt géologique en profondeur pour le stockage du combustible nucléaire irradié ou des déchets de haute activité. En particulier :

- Un examen exhaustif des options possibles de gestion du combustible irradié mené en 2013 pour la Corée stipule ceci : « … il n'y a aucun motif de considérer la séparation et la transmutation comme une option de rechange à l'évacuation géologique directe, aucune donnée ne permet de penser que les systèmes de séparation et de transmutation conventionnels pourraient, même s'ils pouvaient être mis en oeuvre, éliminer la nécessité de recourir à l'évacuation géologique en profondeur ou même rendre l'évacuation substantiellement plus facile ou plus sûre » [MIIS, 2013].
- La Commission royale australienne sur le cycle de combustible nucléaire a déclaré que « selon le consensus international, le stockage géologique en profondeur est la meilleure solution disponible pour la gestion à long terme du combustible irradié » [Gouvernement de l'Australie du Sud, 2016].

- L'Agence pour l'énergie nucléaire (AEN) a déclaré dans sa note d'orientation sur le stockage des déchets radioactifs publiée en juin 2020 (Policy Brief on the disposal of radioactive waste) qu'« il y a un solide consensus scientifique international voulant que la solution du dépôt géologique en profondeur (DGP) constitue une approche sûre et efficace pour le stockage permanent des déchets de haute activité et du combustible nucléaire irradié » [AEN/OCDE, 2020a].
- Une étude menée récemment aux États-Unis par les National Academies of Sciences, Engineering and Medicine sur les avantages et la viabilité de différents cycles de combustible nucléaire à base de réacteurs avancés a conclu ceci : « Chose importante, les réacteurs avancés et les cycles de combustible associés n'élimineraient pas la nécessité de recourir à un dépôt géologique pour certains déchets radioactifs, puisque même les réacteurs avancés nécessiteront le stockage de produits de fission radioactifs » [NASEM, 2022].

Le point sur les technologies liées aux cycles de combustible avancés

Les cycles de combustible avancés continuent de susciter de l'intérêt, et des progrès ont été réalisés à leur égard sur le plan scientifique et technologique. Les constats les plus récents ont été présentés en 2022 lors de diverses conférences internationales et réunions techniques tenues en personne et virtuellement, notamment :

- Le 11e Sommet international sur les PRM et les réacteurs avancés de 2022 (mai 2022, Atlanta, États-Unis) [Reuters Events, 2022];
- La Conférence internationale GLOBAL 2022 sur le cycle du combustible nucléaire, les nouvelles perspectives nucléaires relatives à la crise de l'approvisionnement énergétique et l'urgence climatique (juillet 2022, Reims, France) [SFEN, 2022];
- La 29e Conférence internationale sur le génie nucléaire, ICONE29 (août 2022, Shenzhen, Chine) [ICONE, 2022];
- Le Symposium de la World Nuclear Association (septembre 2022, Londres, Royaume-Uni) [WNA, 2022a];
- TopFuel 2022 (octobre 2022, Raleigh, États-Unis) [ANS, 2022];
- Le Forum international GEN IV (octobre 2022, Toronto, Canada) [GIF, 2022a];
- La 4e Conférence internationale de la Société nucléaire canadienne sur les réacteurs de IVe génération et les petits réacteurs (G4SR-4) (octobre 2022, Toronto, Canada) [SNC, 2022];
- Le Symposium de la Materials Research Society, EN08-Fondements scientifiques de la gestion des déchets nucléaires (novembre et décembre 2022, Boston, États-Unis) [MRS, 2022].

La SGDN assure un suivi des présentations données à l'occasion de ces conférences ainsi que des rapports techniques publiés par l'Agence pour l'énergie nucléaire de l'Organisation de coopération et de développement économiques (AEN/OCDE) [p. ex., AEN/OCDE, 2011-2021c], l'Agence internationale de l'énergie atomique [p. ex., AIEA, 2012-2022e], le Commissariat à l'énergie atomique et aux énergies alternatives (CEA, France) [p. ex., CEA, 2015], la Nuclear Regulatory Commission des États-Unis [U.S. NRC, 2012], l'Electric Power Research Institute [p. ex., EPRI, 2015-2021], l'agence Radioactive Waste Management du Royaume-Uni [RWM, 2017] et divers projets de collaboration internationale (comme les projets European Sustainable Nuclear Energy Technology Platform [SNETP, 2012-2021], Advanced Fuels for Generation IV Reactors: Reprocessing and Dissolution [ASGARD, 2016] et GEN IV Integrated Oxide Fuels Recycling Strategies [GENIORS, 2020]).

Le personnel de la SGDN a également préparé des rapports techniques et des exposés de conférences connexes décrivant les incidences potentielles des cycles de combustible avancés sur les inventaires canadiens de combustible irradié et les besoins de gestion à long terme qui en découlent [SGDN, 2015a,b; Ion, 2016; Gobien, 2016].

Le point sur les réacteurs avancés

Les cycles de combustible avancés sont généralement examinés en fonction de la conception particulière de réacteur considéré, puisque la solution du retraitement est étroitement reliée à la conception du réacteur utilisé ou envisagé.

Les conceptions de réacteurs avancés peuvent être globalement considérées comme des conceptions de 3e génération avancée (GEN-III+) ou de 4e génération (GEN-IV), alors que les réacteurs commerciaux actuellement en construction sont considérés comme des conceptions de 3e génération. Un projet de collaboration internationale sur les réacteurs de 4e génération examine actuellement plusieurs conceptions de types thermiques et RNR [GIF, 2022b] [AIEA, 2019, 2022d, 2022e]. Ces conceptions de réacteurs avancés fonctionnent habituellement à des températures très élevées (généralement à une température de 400 °C ou plus) et utilisent des métaux liquides (p. ex., le sodium ou le plomb), des sels en fusion (tels que des mélanges à base de fluorure ou de chlorure) ou des gaz (l'hélium) comme réfrigérants plutôt que l'eau légère ou de l'eau lourde.

Par ailleurs, les PRM ont également suscité beaucoup d'intérêt à l'échelle internationale. Ces réacteurs ont une puissance de sortie moins élevée, ce qui leur permet d'être d'une construction plus modulaire, à plus bas prix et peuvent être utilisés à davantage d'endroits que les réacteurs plus conventionnels d'une puissance de 1000 MWe. Les conceptions de PRM regroupent des versions réduites de réacteurs thermiques conventionnels ainsi que des RNR.

Bien qu'un grand nombre de conceptions de PRM aient été proposées dans le monde [AIEA, 2022d], celles qui sont décrites dans le tableau 4 sont actuellement considérées au Canada et en sont à différentes étapes du processus d'examen de la conception du fournisseur de la Commission canadienne de sûreté nucléaire (CCSN). Outre les PRM figurant au tableau 4, deux fournisseurs (Westinghouse Electric Company, LLC et StarCore Nuclear) ont également demandé à la CCSN de conclure des ententes de service afin d'évaluer leurs concepts (coeur solide et tuyaux caloriporteurs pour le microréacteur eVinci, et gaz haute température pour le module StarCore, respectivement) [CCSN, 2022].

En 2020, le gouvernement du Canada a lancé un Plan d'action canadien pour les PRM, qui décrit le plan de développement, de démonstration et de déploiement des PRM pour diverses applications [Plan d'action pour les PRM, 2020]. Un protocole d'entente a été conclu en 2019 entre les gouvernements de l'Ontario, de la Saskatchewan et du Nouveau-Brunswick relativement à une collaboration au développement des PRM et à leur déploiement dans ces provinces. L'Alberta a signé le protocole d'entente en 2021.

Un certain nombre de sociétés d'électricité ont exprimé le souhait de soutenir le développement de technologies de PRM. Un rapport de faisabilité, préparé par Ontario Power Generation (OPG), Bruce Power, Énergie NB et SaskPower, a été publié en 2021, a fourni une évaluation de la faisabilité du développement et du déploiement des PRM dans chacune des trois provinces [OPG, Bruce Power, Énergie NB et SaskPower, 2021].

OPG a repris en 2020 ses activités de planification sur le site de Darlington en vue d'accueillir un PRM de taille compatible avec son réseau [OPG, 2020]. En décembre 2021, OPG a annoncé qu'elle collaborerait avec GE Hitachi Nuclear Energy pour déployer un PRM BWRX-300 sur le nouveau site nucléaire de Darlington, qui est le seul site actuellement autorisé au Canada pour la construction de nouveaux réacteurs nucléaires [OPG, 2021]. OPG a l'intention de commencer les activités non nucléaires de préparation du site pour un PRM à Darlington d'ici la fin de 2022 et a soumis en octobre 2022 une demande à la CCSN pour le permis de construction [OPG, 2022].

Tableau 4 : PRM en cours d'évaluation au Canada

Réacteur	Fournisseur	Combustible/ réfrigérant	Type	État d'avancement de l'examen de la conception du fournisseur de la CCSN [CCSN, 2022]
ARC-100	ARC Nuclear Canada Inc.	Métal/sodium liquide	Réacteur à neutrons rapides	Phase 1 terminée Phase 2 en cours
MMR-5, MMR-10	Ultra Safe Nuclear Corporation	Oxyde enrobé, dans une pastille de SiC/hélium	Réacteur thermique	Phase 1 terminée Phase 2 en cours Global First Power a présenté une demande de permis de préparation d'un emplacement
SSR	Moltex Energy	Sel en fusion/sel en fusion	Réacteur à neutrons rapides	Phase 1 terminée
IMSR	Terrestrial Energy Inc.	Sel en fusion/sel en fusion	Réacteur thermique	Phase 1 terminée Phase 2 en cours
Xe-100	X-energy, LLC	Oxyde enrobé, dans une bille de graphite/hélium	Réacteur thermique	Phase 2 en cours
BWRX-300	GE-Hitachi Nuclear Energy	UO_2/eau légère	Réacteur thermique	Phase 2 en cours Le BWRX-300 a été choisi par OPG pour être déployé sur le site de Darlington
SMR-160	SMR, LLC (filiale de Holtec International)	UO_2/eau légère	Réacteur thermique	Phase 1 terminée
NuScale	NuScale Power, LLC	UO_2/eau légère	Réacteur thermique	Phase 2 en cours

En 2019, Global First Power, Ultra Safe Nuclear Corporation et OPG ont formé une coentreprise pour posséder et exploiter le projet de microréacteur modulaire à Chalk River [GFP, 2020a]. Global First Power a présenté à la CCSN une demande initiale de permis de préparation de l'emplacement, et l'examen réglementaire est en cours [GFP, 2019a, 2019b]. En 2022, l'Université McMaster et les sociétés Ultra Safe Nuclear Corporation et Global First Power ont formé un partenariat et signé un protocole d'accord pour étudier la possibilité de déployer un microréacteur modulaire à l'Université McMaster ou sur un site affilié [USNC, 2022].

Énergie Nouveau-Brunswick collabore avec Moltex Energy et Advanced Reactor Concepts (ARC) Clean Energy Canada pour mettre au point et démontrer une grappe de recherche sur l'énergie nucléaire axée sur un PRM avancé [Énergie NB, 2019].

SaskPower a sélectionné en juin 2022 le réacteur nucléaire BWRX-300 de GE Hitachi pour un déploiement éventuel dans la province [SaskPower, 2022a]. En septembre 2022, SaskPower a identifié deux régions en Saskatchewan en vue d'une étude plus approfondie pour évaluer la possibilité d'accueillir un PRM [SaskPower, 2022b].

Bruce Power et Westinghouse ont annoncé la conclusion d'une entente visant à poursuivre les applications du programme de microréacteur eVinci[MC] proposé par Westinghouse au Canada [Bruce Power, 2020]. Bruce Power s'est également engagée à développer la technologie des PRM, notamment en signant des protocoles d'entente avec MIRARCO Mining Innovation et l'Université Laurentienne [Bruce Power, 2018a], ainsi qu'avec NuScale Power [Bruce Power, 2018b].

Les Laboratoires nucléaires canadiens (LNC) cherche à établir des partenariats avec des promoteurs de technologies de PRM pour mettre au point, promouvoir et démontrer ce type de technologie au Canada [LNC, 2017]. En ce moment, quatre promoteurs en sont à divers stades de l'évaluation des LNC [LNC, 2019; GFP, 2020b]. Les LNC ont également conclu des partenariats avec des concepteurs de PRM pour la réalisation de recherches sur les combustibles de PRM et les technologies avancées de PRM au Canada [LNC, 2020a, 2020b, 2020c, 2020d]. Les LNC ont récemment lancé un appel à propositions pour la troisième ronde de son programme d'Initiative canadienne de recherche nucléaire (ICRN), qui a été établie pour accélérer le déploiement des PRM et des réacteurs avancés, y compris les concepts de PRM [LNC, 2021].

En 2021, le Groupe CSA (Association canadienne de normalisation) a publié un rapport sur le rôle des normes dans la facilitation du déploiement des PRM au Canada [CSA, 2021].

Les conceptions de PRM de type RNR rendues à un stade de considération avancé utilisent des combustibles métalliques ou à base de sels; le combustible d'ARC pourrait être de type métallique, composé d'un mélange d'U et de Zr, et le combustible de Moltex pourrait être un mélange de chlorures ou de fluorures de sodium/plutonium/actinide. Les conceptions de PRM thermiques utilisent un sel à base de fluorure d'uranium comme combustible et comme réfrigérant (Terrestrial Energy), des pastilles de SiC contenant du dioxyde d'uranium (UO_2) enrobé (Ultra Safe Nuclear Corporation), des billes de graphite contenant du dioxyde d'uranium ou du carbure d'uranium (UO_2/UC) enrobé (X-energy) ou de l'UO_2 (BWRX-300, SMR-160 et NuScale). Aux fins de comparaison, le combustible CANDU actuel est de l'UO_2.

Le point sur le retraitement

Les cycles de combustible avancés nécessitent un type ou un autre de retraitement. La technologie commerciale actuelle de retraitement employée par les installations énumérées dans le tableau 1 utilise des combustibles à base d'oxydes et la chimie humide (le procédé « PUREX »). Le combustible d'UO_2 irradié est dissous dans des acides concentrés, puis soumis à une série de procédés chimiques visant à en séparer les divers constituants. Du Pu relativement pur est séparé et converti en un oxyde qui peut être mélangé à de l'UO_2 pour former du combustible MOX, qui peut être réutilisé dans un réacteur thermique classique. Des descriptions du procédé utilisé sont fournies dans la littérature technique, par exemple dans [AEN/OCDE, 2012b].

Puisque le combustible nucléaire irradié est hautement radioactif, tout cela doit se faire à l'aide d'équipements télécommandés et d'installations lourdement blindées. Même les opérations régulières d'entretien doivent être menées à distance en raison de la contamination résiduelle de l'équipement. Les étapes de retraitement et de séparation produisent également de grandes quantités de déchets chimiquement complexes. Certaines de ces matières pourront être recyclées dans le cadre du processus, mais la plupart d'entre elles deviendront des déchets radioactifs secondaires qui devront être stabilisés avant d'être entreposés, puis finalement stockés dans un dépôt [MIT, 2011; MIIS, 2013].

Ce processus est la référence en matière de retraitement du combustible et est relativement coûteux. Certaines recherches en cours ont pour but d'optimiser ce processus. Deux options principales sont en cours de développement – des procédés hydrométallurgiques et électrométallurgiques. La séparation

hydrométallurgique, aussi appelée « extraction par solvants », s'appuie sur l'expérience industrielle actuelle. Le concept électrométallurgique, ou le pyrotraitement, est un procédé non aqueux. Un autre concept qui est moins avancé dans son développement est le procédé basé sur la volatilité des fluorures.

La méthode du pyrotraitement convient aux combustibles métalliques et à base de sels. Cette approche a été employée dans le passé dans des prototypes de RNR (notamment dans le cadre du programme américain Experimental Breeder Reactor qui a eu cours des années 1950 aux années 1980 [AIEA, 2012]) et a été proposée pour d'autres systèmes, comme Integral Fast Reactors et PRISM [Triplett et coll., 2012] et le PRM d'ARC [Cheng et coll., 2018]. Bien qu'il ait été utilisé avec succès dans des essais de démonstration, le pyrotraitement n'a pas encore atteint le stade de la mise en oeuvre à l'échelle commerciale. (Voir, par exemple, [AIEA, 2021], et Iizuka et coll. dans [AEN/OCDE, 2012a].) La Corée mène depuis un certain temps des études de démonstration à l'échelle du laboratoire et de l'ingénierie [AEN/OCDE, 2019c].

Moltex Energy propose d'utiliser une forme de pyrotraitement, appelée WATSS (WAste To Stable Salts), pour convertir un combustible usé à base d'oxyde en un combustible à base de sel pour son Stable Salt Reactor (SSR). Une caractéristique particulière de ce concept de SSR est qu'il tolère davantage les actinides présents dans le combustible, ce qui signifie qu'il n'est pas nécessaire que le retraitement aboutisse à un produit hautement purifié. La conception est donc simplifiée. Actuellement, des recherches et de la planification pour le développement et la démonstration inactive du procédé WATSS sont en cours.

Pour que ces réacteurs avancés et procédés de retraitement puissent être déployés avec succès sur une base commerciale, le coût de leur cycle de vie doit être inférieur au coût des autres moyens de production d'électricité, y compris des centrales nucléaires classiques et des technologies non nucléaires actuelles. Une étude publiée en 2013 par l'AEN de l'OCDE [AEN/OCDE, 2013a] a examiné le coût du cycle de vie entier associé à diverses options de cycles de combustible et a conclu que le cycle à passage unique demeurait le plus économique à ce moment-là. Le coût du cycle de vie comprend les coûts de développement, de construction, d'exploitation, d'entretien, de déclassement et de gestion des déchets produits par la centrale nucléaire ainsi que par les installations du cycle de combustible et les systèmes de transport associés. Une autre étude, publiée par l'Idaho National Laboratory en 2017, a fourni un ensemble exhaustif de données liées aux coûts, aux processus et aux structures à l'appui de l'évaluation menée par le Département américain de l'énergie sur les cycles de combustible nucléaire avancés [INL, 2017].

Une étude technique commandée par le gouvernement de l'Ontario [LNC, 2016] examinait divers scénarios de recyclage du combustible irradié des réacteurs CANDU ontariens, y compris la réutilisation du combustible dans les réacteurs CANDU actuels et divers scénarios impliquant des RNR. L'étude montrait que le coût du cycle de vie de chaque option de recyclage était plus élevé que celui du plan de référence actuel, qui consiste à stocker le combustible CANDU irradié dans un dépôt géologique en profondeur. Ces options de recyclage nécessitent un investissement initial important et posent des défis sociaux et techniques considérables. En outre, elles généraient des quantités importantes de déchets radioactifs à vie longue et thermogènes qui devront aussi être stockés un jour dans un dépôt géologique en profondeur.

Plusieurs de ces études soulignent que comme solution de rechange au retraitement du combustible nucléaire irradié des réacteurs actuels, il y aurait suffisamment d'uranium appauvri (issu de l'enrichissement du combustible utilisé dans les REL) pour soutenir des réacteurs avancés partout dans le monde pendant plusieurs siècles. Cet uranium est de radioactivité relativement faible et plus facile à manipuler. Approximativement 1,2 million de tonnes d'uranium appauvri sont actuellement stockées dans le monde. De plus, l'utilisation d'uranium enrichi pourrait remplacer le plutonium recyclé, au moins à court terme [WNA, 2022b].

Le point sur la transmutation

La transmutation des actinides en des éléments moins radioactifs ou des éléments stables peut également se faire dans un SPA, où les neutrons produits par un accélérateur sont dirigés vers un assemblage de couverture contenant les déchets (éléments de la catégorie des actinides) ainsi que du combustible fissile. Contrairement à un réacteur nucléaire, il s'agit d'un système sous-critique : la réaction nucléaire s'arrête lorsque l'accélérateur est éteint. Une autre proposition utilise un puissant laser à impulsion brève comme accélérateur de particules. Un SPA pourra potentiellement accepter un large éventail de combinaisons d'isotopes, fournissant ainsi des actinides de transmutation très efficaces et certains autres radionucléides à vie longue.

Une quantité importante d'électricité est nécessaire pour générer les neutrons. Certaines recherches sont en cours en Europe, au Japon et ailleurs pour le développement de la technologie de SPA. Toutefois, la technologie n'a guère progressé au-delà du stade théorique et la disponibilité de faisceaux continus de neutrons de forte puissance constitue actuellement un facteur contraignant clé. Les résultats des recherches sont rapportés dans des conférences scientifiques et des réunions comme le 4e Atelier international sur la technologie et les composants des systèmes pilotés par accélérateur [AEN/OCDE, 2019a].

Le point sur le stockage en forages très profonds

Une autre approche proposée pour la gestion des déchets serait de placer le combustible irradié dans des forages très profonds. Ce concept consisterait à placer des conteneurs de déchets à des profondeurs supérieures à 1 kilomètre, à l'intérieur de trous individuels forés depuis la surface. Dans chaque puits foré, les colis de déchets seraient empilés les uns sur les autres sur une certaine distance. Une fois les déchets en place, les trous de forage seraient remblayés et scellés en surface. Si les déchets étaient stockés à cette profondeur, plus loin de la biosphère que dans le concept du dépôt excavé, la sûreté à long terme du système reposerait principalement sur la séparation du réseau hydrogéologique qui existe à la profondeur des colis de déchets du réseau près de la surface, ainsi que sur l'intégrité des bouchons et sceaux des puits.

Jusqu'ici, un certain nombre d'études ont conclu que les forages profonds pourraient présenter un certain nombre d'avantages techniques par rapport aux dépôts géologiques excavés pour certains types de déchets de haute activité, par exemple la possibilité d'un isolement plus complet des déchets et d'une mobilité réduite des radionucléides en raison de la profondeur accrue des déchets, et la modularité du concept, en vertu de laquelle la capacité de stockage pourrait être étendue relativement facilement en forant des puits supplémentaires une fois une zone appropriée sélectionnée et autorisée.

Le concept du stockage en forages très profonds a été étudié comme solution de remplacement à un dépôt géologique en profondeur aux États-Unis [Sandia, 2009-2019; U.S. BRC, 2012; U.S. NWTRB, 2016; Deep Isolation, 2020], en Suède [SKB, 1989-2013c; KASAM, 2007], au Royaume-Uni [NIREX, 2004] et ailleurs dans le monde [von Hippel et Hayes, 2010; Chapman, 2013]. Une étude a été menée en 2020 par l'Electric Power Research Institute pour examiner la possibilité de placer sur un même site aux États-Unis un dépôt à forages profonds et un réacteur avancé [EPRI, 2020].

Le concept des forages très profonds est envisagé pour le stockage souterrain des petits inventaires de déchets de moyenne et de haute activité [AIEA, 2017c, 2020d; ARPANSA, 2008]. L'Australie envisage actuellement le stockage en puits pour les déchets de moyenne activité [ARPANSA, 2020], et l'Estonie et la Slovénie étudient ce concept pour le stockage du combustible irradié généré par leurs PRM et réacteur de recherche, respectivement [WNN, 2021a, 2021b].

Le Département de l'énergie des États-Unis (U.S. DOE) a entrepris des études en 2009 sur le concept des forages très profonds en vue du stockage des assemblages de combustible irradié des réacteurs de centrales nucléaires américaines. Des études initiales publiées par les Sandia National Laboratories ont présenté une évaluation préliminaire du concept [Sandia, 2009] et une conception de référence [Sandia, 2011a,b]. Suivant cette dernière, il est présumé que les déchets seraient stockés dans la portion du 1er et du 2e kilomètres les plus profonds d'un trou de 3 à 5 kilomètres de profondeur et d'approximativement 45 centimètres de diamètre foré verticalement dans la couche de roche supérieure jusque dans la roche cristalline du socle. Bien que la récupération du combustible reste possible pendant les opérations de mise en place, il est présumé qu'elle ne serait pas requise une fois le forage scellé.

En 2014, le U.S. DOE a lancé un projet de perçage d'un trou de forage en profondeur pour évaluer la technologie pour des types précis de déchets de haute activité de petite taille (comme des capsules de Cs et de Sr concentrés actuellement stockés sur le site de Hanford) [Sandia, 2014b; U.S. DOE, 2014a,b; U.S. NWTRB, 2016]. Le programme Deep Borehole Field Test prévoyait la conception, la sélection d'un site et la réalisation d'au moins un forage non radioactif à pleine échelle percé à une profondeur de 5 kilomètres [Sandia, 2012c, 2015a,b]. Un dossier de sûreté générique préliminaire avait été monté pour démontrer la faisabilité du concept de stockage des capsules de Cs et de Sr [Sandia, 2016, 2019]. En 2016, le U.S. DOE avait annoncé qu'un site de 20 acres de terres publiques près de Rugby, au Dakota du Nord, avait été choisi pour l'essai [U.S. DOE, 2016]. Toutefois, même si aucun véritable déchet radioactif ne devait être utilisé dans l'essai, celui-ci s'est heurté à une importante opposition locale et le permis de forage nécessaire n'a pas été accordé. Le projet a été discontinué en 2017 [U.S. DOE, 2017].

Un autre concept a aussi été proposé : le stockage des déchets radioactifs dans des forages horizontaux moins profonds, où les colis de déchets subiraient moins de pression et pourraient être récupérés. Selon ce concept, un trou serait foré verticalement depuis la surface, à travers la roche sédimentaire, ignée ou métamorphique, à une profondeur d'approximativement 1 kilomètre. Ensuite, le forage prendrait une direction subhorizontale [Deep Isolation, 2020]. Plusieurs longs forages subhorizontaux seraient utilisés pour confiner les colis de déchets radioactifs. Une société privée de stockage des déchets nucléaires aux États-Unis, Deep Isolation, a proposé d'utiliser les technologies existantes de forage directionnel et a réalisé un essai public de démonstration en 2019 de ce concept en plaçant et en récupérant un prototype de conteneur d'un forage horizontal percé à une profondeur d'approximativement 600 mètres [Deep Isolation, 2019].

Bien que le concept du stockage du combustible irradié en forages profonds soit considéré comme techniquement faisable, l'approche présente certains défis d'importance :

- Les forages au diamètre et à la profondeur requis;
- La mise en place contrôlée des colis de déchets (p. ex., les problèmes d'ingénierie posés par la taille restreinte que devraient avoir les conteneurs/colis de combustible irradié ainsi que les problèmes à résoudre au cas où un colis resterait pris dans le trou de forage avant qu'il n'ait atteint la profondeur souhaitée);
- La mise au point d'une technologie robuste de surveillance pour une superficie et une profondeur substantielles;
- La mise au point de dispositifs de scellement des forages qui pourraient être placés à distance depuis la surface;
- Une fois les colis de déchets en place et scellés, la récupération serait très difficile.

Globalement, l'United States Nuclear Waste Technical Review Board [U.S. NWTRB, 2016] a conclu que même si la faisabilité des forages profonds avait été démontrée pour certains types de déchets, ils n'élimineraient pas la nécessité de construire un dépôt géologique excavé. De plus, il a conclu que le temps nécessaire pour trouver un site pour une installation de forages profonds, obtenir les autorisations nécessaires et construire l'installation serait comparable au temps requis pour construire un dépôt excavé conventionnel.

La SGDN continuera de surveiller le concept des forages très profonds dans le cadre de notre examen continu de l'approche de la GAP.

Conclusions

La SGDN continue de surveiller les développements dans le domaine des cycles de combustible avancés et des méthodes de remplacement pour la gestion à long terme des déchets.

Les principales conclusions de la SGDN sont que :

- Les nouveaux cycles de combustible et le concept du forage à très grande profondeur continuent de susciter de l'intérêt dans le monde, mais il n'y a eu aucune percée technologique qui modifierait la précédente conclusion concernant l'approche de la GAP et la gestion de l'inventaire actuel de combustible nucléaire irradié canadien.
- L'exploitation de PRM au Canada générera, en petites quantités, de nouveaux types de déchets de combustible nucléaire. Les répercussions de ces possibles nouveaux déchets sur le programme de la SGDN sont évaluées dans le cadre de son examen des technologies liées aux PRM.
- Les cycles de combustible avancés considérés jusqu'à maintenant produiront des déchets de combustible nucléaire à vie longue qui devront être gérés de manière sûre, socialement acceptable, techniquement rigoureuse, responsable sur le plan environnemental et économiquement viable par la SGDN.
- La SGDN continuera d'assurer un suivi des développements liés aux cycles de combustible avancés et aux méthodes techniques de remplacement qui pourraient avoir une incidence sur les exigences canadiennes futures en matière de gestion des déchets.

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NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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Rapport de suivi sur les cycles de combustible avancés et les technologies de remplacement pour la gestion des déchets

La Société de gestion des déchets nucléaires (SGDN) a élaboré l'approche de la Gestion adaptative progressive (GAP) en nous appuyant sur une vaste étude et des activités de concertation menées de 2002 à 2005 auprès des Canadiens pour trouver une approche de gestion à long terme pour le combustible nucléaire irradié canadien. En considérant différentes méthodes de gestion à long terme du combustible nucléaire irradié, les Canadiens ont clairement établi leurs valeurs et priorités :

- La sûreté et la sécurité doivent constituer notre plus haute priorité;
- La génération actuelle doit assumer la responsabilité des déchets qu'elle a produits;
- Nous devons nous appuyer sur les meilleures pratiques internationales;
- Nous devons pouvoir offrir aux générations futures la latitude voulue pour qu'elles puissent prendre leurs propres décisions.

L'approche de la GAP est celle qui correspond le plus à ces valeurs et priorités. Le gouvernement du Canada en a fait le plan canadien en 2007. L'aboutissement technique de la GAP consistera à confiner et isoler de manière sûre le combustible nucléaire irradié au sein d'une formation géologique profonde. Ce concept est conforme aux politiques adoptées par tous les pays dotés de programmes d'énergie nucléaire importants – même ceux qui mettent en oeuvre ou qui préconisent actuellement diverses formes de recyclage prévoient construire des dépôts géologiques en profondeur pour gérer les déchets à vie longue qui en résulteront.

Au cours de l'étude nationale, les Canadiens avaient exprimé l'intérêt d'en savoir plus sur la possibilité de recycler ou de réutiliser le combustible nucléaire irradié et sur les solutions de rechange pour la gestion à long terme du combustible nucléaire irradié. Selon l'analyse réalisée par la SGDN, le retraitement du combustible irradié était très peu probable pour le Canada à l'époque. De plus, aucune méthode technique de remplacement n'avait été jugée préférable. Toutefois, la SGDN avait recommandé de maintenir un dossier de suivi de l'état de la technologie dans le monde et des changements qui pourraient se produire dans le cycle du combustible au Canada.

La SGDN maintient et publie régulièrement ce dossier de suivi depuis 2008. La présente édition de ce rapport de suivi décrit les plus récents travaux de recherche-développement survenus dans le monde relativement aux cycles de combustible avancés, ainsi que les derniers développements qui se sont produits concernant le concept de stockage en forages profonds. Les principales conclusions sont que :

- Les nouveaux cycles de combustible et le concept du forage à très grande profondeur continuent de susciter de l'intérêt dans le monde, mais il n'y a eu aucune percée technologique qui modifierait la précédente conclusion concernant l'approche de la GAP et la gestion de l'inventaire actuel de combustible nucléaire irradié canadien.
- L'exploitation de petits réacteurs modulaires (PRM) au Canada générera, en petites quantités, de nouveaux types de déchets de combustible nucléaire. Les répercussions de ces possibles nouveaux déchets sur le programme de la SGDN sont évaluées dans le cadre de son examen des technologies liées aux PRM.
- Les cycles de combustible avancés considérés jusqu'à maintenant produiront des déchets de combustible nucléaire à vie longue qui devront être gérés de manière sûre, socialement acceptable, techniquement rigoureuse, responsable sur le plan environnemental et économiquement viable par la SGDN.
- La SGDN continuera d'assurer un suivi des développements liés aux cycles de combustible avancés et aux méthodes techniques de remplacement qui pourraient avoir une incidence sur les exigences canadiennes futures en matière de gestion des déchets.

Introduction

La SGDN maintien un dossier de suivi sur les récents développements survenus dans le monde concernant les cycles de combustible avancés, y compris les technologies de retraitement et de recyclage, et sur les méthodes techniques de remplacement pour la gestion à long terme du combustible nucléaire irradié. Les rapports techniques détaillés précédents [Jackson, 2008-2010] et les résumés des rapports de suivi [p. ex., SGDN, 2021] peuvent être consultés sur le site Web de la SGDN.

En 2022, plusieurs pays et programmes de collaboration internationale ont poursuivi des travaux de recherche-développement pour évaluer la technologie et les conséquences de l'utilisation des cycles de combustible avancés, y compris les cycles fermés basés sur le retraitement, la séparation et la transmutation (RST) et les méthodes techniques de remplacement pour la gestion à long terme du combustible nucléaire irradié.

Cycles de combustible actuels

Il existe trois types de cycles du combustible nucléaire :

- Le cycle « ouvert », ou « à passage unique », où le combustible, qui est irradié dans le réacteur, est considéré comme un déchet au moment de son retrait.
- Le « recyclage partiel » ou le « cycle à deux passages », où le combustible irradié est réutilisé. Dans une version, le combustible irradié est retraité pour récupérer le plutonium, qui est converti en combustible d'oxyde mixte (Pu-U), ou MOX, et est utilisé une autre fois dans un type existant de réacteur (ce cycle est utilisé dans une certaine mesure en France). Dans une autre version, le combustible irradié d'un réacteur à eau légère (REL) est considéré comme étant converti en combustible pouvant être réutilisé dans un réacteur CANDU (la Chine prévoit utiliser ce cycle).
- Le cycle « fermé », ou « à recyclage complet », où le combustible irradié est retraité pour en récupérer les isotopes fissiles comme le plutonium et d'autres actinides, puis est utilisé dans des réacteurs avancés tels que les réacteurs à neutrons rapides (RNR). Le combustible irradié d'un RNR peut ensuite être

retraité et continuellement recyclé dans les RNR pour en extraire l'énergie restante. Selon le réacteur, des quantités supplémentaires d'uranium naturel ou appauvri ou de combustible irradié retraité peuvent être ajoutées pour remplacer le combustible consommé par le RNR.

D'autres variantes peuvent inclure diverses combinaisons de réacteurs thermiques conventionnels, de RNR et/ou de systèmes pilotés par accélérateur (SPA).

Les réacteurs nucléaires commerciaux actuellement exploités dans le monde sont en majorité basés sur les neutrons thermiques (« de faible énergie »). Ces réacteurs utilisent une substance modératrice pour ralentir les neutrons de haute énergie produits par les réactions de fission – les modérateurs sont habituellement de l'eau normale, ou légère (comme dans la plupart des réacteurs autres que CANDU), de l'eau lourde (les réacteurs CANDU) ou du graphite (les réacteurs refroidis au gaz). Les combustibles utilisés dans ces réacteurs contiennent soit de l'uranium naturel (0,7 pour cent d'U-235 et 99,3 pour cent d'U-238), comme dans les réacteurs CANDU par exemple, ou de l'uranium à plus forte concentration d'U-235 fissile (généralement de 3 à 5 pour cent). Le procédé employé pour obtenir cette concentration plus élevée d'U-235 est appelé « enrichissement ». L'exploitation des types de réacteurs actuels requiert un approvisionnement continu en uranium d'extraction comme source d'U-235. Un sous-produit de ce processus d'enrichissement est l'uranium appauvri, qui contient moins d'U-235, soit approximativement 0,3 pour cent, et est aujourd'hui généralement considéré comme un déchet par les pays qui exploitent des installations d'enrichissement. Toutefois, l'uranium appauvri issu du processus d'enrichissement constitue une source potentielle de combustible pour certains cycles de combustible avancés.

Un cycle de combustible fermé doit comprendre un RNR pour que le combustible soit utilisé de manière efficace. Les RNR n'utilisent pas de modérateur et leur technologie est plus complexe. Le tableau 1 énumère les RNR électrogènes actuellement exploités ou projetés. Ils peuvent extraire de l'énergie de l'U-238 ainsi que d'autres actinides (plutonium, américium, neptunium, etc.). Dans le cas de l'U-238, cela s'effectue en convertissant premièrement l'U-238 en Pu-239 par le biais de la capture neutronique et de la désintégration radioactive subséquente, puis en provoquant la fission du Pu-239 par un autre neutron. À mesure que l'U-238 est consommé, on peut ajouter de l'uranium ou d'autres actinides issus du retraitement du combustible d'un réacteur thermique, ou de l'uranium appauvri résultant des processus d'enrichissement. L'uranium appauvri est largement disponible, son taux de radioactivité spécifique est faible et il peut être manipulé plus facilement, alors que l'uranium retraité et d'autres actinides tendent à être très radioactifs.

Tableau 1 : Réacteurs à neutrons rapides actuellement en exploitation ou en construction pour la production d'électricité

Pays	Installation	Puissance (MWe)	État
Fédération de Russie	BN-600 BN-800	600 880	En exploitation depuis 1980 – type à cuve de sodium En exploitation depuis 2016 – type à cuve de sodium
Inde	Prototype de réacteur surgénérateur (PFBR)	500	En construction – type à cuve de sodium
Chine	CFR-600	2 x 600	En construction – type à cuve de sodium

Le Canada, comme la plupart des pays qui exploitent l'énergie nucléaire, utilise actuellement le cycle de combustible ouvert. Comme le montre le tableau 2, quelques pays, notamment la France, la fédération de Russie et l'Inde, retraitent une partie de leur combustible et utilisent une portion du combustible MOX résiduel dans un cycle de combustible à recyclage partiel ou l'accumulent en vue de le recycler dans d'éventuels réacteurs de types encore indéterminés. Certains pays ont retraité une partie de leur combustible dans le passé, mais ne le font plus; leur combustible retraité est traité comme un déchet. Le tableau 3 résume la capacité mondiale de retraitement du combustible commercial, qui ne comprend pas le combustible des installations plus petites et déjà fermées et celui des installations utilisées uniquement à des fins militaires. Il contient également des informations sur les stratégies de gestion du cycle du combustible nucléaire pour les pays utilisant du combustible CANDU.

Tableau 2 : Résumé de la situation actuelle concernant le retraitement pour le cycle du combustible nucléaire

Pays	Installation commerciale de retraitement		Combustible irradié actuellement retraité dans un autre pays	Une certaine quantité de combustible irradié recyclée dans le passé	Prévoit le stockage direct du combustible irradié dans un dépôt
	Existante	Prévue			
Allemagne				✓	✓
Belgique				✓	✓
Bulgarie			✓	✓ (7)	
Canada					✓
Chine(3)		✓			✓ (4)
Espagne				✓	✓
États-Unis(3)				✓	✓
Fédération de Russie	✓	✓			
Finlande				✓ (7)	✓
France(3)	✓ (2)				
Hongrie				✓ (7)	✓
Inde(3)	✓	✓			
Italie			✓		
Japon		✓ (6)	✓		
Mexique					✓
Pakistan(3)					
Pays-Bas			✓ (5)		
Rép. de Corée					✓
République tchèque				✓ (7)	✓
Roumanie					✓
Royaume-Uni(1)				✓	✓
Slovaquie				✓ (7)	✓
Slovénie					✓
Suède				✓	✓
Suisse				✓	✓
Ukraine				✓ (7)	✓

(1) Le Royaume-Uni a totalement cessé de retraiter du combustible en juillet 2022.

(2) La France a fourni des services de retraitement commercial à quelques pays européens et asiatiques.

(3) La Chine, la France, le Royaume-Uni, la fédération de Russie, les États-Unis, le Pakistan et l'Inde pratiquent actuellement ou ont pratiqué dans le passé le retraitement pour des motifs militaires et aux fins des centrales nucléaires.

(4) La Chine prévoit stocker directement son combustible irradié de type CANDU dans un dépôt. Elle prévoit réutiliser une partie de son combustible de REL dans ses réacteurs CANDU.

(5) Combustible irradié envoyé en France pour y être retraité. Le contrat a été prolongé en 2015 pour couvrir la durée de vie des réacteurs actuels.

(6) Installation d'échelle commerciale construite à Rokkasho-mura et en cours d'essai final de mise en service.

(7) Une partie du combustible irradié a été envoyée dans l'ancienne Union soviétique pour y être retraitée. Cette pratique a cessé au début des années 1990.

Tableau 3 : Résumé de la capacité mondiale actuelle de retraitement des combustibles commerciaux

Pays	Installation	Capacité (tonnes par année)	État
Chine	Gansu	200	En construction (achèvement prévu vers 2025)
France	UP1, Marcoule UP2-400, La Hague UP2-800, La Hague UP3, La Hague	600 400 800 800	Fermée/en déclassement Fermée/en déclassement En exploitation En exploitation
Inde	Tarapur Kalpakkam	100 100	En exploitation En exploitation
Japon	Tokai Rokkasho	90 800	Fermée/en déclassement En cours de mise en service (démarrage prévu vers 2024)
Fédération de Russie	RT-1, Mayak MCC-PDC RT-2, Zheleznogorsk	400 250 700	En exploitation (fermeture prévue vers 2030) En construction En construction (achèvement prévu vers 2025)
Royaume-Uni	MAGNOX, Sellafield THORP, Sellafield	1,500 900	Fermée en 2022 Fermée en 2018
États-Unis	West Valley	300	Exploitée de 1966 à 1972, déclassée

Cycles de combustible avancés

Les principaux cycles de combustible avancés qui revêtent un intérêt sont les combustibles fermés (bien que des cycles à recyclage partiel soient actuellement utilisés de manière limitée). Ces cycles de combustible avancés ont un intérêt parce qu'ils utilisent le combustible d'uranium de manière très efficace. En particulier, certains cycles de combustible avancés sont théoriquement presque auto-soutenables lorsque l'équilibre est atteint.

Réduire le besoin en uranium d'extraction est le principal avantage. Pour le Canada, qui dispose d'importantes ressources d'uranium, cela réduirait l'impact environnemental de l'exploitation minière en utilisant de manière efficiente l'uranium d'extraction.

Un second avantage potentiel serait de réduire la « radiotoxicité » des déchets. Cela pourrait être réalisé en retraitant le combustible et en recyclant une partie, voire la plus grande partie des actinides, c.-à-d. l'uranium et les transuraniens, dans un RNR. Les actinides sont généralement à vie longue; les consommer dans un RNR réduit donc la charge radioactive imposée au dépôt qui sera requis pour gérer les déchets à vie longue restantes.

Le troisième avantage est de réduire la taille requise du dépôt, étant donné que le volume de déchets à stocker est plus faible, ou, semblablement, de permettre au dépôt de desservir un plus grand parc de centrales nucléaires. L'uranium constitue la majeure partie du combustible irradié. Le séparer et le réutiliser en diminue donc le volume.

Toutefois, les cycles de combustible avancés posent des problèmes d'ordre scientifique et technique, tels que la mise au point des matériaux spécialisés nécessaires et la mise à échelle des prototypes expérimentaux pour produire des réacteurs pleine grandeur. Des défis économiques et sociopolitiques se posent également, y compris en ce qui a trait aux coûts liés à la construction et à la sélection d'un site pour les installations, ainsi

qu'aux mesures qui doivent être prises pour empêcher la prolifération. La réalisation des avantages repose sur l'hypothèse que l'énergie nucléaire continuera de représenter une bonne solution économique pour le pays en question.

Sur le plan de la taille du dépôt, recycler le combustible irradié dans des RNR peut réduire le volume de déchets de haute activité produits par mégawatt d'électricité généré. Cela peut diminuer la quantité de roche à excaver par mégawatt pour construire le dépôt, mais ne réduira pas nécessairement de manière substantielle l'empreinte totale du dépôt. La raison en est que l'empreinte est déterminée par la charge thermique totale des déchets et non pas par leur volume total ou leur volume par mégawatt généré. La charge thermique des déchets correspond principalement à la quantité d'énergie qui a été produite, quel que soit le cycle de combustible employé. Pour une réduction substantielle de l'empreinte d'un dépôt, il faudrait également séparer les produits de fission à vie plus courte et stocker préalablement les déchets en surface pendant une longue période pour laisser suffisamment décroître les radionucléides qui dégagent de la chaleur. Même dans ce cas, la diminution de l'espace de stockage requis pour les déchets de haute activité peut être neutralisée par l'augmentation de la quantité de déchets de moyenne activité à vie longue générés par ces cycles de combustible [RED-IMPACT, 2008].

De plus, la réduction des actinides ne supprime pas la nécessité d'un stockage à long terme, puisqu'il faut tout de même confiner les actinides résiduels et les produits de fission à vie longue. Bien qu'une diminution des actinides à vie longue diminue la « radiotoxicité » des déchets, ce qui est nettement avantageux, cela n'améliore pas substantiellement la sûreté globale d'un dépôt parce que les éléments actinides ont une très faible mobilité dans l'environnement d'un dépôt. Ce sont les produits de fission à vie longue, comme l'I-129, qui sont les radionucléides qui déterminent généralement la sûreté à long terme d'un dépôt [Kessler et coll., 2012; Sandia, 2012a; Posiva, 2021; EASAC, 2014; SGDN, 2017, 2018]. Ces produits de fission à vie longue ne sont généralement pas réduits dans les cycles de combustible avancés. De plus, recycler le combustible pour produire davantage d'électricité aboutit au total à une plus grande quantité de produits de fission, qui correspond approximativement à la quantité totale d'électricité produite, quel que soit le cycle de combustible employé.

Quoi qu'il en soit, la mise en oeuvre complète d'un cycle de combustible fermé nécessite le déploiement à l'échelle commerciale de réacteurs avancés comme des RNR, ainsi que l'infrastructure associée, par exemple des usines de retraitement et des installations de fabrication du combustible. Bien que les RNR existent depuis les années 50, ils ne sont pas encore largement acceptés et déployés commercialement (voir le tableau 1). Voir par exemple [AIEA, 2012, 2013, 2022d] pour une description de divers prototypes de RNR et pour un historique de leur exploitation.

Ces facteurs ont été abordés dans divers examens nationaux, qui ont continué de confirmer la nécessité d'un dépôt géologique en profondeur pour le stockage du combustible nucléaire irradié ou des déchets de haute activité. En particulier :

- Un examen exhaustif des options possibles de gestion du combustible irradié mené en 2013 pour la Corée stipule ceci : « … il n'y a aucun motif de considérer la séparation et la transmutation comme une option de rechange à l'évacuation géologique directe, aucune donnée ne permet de penser que les systèmes de séparation et de transmutation conventionnels pourraient, même s'ils pouvaient être mis en oeuvre, éliminer la nécessité de recourir à l'évacuation géologique en profondeur ou même rendre l'évacuation substantiellement plus facile ou plus sûre » [MIIS, 2013].
- La Commission royale australienne sur le cycle de combustible nucléaire a déclaré que « selon le consensus international, le stockage géologique en profondeur est la meilleure solution disponible pour la gestion à long terme du combustible irradié » [Gouvernement de l'Australie du Sud, 2016].

- L'Agence pour l'énergie nucléaire (AEN) a déclaré dans sa note d'orientation sur le stockage des déchets radioactifs publiée en juin 2020 (Policy Brief on the disposal of radioactive waste) qu'« il y a un solide consensus scientifique international voulant que la solution du dépôt géologique en profondeur (DGP) constitue une approche sûre et efficace pour le stockage permanent des déchets de haute activité et du combustible nucléaire irradié » [AEN/OCDE, 2020a].
- Une étude menée récemment aux États-Unis par les National Academies of Sciences, Engineering and Medicine sur les avantages et la viabilité de différents cycles de combustible nucléaire à base de réacteurs avancés a conclu ceci : « Chose importante, les réacteurs avancés et les cycles de combustible associés n'élimineraient pas la nécessité de recourir à un dépôt géologique pour certains déchets radioactifs, puisque même les réacteurs avancés nécessiteront le stockage de produits de fission radioactifs » [NASEM, 2022].

Le point sur les technologies liées aux cycles de combustible avancés

Les cycles de combustible avancés continuent de susciter de l'intérêt, et des progrès ont été réalisés à leur égard sur le plan scientifique et technologique. Les constats les plus récents ont été présentés en 2022 lors de diverses conférences internationales et réunions techniques tenues en personne et virtuellement, notamment :

- Le 11e Sommet international sur les PRM et les réacteurs avancés de 2022 (mai 2022, Atlanta, États-Unis) [Reuters Events, 2022];
- La Conférence internationale GLOBAL 2022 sur le cycle du combustible nucléaire, les nouvelles perspectives nucléaires relatives à la crise de l'approvisionnement énergétique et l'urgence climatique (juillet 2022, Reims, France) [SFEN, 2022];
- La 29e Conférence internationale sur le génie nucléaire, ICONE29 (août 2022, Shenzhen, Chine) [ICONE, 2022];
- Le Symposium de la World Nuclear Association (septembre 2022, Londres, Royaume-Uni) [WNA, 2022a];
- TopFuel 2022 (octobre 2022, Raleigh, États-Unis) [ANS, 2022];
- Le Forum international GEN IV (octobre 2022, Toronto, Canada) [GIF, 2022a];
- La 4e Conférence internationale de la Société nucléaire canadienne sur les réacteurs de IVe génération et les petits réacteurs (G4SR-4) (octobre 2022, Toronto, Canada) [SNC, 2022];
- Le Symposium de la Materials Research Society, EN08-Fondements scientifiques de la gestion des déchets nucléaires (novembre et décembre 2022, Boston, États-Unis) [MRS, 2022].

La SGDN assure un suivi des présentations données à l'occasion de ces conférences ainsi que des rapports techniques publiés par l'Agence pour l'énergie nucléaire de l'Organisation de coopération et de développement économiques (AEN/OCDE) [p. ex., AEN/OCDE, 2011-2021c], l'Agence internationale de l'énergie atomique [p. ex., AIEA, 2012-2022e], le Commissariat à l'énergie atomique et aux énergies alternatives (CEA, France) [p. ex., CEA, 2015], la Nuclear Regulatory Commission des États-Unis [U.S. NRC, 2012], l'Electric Power Research Institute [p. ex., EPRI, 2015-2021], l'agence Radioactive Waste Management du Royaume-Uni [RWM, 2017] et divers projets de collaboration internationale (comme les projets European Sustainable Nuclear Energy Technology Platform [SNETP, 2012-2021], Advanced Fuels for Generation IV Reactors: Reprocessing and Dissolution [ASGARD, 2016] et GEN IV Integrated Oxide Fuels Recycling Strategies [GENIORS, 2020]).

Le personnel de la SGDN a également préparé des rapports techniques et des exposés de conférences connexes décrivant les incidences potentielles des cycles de combustible avancés sur les inventaires canadiens de combustible irradié et les besoins de gestion à long terme qui en découlent [SGDN, 2015a,b; Ion, 2016; Gobien, 2016].

Le point sur les réacteurs avancés

Les cycles de combustible avancés sont généralement examinés en fonction de la conception particulière de réacteur considéré, puisque la solution du retraitement est étroitement reliée à la conception du réacteur utilisé ou envisagé.

Les conceptions de réacteurs avancés peuvent être globalement considérées comme des conceptions de 3e génération avancée (GEN-III+) ou de 4e génération (GEN-IV), alors que les réacteurs commerciaux actuellement en construction sont considérés comme des conceptions de 3e génération. Un projet de collaboration internationale sur les réacteurs de 4e génération examine actuellement plusieurs conceptions de types thermiques et RNR [GIF, 2022b] [AIEA, 2019, 2022d, 2022e]. Ces conceptions de réacteurs avancés fonctionnent habituellement à des températures très élevées (généralement à une température de 400 °C ou plus) et utilisent des métaux liquides (p. ex., le sodium ou le plomb), des sels en fusion (tels que des mélanges à base de fluorure ou de chlorure) ou des gaz (l'hélium) comme réfrigérants plutôt que l'eau légère ou de l'eau lourde.

Par ailleurs, les PRM ont également suscité beaucoup d'intérêt à l'échelle internationale. Ces réacteurs ont une puissance de sortie moins élevée, ce qui leur permet d'être d'une construction plus modulaire, à plus bas prix et peuvent être utilisés à davantage d'endroits que les réacteurs plus conventionnels d'une puissance de 1000 MWe. Les conceptions de PRM regroupent des versions réduites de réacteurs thermiques conventionnels ainsi que des RNR.

Bien qu'un grand nombre de conceptions de PRM aient été proposées dans le monde [AIEA, 2022d], celles qui sont décrites dans le tableau 4 sont actuellement considérées au Canada et en sont à différentes étapes du processus d'examen de la conception du fournisseur de la Commission canadienne de sûreté nucléaire (CCSN). Outre les PRM figurant au tableau 4, deux fournisseurs (Westinghouse Electric Company, LLC et StarCore Nuclear) ont également demandé à la CCSN de conclure des ententes de service afin d'évaluer leurs concepts (coeur solide et tuyaux caloriporteurs pour le microréacteur eVinci, et gaz haute température pour le module StarCore, respectivement) [CCSN, 2022].

En 2020, le gouvernement du Canada a lancé un Plan d'action canadien pour les PRM, qui décrit le plan de développement, de démonstration et de déploiement des PRM pour diverses applications [Plan d'action pour les PRM, 2020]. Un protocole d'entente a été conclu en 2019 entre les gouvernements de l'Ontario, de la Saskatchewan et du Nouveau-Brunswick relativement à une collaboration au développement des PRM et à leur déploiement dans ces provinces. L'Alberta a signé le protocole d'entente en 2021.

Un certain nombre de sociétés d'électricité ont exprimé le souhait de soutenir le développement de technologies de PRM. Un rapport de faisabilité, préparé par Ontario Power Generation (OPG), Bruce Power, Énergie NB et SaskPower, a été publié en 2021, a fourni une évaluation de la faisabilité du développement et du déploiement des PRM dans chacune des trois provinces [OPG, Bruce Power, Énergie NB et SaskPower, 2021].

OPG a repris en 2020 ses activités de planification sur le site de Darlington en vue d'accueillir un PRM de taille compatible avec son réseau [OPG, 2020]. En décembre 2021, OPG a annoncé qu'elle collaborerait avec GE Hitachi Nuclear Energy pour déployer un PRM BWRX-300 sur le nouveau site nucléaire de Darlington, qui est le seul site actuellement autorisé au Canada pour la construction de nouveaux réacteurs nucléaires [OPG, 2021]. OPG a l'intention de commencer les activités non nucléaires de préparation du site pour un PRM à Darlington d'ici la fin de 2022 et a soumis en octobre 2022 une demande à la CCSN pour le permis de construction [OPG, 2022].

Tableau 4 : PRM en cours d'évaluation au Canada

Réacteur	Fournisseur	Combustible/ réfrigérant	Type	État d'avancement de l'examen de la conception du fournisseur de la CCSN [CCSN, 2022]
ARC-100	ARC Nuclear Canada Inc.	Métal/sodium liquide	Réacteur à neutrons rapides	Phase 1 terminée Phase 2 en cours
MMR-5, MMR-10	Ultra Safe Nuclear Corporation	Oxyde enrobé, dans une pastille de SiC/hélium	Réacteur thermique	Phase 1 terminée Phase 2 en cours Global First Power a présenté une demande de permis de préparation d'un emplacement
SSR	Moltex Energy	Sel en fusion/sel en fusion	Réacteur à neutrons rapides	Phase 1 terminée
IMSR	Terrestrial Energy Inc.	Sel en fusion/sel en fusion	Réacteur thermique	Phase 1 terminée Phase 2 en cours
Xe-100	X-energy, LLC	Oxyde enrobé, dans une bille de graphite/hélium	Réacteur thermique	Phase 2 en cours
BWRX-300	GE-Hitachi Nuclear Energy	UO_2/eau légère	Réacteur thermique	Phase 2 en cours Le BWRX-300 a été choisi par OPG pour être déployé sur le site de Darlington
SMR-160	SMR, LLC (filiale de Holtec International)	UO_2/eau légère	Réacteur thermique	Phase 1 terminée
NuScale	NuScale Power, LLC	UO_2/eau légère	Réacteur thermique	Phase 2 en cours

En 2019, Global First Power, Ultra Safe Nuclear Corporation et OPG ont formé une coentreprise pour posséder et exploiter le projet de microréacteur modulaire à Chalk River [GFP, 2020a]. Global First Power a présenté à la CCSN une demande initiale de permis de préparation de l'emplacement, et l'examen réglementaire est en cours [GFP, 2019a, 2019b]. En 2022, l'Université McMaster et les sociétés Ultra Safe Nuclear Corporation et Global First Power ont formé un partenariat et signé un protocole d'accord pour étudier la possibilité de déployer un microréacteur modulaire à l'Université McMaster ou sur un site affilié [USNC, 2022].

Énergie Nouveau-Brunswick collabore avec Moltex Energy et Advanced Reactor Concepts (ARC) Clean Energy Canada pour mettre au point et démontrer une grappe de recherche sur l'énergie nucléaire axée sur un PRM avancé [Énergie NB, 2019].

SaskPower a sélectionné en juin 2022 le réacteur nucléaire BWRX-300 de GE Hitachi pour un déploiement éventuel dans la province [SaskPower, 2022a]. En septembre 2022, SaskPower a identifié deux régions en Saskatchewan en vue d'une étude plus approfondie pour évaluer la possibilité d'accueillir un PRM [SaskPower, 2022b].

Bruce Power et Westinghouse ont annoncé la conclusion d'une entente visant à poursuivre les applications du programme de microréacteur eVinci[MC] proposé par Westinghouse au Canada [Bruce Power, 2020]. Bruce Power s'est également engagée à développer la technologie des PRM, notamment en signant des protocoles d'entente avec MIRARCO Mining Innovation et l'Université Laurentienne [Bruce Power, 2018a], ainsi qu'avec NuScale Power [Bruce Power, 2018b].

Les Laboratoires nucléaires canadiens (LNC) cherche à établir des partenariats avec des promoteurs de technologies de PRM pour mettre au point, promouvoir et démontrer ce type de technologie au Canada [LNC, 2017]. En ce moment, quatre promoteurs en sont à divers stades de l'évaluation des LNC [LNC, 2019; GFP, 2020b]. Les LNC ont également conclu des partenariats avec des concepteurs de PRM pour la réalisation de recherches sur les combustibles de PRM et les technologies avancées de PRM au Canada [LNC, 2020a, 2020b, 2020c, 2020d]. Les LNC ont récemment lancé un appel à propositions pour la troisième ronde de son programme d'Initiative canadienne de recherche nucléaire (ICRN), qui a été établie pour accélérer le déploiement des PRM et des réacteurs avancés, y compris les concepts de PRM [LNC, 2021].

En 2021, le Groupe CSA (Association canadienne de normalisation) a publié un rapport sur le rôle des normes dans la facilitation du déploiement des PRM au Canada [CSA, 2021].

Les conceptions de PRM de type RNR rendues à un stade de considération avancé utilisent des combustibles métalliques ou à base de sels; le combustible d'ARC pourrait être de type métallique, composé d'un mélange d'U et de Zr, et le combustible de Moltex pourrait être un mélange de chlorures ou de fluorures de sodium/plutonium/actinide. Les conceptions de PRM thermiques utilisent un sel à base de fluorure d'uranium comme combustible et comme réfrigérant (Terrestrial Energy), des pastilles de SiC contenant du dioxyde d'uranium (UO_2) enrobé (Ultra Safe Nuclear Corporation), des billes de graphite contenant du dioxyde d'uranium ou du carbure d'uranium (UO_2/UC) enrobé (X-energy) ou de l'UO_2 (BWRX-300, SMR-160 et NuScale). Aux fins de comparaison, le combustible CANDU actuel est de l'UO_2.

Le point sur le retraitement

Les cycles de combustible avancés nécessitent un type ou un autre de retraitement. La technologie commerciale actuelle de retraitement employée par les installations énumérées dans le tableau 1 utilise des combustibles à base d'oxydes et la chimie humide (le procédé « PUREX »). Le combustible d'UO_2 irradié est dissous dans des acides concentrés, puis soumis à une série de procédés chimiques visant à en séparer les divers constituants. Du Pu relativement pur est séparé et converti en un oxyde qui peut être mélangé à de l'UO_2 pour former du combustible MOX, qui peut être réutilisé dans un réacteur thermique classique. Des descriptions du procédé utilisé sont fournies dans la littérature technique, par exemple dans [AEN/OCDE, 2012b].

Puisque le combustible nucléaire irradié est hautement radioactif, tout cela doit se faire à l'aide d'équipements télécommandés et d'installations lourdement blindées. Même les opérations régulières d'entretien doivent être menées à distance en raison de la contamination résiduelle de l'équipement. Les étapes de retraitement et de séparation produisent également de grandes quantités de déchets chimiquement complexes. Certaines de ces matières pourront être recyclées dans le cadre du processus, mais la plupart d'entre elles deviendront des déchets radioactifs secondaires qui devront être stabilisés avant d'être entreposés, puis finalement stockés dans un dépôt [MIT, 2011; MIIS, 2013].

Ce processus est la référence en matière de retraitement du combustible et est relativement coûteux. Certaines recherches en cours ont pour but d'optimiser ce processus. Deux options principales sont en cours de développement – des procédés hydrométallurgiques et électrométallurgiques. La séparation

hydrométallurgique, aussi appelée « extraction par solvants », s'appuie sur l'expérience industrielle actuelle. Le concept électrométallurgique, ou le pyrotraitement, est un procédé non aqueux. Un autre concept qui est moins avancé dans son développement est le procédé basé sur la volatilité des fluorures.

La méthode du pyrotraitement convient aux combustibles métalliques et à base de sels. Cette approche a été employée dans le passé dans des prototypes de RNR (notamment dans le cadre du programme américain Experimental Breeder Reactor qui a eu cours des années 1950 aux années 1980 [AIEA, 2012]) et a été proposée pour d'autres systèmes, comme Integral Fast Reactors et PRISM [Triplett et coll., 2012] et le PRM d'ARC [Cheng et coll., 2018]. Bien qu'il ait été utilisé avec succès dans des essais de démonstration, le pyrotraitement n'a pas encore atteint le stade de la mise en oeuvre à l'échelle commerciale. (Voir, par exemple, [AIEA, 2021], et Iizuka et coll. dans [AEN/OCDE, 2012a].) La Corée mène depuis un certain temps des études de démonstration à l'échelle du laboratoire et de l'ingénierie [AEN/OCDE, 2019c].

Moltex Energy propose d'utiliser une forme de pyrotraitement, appelée WATSS (WAste To Stable Salts), pour convertir un combustible usé à base d'oxyde en un combustible à base de sel pour son Stable Salt Reactor (SSR). Une caractéristique particulière de ce concept de SSR est qu'il tolère davantage les actinides présents dans le combustible, ce qui signifie qu'il n'est pas nécessaire que le retraitement aboutisse à un produit hautement purifié. La conception est donc simplifiée. Actuellement, des recherches et de la planification pour le développement et la démonstration inactive du procédé WATSS sont en cours.

Pour que ces réacteurs avancés et procédés de retraitement puissent être déployés avec succès sur une base commerciale, le coût de leur cycle de vie doit être inférieur au coût des autres moyens de production d'électricité, y compris des centrales nucléaires classiques et des technologies non nucléaires actuelles. Une étude publiée en 2013 par l'AEN de l'OCDE [AEN/OCDE, 2013a] a examiné le coût du cycle de vie entier associé à diverses options de cycles de combustible et a conclu que le cycle à passage unique demeurait le plus économique à ce moment-là. Le coût du cycle de vie comprend les coûts de développement, de construction, d'exploitation, d'entretien, de déclassement et de gestion des déchets produits par la centrale nucléaire ainsi que par les installations du cycle de combustible et les systèmes de transport associés. Une autre étude, publiée par l'Idaho National Laboratory en 2017, a fourni un ensemble exhaustif de données liées aux coûts, aux processus et aux structures à l'appui de l'évaluation menée par le Département américain de l'énergie sur les cycles de combustible nucléaire avancés [INL, 2017].

Une étude technique commandée par le gouvernement de l'Ontario [LNC, 2016] examinait divers scénarios de recyclage du combustible irradié des réacteurs CANDU ontariens, y compris la réutilisation du combustible dans les réacteurs CANDU actuels et divers scénarios impliquant des RNR. L'étude montrait que le coût du cycle de vie de chaque option de recyclage était plus élevé que celui du plan de référence actuel, qui consiste à stocker le combustible CANDU irradié dans un dépôt géologique en profondeur. Ces options de recyclage nécessitent un investissement initial important et posent des défis sociaux et techniques considérables. En outre, elles généraient des quantités importantes de déchets radioactifs à vie longue et thermogènes qui devront aussi être stockés un jour dans un dépôt géologique en profondeur.

Plusieurs de ces études soulignent que comme solution de rechange au retraitement du combustible nucléaire irradié des réacteurs actuels, il y aurait suffisamment d'uranium appauvri (issu de l'enrichissement du combustible utilisé dans les REL) pour soutenir des réacteurs avancés partout dans le monde pendant plusieurs siècles. Cet uranium est de radioactivité relativement faible et plus facile à manipuler. Approximativement 1,2 million de tonnes d'uranium appauvri sont actuellement stockées dans le monde. De plus, l'utilisation d'uranium enrichi pourrait remplacer le plutonium recyclé, au moins à court terme [WNA, 2022b].

Le point sur la transmutation

La transmutation des actinides en des éléments moins radioactifs ou des éléments stables peut également se faire dans un SPA, où les neutrons produits par un accélérateur sont dirigés vers un assemblage de couverture contenant les déchets (éléments de la catégorie des actinides) ainsi que du combustible fissile. Contrairement à un réacteur nucléaire, il s'agit d'un système sous-critique : la réaction nucléaire s'arrête lorsque l'accélérateur est éteint. Une autre proposition utilise un puissant laser à impulsion brève comme accélérateur de particules. Un SPA pourra potentiellement accepter un large éventail de combinaisons d'isotopes, fournissant ainsi des actinides de transmutation très efficaces et certains autres radionucléides à vie longue.

Une quantité importante d'électricité est nécessaire pour générer les neutrons. Certaines recherches sont en cours en Europe, au Japon et ailleurs pour le développement de la technologie de SPA. Toutefois, la technologie n'a guère progressé au-delà du stade théorique et la disponibilité de faisceaux continus de neutrons de forte puissance constitue actuellement un facteur contraignant clé. Les résultats des recherches sont rapportés dans des conférences scientifiques et des réunions comme le 4e Atelier international sur la technologie et les composants des systèmes pilotés par accélérateur [AEN/OCDE, 2019a].

Le point sur le stockage en forages très profonds

Une autre approche proposée pour la gestion des déchets serait de placer le combustible irradié dans des forages très profonds. Ce concept consisterait à placer des conteneurs de déchets à des profondeurs supérieures à 1 kilomètre, à l'intérieur de trous individuels forés depuis la surface. Dans chaque puits foré, les colis de déchets seraient empilés les uns sur les autres sur une certaine distance. Une fois les déchets en place, les trous de forage seraient remblayés et scellés en surface. Si les déchets étaient stockés à cette profondeur, plus loin de la biosphère que dans le concept du dépôt excavé, la sûreté à long terme du système reposerait principalement sur la séparation du réseau hydrogéologique qui existe à la profondeur des colis de déchets du réseau près de la surface, ainsi que sur l'intégrité des bouchons et sceaux des puits.

Jusqu'ici, un certain nombre d'études ont conclu que les forages profonds pourraient présenter un certain nombre d'avantages techniques par rapport aux dépôts géologiques excavés pour certains types de déchets de haute activité, par exemple la possibilité d'un isolement plus complet des déchets et d'une mobilité réduite des radionucléides en raison de la profondeur accrue des déchets, et la modularité du concept, en vertu de laquelle la capacité de stockage pourrait être étendue relativement facilement en forant des puits supplémentaires une fois une zone appropriée sélectionnée et autorisée.

Le concept du stockage en forages très profonds a été étudié comme solution de remplacement à un dépôt géologique en profondeur aux États-Unis [Sandia, 2009-2019; U.S. BRC, 2012; U.S. NWTRB, 2016; Deep Isolation, 2020], en Suède [SKB, 1989-2013c; KASAM, 2007], au Royaume-Uni [NIREX, 2004] et ailleurs dans le monde [von Hippel et Hayes, 2010; Chapman, 2013]. Une étude a été menée en 2020 par l'Electric Power Research Institute pour examiner la possibilité de placer sur un même site aux États-Unis un dépôt à forages profonds et un réacteur avancé [EPRI, 2020].

Le concept des forages très profonds est envisagé pour le stockage souterrain des petits inventaires de déchets de moyenne et de haute activité [AIEA, 2017c, 2020d; ARPANSA, 2008]. L'Australie envisage actuellement le stockage en puits pour les déchets de moyenne activité [ARPANSA, 2020], et l'Estonie et la Slovénie étudient ce concept pour le stockage du combustible irradié généré par leurs PRM et réacteur de recherche, respectivement [WNN, 2021a, 2021b].

Le Département de l'énergie des États-Unis (U.S. DOE) a entrepris des études en 2009 sur le concept des forages très profonds en vue du stockage des assemblages de combustible irradié des réacteurs de centrales nucléaires américaines. Des études initiales publiées par les Sandia National Laboratories ont présenté une évaluation préliminaire du concept [Sandia, 2009] et une conception de référence [Sandia, 2011a,b]. Suivant cette dernière, il est présumé que les déchets seraient stockés dans la portion du 1er et du 2e kilomètres les plus profonds d'un trou de 3 à 5 kilomètres de profondeur et d'approximativement 45 centimètres de diamètre foré verticalement dans la couche de roche supérieure jusque dans la roche cristalline du socle. Bien que la récupération du combustible reste possible pendant les opérations de mise en place, il est présumé qu'elle ne serait pas requise une fois le forage scellé.

En 2014, le U.S. DOE a lancé un projet de perçage d'un trou de forage en profondeur pour évaluer la technologie pour des types précis de déchets de haute activité de petite taille (comme des capsules de Cs et de Sr concentrés actuellement stockés sur le site de Hanford) [Sandia, 2014b; U.S. DOE, 2014a,b; U.S. NWTRB, 2016]. Le programme Deep Borehole Field Test prévoyait la conception, la sélection d'un site et la réalisation d'au moins un forage non radioactif à pleine échelle percé à une profondeur de 5 kilomètres [Sandia, 2012c, 2015a,b]. Un dossier de sûreté générique préliminaire avait été monté pour démontrer la faisabilité du concept de stockage des capsules de Cs et de Sr [Sandia, 2016, 2019]. En 2016, le U.S. DOE avait annoncé qu'un site de 20 acres de terres publiques près de Rugby, au Dakota du Nord, avait été choisi pour l'essai [U.S. DOE, 2016]. Toutefois, même si aucun véritable déchet radioactif ne devait être utilisé dans l'essai, celui-ci s'est heurté à une importante opposition locale et le permis de forage nécessaire n'a pas été accordé. Le projet a été discontinué en 2017 [U.S. DOE, 2017].

Un autre concept a aussi été proposé : le stockage des déchets radioactifs dans des forages horizontaux moins profonds, où les colis de déchets subiraient moins de pression et pourraient être récupérés. Selon ce concept, un trou serait foré verticalement depuis la surface, à travers la roche sédimentaire, ignée ou métamorphique, à une profondeur d'approximativement 1 kilomètre. Ensuite, le forage prendrait une direction subhorizontale [Deep Isolation, 2020]. Plusieurs longs forages subhorizontaux seraient utilisés pour confiner les colis de déchets radioactifs. Une société privée de stockage des déchets nucléaires aux États-Unis, Deep Isolation, a proposé d'utiliser les technologies existantes de forage directionnel et a réalisé un essai public de démonstration en 2019 de ce concept en plaçant et en récupérant un prototype de conteneur d'un forage horizontal percé à une profondeur d'approximativement 600 mètres [Deep Isolation, 2019].

Bien que le concept du stockage du combustible irradié en forages profonds soit considéré comme techniquement faisable, l'approche présente certains défis d'importance :

- Les forages au diamètre et à la profondeur requis;
- La mise en place contrôlée des colis de déchets (p. ex., les problèmes d'ingénierie posés par la taille restreinte que devraient avoir les conteneurs/colis de combustible irradié ainsi que les problèmes à résoudre au cas où un colis resterait pris dans le trou de forage avant qu'il n'ait atteint la profondeur souhaitée);
- La mise au point d'une technologie robuste de surveillance pour une superficie et une profondeur substantielles;
- La mise au point de dispositifs de scellement des forages qui pourraient être placés à distance depuis la surface;
- Une fois les colis de déchets en place et scellés, la récupération serait très difficile.

Globalement, l'United States Nuclear Waste Technical Review Board [U.S. NWTRB, 2016] a conclu que même si la faisabilité des forages profonds avait été démontrée pour certains types de déchets, ils n'élimineraient pas la nécessité de construire un dépôt géologique excavé. De plus, il a conclu que le temps nécessaire pour trouver un site pour une installation de forages profonds, obtenir les autorisations nécessaires et construire l'installation serait comparable au temps requis pour construire un dépôt excavé conventionnel.

La SGDN continuera de surveiller le concept des forages très profonds dans le cadre de notre examen continu de l'approche de la GAP.

Conclusions

La SGDN continue de surveiller les développements dans le domaine des cycles de combustible avancés et des méthodes de remplacement pour la gestion à long terme des déchets.

Les principales conclusions de la SGDN sont que :

- Les nouveaux cycles de combustible et le concept du forage à très grande profondeur continuent de susciter de l'intérêt dans le monde, mais il n'y a eu aucune percée technologique qui modifierait la précédente conclusion concernant l'approche de la GAP et la gestion de l'inventaire actuel de combustible nucléaire irradié canadien.
- L'exploitation de PRM au Canada générera, en petites quantités, de nouveaux types de déchets de combustible nucléaire. Les répercussions de ces possibles nouveaux déchets sur le programme de la SGDN sont évaluées dans le cadre de son examen des technologies liées aux PRM.
- Les cycles de combustible avancés considérés jusqu'à maintenant produiront des déchets de combustible nucléaire à vie longue qui devront être gérés de manière sûre, socialement acceptable, techniquement rigoureuse, responsable sur le plan environnemental et économiquement viable par la SGDN.
- La SGDN continuera d'assurer un suivi des développements liés aux cycles de combustible avancés et aux méthodes techniques de remplacement qui pourraient avoir une incidence sur les exigences canadiennes futures en matière de gestion des déchets.

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NUCLEAR WASTE MANAGEMENT ORGANIZATION

SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

QUI NOUS SOMMES


nwmo

Bonjour.

Nous sommes la

SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

(ou, pour faire court, la SGDN).

Nous sommes une organisation à but non lucratif qui a pour mission de faire en sorte que le combustible nucléaire irradié canadien – y compris celui qui sera produit par des technologies nouvelles ou naissantes – soit géré de manière sûre pour des générations à venir.

En 2002, une loi fédérale nous a confié la responsabilité de gérer de manière sûre à long terme le combustible nucléaire irradié canadien.

Depuis, nous avons travaillé étroitement avec des collectivités municipales et autochtones, l'industrie, les autorités de réglementation et tous les ordres de gouvernement en vue de protéger les gens et l'environnement, dès maintenant et dans le futur.

Bref, ***votre sécurité est notre vocation***.

L'énergie nucléaire au Canada

Les Canadiens et les peuples autochtones dépendent de l'énergie nucléaire depuis des décennies pour alimenter leurs foyers et leurs entreprises. En Ontario, l'énergie nucléaire constitue à l'heure actuelle la source la plus importante d'électricité, elle qui produit environ 60 pour cent de l'énergie électrique de la province.

Des centaines d'entreprises et des dizaines de milliers d'emplois d'un bout à l'autre du Canada dépendent de l'industrie nucléaire. Celle-ci joue un rôle crucial dans la production d'isotopes médicaux destinés à des diagnostics et des traitements qui sauvent des vies, ici au pays et à l'étranger. Comme source d'énergie sans émissions de dioxyde de carbone, l'énergie nucléaire contribue à plusieurs stratégies gouvernementales mises en oeuvre au Canada et dans le monde pour lutter contre les changements climatiques.

Alors que les gouvernements cherchent à favoriser une croissance économique soutenue tout en protégeant les gens et la planète, l'énergie nucléaire continuera probablement de gagner en importance.

Toutefois, la production d'énergie nucléaire génère un sous-produit, le combustible nucléaire irradié. Même si son niveau de radioactivité décroît rapidement avec le temps, le combustible irradié continuera de poser un risque pour la santé pendant des centaines de milliers d'années. Le combustible irradié doit être confiné et isolé des gens et de l'environnement pour une période essentiellement indéfinie – et cette exigence de sûreté est la base du plan de gestion à long terme du combustible nucléaire irradié actuellement mis en oeuvre.



Qu'est-ce que le combustible nucléaire irradié?

Contrairement aux représentations utilisées dans plusieurs bandes dessinées et films, le combustible nucléaire irradié canadien ne se présente pas sous forme liquide ou gazeuse. C'est un solide stable – un type de céramique – qui est scellé dans un contenant de conception spéciale. Plusieurs de ces contenants sont soudés ensemble pour former une « grappe ». Chaque grappe pèse approximativement 53 livres (24 kilogrammes) et est sensiblement de la taille et de la forme d'une bûche pour le foyer.

Lorsqu'une grappe est retirée d'un réacteur nucléaire, elle a la même apparence que lorsqu'elle y a été insérée – mais elle est hautement radioactive et elle le demeurera pendant une très longue période.

Une fois la grappe de combustible nucléaire irradié retirée du réacteur, elle est placée dans une piscine remplie d'eau, où sa chaleur et sa radioactivité diminuent avec le temps. Au bout de sept à 10 ans, elle est placée dans un conteneur de stockage à sec, une méthode utilisée à maints endroits dans le monde depuis les années 1980.

Cette approche est très sûre, mais provisoire. Comme il faudra des centaines de milliers d'années pour que la radioactivité du combustible nucléaire irradié se dissipe, ***il nous faut une approche à long terme***.

C'est pourquoi le Canada a un plan pour gérer son combustible nucléaire irradié dans un dépôt géologique en profondeur. En vertu de ce plan, les propriétaires des déchets doivent financer sa mise en oeuvre et les fonds requis pour assurer l'ensemble de son cycle de vie sont déjà en place.

Les décisions sur la construction de nouveaux réacteurs nucléaires pourraient donner lieu à différents volumes ou types de combustible irradié à gérer. La SGDN continuerait d'être responsable de la gestion sûre de ce combustible irradié.

Les Canadiens et les peuples autochtones conviennent que nous ne pouvons tout simplement pas abandonner la gestion du combustible nucléaire irradié aux générations futures – nous devons agir maintenant.

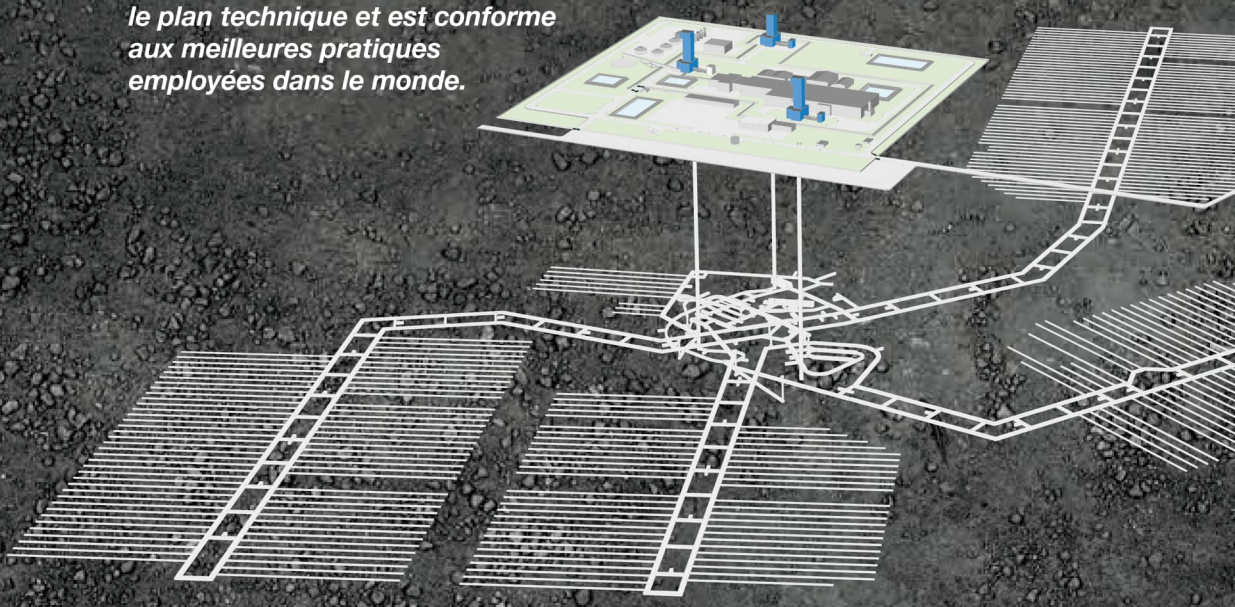
Quel est le plan?

La SGDN a été chargée par une loi fédérale d'étudier les approches possibles de gestion du combustible nucléaire irradié et d'en recommander une. En 2005, au terme d'un processus d'étude et de dialogue mené pendant trois ans avec des Canadiens et des peuples autochtones d'un bout à l'autre du pays, nous avons fourni notre recommandation au ministre des Ressources naturelles. En juin 2007, le gouvernement fédéral a décidé que le plan que nous mettons actuellement en oeuvre – nommé la Gestion adaptative progressive – serait le plan canadien.

Le plan canadien prévoit que le combustible nucléaire irradié sera stocké dans un ***dépôt géologique en profondeur*** : un réseau souterrain de tunnels et de salles de mise en place. Le dépôt géologique en profondeur serait situé à un emplacement sûr et propice associé à des hôtes informés et consentants, qui comprendront les municipalités et les collectivités autochtones locales.

Selon la géologie locale, le dépôt sera construit à une profondeur de plus de 500 mètres (1640 pieds), ce qui correspond à environ la hauteur de la Tour CN. Sa conception comprendra une série de barrières ouvragées et naturelles qui travailleront ensemble pour confiner et isoler le combustible nucléaire irradié.

Cette approche est sûre, pose très peu de risques, est fiable sur le plan technique et est conforme aux meilleures pratiques employées dans le monde.



Le plan canadien s'appuie sur les avis fournis par les Canadiens et les peuples autochtones, sur le consensus scientifique international en la matière, sur le savoir autochtone et sur des décennies de recherche. En fait, la plupart des autres pays qui ont des programmes nucléaires commerciaux, dont la Finlande, la France, le Japon, la Suède et le Royaume-Uni, ont adopté cette approche.

Le plan canadien est cependant beaucoup plus qu'un document ou un cadre réglementaire. En tant que projet national d'infrastructure qui nécessitera des milliards de dollars d'investissements sur plusieurs décennies, le dépôt est susceptible de devenir un moteur économique à long terme pour le secteur où il sera situé ainsi que pour l'ensemble de la région hôte.

Les retombées économiques potentielles constituent qu'un aspect du projet. Nous sommes résolus à mettre en oeuvre le plan d'une manière qui favorisera le bien-être de la région, tel que ses résidents l'auront défini, et nous prenons progressivement connaissance, en discutant avec les collectivités, des multiples facteurs qui sont importants pour elles.

Comme ce projet multigénérationnel sera mis en oeuvre en plusieurs phases au cours d'une période d'environ 175 ans, nous examinerons, renforcerons et ajusterons continuellement le plan en tenant compte des nouvelles informations, orientations et directives à mesure qu'elles deviendront disponibles.



Sur le site du dépôt ou à proximité, un **Centre d'expertise** sera construit pour soutenir les travaux – initialement en facilitant les essais et les évaluations de sûreté, mais aussi en constituant un lieu servant les intérêts de la collectivité ainsi qu'un carrefour d'innovation.

La conception et l'utilisation du centre seront déterminées en collaboration avec les résidents de la région choisie. Si les collectivités autochtones locales le souhaitent, il pourrait comprendre un espace d'apprentissage expliquant comment le savoir autochtone est appliqué au projet.

Plus tard, le Centre d'expertise pourrait loger des programmes de recherche et un programme de démonstration technologique où travailleraient des spécialistes d'un éventail de disciplines.





La collaboration avec les collectivités est au coeur de ce que nous faisons

La gestion sûre à long terme du combustible nucléaire irradié devra s'appuyer sur une de nos meilleures et de nos plus précieuses ressources : la détermination des Canadiens et des peuples autochtones à bâtir un avenir sûr et respectueux de l'environnement.

Protéger l'environnement en mettant en oeuvre le plan canadien nécessitera une collaboration ouverte à un éventail diversifié de points de vue et de sources, notamment les commentaires du public, les différents ordres de gouvernement, le savoir autochtone et la communauté scientifique.

Bien que la construction du dépôt géologique en profondeur et le transport du combustible nucléaire irradié ne doivent pas commencer avant les années 2030 et 2040 respectivement, nous sommes résolus à dialoguer d'ici là avec les Canadiens et les peuples autochtones touchés par ces décisions.

Ces valeurs fondamentales suivantes sont la base de notre travail.

Sûreté	Intégrité	Excellence
Collaboration	Responsabilité	Transparence



Engagement envers la réconciliation et alignement sur le savoir autochtone

En cheminant ensemble avec les peuples autochtones, nous prenons en considération plusieurs visions du monde et la façon dont le savoir autochtone peut éclairer tous les aspects de nos travaux, de la prise de décision et de la planification stratégique aux travaux sur le terrain et aux ressources humaines.

Au moyen d'échanges de connaissances respectueux, la SGDN travaille à créer des possibilités pour les multiples voix autochtones d'être reconnues et entendues. La clé du cheminement vers la réconciliation est l'établissement d'une solide base de reconnaissance et de respect à travers une série continuelle d'occasions éducatives.

En 2019, nous avons fait un pas important en officialisant notre *Politique sur la réconciliation*. Nous nous sommes engagés à élaborer chaque année un plan de mise en oeuvre pour mesurer et déclarer publiquement nos progrès et à bâtir des relations durables avec les collectivités autochtones et municipales.

Et en nous appuyant sur les conseils avisés du Conseil des détenteurs du savoir autochtone et des détenteurs du savoir autochtone des collectivités hôtes potentielles, ainsi que sur la *Politique sur le savoir autochtone* que nous avons adoptée en 2016, nous continuons d'aligner intentionellement nos travaux sur les éclairages de différents systèmes de connaissances.



Guidés par le savoir, ancrés dans la collectivité

La transparence et la responsabilité ne sont pas importantes uniquement pour nous : elles sont essentielles pour tous les Canadiens et les peuples autochtones qui comptent sur nous pour que le plan canadien se réalise en toute sûreté. Il est d'une importance capitale que les gens et les collectivités puissent participer à tous les aspects de ce processus qui les concerne.

C'est pourquoi notre équipe de spécialistes techniques de classe mondiale – qui comprend des scientifiques et des ingénieurs expérimentés – travaille en collaboration avec les collectivités municipales et autochtones touchées, le public, tous les ordres de gouvernement, les autorités de réglementation nationales et internationales, l'industrie et le milieu universitaire pour mettre en oeuvre le plan canadien.

Depuis 2010, nous menons un processus axé sur les besoins des collectivités, qui a pour but de choisir un site où le combustible nucléaire irradié canadien pourrait être confiné et isolé en toute sûreté. Ce processus est le fruit de deux années de dialogue et a été conçu pour répondre aux normes scientifiques, professionnelles et éthiques les plus rigoureuses.

Nous prévoyons avoir choisi un site optimal unique en 2024. Le projet n'avancera que dans une région avec des hôtes informés et consentants, où la municipalité, les collectivités des Premières Nations et métisses et les autres de la région travaillent ensemble pour sa mise en oeuvre.

Au terme d'un processus par étapes comprenant des études sur le terrain, un processus d'approbation réglementaire exhaustif et un programme de concertation avec les collectivités et le public, le dépôt géologique en profondeur sera construit sur une période estimée à une dizaine d'années.

Pendant notre mise en oeuvre du plan canadien, nous continuerons de servir les collectivités où nous travaillons en soutenant des programmes jeunesse, les services aux personnes âgées des collectivités, la viabilité des collectivités, l'efficacité énergétique, le développement économique et d'autres initiatives qui suscitent un grand intérêt et l'appui des populations locales.

Apprendre est un processus en soi, et nous anticipons que les occasions d'apprendre continueront de se manifester tout au long de la mise en oeuvre du plan canadien. Maintenir une approche adaptative et orientée vers la collectivité contribuera à satisfaire aux besoins des collectivités.

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