Overview of Used Fuel Management in Canada

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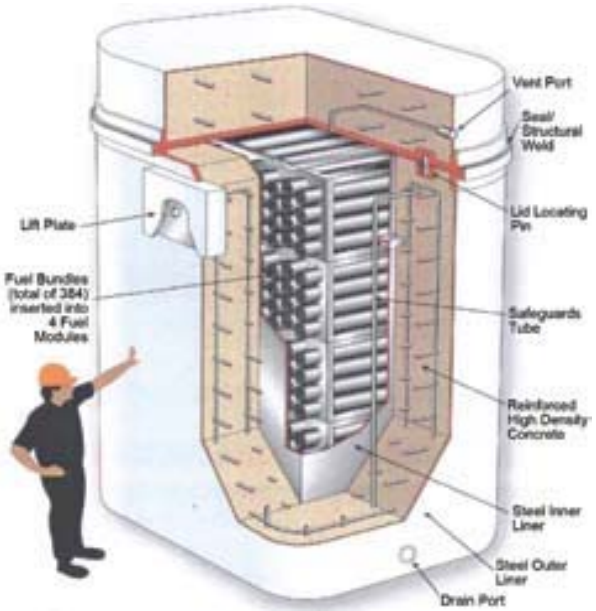
Unrestricted

Presentation Outline

- Dry Storage of Used Fuel in Canada
  - Power Reactor Fuel (CANDU)
    - Ontario Power Generation
    - Hydro-Quebec
    - New Brunswick Power
  - Research Reactor Fuel
    - Atomic Energy of Canada Limited (AECL)
      - Stabilization of historic fuel
      - Continued dry storage of newer RR fuel
      - Return of US-origin fuel
- Disposal of Used Fuel in Canada
  - NWMO

Radioactive Waste Management Sites in Eastern Canada

Utility Used Fuel Dry Storage
Ontario Power Generation (OPG)



- OPG-designed Dry Storage Container (DSC), used exclusively at OPG sites.
- Approximately 85-90% of used CANDU fuel in Canada will be stored in DSCs.

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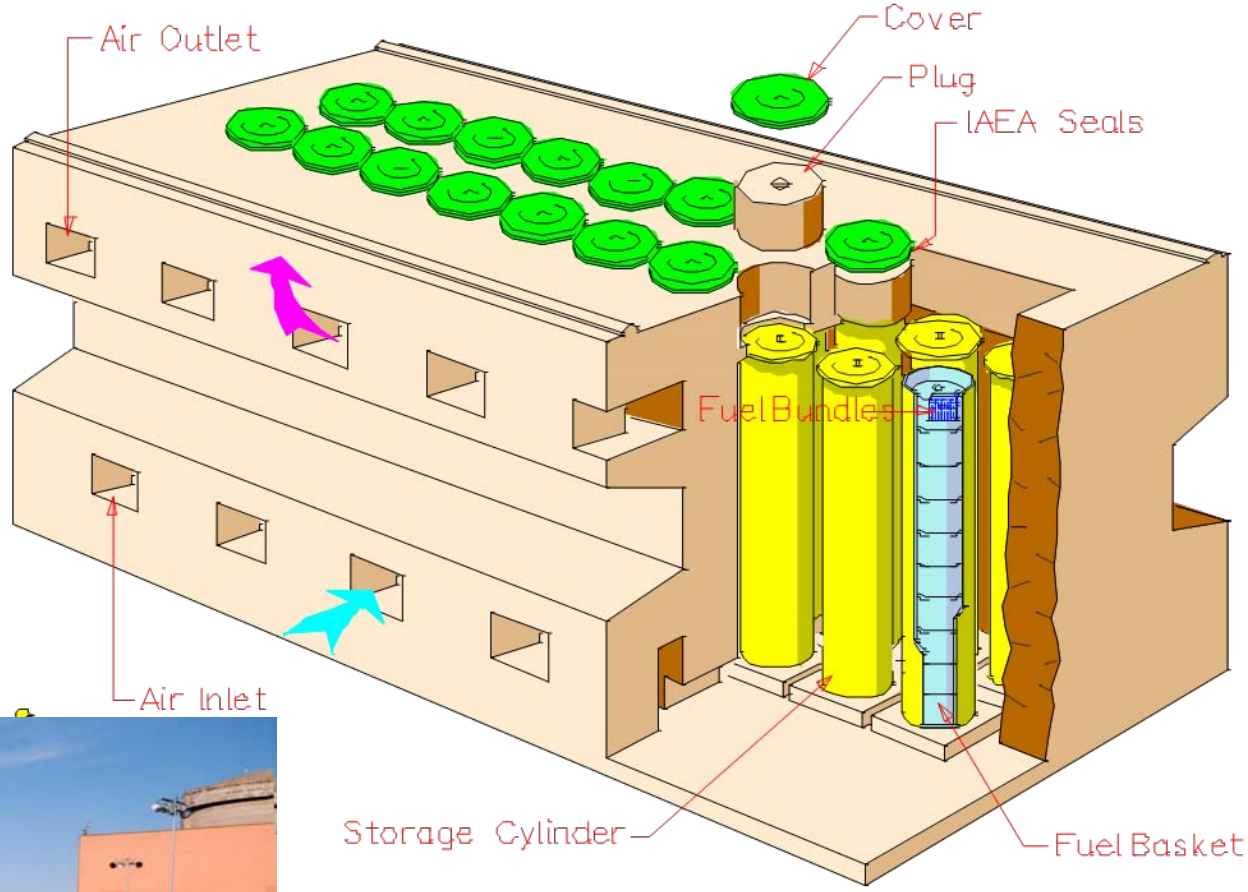
Utility Used Fuel Dry Storage Hydro-Quebec (HQ)

- AECL-designed dry storage system used at many international CANDU plants.
- Two versions marketed, MACSTOR-200 and MACSTOR-400.



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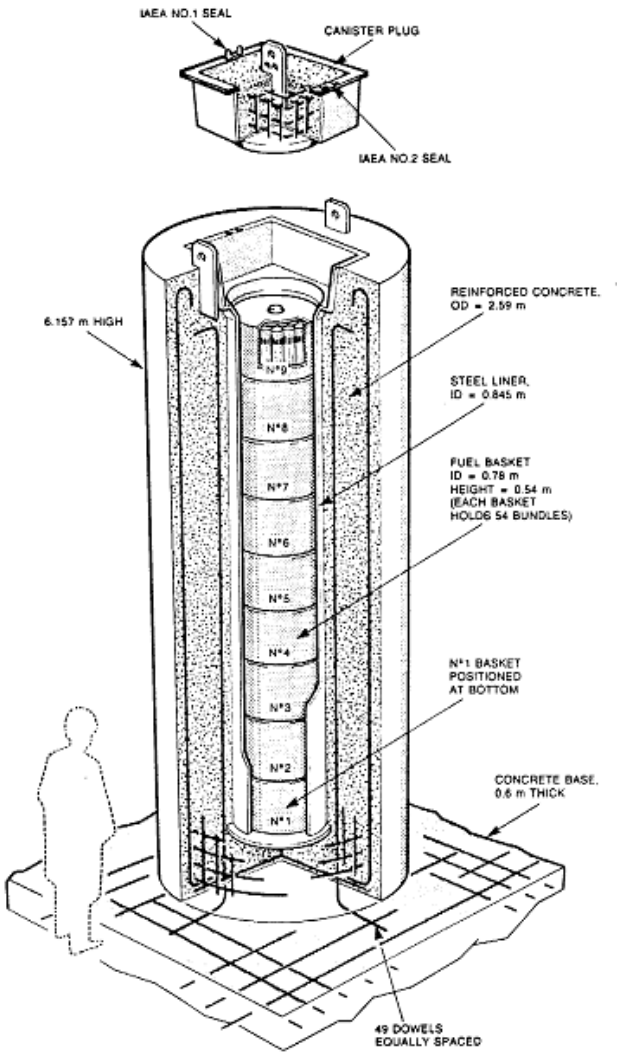
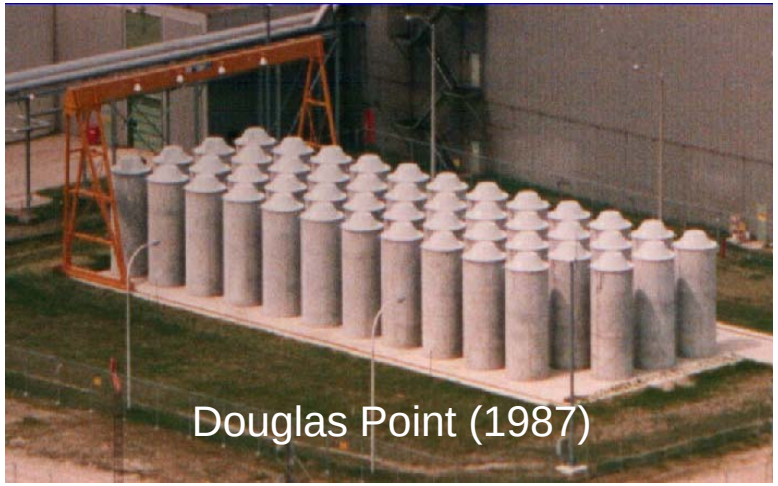
Utility Used Fuel Dry Storage
New Brunswick Power (NBP)





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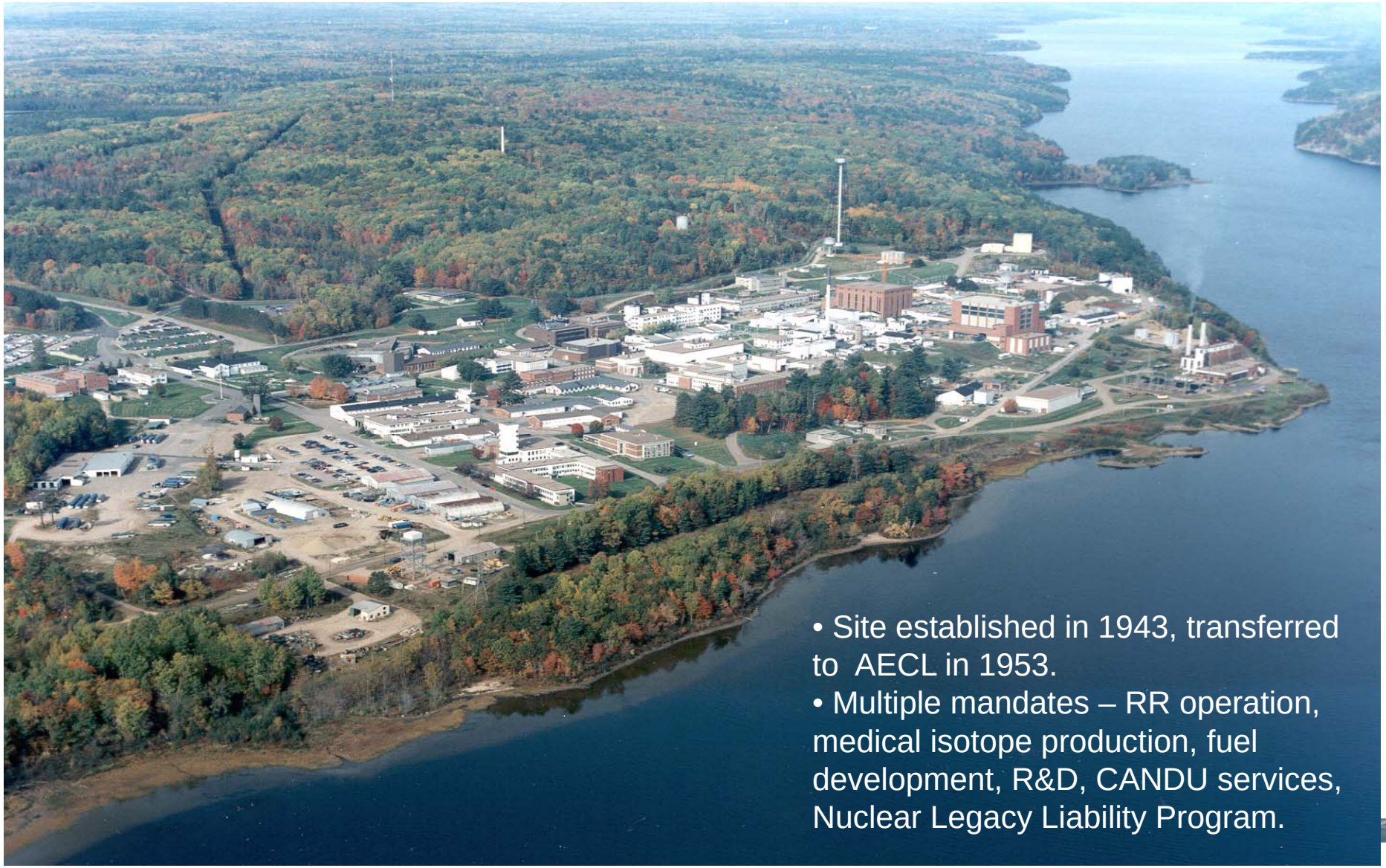
AECL Chalk River Laboratories



- Site established in 1943, transferred to AECL in 1953.
- Multiple mandates – RR operation, medical isotope production, fuel development, R&D, CANDU services, Nuclear Legacy Liability Program.

NRU and NRX Reactors at CRL

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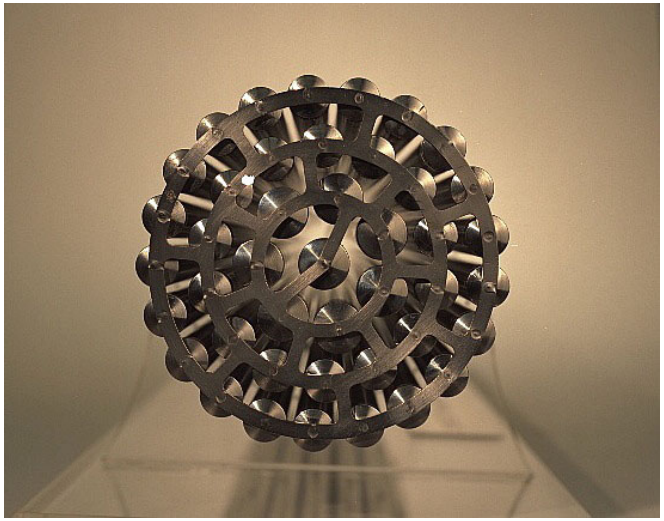
AECL Fuel Inventory

- Since 1945, AECL has operated several Research Reactors and Prototype CANDU Reactors. AECL manages a total of 504 tonnes (HE mass) of spent fuel.
- Prototype CANDU power reactors include DPNGS, NPD, and G-1.
  - Fuel from prototype CANDU reactors totals 408 tonnes.
  - Spent fuel from prototype CANDU reactors is similar to CANDU fuel and is stored using AECL's Concrete Canister Dry Storage technology.
  - RR Fuel from WR-1 is similar (geometry and cladding) and is dry stored using the same technology.
- Research Reactors include NRU*, NRX, WR-1, PTR, SLOWPOKE, ZED-2*, ZEEP (*operational)
  - Inventory of RR fuel is 96 tonnes, comprised of various chemical forms, cladding materials, enrichments, and geometries.
  - The majority of RR fuel irradiated at CRL between 1947-1985 was sent to the United States (U-metal and HEU/Al).

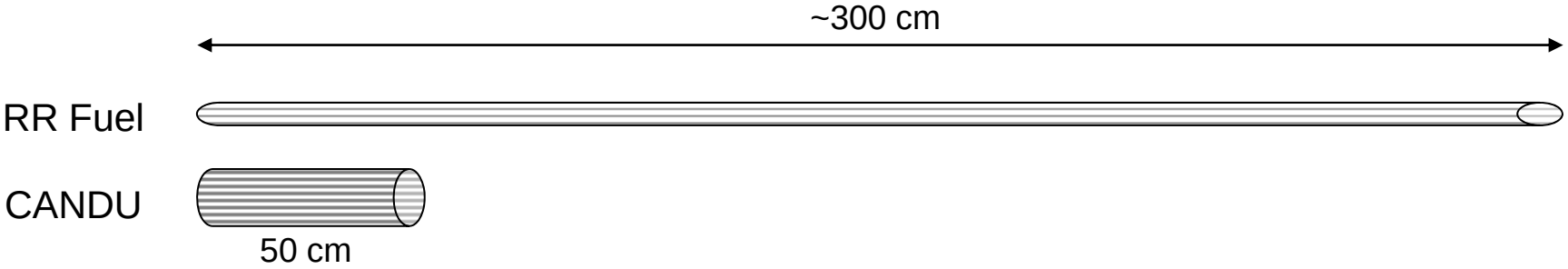
AECL CRL RR Fuel vs. CANDU Fuel

NRX

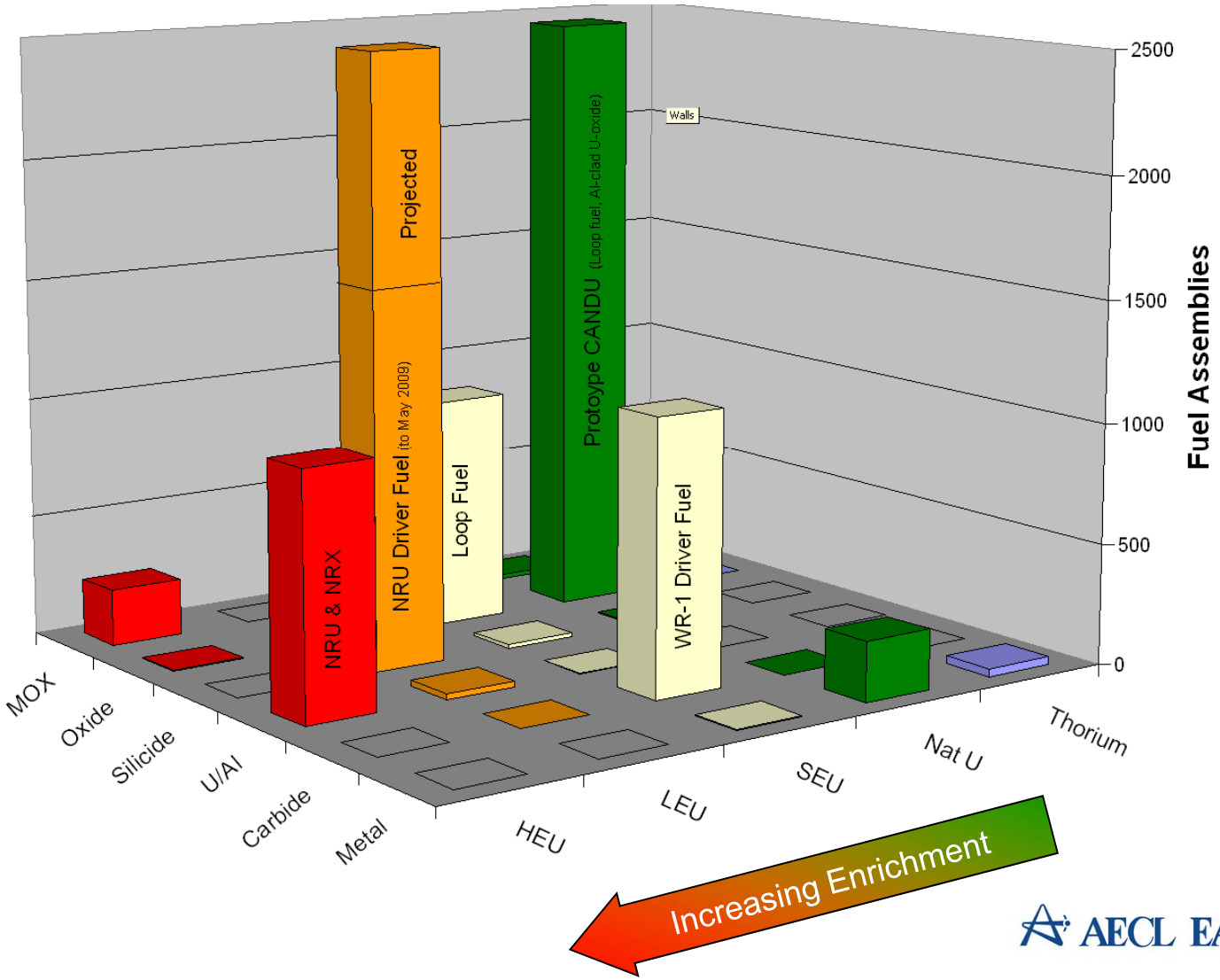
NRU



CANDU



AECL RR Fuel Groupings



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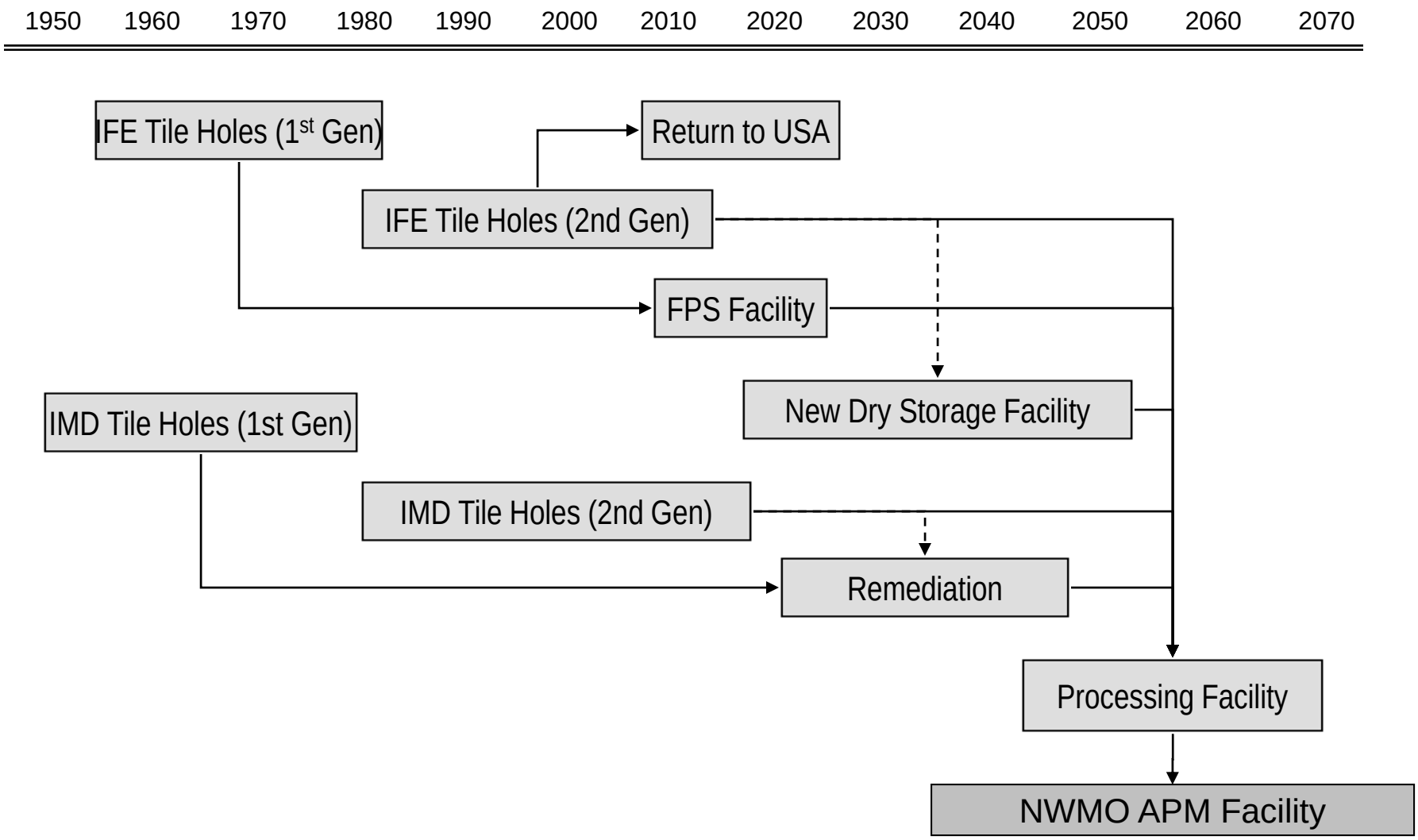
AECL RR Fuel Management Timeline



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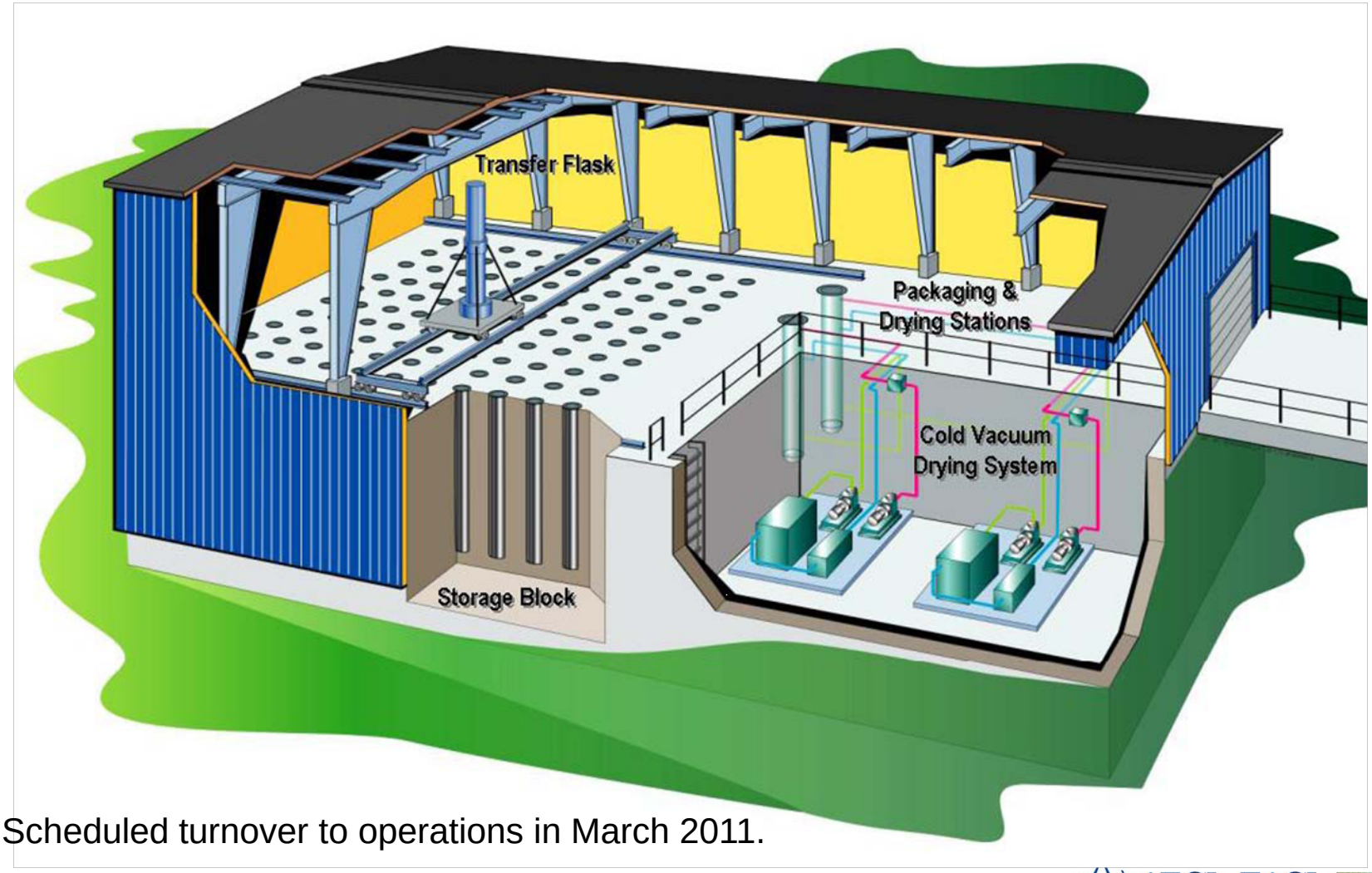
Remediation of Historic RR Fuel

- Field inspections from 1998-2000 of historic fuel (irradiated1947-1962) observed some fuel degradation, contamination, hydrogen generation, and potentially pressurized storage containers.
- Operations project was initiated to reduce immediate HSE (Health, Safety, Environment) risks and prepare fuel cans for retrieval.
  - Remove and treat high-activity water
  - Remotely puncture storage containers to remove accumulated hydrogen gas and passivate uranium hydride in a controlled manner.
  - Confirm integrity of storage can and install standardized lifting adaptors.
- AECL formed the Fuel Packaging and Storage (FPS) Project to:
  - Design, construct, license, and commission the equipment and facilities to retrieve and transfer historic fuel to a new facility for conditioning and interim dry storage.

Fuel Packaging and Storage (FPS) Facility



Scheduled turnover to operations in March 2011.

FPS Design Highlights

- The nested configuration of the packaging and inferred condition of the fuel assemblies led to the decision it would not be feasible to confirm sufficient dryness for unmonitored sealed storage.
  - A modified AECL MACSTOR dry storage system (incorporating venting capability) was selected as the reference concept.
  - Storage cans will have a mechanical closure and metal HEPA filters in the lid to vent gas into the sealed storage location.
- Fuel will be subjected to cold vacuum drying prior to emplacement in storage.
  - Pressure rebound method will be used to confirm dryness.
- Inert cover gas to be used at all stages (recovery from tile hole, transport, drying, and final storage).
  - Each storage location is continuously monitored for pressure change.
  - Cover gas in storage location may be sampled and replaced if necessary.
  - Storage can may be returned to drying station for supplemental drying cycles.

Interior Bridge and Trolley

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FPS Retrieval Flask Transfer Vehicle

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Second-Generation IFE Tile Holes

- Design improvements from early tile hole configurations.
- Fuel has been safely stored in these facilities for 20 years.
- Sample line allows for confirmation of internal conditions without removing shield plug or opening the tile hole.
- While overall performance has been excellent, this technology is scheduled to be phased out over the next 10 years.

AECL Used Fuel Management Summary

- **AECL manages a wide variety of RR fuel types.**
  - Initial storage in reactor pool for an average of two years followed by interim dry storage in concrete canisters or tile holes.
- **AECL is implementing improved dry storage systems to maintain fuel integrity and operational safety until national repository is available.**
  - Monitored vented storage has been selected.
  - Facilities will be licensed for 50 years of operation.
- **AECL anticipates these dry storage systems will provide safe interim storage of RR fuel until transfer to the NWMO repository (2050+).**
- **AECL is repatriating US-origin HEU RR fuel.**

Used Fuel Disposal in Canada

- Repository 1.0
  - AECL led development of the Canadian repository concept in the 1980s; most work performed at the Whiteshell Labs in Manitoba.
  - Constructed the Underground Research Laboratory (URL) nearby.
  - In 1996, a federally appointed review panel determined that while the repository was technically acceptable, it did not have sufficient public support to move forward with the siting process.
  - The repository program scaled down, and the Whiteshell site and URL have since transitioned into decommissioning.
- Repository 2.0
  - Nuclear Waste Management Organization (NWMO)
  - Created by the Nuclear Fuel Waste Act in 2002

Nuclear Waste Management Organization (NWMO)

- Mission Statement
  - 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.
- Tasked with assessing 3 options:
  - Continued storage at generating sites
  - Centralized long-term storage
  - Disposal in national repository
- Funded by major waste owners (OPG, NBP, HQ, AECL)
  - Trust funds in place by each corporation; waste owners make annual deposits
  - Federal government approved funding formula
  - Separated from OPG in January 2009

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Adaptive Phased Management

- Nuclear Fuel Waste Act requires NWMO to engage Canadians in the review of different approaches for managing used fuel
- NWMO engaged nation-wide:
  - 18,000 Canadians contributed to 3-year study between 2002-2005
  - 120 information & discussion sessions – every province and territory
  - 2500 Aboriginal people participated in dialogues
- What Canadians said:
  - Safety and security is top priority
  - This generation must take action now
  - Approach must be adaptable: allow improvements based on new knowledge or societal priorities

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Adaptive Phased Management

Main Safety Arguments for a Geologic Repository

- Use of multiple barriers (i.e., waste form, container, sealing materials, host rock)
- Host rock is stable and predictable over long time periods
- Low rock permeability ensures waters are isolated and do not mix with surface waters
- Maintains a favourable chemical and hydrogeological environment
- Natural analogues provide evidence that engineered barrier components are stable for very long times
- Depth is such that inadvertent human intrusion is unlikely
- International progress provides additional assurance
- Safety assessments indicate impacts are likely to be well below recommended dose rates and natural background dose rates
- Can be built using proven technologies

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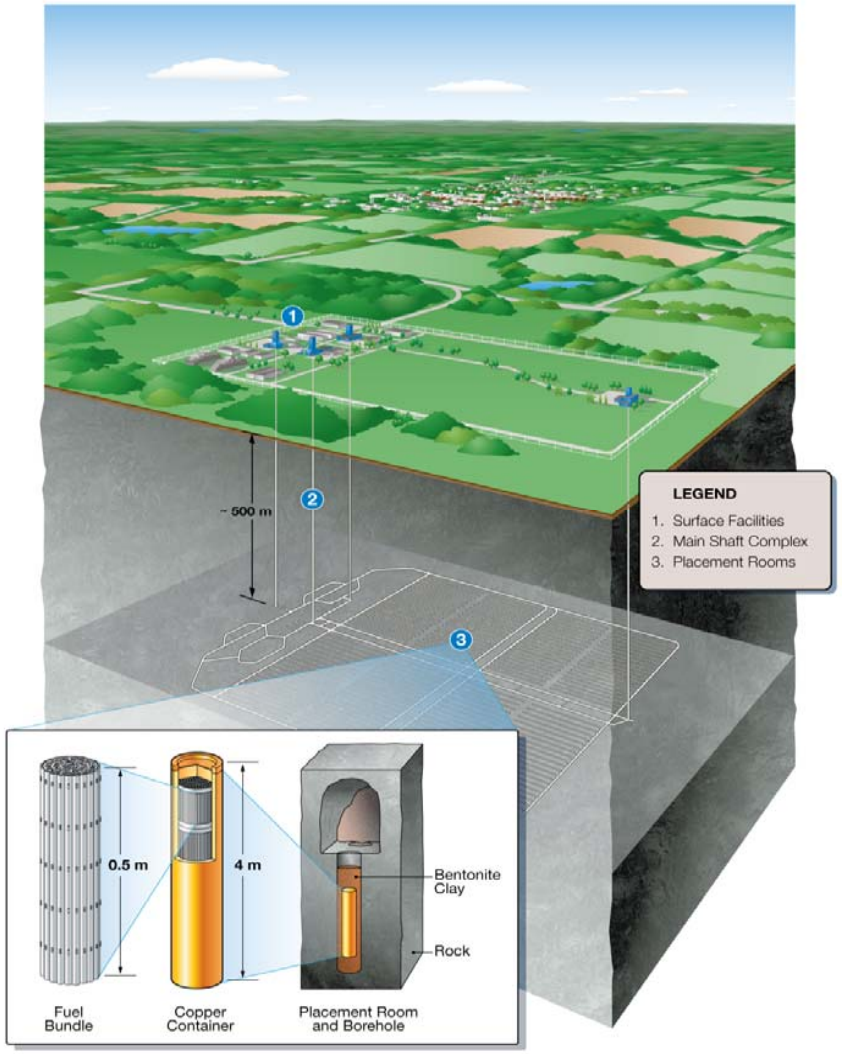
Adaptive Phased Management

- Federally mandated project
- Investment of $16 to $24 billion
- To be implemented locally in an informed, willing host community
- High technology project, skilled employment for hundreds over many decades
- Vision to operate as a centre of excellence
- Drawing on national research networks and international research collaboration
- Highly regulated – strict scientific, and technical criteria assure safety
- Opportunity for host community to work closely with NWMO in implementing project for many years to come



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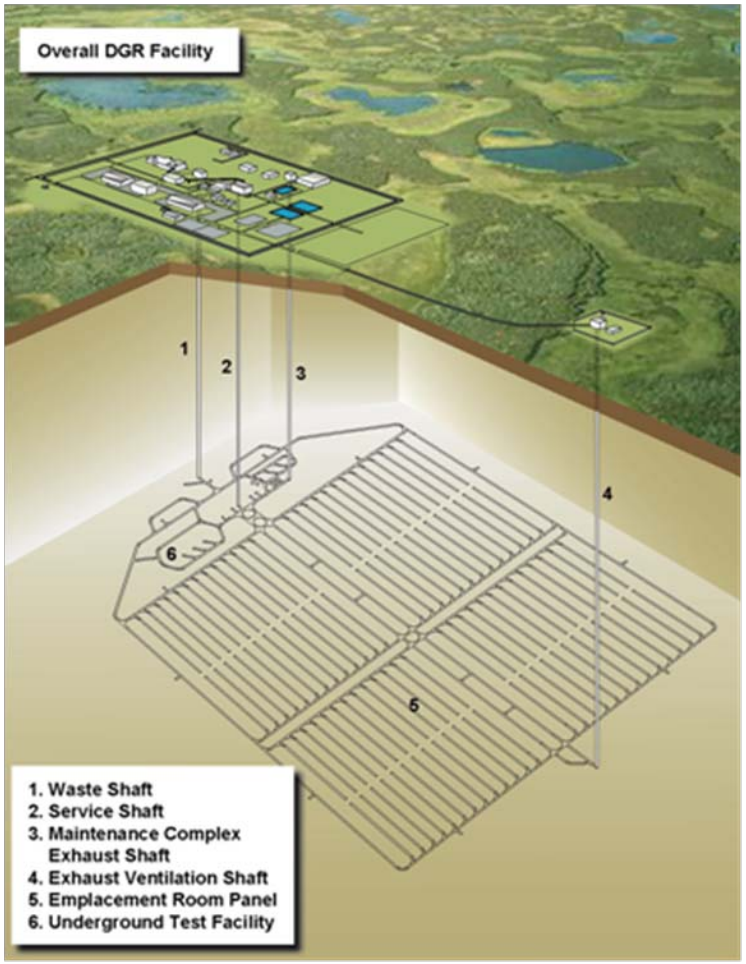
Adaptive Phased Management



- May be situated in crystalline or sedimentary rock
- Current studies are considering designs for 3.6 million and 7.2 million fuel bundles
- The layout will be adapted to the local conditions
- Depth will to be 500 m – 700 m below the surface
- Underground footprint is about 2 km X 3 km (for 3.6 million bundles)

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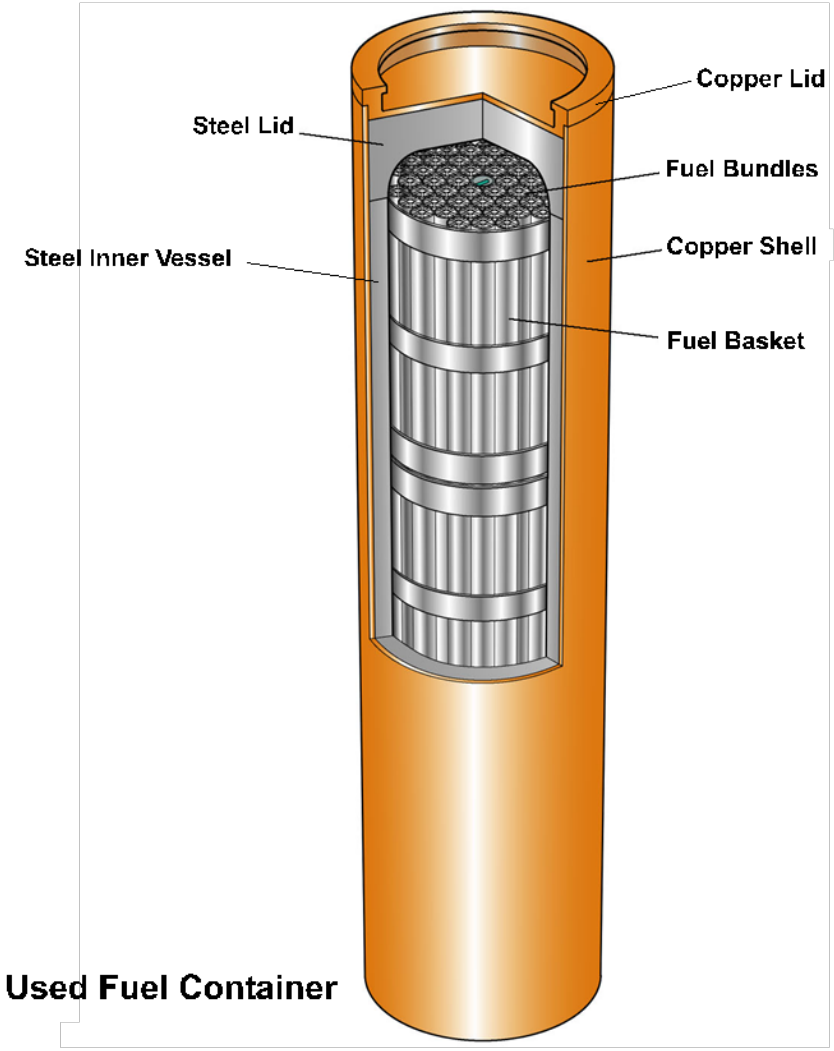
Adaptive Phased Management



- 360 fuel bundles per container
- Minimum 30 year decay period prior to emplacement
- 1.25 m OD X 3.9 m
- 25 metric tonnes loaded
- Steel inner vessel for strength
- Designed to withstand the local hydrostatic pressure, the bentonite swelling pressure and a glacial load equivalent to a 3 km thick ice sheet
- 25 mm thick Cu outer vessel (provides a corrosion barrier)
- Minimum design life is 100,000 years

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Process for Site Selection

KEY PRINCIPLES

- Safety
- Informed, willing community; focus on 4 nuclear provinces
- Communities choose to participate and have the right to withdraw
- Respect Aboriginal rights and treaties
- Inclusiveness of the views of others, including those along possible transportation routes
- Partnership-based approach
- Foster long-term community well-being in the host community
- Shared decision-making with potential host community

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Process for Site Selection

CURRENT TIMELINE

1.	Site Selection	Y01-Y09	Start 2010 End 2018
2.	Licensing	Y10-Y15	Start 2019 End 2024
3.	Construction UDF	Y16-Y20	Start 2025 End 2029
4.	Construction DGR	Y21-Y25	Start 2030 End 2034
5.	Operation	Y26-Y55	Start 2035 End 2064
6.	Monitoring	Y56-Y65	Start 2065 End 2074
7.	Decommissioning	Y66-Y90	Start 2075 End 2099
8.	Abandonment	Y91	Start 2100 End TBD

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