Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities

Final Program

September 11 to 14, 2011

Marriott Toronto Downtown Eaton Centre Hotel
Toronto, Ontario

The conference is organized by the Canadian Nuclear Society in cooperation with the International Atomic Energy Agency, and is co-sponsored by the American Nuclear Society, the Argentina Nuclear Technology Association, the Atomic Energy Society of Japan, the Chinese Nuclear Society, the Indian Nuclear Society, the Korean Nuclear Society, the Nuclear Energy Agency of the OECD and the Romanian Nuclear Energy Association.

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Table of Contents

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Conference at a Glance

Sunday, September 11, 2011

15:00 – 19:00 **Registration**

15:00 – 18:00 **Exhibit Set–Up**

19:00 – 21:00 **Welcome Reception**

Monday, September 12, 2011

07:00 – 08:00 **Speakers and Chairs-of-the-Day Breakfast**

07:30 – 17:30 **Registration**

08:30 – 10:00 **Opening Plenary Session**

10:00 – 10:20 **Networking Break**

10:20 – 11:20 **Opening Plenary Session (continued)**

11:20 – 12:00 **Visit Business Exposition**

12:00 – 13:30 **Luncheon**

13:30 – 15:10 **Parallel Technical Sessions**

15:10 – 15:40 **Refreshment Break**

15:40 – 17:45 **Parallel Technical Sessions**

17:45 – 19:00 **Business Exposition Reception**

Tuesday, September 13, 2011

07:00 – 08:00 **Speakers and Chairs-of-the-Day Breakfast**

07:30 – 17:30 **Registration**

08:30 – 10:00 **Low- and Intermediate-level Waste Panel**

10:00 – 10:15 **Networking Break**

10:15 - 11:15 **Low- and Intermediate-level Waste Panel (continued)**

11:15 - 12:00 **Visit Business Exposition**

12:00 – 13:30 **Luncheon**

13:30 – 15:10 **Parallel Technical Sessions**

15:10 – 15:40 **Refreshment Break**

15:40 – 17:45 **Parallel Technical Sessions**

18:30 – 22:00 **Reception and Banquet**

Banquet Speaker

Dan Gardner, Journalist & Author of *'Risk'* and *'Future Babble'*

In the tradition of Malcolm Gladwell, Dan Gardner explores a new way of thinking about the decisions we make. Gladwell told us about "the black box" of our brains; Gardner takes us inside, helping us to understand how to deconstruct the information we're bombarded with and respond more logically and adaptively to our world.

In his book Risk, Gardner works with risk science pioneer Paul Slovic to explain how we make decisions and run our lives. The brain has not one but two systems to analyze risk. One is primitive, unconscious, and intuitive. The other is conscious and rational. The two systems often agree, but occasionally they come to very different conclusions. When that happens, we can find ourselves worrying about what the statistics tell us is a trivial threat – terrorism, child abduction, cancer caused by chemical pollution – or shrugging off serious risks like obesity and smoking. Gardner's latest book, Future Babble, was published in October 2010.

Gardner is a columnist and senior writer for The Ottawa Citizen and The National Post, specializing in criminal justice and other investigative issues.

Wednesday, September 14, 2011

07:00 – 08:00 **Speakers and Chairs-of-the-Day Breakfast**

07:30 – 17:30 **Registration**

08:30 – 10:10 **International Plenary Session**

10:10 – 10:30 **Networking Break**

10:30 - 11:20 **International Plenary Session (continued)**

11:20 - 12:00 **Visit Business Exposition**

12:00 – 13:30 **Luncheon**

13:30 – 15:10 **Parallel Technical Sessions**

15:10 – 15:40 **Refreshment Break**

15:40 – 17:00 **Parallel Technical Sessions**

17:00 **Conference Adjourns**

18:00 **Participants in Technical Tour 1 depart for Kincardine**

Thursday, September 15, 2011

07:30 **Participants in Tour 2 depart for Port Hope**

Post-Conference Technical Tours

Tour 1:
Ontario Power Generation's Deep Geologic Repository site and core storage facility, and Western Waste Management Facility, Kincardine, Ontario

Wednesday, September 14, 2011

18:00 Bus departs Marriott Toronto Downtown Eaton Centre hotel for Kincardine. Boxed dinner provided on-board the motor coach.

22:00 Bus arrives at the Best Western Governor's Inn, Kincardine.

Thursday, September 15, 2011

07:00 Breakfast at the Governor's Inn.

08:00 Bus departs for the Western Waste Management Facility. All participants must have Photo ID (Valid driver's licence or Passport).

08:30 Arrive Bruce Power Visitor Centre.
Welcome and Security Clearance.

09:00 Load bus and arrive at the Waste Management Facility, for tour by Darren Howe, Don Jones and Lise Morton.

10:30 Exit OPG Waste Facility and arrive at OPG's Deep Geologic Repository Project core storage area for Coffee Break and opportunity for Q&As.

10:45 DGR presentation from Nuclear Waste Management Organization – Marie Wilson, Mark Jensen, Dylan Luhowy, and Jim McLay.

12:00 Load onto Bus, Depart site for Best Western Governor's Inn.

12:30 Lunch meeting with Mayor of Kincardine and Municipal Council.

14:00 Depart for Toronto.

18:00 Arrive Marriott Toronto Downtown Eaton Centre Hotel.

Tour 2
Port Hope Area Initiative Welcome Waste Management Facility, and Ontario Power Generation's Darlington Waste Management Facility

Thursday, September 15, 2011

07:30 Depart Marriott Toronto Downtown Eaton Centre hotel. All participants must have Photo ID (Driver's licence or Passport).

09:00 Bus arrives in Port Hope (arrival time subject to weather/ traffic conditions).

09:00 Coffee and snacks provided at the Port Hope Area Initiative Management Office (PHAI-MO) at 115 Toronto Road, Port Hope

09:15 Overview of the Port Hope Project

- Welcome from PHAI Project Director, Christine Fahey and Mayor Linda Thompson.
- Background and History of the Port Hope Area Initiative – presentation.

10:00 Delegates board bus for tour of Port Hope Waste Sites (PHAI staff will explain remediation sites and history, a detailed tour guide will be provided.)

10:50 Delegates visit Welcome Waste Management Facility (tour will include details of future long term waste management facility and water treatment technologies.)

11:15 Delegates return to PHAI MO.

11:30 Lunch provided by PHAI MO.

12:00 Bus departs Port Hope for OPG's Darlington Waste Management Facility.

12:30 Bus arrives at Darlington Nuclear Information Centre.

13:00 Group tour of DSC processing and storage facilities.

14:00 Q&A at Darlington Waste Management Facility.

14:30 Depart for Toronto.

15:30 Bus arrives at Marriott Toronto Downtown Eaton Centre hotel.

Sunday, September 11, 2011

15:00 - 19:00	Registration **(Trinity Ballroom Foyer, lower level)**
19:00 - 21:00	Welcome Reception

Monday, September 12, 2011

07:30 - 17:30	Registration (**Trinity Ballroom Foyer, lower level**)
Grand Ballroom 08:30 - 10:00	**Welcome** 08:30 Frank Doyle, President, Canadian Nuclear Society **Opening Plenary** 08:40 **Canadian Radioactive Waste Management: Building Public Confidence for the Future through Our Actions and Our Achievements,** Mark Corey, Assistant Deputy Minister, Energy Sector, Natural Resources Canada 09:00 **Regulatory Developments and Issues,** Michael Binder, President & CEO, Canadian Nuclear Safety Commission 09:20 **Nuclear Environmental Stewardship – The Social Contract,** Bob Walker, Senior Vice-President, AECL Nuclear Laboratories 09:40 **Nuclear Waste Management Organization: Moving Forward Together – Program Update,** Ken Nash, President, Nuclear Waste Management Organization
10:00 - 10:20	Networking Break – **Ballroom Foyer**
Grand Ballroom 10:20 - 11:20	10:20 Challenges in Waste Management and Environmental Restoration in the Uranium Mining Industry, John Jarrell, Executive Advisor, Safety, Health and Environment, Cameco Corporation 10:40 Providing Value to Ontario: OPG's Approach to Nuclear Waste Management, Tom Mitchell, President & CEO, Ontario Power Generation 11:00 Panel Discussion
11:20 - 11:40	Visit Business Exposition
12:00 - 13:30	Luncheon – **Grand Ballroom**

	Trinity 1	Trinity 2	Trinity 3	Trinity 4	Trinity 5	Simcoe
13:30 - 15:10	OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 1	Stakeholder Interactions – 1	Decommissioning Projects - 1	Uranium Mine Waste Management – 1	Used Fuel Repository – Design and Safety Assessment	Federal Policies, Programs and Oversight
15:10 - 15:40	Networking Break – **Ballroom Foyer**					
	Trinity 1	**Trinity 2**	**Trinity 3**	**Trinity 4**	**Trinity 5**	**Simcoe**
15:40 - 17:45	OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 2	Stakeholder Interactions – 2	Decommissioning Projects - 2	Uranium Mine Waste Management – 2	Used Fuel Repository – Design and Modelling	Port Hope Area Initiative – 1
17:45 - 19:00	Business Exposition Reception					

Tuesday, September 13, 2011

07:30 - 08:30	Registration (**Trinity Ballroom Foyer, lower level**)
Grand Ballroom 08:30 - 10:00	**Low- and Intermediate-level Waste Panel** 08:30 **Introduction,** Jonathan Will, Natural Resources Canada 08:45 **Canadian Approaches and Strategies for Low- and Intermediate- Level Radioactive Waste in Canada,** Dave McCauley, Natural Resources Canada 09:00 **Canada's Regulatory Framework,** Don Howard, Canadian Nuclear Safety Commission 09:15 **OPG's Deep Geologic Repository for LILW - Facility Scope,** Pauline Witzke, Ontario Power Generation 09:30 **Managing Wastes from the Atomic Age and into the Future: Programs, Plans and Challenges,** Joan Miller, Atomic Energy of Canada Limited 09:45 **Refurbishment Implications on Long-term Waste Management Strategies at Point Lepreau,** Charles Hickman, New Brunswick Power Nuclear
10:00 - 10:15	Networking Break – **Ballroom Foyer**
Grand Ballroom 10:15 - 11:15	10:15 **Hydro-Québec's Long-Term Strategy for Low and Intermediate Level Waste Management,** François Bilodeau, Hydro-Québec 10:30 **Waste Management Practices at Cameco,** Karen Chovan, Cameco Corporation 10:45 **Panel Discussion**
11:15 - 12:00	Visit Business Exposition
12:00 - 13:30	Luncheon – **Grand Ballroom**

	Trinity 1	Trinity 2	Trinity 3	Trinity 4	Trinity 5	Simcoe
13:30 - 15:10	OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 3	Regulatory Considerations – 1	Aboriginal Traditional Knowledge – Panel Presentation	Geological Disposal - CRL Site Characterization	Geological Disposal – Modelling and Engineered Barriers – 1	Port Hope Area Initiative – 2
15:10 - 15:40	Networking Break – **Ballroom Foyer**					
	Trinity 1	**Trinity 2**	**Trinity 3**	**Trinity 4**	**Trinity 5**	**Simcoe**
15:40 - 17:45	OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 4	Regulatory Considerations – 2	CRL Waste Management – Program Overview	Geological Disposal - Thermal Aspects	Geological Disposal – Modelling and Engineered Barriers – 2	Port Hope Area Initiative – 3
18:30 - 22:00	Reception and Banquet – **Grand Ballroom**					

Wednesday, September 14, 2011

07:30 - 08:30	Registration **(Trinity Ballroom Foyer, lower level)**
Grand Ballroom 08:30 - 10:10	**International Plenary** 08:30 **Introductory Remarks** (TBD) 08:40 **Status and Challenges for Radioactive Waste Management,** Hans Riotte, Head, Radiation Protection and Radioactive Waste Management Division,OECD-NEA 09:10 **The License Application for the KBS-3 System as a Step Towards Implementation of Final Disposal in Sweden,** Anders Ström, Director, Nuclear Fuel Programme, SKB, Sweden 09:40 **A Brief Review of Decommissioning and Waste Management in the UK,** Adrian Simper, Strategy & Technology Director, Nuclear Decommissioning Authority, UK
10:10 - 10:30	Networking Break – **Ballroom Foyer**
10:30 - 11:20	**International Plenary cont'd** 10:30 **The U.S. Blue Ribbon Commission on America's Nuclear Future: Status and Plans,** Tom Isaacs, Lead Advisor to the Blue Ribbon Commission on America's Nuclear Future, USA 11:00 **Q&A and Discussion**
11:20 - 12:00	Visit Business Exposition
12:00 - 13:30	Luncheon – **Grand Ballroom**

	Trinity 1	Trinity 2	Trinity 3	Trinity 4	Trinity 5	Simcoe
13:30 - 15:10	Waste Characterization	LILWM – Treatment and Processing – 1	Decommissioning Projects and Information and Systems Management-1	Waste Disposal - International Experience	Environmental Remediation – 1	Fuel Cycles and Waste Processing - 1
15:10 - 15:40	Networking Break – Ballroom Foyer					
	Trinity 1	**Trinity 2**	**Trinity 3**	**Trinity 4**	**Trinity 5**	**Simcoe**
15:40 - 16:55	Cemented Mo-99 Waste Treatment	LILWM – Treatment and Processing – 2	Decommissioning Projects and Information and Systems Management-2	Used Fuel Storage	Environmental Remediation – 2	Fuel Cycles and Waste Processing - 2
17:00	Conference Adjourns					

Grand Ballroom

Opening Plenary Session

Session Co-Chairs: Frank Doyle, Canadian Nuclear Society and Ken W. Dormuth, Canadian Nuclear Society

08:30
Welcome
Frank Doyle, President, Canadian Nuclear Society

08:40
Canadian Progress in Radioactive Waste Management
Mark Corey, Assistant Deputy Minister, Energy Sector, Natural Resources Canada

Canada is a clean energy superpower, and our reliance on nuclear energy is an important element of our ability to make that statement. Our current and future use of nuclear energy must rely on public confidence in the technology. Key to public confidence, in the ongoing use of nuclear energy and the deployment of new nuclear generating facilities, is the need to demonstrate that the industry can operate its nuclear facilities safely and that it can also safely manage its radioactive waste.

While the nuclear industry does a good job at managing all levels of radioactive waste, the public still requires much convincing. Canada is making good progress in the long-term management of radioactive wastes on a number of fronts. From nuclear fuel waste to low-level waste to uranium mine tailings, Canada's progress has been deliberate, measured and steady. It involves ongoing engagement and involvement with the public, stakeholders, decision makers and local communities to build confidence in proposed solutions for radioactive waste that can be implemented in a manner that they can support. Industry and Government are on the brink of some long-sought after achievements in this area. However, there remains much more work to be done. The foundation of our work, and ultimate success, will be based on our experiences, lessons learned to date, best practices, and without doubt require continued collaboration and cooperation with the public and among stakeholders.

09:00
Regulatory Developments and Issues
Michael Binder, President & CEO, Canadian Nuclear Safety Commission

The Canadian Nuclear Safety Commission (CNSC) regulates virtually all aspects of the nuclear industry in Canada, and Dr. Binder, President and Chief Executive Officer, will be opening his talk with a brief overview of the work done by the CNSC and its regulatory framework. Specifically, Dr. Binder will explore the CNSC's role with regard to waste management and will discuss site decommissioning both at present and in the near future.

Touching on the impacts of the events in Japan, Dr. Binder will walk through the regulations governing waste, highlighting upcoming regulatory activities, exploring the CNSC's current approach to regulating decommissioning, and discussing potential future improvements.

The presentation will conclude with a snapshot of questions facing the industry with regard to waste management and how industry could best tackle these challenges.

09:20
Nuclear Environmental Stewardship – The Social Contract
Bob Walker, Senior Vice-President, AECL Nuclear Laboratories

The recent accident at Fukushima Dai-ichi has reminded us in the nuclear industry of the importance of our role in ensuring the health, safety and security of the public and of our environment. As a federal government science and technology organization, AECL's Nuclear Laboratories' programs are focused on developing science and technology which will continue to positively influence the Canadian public's perception, acceptance and support for nuclear technology. Nuclear environmental stewardship is a focus within many of our science and technology and operational activities. Those activities address immediate and long-term environmental improvements to the nuclear sites that we have responsibility for, advance our understanding of the impact of nuclear operations on the environment, and develop new technologies that can be applied to secure clean energy sources for the future. The role of the Nuclear Laboratories in delivering the "social contract" that the nuclear industry must have with Canadians will be discussed.

09:40
Nuclear Waste Management Organization: Moving Forward Together – Program Update
Ken Nash, President, Nuclear Waste Management Organization

In June 2007, the Government of Canada selected Adaptive Phased Management as Canada's plan for safeguarding the public and environment over the very long time in which used nuclear fuel must be managed. The plan requires that Canada's used nuclear fuel be safely and securely contained and isolated from people and the environment in a deep geological repository in a suitable rock formation.

In May 2010, the NWMO published a process for identifying an informed and willing community to host the project and currently a number of communities in northwestern Ontario and Saskatchewan have expressed interest in learning about the project.

The NWMO anticipates that it will take between seven and ten years to decide on where to locate the deep geological repository and associated facilities. By international standards, this is an ambitious timeline. Ultimately, there will have to be a compelling demonstration of willingness expressed by the citizens of any interested community after a long period of site assessment, and learning about the project, before it is selected to host the project.

The presentation will cover the history leading to the 2007 government decision and the full range of activities being undertaken to implement that decision.

10:00 – 10:20
Networking Break

10:20
Challenges in Waste Management and Environmental Restoration in the Uranium Mining Industry
John Jarrell, Executive Advisor, Safety, Health and Environment, Cameco Corporation

Two components dominate the waste management efforts at conventional Canadian uranium mining and milling operations. These are the waste rock generated in the mining of ore as well as the mill tailings – which are the residue solids remaining after uranium extraction. Much has changed in the management of these wastes over the years. Visually, current sites are generally more compact than those developed earlier, due to higher grade ores and less land disturbance. However, the more significant strides being made to better manage uranium mining wastes deal more with improved chemical and physical controls rather than those changes which are visible.

Segregation of waste rock to separate out potentially problematic material within the more weakly mineralized halo surrounding the ore is now a core strategy. This segregation is based on both the waste rock's chemical and radiological characteristics. Better controls have also been introduced on tailings physical properties to minimize their permeability, along with better chemical controls to minimize tailings contaminant solubility. Efforts to engineer tailings properties are coupled with contrasting hydraulic conductivity between the consolidated tailings mass and surrounding geologic materials. This creates the necessary long-term containment controls built into modern tailings management facilities.

Current challenges include selecting the correct decommissioning assumptions such as future land use and required environmental acceptance criteria, along with decisions as to when to carry out reclamation work in the life cycle of the mine and mill. Public discussion of restoration plans throughout the life of the facility is essential to build acceptable solutions.

Along with challenges come successes. Most recently, improvements have been made in reducing treated water molybdenum and selenium levels. Other successes include the application of reverse osmosis technology on a large scale, recycling of uranium-bearing products from downstream fuel production facilities, and implementation of significant progressive reclamation projects to reduce environmental footprint prior to site closure. Continually improving environmental performance in the uranium mining sector helps solidify support for the many environmental advantages of the nuclear power option.

10:40
Providing Value to Ontario: OPG's Approach to Nuclear Waste Management
Tom Mitchell, President & CEO, Ontario Power Generation

11:00
Questions and Panel Discussion

11:20 – 12:00
Visit Business Exposition

12:00 – 13:30
Luncheon, Grand Ballroom

Concurrent Technical Sessions

Trinity 1

OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 1

Session Co-Chairs: Frank King, Nuclear Waste Management Organization and Terry Doran, Ontario Power Generation

13:30
OPG's Deep Geologic Repository for Low and Intermediate Level Waste — Project Overview
F. King, Nuclear Waste Management Organization; G. Sullivan, Ontario Power Generation

Ontario Power Generation (OPG) is undergoing a multi-year planning and regulatory approvals process for a deep geologic repository (DGR) for the long-term management of low and intermediate level waste (L&ILW). The DGR Project involves the construction, operation and eventual decommissioning of a repository situated nominally at 680 metres below the Bruce nuclear site, near Tiverton, Ontario, in an argillaceous limestone formation. The basic need for the DGR Project derives from the fact that L&ILW consists of materials that can remain hazardous for hundreds, and in some case, thousands of years due to the presence of long-lived radionuclides. These long timeframes require that a solution be found that protects humans and the environment, that is passive, and that does not rely on long-term institutional control. The Environmental Impact Statement (EIS), Preliminary Safety Report (PSR) and other supporting documents in support of a site preparation and construction licence for the project were submitted to the Joint Review Panel (JRP) on April 14, 2011 as part of the regulatory approvals process. The DGR is a first-of-a-kind facility in Canada for the long-term management of radioactive wastes. It is consistent with government policy and regulatory expectations and has the support of the local host community. Construction of the DGR is expected to start in 2013 with waste emplacement commencing about 2018. This paper provides an overview of the DGR project.

13:55
OPG's Deep Geologic Repository for Low and Intermediate Level Waste — Project Description – Design and Construction
D. Wilson, J. van Heerden and R. Heystee, Nuclear Waste Management Organization

Ontario Power Generation's (OPG's) is planning to construct a Deep Geologic Repository (DGR) for the long-term management of operational Low and Intermediate Level Radioactive Waste (L&ILW) at the 932-ha Bruce nuclear site. The Bruce nuclear site is located approximately 225 kilometres northwest of Toronto near Tiverton, Ontario. The project is currently in the regulatory approvals phase. OPG's proposed underground repository will be comprised of horizontally-excavated emplacement rooms arranged in two panels with access provided via two vertical concrete-lined shafts. The emplacement rooms will be constructed at a depth of about 680 m below surface within limestone. This limestone formation is laterally extensive and is directly overlain by 200 m

of shale which acts as a low permeability cap rock. The underground repository will be supported by a surface infrastructure comprised of two headframes, an office building and various ancillary facilities. It is estimated that it will take about five to seven years to construct the DGR facility.

14:20

OPG's Long Term Management Proposal for Low and Intermediate Level Radioactive Waste: Project Description, Operations

P. Witzke, Ontario Power Generation

Although the Deep Geologic Repository (DGR) is approximately 8 years away from being placed into service, it is time to start planning for operations. Ontario Power Generation's (OPG) Nuclear Waste Management Division (NWMD) has a systematic approach to preparing for operation of any new facility that is readily applicable to the DGR. The DGR Operational Readiness Plan has been benchmarked at similar facilities in North America and Europe. The operating vision is a living model, and is constantly being reviewed and refined to align with the detailed design of the DGR as it proceeds through phases of development.

Combined with 40 years of operating surface storage facilities for the storage of Low and Intermediate Level Waste (LILW), the DGR operating vision will enable NWMD to provide meaningful input during COMS (Constructability, Operability, Maintainability, and Safety) review in the DGR project detailed-design phase in 2011/2012. A Work Breakdown Structure has been used to communicate the detail of the operating vision, and also to estimate the costs of Operational Readiness and Operations during the lifetime of the facility.

14:45

Ontario Power Generation's Proposed L&ILW Deep Geologic Repository: Geoscientific Assessment

M. Jensen, Nuclear Waste Management Organization;
K. Raven, Geofirma Engineering Limited; R. Leech, AECOM Ltd.

The Nuclear Waste Management Organization (NWMO) recently completed geoscientific studies on behalf of Ontario Power Generation (OPG) to verify the suitability of the Bruce nuclear site, Municipality of Kincardine, Ontario, to host a Deep Geologic Repository (DGR) for OPG's Low and Intermediate Level Nuclear Waste (L&ILW). The results of the multi-phase 4-year investigation indicate that the middle-upper Ordovician formations proposed to host and enclose the DGR comprise a stable, saline (TDS>250 g l^{-1}) and extremely low permeability ($\leq 10^{-13}$ m sec^{-1}) groundwater regime. This paper provides an overview of coordinated site-specific and regional studies to characterize the Bruce site and support the DGR safety case.

15:10 – 15:40

Networking Break

Trinity 1

OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 2

Session Co-Chairs: Angelo Castellan, Nuclear Waste Management Organization and Terry Doran, Ontario Power Generation

15:40

OPG's Deep Geologic Repository for Low and Intermediate Level Waste — Project Description – Safety Assessment

P. Gierszewski and H. Leung, Nuclear Waste Management Organization; R. Little, Quintessa Limited; J.D. Avis, Geofirma Engineering Limited; N.C. Garisto, SENES Consultants Inc.

Ontario Power Generation (OPG) is proposing to build a Deep Geologic Repository (DGR) for Low and Intermediate Level Waste near the existing Western Waste Management Facility (WWMF) at the Bruce nuclear site in the Municipality of Kincardine, Ontario. The safety of the proposed DGR was assessed under both preclosure and postclosure conditions.

Under normal operation, there will be some release of tritium and carbon-14 as off-gassing from the waste packages, as currently occurs at WWMF, until underground rooms are closed off. The maximum dose to the public due to normal DGR operations is small, similar to the impacts that would be expected from WWMF for similar amounts of low and intermediate level waste.

Accidents during operations were assessed for potential release of radionuclides or non-radiological elements in the wastes. Although unlikely, credible accidents include fires involving packages, package breach accidents, failure of the ventilation system, and inadequate shielding. The assessment results indicate that effects on a member of the public at the Bruce nuclear site boundary are well below criteria. Overall, both WWMF experience as well as the DGR-specific analyses, indicate that the wastes can be handled and emplaced without undue risk to workers or the general public.

The postclosure safety was quantitatively assessed through considering a range of potential future scenarios. Specifically, the assessment considered the expected evolution of the DGR system and the site with time (i.e., the Normal Evolution Scenario) and the potential impacts of unlikely events leading to penetration of barriers and loss of containment (i.e., Disruptive Scenarios or "What If" Scenarios). The safety assessment was conducted in a systematic manner, consistent with Canadian Nuclear Safety Commission Regulatory Guidance G-320 and with international best practice.

The postclosure assessment calculations for the Normal Evolution Scenario indicate that the DGR system provides effective containment of the emplaced waste. Most radionuclides decay within the repository or the deep geosphere. The amount of contaminants eventually reaching the surface is very small, such that calculated impacts are orders of magnitude less than the public and environmental criteria. The isolation afforded by the location and design of the DGR limits the disruptive events potentially able to bypass the natural barriers to a small number of very unlikely situations. Even if these events were to occur, the analysis shows that the contaminants in the waste would continue to be contained effectively by the DGR system such that the risk criterion is met.

16:05

Environmental Assessment for OPG's Deep Geologic Repository for Low and Intermediate Level Waste

D. Barker, Nuclear Waste Management Organization; M. Rawlings and A. Beal, Golder Associates Ltd.

The environmental assessment process for the Deep Geologic Repository (DGR) Project was initiated very early in the planning stages. Feasibility studies were initiated in 2003, after OPG and the Municipality of Kincardine signed a Memorandum of Understanding agreeing to assess options for long-term management of low and intermediate level waste options at the Bruce nuclear site. The location of the DGR, in the Municipality of Kincardine, is based on a willing and informed host community. The preferred approach, the DGR at the Bruce nuclear site, was advanced based on results of feasibility studies which looked at a number of options for long-term management of L&ILW and support from the local community and their elected representatives.

The federal environmental assessment of the project was initiated following the signing of a Host Community Agreement and completion of a telephone poll, the results of which indicated that the majority of Municipality of Kincardine residents support the project. The environmental assessment began in 2006 as a comprehensive study and was ultimately referred to a Joint Review Panel in 2009.

The environmental assessment considers the potential near-term effects of the construction and operations of the proposed project. Because of the nature of the project, the assessment of effects also considers long-term effects extending out to the million year time-frame, including effects of climate change, glaciations and seismic activity.

16:30

OPG's Deep Geologic Repository for Low and Intermediate Level Waste — Public Participation and Aboriginal Engagement

M. Wilson, Nuclear Waste Management Organization

Ontario Power Generation (OPG)'s Public Participation and Aboriginal Engagement Program for the proposed Deep Geologic Repository (DGR) for low and intermediate level waste (L&ILW) began with the signing of a Memorandum of Understanding (MOU) in 2002 between OPG and the Municipality of Kincardine. The MOU set out the terms under which the two parties would jointly study the feasibility of different options for the long-term management of L&ILW at the Bruce nuclear site. A consultant, independent from both the Municipality of Kincardine and OPG, was retained to manage the assessment of options as well as a communication plan to ensure the public and Aboriginal peoples were kept apprised of all activities associated with the MOU. This early commitment to transparency and openness, with its ensuing opportunities for the public and Aboriginal peoples to become informed, ask questions, and engage in meaningful two-way dialogue about the early assessment of options, established the foundation and later became the hallmark of the DGR Project's Public Participation and Aboriginal Engagement program. This paper provides an overview of the development, nature and results of that program as it has evolved through the early investigative stages of options and through the environmental assessment and licencing process for the proposed DGR Project.

Trinity 2

Stakeholder Interactions – 1

Session Chair: To be announced

13:30

Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel

J. Facella and M. Ben Belfadhel, Nuclear Waste Management Organization

The Nuclear Waste Management Organization (NWMO) is responsible for implementing Adaptive Phased Management, the approach selected by the Government of Canada for long-term management of used nuclear fuel waste generated by Canadian nuclear reactors. The ultimate objective of Adaptive Phased Management is the centralized containment and isolation of Canada's used nuclear fuel in a Deep Geological Repository in a suitable crystalline or sedimentary rock formation at a depth of about 500m. The repository will consist of a series of access and service shafts and a series of tunnels leading to placement rooms where used fuel will be placed and sealed in competent rock using a multi-barrier system which includes long lived specially designed containers, sealing materials such as bentonite and the rock itself. The used fuel will be monitored throughout all phases of implementation and will also remain retrievable for an extended period of time.

In May 2010, the NWMO published the site selection process that serves as the road map to decision-making on the location for the deep geological repository. NWMO initiated the process with a first stage that invites communities to learn more about the project and the site selection process. NWMO is actively building awareness of the project and, on request of communities, is delivering briefings, supporting community capacity building and undertaking high-level screenings of site suitability.

The paper provides a brief description of: Adaptive Phased Management including the deep geological repository which is its ultimate goal, and the design of the site selection process, and importantly the approach to assessing the suitability of sites from both a social and technical perspective. The paper will outline how NWMO sought to develop a socially-acceptable site selection process as a firm foundation for future decisions on siting. Through a two-year collaborative process, NWMO sought to understand the expectations of Canadians concerning key principles and elements of a fair and acceptable site selection process, and the experiences and lessons learned in siting large projects internationally. The paper will highlight the requirements identified by citizens, and outline the goals and principles associated with the site selection process that emerged from this process of collaboration.

NWMO will share its observations based on the lessons learned to date as the organization implements this community-driven site selection process. NWMO will reflect on challenges and opportunities encountered as the journey unfolds.

13:55

Engaging Aboriginal Peoples in Canada's Plan for the Long-Term Management of Used Nuclear Fuel

P. Patton, Nuclear Waste Management Organization

The interests and concerns of Aboriginal peoples are integral to development and implementation of Canada's plans for the long-term management of used nuclear fuel. The Nuclear Waste Management Organization (NWMO) has an ongoing statutory obligation and a commitment to active and meaningful participation with Aboriginal peoples. The organization has worked with Aboriginal organizations and individuals to develop long-term engagement and dialogue processes that respect traditional Aboriginal practices, culture, protocols and approaches to decision-making. Aboriginal peoples were significant participants in the 2003-2005 study that resulted in the recommendation for Adaptive Phased Management (APM). After the Canadian government agreed to proceed with APM, Aboriginal peoples provided valuable input into development of the process for selecting a site for a deep geological repository (DGR) for the long-term management of Canada's used nuclear fuel. The involvement of Aboriginal stakeholders continues to be important as Canada moves into the siting process. Engagement of Aboriginal peoples is guided by principles that respond to the unique interests, perspectives and culture of Aboriginal peoples. These principles recognize and honour the special relationship that Aboriginal peoples have with the natural environment, their unique stewardship responsibilities, and the fact that Aboriginal peoples are holders of Aboriginal Traditional Knowledge (ATK), which brings value to planning processes. The NWMO has been working with Aboriginal Elders and others to learn about ATK and to interweave this knowledge into its work. ATK includes important knowledge about the land, ecology and intergenerational decision-making. The NWMO and Aboriginal peoples have given life to engagement principles and the wisdom of ATK by collaboratively developing a number of programs including agreements with national, regional and local Aboriginal organizations. Additionally, the NWMO has developed communication materials with Aboriginal stakeholders, with a view to building the capacity of Aboriginal peoples to remain engaged over time. Another key process has been the establishment of the Elders Forum. As Canada moves more deeply into the process of selecting an "informed and willing community", Aboriginal peoples and the NWMO continue to develop engagement mechanisms and to work to include ATK in plans and decision-making. The contributions of Aboriginal peoples and Elders have helped the NWMO develop its Aboriginal engagement program and have shaped broader engagement principles and strategies. Moving forward, the NWMO will continue to build on the approaches and activities for Aboriginal engagement that have brought so much value to its work and its collaboration with all Canadians.

14:20

Engaging Youth and Transferring Knowledge

E. Mantagaris, Nuclear Waste Management Organization

Youth engagement is a key component of the work of the Nuclear Waste Management Organization (NWMO) as it collaborates with Canadians to implement Adaptive Phased Management (APM), Canada's plan for the long-term management of used nuclear fuel. Knowledge transfer is an important aspect of APM implementation, which will span several decades and will need to be flexible enough to adjust to changing societal values and new information. By engaging youth, the NWMO is putting in place mechanisms for ongoing societal learning and capacity building, so that future generations will be well-equipped to make decisions and participate in future dialogues on APM. The NWMO convened a Youth Roundtable, comprised of 18- to 25-year-olds with a diversity of backgrounds and experience, to seek advice on the best approaches to engaging youth on this topic. In May 2009, the Roundtable presented its recommendations to the NWMO and its Advisory Council, providing valuable guidance on: development of dynamic messages and communications materials that will resonate with young people; use of new technologies and social media to engage youth where they are already connecting and conversing; and a range of activities to engage youth through the educational system and in their communities. The NWMO has begun to implement many of the Youth Roundtable recommendations and is developing longer-term implementation plans, including a framework for education and outreach to youth. Through its Corporate Social Responsibility (CSR) Program, the NWMO is laying the foundation for greater science and technology literacy and enhanced community engagement among young Canadians. Additionally, the NWMO is working with Aboriginal peoples to develop strategies for further engagement of Aboriginal youth, as part of the organization's ongoing collaborative work with Aboriginal peoples that could be affected by the implementation of APM. Youth engagement will continue to be a NWMO priority moving forward, and efforts will be made to augment youth participation as appropriate. Although the formal mandate of the Youth Roundtable has ended, the NWMO is considering opportunities for the group's future involvement.

14:45

Engaging at the Local Level, the Work of the NWMO Municipal Forum

P. Simmons, Nuclear Waste Management Organization

Canada's plan for the long-term management of used nuclear fuel, called Adaptive Phased Management (APM), will be implemented in an informed and willing host community. As the Nuclear Waste Management Organization (NWMO) designs and refines its plans and processes for selection of that community, it is critical for the organization to understand the local and community perspective. The NWMO has undertaken a number of initiatives to increase this understanding, to build relationships, and to work with municipal representatives and community leaders to develop long-term frameworks for decision-making at the local level. The activities have included seeking advice through ongoing meetings with nuclear host communities; engagement of national and provincial associations/federations; and participation in the annual conferences and trade shows of municipal associations in the four nuclear provinces (Saskatchewan, Ontario, Quebec and New Brunswick). In addition to building relationships, the NWMO is

increasing its knowledge about municipal structures and policy-making processes, administration, land-use and community planning, political oversight and community engagement. As interested communities come forward to learn more about APM, they may access the NWMO "Learn More" program, which makes information and funding available to assist communities and individuals in learning more about APM and the site-selection process. In 2008, the NWMO and senior municipal leaders from the four nuclear provinces agreed to form a Municipal Forum, which was launched in December of that year. The NWMO Forum was modelled, in part, on a construct in the United Kingdom known as NuLeAF, which provided local perspectives considered key to the success of the nuclear waste management initiative in that country. The NWMO Municipal Forum brings together municipal experts to provide information about best practices for communicating with local governments and their communities. The Forum members represent large and small, urban, rural and northern communities and advise the NWMO on broad policies based on their professional, political, community and personal expertise and experience. The Forum has provided valuable insights and feedback, including guidance on enhancing communications materials for municipalities, and on potential collaborative research projects for communities that choose to take part in the site-selection process. The Forum has helped the NWMO better understand how to communicate and work with municipalities, while also being an effective conduit to municipal associations, their affiliates and membership, and a wide range of professional associations, locally, provincially and nationally.

15:10 – 15:40
Networking Break

Trinity 2

Stakeholder Interactions – 2

Session Chair: To be announced

15:40

Addressing Host Community Issues through Enhancing Community Well-Being: A Practical Framework for Siting Major Nuclear Projects in Canada

M. Stemeroff, D. Richardson and T.L. Wlodarczyk, AECOM Canada Limited

Any major project development, including those related to nuclear activities in Canada, will certainly impose a wide range of effects and consequences for a host community and region. These wide ranging effects can be positive as well as negative and last for varying time periods. However, the challenge is not to simply identify effects of a project and then mitigate and/or compensate for them. Rather, we have witnessed a transition in recent years that gaining community social acceptance for projects has taken on new meaning. Specifically, communities have taken a "longer view" of themselves and are more interested in how the project will enhance their long-term well-being. There is considerable evidence to suggest that assessing and demonstrating effects on community well-being has become the focal point for community understanding and decision-making about how to proceed with any new development.

This paper will examine what the term "community well-being" is and how it applies to gaining social acceptance for major nuclear projects in Canada. Insights and examples will be gathered from a range of cases in Canada and elsewhere to demonstrate its diverse meaning and application. A discussion of its application to gaining social acceptance for nuclear projects will be generic in nature and provide a useful framework that can be adapted to the meet the needs in unique situations.

There is extensive literature with a cornucopia of subject headers including: community well-being, sustainable development, sustainability, social capital, social well-being, participatory development, and so on. In many cases, these and other terms are used interchangeably or applied as a sub-set to another term. There is no distinct rule or collective wisdom regarding which term to use under different circumstances or situations. Suffice it to say that the notion of community well-being, sustainable development and the like are not new terms or concepts, even in Canada. Despite the wide use of different terminology, all relate to a similar set of goals, largely being the improvement of community and/or individual quality-of-life or state of well-being over the long-term.

There is an old adage that says "you get what you measure". In this case, simply defining community well-being, no matter the nature or scope of it, is not enough to make it happen. For many, the process of measuring community well-being provides a concrete focus to engage local citizens and to strengthen communities through discussions about what matters most to them. The process of defining community well-being and developing community wellbeing indicators and community plans is seen by many as an excellent way to inform and involve local people and organizations, and it is a meaningful undertaking for local citizens. It enables them to identify their key issues, discuss their priorities and contribute to possible actions and plans for their community that they feel they have developed for themselves. Involving citizens in the process is more likely to lead to change (hopefully increase) in community well-being. It will be shown that local community stakeholders "buy-in" to or adopt changes more readily when they are a part of the "well-being assessment" process from the beginning and are involved in assessing how it directly applies to them.

What this means for the nuclear industry in siting and implementing its projects and activities, (from uranium mining, milling and processing, power generation and transmission, to decommissioning and waste management), will be discussed. The end game is earning social acceptance by leveraging publically accessible and open communication medium (which we refer to as "Open Source" approaches,), such as Facebook, Twitter, etc. In some sense this is the new reality of project approvals – which we refer to later as Project Approvals 2.0.

Using a community well-being framework is a tactic that when applied in right measure and context, can be most effective in demonstrating your commitment to an outcomes based approach for the community that can withstand the test of time.

The paper will conclude with direct and meaningful ideas of how to effectively implement such a framework to engage Aboriginal and non-aboriginal communities and other affected stakeholders in social acceptance process for your projects.

16:05

Coordination of the Environmental Assessment Process for the Nuclear Legacy Liabilities Program

W. Turner and M. Klukas, Atomic Energy of Canada Limited; C. Badke and C. Johnson, Natural Resources Canada

The Nuclear Legacy Liabilities Program (NLLP) manages Canada's nuclear legacy liabilities at Atomic Energy of Canada Limited (AECL) sites and is funded by the Government of Canada through Natural Resources Canada (NRCan). The objective of the NLLP is to safely and cost-effectively reduce the legacy liabilities and associated risks based on sound waste management and environmental principles in the best interest of Canadians. The legacy liabilities consist of shutdown nuclear and industrial facilities, buried and stored wastes and contaminated lands at Chalk River Laboratories, Whiteshell Laboratories, and other AECL nuclear facilities in Canada.

This paper summarizes the collaboration activities of NRCan and AECL to address coordination of the environmental assessment (EA) work for the projects undertaken on behalf of the NLLP as required by the Canadian Environmental Assessment Act (CEAA).

This paper will provide examples of successes and challenges encountered. Included will be a discussion of the rationale for grouping projects where possible to maximize efficiency and effectiveness of the EA process, and the role of other federal organizations, such as the Canadian Nuclear Safety Commission, in NLLP environmental assessments.

16:30

Developing and Initiating a Public Engagement Process for a Nuclear Decommissioning and Waste Management Program

C. Badke and C. Johnson, Natural Resources Canada; S. Brooks and M. MacCafferty, AECL, Chalk River Laboratories

Public consultation is key to any major nuclear initiative, but how do you engage the public in a complex multi-site nuclear decommissioning and environmental restoration program that will last 70 years? A clear message of sound environmental stewardship throughout the process is critical to building the trust required to attract public interest and support.

The Nuclear Legacy Liabilities Program (NLLP) manages Canada's nuclear legacy liabilities at Atomic Energy of Canada Limited (AECL) sites and is funded by the Government of Canada through Natural Resources Canada (NRCan). The objective of the NLLP is to safely and cost-effectively reduce the federal legacy liabilities and associated risks, based on sound waste management and environmental principles, in the best interest of Canadians.

An important area of focus for the NLLP in both the short- and long-term is to inform the public, stakeholders and Aboriginal people about the Program, and to gather input on the long-term strategy for site restoration and waste management. This paper describes progress made to date on developing and initiating a public engagement process for the NLLP in the initial phase of the Program. Furthermore, it examines general best practices for public participation, specific challenges and opportunities which have been identified, as well as the next steps for communications activities related to the Program.

16:55

Facilitating Stakeholder Involvement in Environmental Rulemaking for Uranium

A. Nesky and R. Rosnick, U.S. Environmental Protection Agency

This paper will illustrate how the Radiation Protection Division (RPD) of the U.S. Environmental Protection Agency (EPA) is drawing upon the Agency's strong legacy in stakeholder outreach and employing new "social media" tools to enhance its efforts to involve the public in decision-making for environmental rules applicable to uranium milling.

17:20

Follow-up and Monitoring of Socio-economic Effects of the Darlington and Pickering Waste Management Facilities

T.L. Wlodarczyk and E. Foong, AECOM Ltd.; L. Cain, Ontario Power Generation

Working in a regulatory climate where public acceptance is a decisive consideration in a project's approval, the accurate prediction of likely adverse effects in an environmental assessment (EA) is essential so that regulatory decisions can be made with the greatest amount of confidence. Increasingly, regulators such as the Canadian Nuclear Safety Commission (CNSC) are requiring that key predictions made in an EA, including predictions of biophysical as well as the socio-economic effects, be verified for accuracy through a variety of follow-up and monitoring activities. This was the case for two Ontario Power Generation (OPG) projects for the construction and operation of used fuel dry storage facilities at the Darlington and Pickering Nuclear sites.

In accordance with the requirements of the Canadian Environmental Assessment Act, OPG completed and submitted to the CNSC an EA for the Darlington Used Fuel Dry Storage Facility (now refer to as Darlington Waste Management Facility (DWMF) and another EA for the Pickering Waste Management Facility Phase II (PWMF II) project in 2003. Following public reviews and CNSC hearings, the CNSC concluded that these projects were not likely to cause significant adverse effects after taking into account the identified mitigation measures. Both projects were granted EA approval with requirements to prepare and implement Follow-up and Monitoring (F/U & M) plans.

In 2002, OPG conducted public attitude research (PAR) surveys in support of the socio-economic assessments for the two Darlington and Pickering waste management facility projects. The F/U & M plans for the two projects included requirements for the development and implementation of a program to monitor public attitudes in order to verify the accuracy of predictions and confirm the effectiveness of the proposed mitigation measures. Once both waste management facilities were operational in 2009, OPG conducted additional PAR studies.

This paper presents comparisons between the initial PAR studies conducted in 2002 as part of the technical studies and the follow

up PAR studies conducted in 2009. The aim of this paper is to demonstrate the effectiveness of PAR as a research tool to understand potential project-related effects as part of socio-economic assessments.

Trinity 3

Decommissioning Projects – 1

Session Chair: Daniel Grondin, Atomic Energy of Canada Limited

13:30

Decommissioning and Demolition of a Redundant UK Research Facility at AWE Aldermaston

K. Miller, Nuvia Limited; I. Barnes, AWE

The redundant two-storey, brick built research facility on the AWE Site at Aldermaston, UK is in the latter stages of decommissioning by Nuvia Limited. The facility was used for a variety of purposes up to 1995 involving the use predominately of alpha-emitting isotopes. After a period of site establishment and preparation of supporting safety case documentation, the two main areas of alpha-based contamination have largely been decommissioned with the removal of hot -boxes and fume cupboards on the ground floor and HEPA filter units and ventilation equipment on the first floor. Many of these activities have been undertaken using both airline fed suits and respirators, the former supplied from a free standing, mobile unit newly located outside the building to allow reuse on future projects. The late detection of exposed asbestos on the first floor associated with an electrostatic particulate filter caused some delay to the programme but these materials have now been removed by a specialist contractor to allow the programme to continue. At an early stage of the programme all sections of active drains running from the building to the site-based active effluent disposal system have been removed from the external drain ducts without incident using well-established techniques.

Specialist monitoring equipment is being used in order to provide confidence in the data required for disposal of the decommissioning debris. In particular a dedicated high resolution gamma scanning unit for waste drums and wrapped packages has been utilised. The final stages of the building decommissioning are in sight and the monitoring and sampling of the structure will become important milestones ahead of the development of the demolition plan. A number of useful lessons have been learnt during the operations and are set out in the main text of this paper.

13:55

From Meadow to Lawn: When Nuclear Decommissioning is Over

M. Laraia, International Atomic Energy Agency

The traditional, safety-driven image of nuclear decommissioning tends to view decommissioning as a process ending by unrestricted release of remaining facilities and site. And yet, although this image may be right insofar as nuclear safety and radiation protection are concerned, a lot of work still remains after the above-mentioned (radiological) end state is reached. This paper intends to draw attention to post-decommissioning aspects, which are inevitably linked to the nuclear decommissioning strategy, and are essential for successful completion of the whole project. Moreover, the paper shows that thorough planning for decommissioning should not be limited to its nuclear or radiological component. This paper will focus primarily on three aspects:

- conventional demolition, landscaping, and demobilization
- environmental remediation of the site, and
- reuse and redevelopment.

14:20

An Overview of the NASA Plum Brook Reactor Facility Decommissioning – Facilities

K. Peecook, NASA

The National Aeronautics and Space Administration (NASA) is nearing the successful completion of its $230 Million (US), 12 year effort to decommission the Plum Brook Reactor Facility (PBRF). This paper will examine the challenges and solutions involved in the segmentation and removal of the reactor and its internals, and the decontamination of the hot cells.

14:45

Piping, Public Outreach, and Soil Assaying at the NASA Plum Brook Reactor Facility

K. Peecook, NASA

The National Aeronautics and Space Administration (NASA) is nearing the successful completion of its US $230 Million, 12 year effort to decommission the Plum Brook Reactor Facility (PBRF). This paper will consider several different key elements of the project, including cleaning and survey of embedded and buried piping, soil assaying, and community outreach.

15:10 – 15:40

Networking Break

Trinity 3

Decommissioning Projects – 2

Session Chair: Joan Miller, Atomic Energy of Canada Limited

15:40

Decommissioning Projects at the Chalk River Laboratories Over the Next Five Years and the Challenges with Delivery

K. Schruder, J. McKenna and A. Winter, Atomic Energy of Canada Limited

Nuclear research and development carried out on behalf of the Government of Canada have resulted in 60 years of nuclear legacy liabilities at the Chalk River Laboratories. The liabilities consist of shutdown reactors, research facilities and supporting infrastructure. The Government of Canada in 2006 initiated a five-year, $520 million start-up phase and in April 2011 entered the next five-year program of decommissioning as part of the long term strategy to address the legacy liabilities. A number of planned projects in Facilities Decommissioning at the Chalk River Laboratories have been defined for the next three years and will be described in this paper in combination with operational lessons learned for future decommissioning project work.

16:05

Lessons Learned in Planning the Canadian Nuclear Legacy Liabilities Program

M. Stephens, S. Brooks, J. Miller, P. Neal and R. Mason, Atomic Energy of Canada Limited

In 2006, Atomic Energy of Canada Limited (AECL) and Natural Resources Canada (NRCan) began implementing a $7B CDN, 70-year Nuclear Legacy Liabilities Program (NLLP) to deal with legacy decommissioning and environmental issues at AECL nuclear sites. The objective of the NLLP is to safely and cost-effectively reduce the nuclear legacy liabilities and associated risks based on sound waste management and environmental principles in the best interest of Canadians.

The NLLP comprises a number of interlinked decommissioning, waste management and environmental restoration activities that are being executed at different sites by various technical groups. Many lessons about planning and executing such a large, diverse Program have been learned in planning the initial five-year "start-up" phase (concluded 2011 March), in planning the three-year second phase (currently being commenced), and in planning individual and interacting activities within the Program.

The activities to be undertaken in the start-up phase were planned by a small group of AECL technical experts using the currently available information on the liabilities. Several internal and external reviews of the Program during the start-up phase examined progress and identified several improvements to planning. These improvements included strengthening communications among the groups within the Program, conducting more detailed advance planning of the interlinked activities, and being cautious about making detailed commitments for activities for which major decisions had yet to be made.

The second phase was planned by a dedicated core team. More and earlier input was solicited from the suppliers than in the planning for the first phase. This was to ensure that the proposed program of work was feasible, and to be able to specify in more detail the resources that would be required to carry it out.

The NLLP has developed several processes to assist in the detailed planning of the numerous projects and activities. These include developing a more formal procedure for setting priorities of the different parts of the Program, preparing an Integrated Waste Plan to identify the optimal suite of support facilities to be constructed, the creation of a series of "pre-project initiation" procedures and documents to guide the development of well-founded projects, and the use of staged decision-making to incorporate more flexibility to adjust Program strategy and the details of implementation at planned decision points. Several Case Studies will be outlined to illustrate examples of the application of these planning techniques.

16:30

ZIONSolutions: A Unique License Stewardship Decommissioning Approach

T. Carraway and J. Hess, EnergySolutions

The Zion Nuclear Station is a two-unit Pressurized Water Reactor (PWR) site that is located 40 miles north of Chicago in Zion, Illinois. Both Zion units were licensed for operation in 1973 and operated by Exelon until the decision to permanently shut down the station was made in January 1998. Since then the Zion Nuclear Station has been in SAFSTOR status.

On September 1, 2010, the Zion Nuclear Station's 10 CFR 50 license was transferred from Exelon to Zion*Solutions* for the purpose of expediting the decommissioning of the site.

This paper will discuss the License Stewardship approach that is currently being utilized by ZionSolutions to decommission the Zion Nuclear Station. A primary attribute of the License Stewardship approach involves a single company with decommissioning as their core competency taking control of a nuclear site and assuming all risks and liabilities for the decommissioning work performed.

As the first commercial application of the License Stewardship approach, this paper will include discussions of some of the primary project elements such as the project funding method, dismantlement process and schedule, management of spent fuel, end-state conditions and license termination.

16:55

Decommissioning of AECL Whiteshell Laboratories: Progress from First Five Years of Legacy Funding

R.S. Swartz, D.M. Bilinsky, J.W. Harding and W.R. Ridgway, Atomic Energy of Canada Limited

In 2006, the Government of Canada adopted a new long-term strategy to deal with the nuclear legacy liabilities and initiated a five-year start-up phase. The objective is to safely and cost-effectively reduce these liabilities, and associated risks, based on sound waste management and environmental principles in the best interests of Canadians. AECL's Whiteshell Laboratories is part of the long-term strategy and decommissioning activities are underway. Several redundant non-nuclear buildings have been removed/decommissioned, and redundant nuclear facilities (hot cell facilities, radiochemical laboratories) are being decontaminated and prepared for demolition. This paper describes the progress in the first five-year funding period (2006 April to 2011 March).

17:20

URL Closure: What it Takes to Decommission an Underground Research Facility

D.P. Onagi, J.B. Martino, C-S Kim, D.A. Dixon and D.M. Bilinsky, AECL, Whiteshell Laboratories

Atomic Energy of Canada Limited's (AECL) Underground Research Laboratory (URL) was built to provide a facility where concepts for long-term management of Canada's nuclear fuel waste in a deep geologic repository could be studied. Construction of the URL began in 1982 with completion of the construction phase in 1990 followed by the experimental phase.

In 2003 a decision was made to discontinue operation of AECL's URL and ultimately decommission and permanently close the underground portion of this facility. Following the completion of a number of underground experiments, closure activities commenced in 2005. Decommissioning was managed and planned by AECL with support from J.S. Redpath Ltd., a mining contractor who had provided long

term construction and operations support to the URL. From 2006, the URL decommissioning was funded under the Nuclear Legacy Liabilities Program (NLLP), through Natural Resources Canada (NRCan). All underground-related closure activities were completed in late 2010.

As part of a carefully planned decommissioning process, a comprehensive closure plan was developed and submitted to the Manitoba Provincial government for approval in 2006. The closure plan included the decommissioning of all surface and underground boreholes and the safe removal of all underground infrastructure and equipment where technically and economically feasible to do so. Surface and underground boreholes were decommissioned and grouted to limit the upwards migration of deep, saline groundwater at the site. The final stage of closure was sealing the access and ventilation shafts with concrete caps.

Decommissioning an underground facility to the extent and completeness the URL was decommissioned has never been undertaken in Canada before now. Extensive planning and the development of unique methodology and equipment were keys to the success of the project.

Trinity 4

Uranium Mine Waste Management – 1

Session Chair: Tom Kotzer, Cameco Corporation

13:30

Identification of Poorly Crystalline Scorodite in Uranium Mill Tailings

R. Frey, J. Rowson and K. Hughes, AREVA Resources Canada Inc.; J. Warner, Canadian Light Source Inc.

The McClean Lake mill, located in northern Saskatchewan, processes a variety of uranium ore bodies to produce yellowcake. A by-product of this process is an acidic waste solution enriched in arsenic, referred to as raffinate. The raffinate waste stream is treated in the tailings preparation circuit, where arsenic is precipitated as a poorly crystalline scorodite phase. Raffinate neutralization studies have successfully identified poorly crystalline scorodite using XRD, SEM, EM, XANES and EXAFS methods, but to date, scorodite has not been successfully identified within the whole tailing solids. During the summer of 2008, a drilling program sampled the *in situ* tailings within the McClean Lake tailings management facility. Samples from this drilling campaign were sent to the Canadian Light Source Inc. for EXAFS analysis. The sample spectra positively identify a poorly crystalline scorodite phase within the McClean tailings management facility.

13:55

Aging of Reduced Arsenic Minerals in Uranium Mill Tailings at the McClean Lake Operation

C. Rinas, J. Rowson, R. Frey and K. Hughes, AREVA Resources Canada Inc.

The primary arsenic minerals in the uranium ore processed at the McClean Lake Operation are rammelsbergite, niccolite and gersdorffite. During processing, a large fraction, typically (80 - 95%), of these reduced minerals is oxidized and dissolves primarily as As^{5+} in the leachate solution. In the tailings preparation circuit the dissolved As^{5+} is precipitated as a poorly crystalline form of the mineral scorodite. Following subaqueous deposition in the tailings management facility, a temporal rise and fall in arsenic pore water concentrations has been observed. This is due to the oxidation of the residual quantities of reduced arsenic minerals initially present in the tailings sediment. The XANES (x-ray absorption near edge spectrometry) technique has shown that As1- is gradually oxidized to As^{3+} and then finally to As^{5+} in the tailings sediment. This oxidation process results in a temporary accumulation of As^{3+} in solution and is the source of the rise and fall in arsenic concentration observed.

14:20

Decommissioning of a Former Uranium Mine and Mill in Northern Saskatchewan, Canada

D. Hiller, R. Pollock, P. Bennett, N. Drake, AREVA Resources Canada Inc.

The Cluff Lake Project is a former uranium mine and mill in northern Saskatchewan, Canada. Over 60 million pounds of uranium concentrate were produced in just over twenty years of operation, ending in 2002. The Project is owned and operated by AREVA Resources Canada Inc., part of the AREVA Group, the world leader in nuclear energy development, and increasingly, a provider of other forms of electricity generation systems with low CO_2 emissions. During operation, the facilities at the Cluff Lake Project included open-pit and underground mines, a mill, a tailings management area (TMA) with a two-stage liquid effluent treatment system, a residential camp area and various other support and site infrastructure facilities.

Decommissioning when operations have concluded is both an AREVA Group corporate commitment and a regulatory requirement. The purpose is to conduct all necessary activities including the removal or stabilization of all constructed structures and the reclamation of disturbed areas to meet the following objectives:

- Environment is safe for non-human biota and human use;
- Long-term adverse effects are minimized;
- Reclaimed landscape is self-sustaining; and,
- Restrictions on future land use are minimized.

In addition, any restrictions on land use should not prevent traditional land use including casual access for trapping, hunting, and fishing as the primary site activities.

The Cluff Lake decommissioning project has four major stages which include planning, physical decommissioning activities, post-decommissioning and follow-up monitoring, and transfer of the site to the Provincial Institutional Control Program (ICP).

14:45

Managing Disposal of Uranium Ore Contaminated Soils from a Community Between the Mine Site and the Refinery: The Tulita Project

M. Gardiner and M. Owen, Atomic Energy of Canada Limited

This paper describes the complexities in conducting historic low-level radioactive waste site remediation and management, and the

packaging and transport of bulk quantities of contaminated soil from a remote northern Canadian community to disposal at a facility outside Canada. Uranium ore spilled during the 1940s in the Northwest Territories community of Tulita, during transportation from the Port Radium mine sites to the refinery in Port Hope, Ontario, was remediated and transferred to disposal at a commercial facility in the United States. High public awareness through extensive communications programs was a key to the success of this project. Project management challenges included disposal option identification, international approvals completion, transportation, and weather. The value to the community and success of the project was recognized in commendations from the local Member of the Legislative Assembly of the Northwest Territories and the Territorial Minister of Environment and Natural Resources.

15:10 – 15:40
Networking Break

Trinity 4

Uranium Mine Waste Management – 2

Session Chair: Tom Kotzer, Cameco Corporation

15:40
Electrical Resistance Heating for Thawing of Frozen Layers in a Uranium Tailings Management Facility
C. Melis, P. Landine and T. Kotzer, Cameco Corporation

The Rabbit Lake In-Pit Tailings Management Facility contains frozen layers of tailings due to sub-aerial deposition during successive winter operations. Thawing of the frozen layers is required to ensure full consolidation of the tailings prior to closure and to regain disposal space presently occupied by ice. Electric resistance heating (ERH), which has been used to heat soil for bitumen extraction and remediation of volatile contaminants, is being evaluated as a thawing mechanism. Two bench-scale experiments were performed in late 2009 and early 2010 wherein ERH was tested on about 0.3 cubic metres of frozen tailings. Thawing occurred in both experiments with negligible geochemical effects, demonstrating the viability of ERH as a tailings thawing mechanism. An in-pit field trial was performed from July 2010 until April 2011. Thermal and electric data collected throughout the trial indicate that thawing has occurred as was predicted based on the bench-scale experiment.

16:05
CAMECO Engineered Tailings Program: Linking Research with Industrial Processes for Improved Tailings Performance
T. Kotzer, Cameco Corporation; M.J. Hendry, University of Saskatchewan, Department of Geological Sciences

The waste product from uranium mining and milling that generates the greatest public and regulatory concern is tailings. The tailings contain all of the mined material except uranium plus a host of processing reagents. These minerals and compounds have the potential to harm the local environment if not deposited in a fashion that is both geochemically and geotechnically stable. Environmental leadership impels Cameco Corporation to ensure that the methods used to dispose of tailings are at the forefront of best available technologies whereby tailings production results in a product with geotechnical and geochemical characteristics that minimize the environmental impact associated with long-term storage of this product.

Cameco has developed an Engineered Tailings (ET) program to ensure optimization of long-term tailings performance and minimal impacts of elements of concern (EOCs) to the receiving environment, regardless of the ore being milled. Within this program chemical and physical performance of tailings from geochemical and geotechnical investigations and baseline environmental data, integrated with regulatory requirements and corporate commitments, will be used to evaluate and set criteria for mill- and tailings management facilities-based chemical and physical tailings characteristics, identify key knowledge gaps, prioritize areas of concern and implement appropriate responses. This paper provides an overview of the Engineered Tailings program, the research being conducted as part of the ET program, and how it links with present and future Cameco operations.

16:30
Balancing Risk: Site Remediation Outside the EA
T. Yankovich, A. Klyashtorin, Z. Guo and J. Muldoon, Saskatchewan Research Council; T. Jacklin and T. Heffron, AECOM Ltd.; R. Smith, R.S. Management Services Inc.

In Canada, an environmental assessment (EA) is typically required for physical works or physical activities that are to be undertaken at a given site, such as those that would be required when performing environmental remediation at an abandoned mine site. In general, the type of EA required under the Canadian Environmental Assessment Act (CEAA) tends to be commensurate with risk, whereby a comprehensive study is required for projects with the potential to cause significant adverse environmental effects.

Remediation of the Gunnar Mine Site, an abandoned uranium mine/mill in Northern Saskatchewan, is currently undergoing a comprehensive EA to develop plans for the sustainable remediation of the Gunnar pit, two waste rock piles, three areas of unconfined tailings and the mine site itself. The site was abandoned in 1964, with little to no remediation. As a result, buildings and structures present on the site deteriorated over time due to scavenging of building materials that had taken place and exposure to the harsh northern conditions.

To address the risks associated with buildings and structures in a timely manner, on July 23, 2010, the Canadian Nuclear Safety Commission (CNSC) issued an Order for those that have failed a structural safety assessment to be taken down by no later than October 31, 2011 (prior to approval of the Gunnar EA). To accomplish this, it was necessary for the Saskatchewan Research Council (SRC) to plan the work in a safe and cost-effective manner, with consideration of both the short-term mitigative measures required under the Order and the long-term end-state of the Gunnar Mine Site following remediation. Work is proceeding ahead of schedule on the abatement and demolition of buildings and structures at Gunnar. An overview of the considerations taken, the project accomplishments and the lessons learned will be provided.

16:55

Remediation of the Gunnar Uranium Mine Site, Northern Saskatchewan

T. Calvert and J. Brown, Natural Resources Canada

The Gunnar uranium mine, located in northern Saskatchewan, operated from 1955 to 1963. When the mine was closed, the site was not remediated to the standards that are in place for today's uranium mines. Waste rock and mill tailings were left un-covered and water quality issues were not addressed. As a result, the current state of the site impacts the local environment.

The company that operated the Gunnar Mine no longer exists. In 2006, the Government of Saskatchewan and the Government of Canada entered into an agreement to share the costs for remediating the site. An environment assessment of the project to remediate the site is currently underway. This paper provides an update of the issues and the progress being made.

Trinity 5

Used Fuel Repository – Design and Safety Assessment

Session Chair: To be announced

13:30

Overview of Adaptive Phased Management Repository Design Development

S. Russell, Nuclear Waste Management Organization

The Nuclear Waste Management Organization is implementing Adaptive Phased Management, Canada's plan for long-term management of used nuclear fuel. The organization is proceeding with the process for selecting a site in partnership with an informed and willing host community to safely and securely container and isolate used nuclear fuel in a deep geological repository in a suitable rock formation.

Adaptive Phased Management is the culmination of more than 30 years of research, development and demonstration of repository concepts in Canada. Adaptive Phased Management uses a phased and adaptive step-wise approach to the multi-barrier system which is consistent with the long-term waste management approaches being developed in many other countries with nuclear power programs such as Sweden, Finland, Switzerland, the United Kingdom and France.

The Nuclear Waste Management Organization is examining and developing conceptual designs for a deep geological repository and associated facilities for the placement of used nuclear fuel in long-lived containers. This paper will examine two of these generic conceptual designs which have recently been refined and updated. These conceptual designs will be used to support a pre-project review of repository design and safety by the Canadian Nuclear Safety Commission.

13:55

Conceptual Design of a Used Fuel Packaging Plant

K. Gillin, CANDESCO Corporation; A. Nyström, SKB International AB; A. Murchison, Nuclear Waste Management Organization

As part of implementing Adaptive Phased Management for the long-term care of Canada's used nuclear fuel, the Nuclear Waste Management Organization has developed a conceptual design of a used fuel packaging plant. The purpose of the packaging plant is to receive and repackage the used fuel in corrosion-resistant containers before placement in a deep geological repository. It is assumed that the packaging plant will be located on the same site as the repository.

The packaging plant encompasses all necessary areas and equipment for receiving empty containers, receiving used fuel, loading the fuel into the containers – and sealing, inspecting and dispatching filled containers for transfer to the repository. There are also provisions for cutting open and emptying any containers that do not fulfill specified requirements. To ensure reliable delivery of containers to the deep geological repository, the plant includes surge storage for used fuel, empty containers and filled containers.

Most of the processing steps in the packaging plant are remotely operated and performed inside shielded areas. With a container capacity of 360 used CANDU® fuel bundles, the required throughput of the plant is 333 containers per year, which is achieved with a single processing line – except handling of fuel, which requires parallel processing equipment.

The used fuel packaging plant is an important step in the process of transferring Canada's used fuel from interim storage to a deep geological repository. In addition to ensuring safety during operation, the packaging plant must produce containers that fulfill requirements for long-term safety – without frequent or lengthy production stops that would jeopardize the rate of placement in the repository.

To meet all such requirements, further development of the packaging plant design is essential. In particular, methods for transfer of fuel bundles and technologies for fabrication, sealing and non-destructive testing of containers will be evaluated and demonstrated during the coming years. The detailed design and optimization of the packaging plant will be determined once the repository site has been selected and the container design has been finalized. At this conceptual stage of implementing Adaptive Phased Management, this packaging plant design serves as an important stepping stone for future design development and optimization projects.

14:20

Postclosure Safety Assessment of a Deep Geological Repository for Canada's Used Nuclear Fuel

N.G. Hunt, E.P. Kremer, F. Garisto, P. Gierszewski, M. Gobien and C.L.D. Medri, Nuclear Waste Management Organization; J.D. Avis, Geofirma Engineering Limited; T. Chshyolkova, C.I. Kitson, T.W. Melnyk, and L.C. Wojciechowski, Atomic Energy of Canada Limited

The most recent postclosure safety assessment considers a hypothetical site and conceptual design for a deep geologic repository for Canada's used nuclear fuel in crystalline rock. Key differences

relative to the previous case study are the shallower depth (500 m), use of in-floor placement, larger container, and different geosphere. The assessment concluded that the repository would meet international and Canadian postclosure dose rate guidelines. This paper presents several assessment results.

The estimated dose rates occur far in the future and are well below natural background levels. Probabilistic assessments indicate a large range of uncertainty in the peak dose rate; however, the predicted peak dose consequences remain very low with the highest dose rates associated with simultaneous failure of all containers.

The postclosure safety of the deep geologic repository concept for the long-term management of Canada's used nuclear fuel has now been illustrated for four possible combinations of engineering design and hypothetical Canadian Shield sites. This further suggests that a suitable repository could be safely designed, sited and constructed within crystalline rock.

14:45

Building Quality into Performance and Safety Assessment Software

L.C. Wojciechowski, Atomic Energy of Canada Limited

Quality assurance is integrated throughout the development lifecycle for performance and safety assessment software. The software used in the performance and safety assessment of a Canadian deep geologic repository (DGR) follows the CSA quality assurance standard CSA-N286.7, Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants. Quality assurance activities in this standard include tasks such as verification and inspection; however, much more is involved in producing a quality software computer program. The types of errors found with different verification methods are described. The integrated quality process ensures that defects are found and corrected as early as possible.

15:10 – 15:40

Networking Break

Trinity 5

Used Fuel Repository – Design and Modelling

Session Chair: To be announced

15:40

Dose Considerations for a Site Boundary for Surface Operations at a Deep Geological Repository

E. Kremer, Nuclear Waste Management Organization; N.C. Garisto, SENES Consultants Limited

Postulated radiological emissions due to surface operations at a hypothetical deep geological repository facility are used to estimate the minimum distance to the site boundary necessary to ensure any consequent dose to members of the public during the preclosure (or operational) period would not exceed the associated Canadian Nuclear Safety Commission regulatory dose limit.

Public dose is calculated at distances ranging from 100 m to 1500 m away from the aboveground Used Fuel Packaging Plant ventilation exhaust; 100 m coincides roughly with the position of the facility's perimeter fence in the current design and represents the minimum distance for which the applied air dispersion modelling is valid. Environmental pathway analyses are performed as outlined in guidelines N288.1 and N288.2 of the Canadian Standards Association.

Normal Operations of the repository surface handling facilities may result in emissions of radioactivity, for example from routine used fuel receipt from transportation and re-packaging into long-lived containers. Conservative estimates of chronic public dose consequences due to Normal Operations are several orders of magnitude below the regulatory dose limit of 1 mSv/a.

Anticipated Operational Occurrences are considered outside the range of normal operations, but are assumed to occur with frequencies of at least 10^{-2} per year. Several Anticipated Operational Occurrences were considered in this assessment: an Irradiated Fuel Transportation Cask carrying water from an Irradiated Fuel Bay; significantly longer transportation or staging times; increased processing load; a 5-fold increase in pre-existing fuel sheath failures; and failure of the ventilation exhaust filtration system. Conservative estimates of the consequent public dose are several orders of magnitude below 1 mSv.

Design Basis Accidents are outside the range of Anticipated Operational Occurrences and are assumed to occur with frequencies of between 10^{-2} and 10^{-5} per year. Postulated Design Basis Accidents considered in this assessment are scissor lift failure causing an Irradiated Fuel Transportation Cask to fall, and overhead carriage failure causing one used fuel module to fall on another module. All accident scenarios are considered both with and without concurrent failure of the emergency High Efficiency Particulate Air (HEPA) filtration system. Predicted acute public dose consequences from the Design Basis Accidents are well below 1 mSv.

16:05

Sensitivity Analysis of a Coupled Hydro-mechanical Paleoclimate Model of Density-dependent Groundwater Flow in Discretely Fractured Crystalline Rock

S.D. Normani and J.F. Sykes, Department of Civil and Environmental Engineering, University of Waterloo

A high resolution three-dimensional sub-regional scale (104km^2) density-dependent, discretely fractured groundwater flow model with hydro-mechanical coupling and pseudo-permafrost was developed from a larger 5734km^2 regional-scale groundwater flow model of a Canadian Shield setting. The objective of the work is to determine the sensitivity of modelled groundwater system evolution to the hydro-mechanical parameters.

The discrete fracture dual continuum numerical model FRAC3DVS-OPG was used for all simulations. A discrete fracture network model delineated from surface features was superimposed onto an approximate 790000 element domain mesh with approximately 850000 nodes. Orthogonal fracture faces (between adjacent finite element grid blocks) were used to best represent the irregular discrete fracture zone network. Interconnectivity of the permeable fracture zones is an important pathway for the possible migration and subsequent reduction in groundwater and contaminant residence times. The crystalline rock matrix between these structural discontinuities

was assigned mechanical and flow properties characteristic of those reported for the Canadian Shield. The variation of total dissolved solids with depth was assigned using literature data for the Canadian Shield. Performance measures for the sensitivity analysis include equivalent freshwater heads, environmental heads, linear velocities, and depth of penetration by conservative non-decaying tracers released at the surface.

A 121000 year North American continental scale paleo-climate simulation was applied to the domain with ice-sheet histories estimated by the University of Toronto Glacial Systems Model (UofT GSM). Hydro-mechanical coupling between the rock matrix and the pore fluid, due to the ice sheet normal stress, was included in the simulations. The flow model included the influence of vertical strain and assumed that areal loads were homogeneous. Permafrost depth was applied as a permeability reduction to both three-dimensional grid blocks and fractures that lie within the time varying permafrost zone. Values of ice sheet normal stress and proglacial lake depth from the UofT GSM were applied to the sub-regional model as surface boundary conditions using a freshwater head equivalent to the normal stress imposed by the ice sheet at its base. The sensitivity of glacial meltwater penetration to different conceptualizations of hydro-mechanical properties were investigated.

16:30

Glaciation and Geosphere Evolution – Greenland Analogue Project

S. Hirschorn, A. Vorauer, M. Ben Belfadhel and M. Jensen, Nuclear Waste Management Organization

The deep geological repository concept for the long-term management of used nuclear fuel involves the containment and isolation of used nuclear fuel in a suitable geological formation. A key objective of the Canadian Nuclear Waste Management Organization (NWMO) geoscience technical research program is to advance the understanding of geosphere stability and its resilience to perturbations over time frames of relevance to a deep geological repository.

Glaciation has been identified as the most probable and intense perturbation relevant to a deep geological repository associated with long-term climate change in northern latitudes. Given that the North American continent has been re-glaciated nine times over the past million years, it is strongly expected that a deep geological repository within a suitable crystalline or sedimentary rock formation in Canada will be subject to glaciation events associated with long-term climate change. As such, NWMO's geoscience research program has placed particular emphasis on investigations of the response of the geosphere to glaciations. As surface conditions change from present day conditions to periglacial, followed by ice-sheet cover of variable thickness and rapid glacial retreat, transient geochemical, hydraulic, mechanical and temperature conditions will be simultaneously imposed on groundwater systems. NWMO research activities related to glaciation events and their impacts on groundwater system evolution are being undertaken using a multi-disciplinary approach aimed at collecting multiple lines of evidence. These investigations include assessment of the:

- Impact of an ice sheet on groundwater composition at repository depth using the Greenland Ice Sheet as an analogue to future glaciations in North America;
- Expected physical and temporal surface boundary conditions related to potential future glaciation events by estimating the magnitude and time rate of change of ice sheet thickness, ground surface temperature and permafrost occurrence, amongst other attributes;
- Evolution of deep groundwater systems and impacts of Coupled Thermo-Hydro-Mechanical effects imposed by glacial cycles;
- Impacts of climate change on redox stability using both numerical simulations and paleohydrogeological investigations; and
- Potential for seismicity and faulting induced by glacial rebound.

This paper presents an overview of studies underway as part of the Greenland Analogue Project (GAP) to evaluate the impact of an ice sheet on groundwater chemistry at repository depth using the Greenland Ice Sheet as an analogue to future glaciations in North America. The study of the Greenland Ice Sheet will allow us to increase our understanding of hydrological, hydrogeological and geochemical processes during glacial conditions.

16:55

Rock Fracture Dynamics Research at AECL's Underground Research Laboratory: Applications to Geological Disposal of Radioactive Waste

R.P. Young, University of Toronto; J.R. Haycox, Applied Seismology Consultants Limited; J.B. Martino, Atomic Energy of Canada Limited

Studies of rock fracture dynamics at AECL's Underground Research Laboratory (URL) have helped to provide a fundamental understanding of how crystalline rock responds to stresses induced from excavation, pressurization and temperature changes. The data acquired continue to provide insights into how a facility for the future geological disposal of radioactive waste could be engineered. Research into microseismic (MS), acoustic emission (AE), and ultrasonic velocity measurements has been performed on the full-scale sealed, pressurized, and heated horizontal elliptical tunnel at the Tunnel Sealing Experiment. The continuous monitoring of the experiment for eight years provides a unique dataset for the understanding of the medium-term performance of an engineered disposal facility.

This paper summarizes the results, interpretations and key findings of the experiment paying particular focus to the heating and cooling/depressurization of the chamber. Initial drilling of the tunnel and bulkheads causes microfracturing around the tunnel mapped by MS and AEs is used as a benchmark for fracturing and represents the excavated damaged zone (EDZ). There is no further extension to the volume during pressurization or heating of the tunnel suggesting an increase in crack density and coalescence of cracks rather than extension into unfractured rock. The dominant structure within the seismic cloud has been investigated using a statistical approach applying the three-point method. MS events in the roof exhibit a dominant pattern of sub-horizontal and shallow-dipping well defined planar features, but during cooling and depressurization with a 45 degree dip normal to the tunnel axis is observed, which may be

caused by movement in the rock-concrete interface due to differential cooling of the bulkhead and host rock. Cooling and depressurization of the TSX have not led to a significant increase in the number of MS or AE events. Ultrasonic results suggest the rock gets even stiffer in the first months of cooling, but this is slowly reduced towards the end of the experiment as microfractures reopen possibly also caused by a relaxation of the rock as the chamber depressurizes. AEs located at the concrete bulkhead delineated three macrofracture zones during curing. The high-resolution locations were used to delineate and monitor the growth of the fault plane allowing focused injection of grout to heal the developed damage.

17:20

Radionuclide Sorption and Transport in Brine Solutions

P. Vilks, Atomic Energy of Canada Limited

The Canadian Nuclear Waste Management Organization (NWMO) is responsible for implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of used nuclear fuel produced by Canada's nuclear reactors. The goal of APM is a long-term containment and isolation of used nuclear fuel in a Deep Geologic Repository (DGR) constructed in a suitable crystalline or sedimentary rock formation.

Sedimentary rocks in Canada are known to contain Na-Ca-Cl brine solutions with total dissolved solids (TDS) in the range of 200 to 300 g/L. The sorption properties of shales and limestone and for clay-based materials used in engineered barriers are required in evaluations of the safety of a deep geologic repository in a Canadian sedimentary setting. The process of defining the role of sorption in the transport of radionuclides in these rocks includes: (1) batch sorption experiments in brine solutions to develop an understanding of processes and mechanisms; (2) the establishment of a defensible database of sorption values; and (3) demonstration that sorption values can be applied to explain mass transport processes.

The sorption of Sr, Ni, Cu, Eu and U was measured on bentonite, shale and limestone in Na-Ca-Cl brine solutions with TDS values as high as 300 g/L. Initial results have confirmed that group 1 and 2 elements, which sorb by non-specific coulombic attraction, are not likely to sorb in brine solutions. Transition metals, such as Ni and Cu, and the trivalent Eu and hexavalent U sorb by surface complexation mechanisms to bentonite, shale and limestone. The high concentrations of Ca in the brine were found to compete with Ni for sorption sites and the formation of complexes with carbonate reduced the sorption of Eu and U.

The development of a sorption database for sedimentary rocks (shale and limestone) and bentonite, in a setting that would include Na-Ca-Cl brine solutions at near neutral pH, was initiated. The elements of interest for performance assessment included C, Cu, As, Se, Zr, Nb, Mo, Tc, Pd, Sn, Pb, Bi, Ra, Th, Pa, U, Np, Pu and Am. The process included a search of the international literature for data relevant for bentonite, shale, limestone, illite, chlorite and calcite in high salinity water, and a consideration of results from new batch experiments. The sorption values determined as part of this process are intended as a starting point for the development of a Canadian sorption database for sedimentary rocks. Future work will include batch and mass transport experiments, combined with modelling to fill data gaps and improve understanding of sorption processes during mass transport, and continued development of a sorption database for sedimentary rocks.

Simcoe

Federal Policies, Programs and Oversight

Session Chair: Joan Miller, Atomic Energy of Canada Limited

13:30

Radioactive Waste Management in Canada: Progress and Challenges 15 Years After the Policy Framework

D. McCauley, M. Blanchette, T. Calvert, K. Hollington and D. Metcalfe, Natural Resources Canada

Canada's Policy Framework for Radioactive Waste Management came into being in 1996, establishing the federal Government's overarching policy on radioactive waste management. Most importantly, the Policy Framework clearly establishes the role of the federal government and the role of the waste producers for radioactive waste management. Since the elaboration of the Policy Framework, there have been major developments on a variety of waste management fronts.

In the area of nuclear fuel waste, legislation was established to provide the framework for advancing a solution to the long-term management of nuclear fuel waste. Advancements also have been made in the area of low and intermediate-level radioactive wastes where Ontario Power Generation has defined a solution for the management of its wastes in cooperation with a supportive host community. And, in the area of uranium mine and mill tailings, progress continues to be made. The Government too has launched programs aimed at developing long-term solutions for historic and legacy and legacy wastes and these are reaching a level of maturity.

This paper provides an overview of not only the progress made in the management of radioactive wastes in Canada in the years since the Policy Framework for Radioactive Waste Management, but also reviews some of the challenges that need to be addressed going forward.

13:55

Canada's Nuclear Fuel Waste Act – The First 10 Years – Key Decisions and Experience in Federal Oversight

K. Hollington, Natural Resources Canada

Canada's *Nuclear Fuel Waste Act* (NFWA) came into force in 2002, and its first decade has been arguably the most important and significant in terms of government decision-making and oversight. There have been a number of key government policy decisions and actions that have taken place during this time to ensure there is a safe, secure, environmentally sound, and comprehensive plan for the long-term management of nuclear fuel waste.

Over the last decade, the Government of Canada has played an instrumental role in shaping how we, as a country, plan to safely and securely manage nuclear fuel waste over the long-term that is in the best interests of Canadians and their environment. In 2007, the Government of Canada selected the Nuclear Waste Management Organization's (NWMO) recommendation of Adaptive Phased

Management as a safe and secure plan for managing the waste that protects the health of Canadians and the environment. This plan involves isolating, containing and long-term monitoring of the nuclear fuel waste in a deep geological repository which would be constructed, operated and maintained at a suitable site in a willing host community.

Today and for many tomorrows, the implementation of this plan by the NWMO is now underway with ongoing federal oversight, as required by law. This Act sets out clear obligations and responsibilities for the Government and for all parties *(i.e., Ontario Power Generation, Hydro-Québec, New Brunswick Power, Atomic Energy of Canada Limited and the NWMO)* that are central to ensuring the safe and secure long-term management of nuclear fuel waste.

14:20

Historic Low-Level Radioactive Waste Federal Policies, Programs and Oversight

M. Blanchette and J. Kenney, Natural Resources Canada; R. Zelmer, Atomic Energy of Canada Limited

From the early industrial uses of radioactive material beginning in the 1930s, there has been a steady accumulation of low-level radioactive waste products. Historic waste is low-level radioactive waste for which the federal government has accepted responsibility for long-term management.

This paper will outline the policy framework used to govern institutional and financial arrangements for the disposal of radioactive waste by waste producers and owners and the major radioactive projects in which the Government of Canada is currently involved. It will provide an overview of the organizations established for the management of historic radioactive waste and NRCan's oversight role. Finally, an overview of the historic waste program activities managed on behalf of the federal government through these organizations in the Port Hope area, the Greater Toronto Area, in Fort McMurray, Alberta and along the Northern Transportation Route is provided.

14:45

Overview of the Government of Canada's Nuclear Legacy Liabilities Program

D. Metcalfe and D. McCauley, Natural Resources Canada; J. Miller and S. Brooks, Atomic Energy of Canada Limited

Nuclear legacy liabilities have resulted from 60 years of nuclear research and development carried out on behalf of Canada by the National Research Council and Atomic Energy of Canada Limited (AECL). These liabilities are located at AECL research and prototype reactor sites, and consist of shutdown reactors, research facilities and associated infrastructure, a wide variety of buried and stored waste, and affected lands.

In 2006, the Government of Canada adopted a new long-term strategy to deal with the nuclear legacy liabilities and initiated a five-year, $520 million start-up phase, thereby creating the Nuclear Legacy Liabilities Program (NLLP). The objective of the long-term strategy is to safely and cost-effectively reduce risks and liabilities based on sound waste management and environmental principles in the best interests of Canadians.

The NLLP is being implemented through a Memorandum of Understanding between Natural Resources Canada (NRCan) and AECL whereby NRCan is responsible for policy direction and oversight, including control of funding, and AECL is responsible for implementing the program of work and holding and administering all licences, facilities and lands.

The NLLP is now in its sixth year of implementation, with funding of $129 million in fiscal year 2011-12. Projects and activities include infrastructure decommissioning, environmental restoration, improving the management of legacy radioactive waste, as well as required care and maintenance activities. Further, over the coming years, there will be an increased emphasis on developing and implementing long-term solutions for the legacy waste and affected lands.

15:10 – 15:40

Networking Break

Simcoe

Port Hope Area Initiative – 1

Session Co-Chairs: Aldo D'Agostino, Vision 2010 and Linda Thompson, Mayor of Port Hope

15:40

Nearly Ready For Construction on the Port Hope Area Initiative

C. Fahey and A. Denby, Atomic Energy of Canada Limited; T. Palmeter, Public Works and Government Services Canada; M. Blanchette, Natural Resources Canada; D. Howard, Canadian Nuclear Safety Commission

The Port Hope Area Initiative is a federally-sponsored project to clean up the historic low-level radioactive waste arising from the operations of Eldorado Nuclear, a former federal crown corporation, and its private sector predecessors. The waste is mostly in the form of contaminated soil and was generated between 1932 and 1988 when Eldorado was dissolved. This paper provides a summary of the origin of the waste, the initial attempt to address the waste issue, and the current initiative which began in 2001. More specifically, this paper provides an introduction to the project and the work accomplished in Phase 1, specific details regarding the ongoing Transition Phase 1A and a sneak peek at the plan for Phase 2 when the construction and remediation activities will be performed and the wastes safely emplaced in new engineered containment mounds.

16:05

Evolution of the Property Value Protection Program – A Study of How a Compensation Plan Has Evolved to Meet Changing Needs

J. Herod and S. Straughan, Atomic Energy of Canada Limited

The Property Value Protection (PVP) Program offers an innovative approach to address the risk of individual property value loss resulting from the cleanup and long-term management of low-level radioactive waste in the Port Hope area. This cleanup is taking place through the Port Hope Area Initiative (PHAI), a federally sponsored waste remediation project.

The Program came into effect on October 1, 2001, having been established as a key element of the Legal Agreement for the Port

Hope Area Initiative, signed between the Government of Canada and the municipalities of Port Hope and Clarington. The PVP Program was designed in direct response to the concerns expressed by the agreement's two municipal signatories that protection of local property owners from the risk of property value loss was critical to their acceptance of the Port Hope Project and Port Granby Project.

The PVP Program compensates owners of residential, commercial or industrial properties for a loss in fair market value on the sale or rental of their properties. Increased mortgage refinancing costs and expenses incurred as a result of delayed sales that can be attributed to the Port Hope Area Initiative are also compensated.

This paper will review the rationale behind the PVP Program and outline how it has evolved since its inception to meet both the needs of its clients and the communities in which it operates. It will focus on the role of the PVP Program in ameliorating financial risks for affected property owners, thereby building stakeholder confidence in the remediation of the historic low-level radioactive waste through the PHAI. Further, the paper will highlight changes that have been made to refine and improve the program and how communications and stakeholder relations strategies have helped to educate the public and the local real estate industry about the program.

16:30

Dredging Up the Past – Removal of Historic Low-level Radioactive Sediment from the Port Hope Harbour

G. Case, Atomic Energy of Canada Limited

16:55

Implementing Best Available Technology for Water Treatment at the Port Hope and Port Granby Low-level Radioactive Waste Clean-up Projects

G. Vandergaast, Atomic Energy of Canada Limited

Through the use of a systematic and flexible developmental strategy, Atomic Energy of Canada Limited (AECL) has been able to specify water treatment requirements for the PHAI's two low-level radioactive waste cleanup projects that are examples of using Best Available Technology (BAT). These will result in substantially reduced loadings of radium-226, arsenic, uranium and other contaminants associated with the waste to Lake Ontario, when compared to the option of simply continuing to use existing water treatment facilities at the project sites. Pilot scale studies carried out by AECL in 2010 have confirmed that individually distinct BAT water treatment process for the two projects can achieve the high contaminant removal efficiencies required to make the water quality improvements. Results of the pilot scale studies have also successfully provided the necessary detailed design requirements and specifications to enable completion of the water treatment facility construction and commissioning stages as part of the PHAI.

17:20

The Role of the Peer Review Process in the Clean-up of Low-level and Historic Radioactive Waste in the Municipalities of Port Hope and Clarington, Ontario, Canada

D. Al-Haydari, Hardy Stevenson and Associates Limited

Peer review processes are increasingly forming an essential part of a successful radioactive waste management projects. This paper describes the role of the Municipal Peer Review Team (MPRT) for the Municipalities of Port Hope (Port Hope Project) and Clarington (Port Granby Project) for the clean-up of low level and historic radioactive waste.

The Municipalities of Port Hope and Clarington are committed to leading the clean-up and safe long-term management of historic low-level radioactive and hazardous wastes deposited in Port Granby and several locations in theMunicipalityofPort Hope. They are supported by the Government of Canada through Atomic Energy of Canada Limited's (AECL) Port Hope Area Initiative Management Office (PHAIMO). The wastes are the result of radium and uranium processing in Port Hope by Eldorado since the 1930s.

The peer review process is required to enable the municipalities to fulfill their roles as equal parties (with the Government of Canada) in the Environmental Assessment (EA), facility licensing, facility design, facility construction and remediation processes. To establish the parameters of the clean-up, including the ability to veto the project, the local municipalities negotiated and signed a Legal Agreement with the Government of Canada in 2001. As a Responsible Authority, Natural Resources Canada has defined and approved the scope of the two projects. The PHAIMO is designated as the proponent.

The Legal Agreement specified that both municipalities would have funded staff to work together to coordinate and expedite the project. Janice Szwarz is the staff person assigned by the Municipality of Clarington and Anthony Hobbs holds the staff position for the Municipality of Port Hope. Under the Legal Agreement, a Municipal Peer Review Team (MPRT) would be retained by the municipalities and funded by the Government of Canada. The MPRT is made up of experienced professionals from a variety of disciplines related to nuclear waste clean up processes and are led by Hardy Stevenson and Associates Limited.

The peer review process has stressed the need for a proactive management approach for low level radioactive waste and marginally contaminated soil clean-ups. The Port Hope and Port Granby Projects are extremely complex. Most important to note is that the clean-up process will be occurring in an urban setting (Port Hope) and a populated rural setting (the Port Granby community in Clarington). Therefore, due to the 'people' element, there is a need to anticipate the project effects (e.g. emissions and dust effects) before they affect the local population and environment.

Grand Ballroom

Low- and Intermediate-level Waste Panel

Session Co-Chairs: Jonathan Will, Natural Resources Canada and Peter Elder, Canadian Nuclear Safety Commission

08:30

Introduction

Jonathan Will, Natural Resources Canada

08:45

Canadian Approaches and Strategies for Low- and Intermediate-Level Radioactive in Canada

Dave McCauley, Natural Resources Canada

Measurable progress is being made on the development and implementation of long-term management solutions for low- and intermediate-level radioactive waste in Canada. Canada has completed the planning necessary for the implementation of long-term management approaches for the bulk of Canada's historic low-level radioactive wastes and is awaiting authority to proceed. Similarly, Ontario Power Generation, with the largest inventory of low- and intermediate-level radioactive wastes among Canadian utilities, is moving ahead with its plan to build a deep geologic repository.

Despite these major advances, there are still important gaps in the infrastructure and strategies needed to address the long-term management of all low- and intermediate-level radioactive waste that resides at sites in Canada. Although, there may be different solutions and strategies amongst the various waste owners for managing their own waste, it is important that they continue discussions to assess gaps and to identify possible synergies with the various waste management initiatives currently in place. As waste owners advance their plans, collaboration, coordination and effective communication must remain a priority.

09:00

Canada's Regulatory Framework

Don Howard, Canadian Nuclear Safety Commission

This paper will discuss the Canadian Nuclear Safety Commission and Canada's Regulatory Framework with respect to Low- and Intermediate-Level Radioactive Waste. The management of low and intermediate level radioactive waste must be ensured in a consistent, environmentally responsible and economical manner throughout its lifecycle – from its production to the final disposal option.

Radioactive waste has been produced in Canada since the early 1930s when the first radium/uranium mine began operating at Port Radium in the Northwest Territories. Pitchblende ore was transported from the Port Radium mine to Port Hope, Ontario where it was refined to produce radium for medical purposes. At present, radioactive waste is generated in Canada from the various stages and uses associated with the nuclear fuel cycle from uranium mining/milling to nuclear reactor operations to radioisotope manufacture and use.

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and to implement Canada's international commitments on the peaceful use of nuclear energy.

The CNSC was established in 2000 under the Nuclear Safety and Control Act and reports to Parliament through the Minister of Natural Resources. The CNSC was created to replace the former Atomic Energy Control Board (AECB), which was founded in 1946.

Under the Nuclear Safety and Control Act, CNSC's mandate involves four major areas:

- regulation of the development, production and use of nuclear energy in Canada to protect health, safety and the environment;
- regulation of the production, possession, use and transport of nuclear substances, and the production, possession and use of prescribed equipment and prescribed information;
- implementation of measures respecting international control of the development, production, transport and use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons and nuclear explosive devices;
- dissemination of scientific, technical and regulatory information concerning the activities of CNSC, and the effects on the environment, on the health and safety of persons, of the development, production, possession, transport and use of nuclear substances.

The prime responsibility for safety including the management of low- and intermediate-level radioactive waste rests with the licensee in possession of the nuclear material.

While neither the NSCA nor its associated regulations define radioactive waste, Regulatory Policy P-290, Managing Radioactive Waste, asserts that radioactive waste is "any liquid, gaseous or solid material that contains a nuclear substance, as defined in section 2 of the NSCA and for which the owner of the material foresees no further use and the owner had declared as waste. By definition, a radioactive waste may contain non-radioactive constituents. Radioactive waste is therefore regulated in the same manner as all other materials that contain a nuclear substance.

The generation of radioactive waste cannot be prevented entirely but it should be kept to the minimum practicable as an essential objective of radioactive waste management. This objective is in line with CNSC Regulatory Policy P-290.

Waste minimization relates to both volume and activity and to both the waste generated by an initial undertaking and the secondary waste resulting from the management of radioactive waste. The chemical characteristics of the waste should also be controlled at source in order to facilitate subsequent processing.

As part of the CNSC's effort to improve and modernize its Regulatory Framework, the CNSC is considering several upgrades to the Framework. The CNSC as part of its licensing framework introduced Safety and Control Areas. One of the Safety and Control Areas is waste management. To address the SCA of waste management, the CNSC will be implementing a requirement that each licensee must have in place a waste management program. CNSC staff is currently developing a Regulatory Document and Guide that will incorporate the policy principles of Regulatory Policy P-290 into requirements and also it will provide guidance on what needs to be included in the waste management. The completion of both Regulatory Documents is projected to be completed by 2013.

An initial analysis will be started in early 2012 to decide whether or not Radioactive Waste and Decommissioning Regulations are needed. These Regulations will encompass all forms of waste, from operational waste including mixed waste; decommissioning waste; and legacy waste. Consideration will also be given to including financial guarantees as part of these Regulations. It is anticipated that it will take approximately one year to complete the initial analysis.

09:15

OPG's Deep Geologic Repository for LILW – Facility Scope

Pauline Witzke, Ontario Power Generation

Ontario Power Generation (OPG) is undergoing a multi-year planning and regulatory approvals process for a deep geologic repository (DGR) for the long-term management of low and intermediate level waste (L&ILW). The Environmental Impact Statement (EIS), Preliminary Safety Report (PSR) and other supporting documents in support of a site preparation and construction licence for the project were submitted to the Joint Review Panel (JRP) on April 14, 2011 as part of the regulatory approvals process. These documents included the Reference Inventory for LILW for the DGR.

The Reference Inventory includes both the waste packages and the waste characteristics. It includes the LILW waste arisings from the operation and refurbishment of all 20 OPG-owned CANDU generating units currently in existence (Pickering 1-8, Darlington 1-4, Bruce 1-8). The inventory is based on a scenario which considers the refurbishment of all reactor units (except Pickering A) with operation for a further 30 years after refurbishment.

The projected emplaced volume is about 200,000m^3 based on 170,000 m^3 of stored volume. This will involve about 53,000 waste containers, and about 84% of the emplaced volume will be LLW.

09:30

Managing Wastes from the Atomic Age and into the Future: Programs, Plans and Challenges

Joan Miller, Atomic Energy of Canada Limited

Various types of waste are generated at Atomic Energy of Canada Limited (AECL) nuclear sites from diversified operations, including research reactor operations, radioisotope production, hot cell operations, nuclear fuel fabrication, research and development activities, facility decommissioning, environmental restoration, etc. AECL is responsible for the safe storage and long-term management of waste generated by Chalk River Laboratories (CRL), Whiteshell Laboratories (WL) and the three partially decommissioned prototype reactors, as well as for the radioactive waste received from off-site waste generators on a fee-for-service basis.

As the home for the first nuclear reactors in Canada and nuclear research facilities, CRL has been a pioneer in the management of nuclear waste. Since the dawn of the nuclear era in the 1940s, CRL's waste management facilities have evolved from storage in simple sand trenches to below-ground concrete storage, to above-ground facilities offering multiple barriers of containment. The evolution in waste management facility designs arose from an improved understanding of the requirements for the safe storage of radioactive waste and the increased social expectations in the management of waste materials in general.

In 2006, AECL and Natural Resources Canada began implementing a Nuclear Legacy Liabilities Program (NLLP) to deal with nuclear legacy liabilities at AECL sites. These liabilities consist of radiochemical laboratories, shutdown research buildings, including several prototype and research reactors, buried and stored wastes, and contaminated lands. Approximately 200,000 to 300,000 cubic metres of waste from AECL earlier operations requires management through the NLLP, with a yearly increase of several thousand cubic metres. Several of the NLLP projects currently underway are focused on improving the robustness of earlier management practices, as older facilities reach the end of their design life. An important element of the NLLP is the development of an Integrated Waste Plan to ensure optimal selection of enabling facilities and their implementation schedules to address the current waste inventory and future wastes from both AECL's operational and decommissioning activities.

Under the NLLP, AECL has also begun assessing options for the long-term management of low- and intermediate-level wastes. Pre-project planning is underway for a Very Low Level Waste (VLLW) facility to receive the large volumes of VLLW wastes that are being generated by infrastructure decommissioning and environmental remediation activities. A feasibility study of the CRL site to host a proposed Geologic Waste Management Facility for low- and intermediate-level waste has also been conducted, with the results currently under review.

There has also been an evolution in AECL's waste management practices with the introduction of a formal Waste Management Program. An important component of this Program is a focus on waste reduction and appropriate waste characterization to ensure wastes are being handled, stored and/or disposed in the most cost-effective manner.

The presentation will provide an overview of our waste management strategy, AECL's low- and intermediate-level waste inventory, current activities for the management of those wastes, and our plans for moving forward.

09:45

Refurbishment Implications on Long-Term Waste Management Strategies at Point Lepreau

Charles Hickman, New Brunswick Power Nuclear

This paper discusses Point Lepreau Generating Station's waste management experiences during the Refurbishment outage. In short, Point Lepreau GS has been challenged during the outage due to the amount of low and intermediate level waste that has been generated compared to that which was expected, which has driven the need to develop a new waste management strategy in the middle of the outage. The paper presents an overview of pre-outage waste handling, what process changes and schedule changes occurred during the outage, and provides a discussion of the operational and financial consequences of those changes. Key issues highlighted by the paper include the need for adequate provision of waste management facilities during large outages, the importance of ensuring that contractors have a stake in waste minimization activities, and long term waste management implications that need to be considered for large outages.

10:00 – 10:15
Networking Break

10:15
Hydro-Québec's Long-Term Strategy for Low and Intermediate Level Waste Management
François Bilodeau, Hydro-Québec

Hydro-Québec operates only one nuclear generating station, with a gross electrical output capacity of 675 MW. It produces approximately 3% of the total capacity of Quebec's power grid and is located in Bécancour, on the south shore of the St. Lawrence River, near Trois-Rivières. Operating a nuclear power plant generates radioactive waste of several types, the storage duration of which varies depending on the radionuclides present in the waste and their level of radioactivity.

Hydro-Québec developed a waste management strategy that covers the entire range of waste generated, whether conventional or radioactive, over a thirty-year timeline. This strategy will be implemented beyond 2040 and is organized under three major activities:

i) Reduction of waste present on site;

ii) Special projects;

iii) Continuous activities.

(i) Reduction of the waste present on site constitutes the core activity of the action plan. To date, implementation of the activities related to this category has succeeded in disposing of over 57 metric tons of very low contamination level concrete residues, reducing by a factor of 6 the volume of over 600 empty metal drums, and reducing from 86 down to 36 the number of containers on site.

In 2011, a liquid waste characterization campaign will be initiated to dispose of the waste that does not exceed regulatory radioactivity levels (e.g. waste oils). For waste exceeding such levels, Hydro-Québec will hire outside firms specialized in this area, which will ensure a gradual elimination of that waste over the next few years.

(ii) Special projects include the following activities: implement the strategy for managing the waste generated during refurbishment of the station planned in late 2012, review in the field the residual hazardous material (RHM) disposal areas and the containers used for sorting potentially radioactive waste, establish conventional waste disposal islands and operate the new solid radioactive waste management facilities (IGDRS).

In that regard, since 2008, Hydro-Québec has been operating Phase 1 of the IGDRS, which currently receives the radioactive waste generated during normal station operations. In 2011, Phase 2 of the IGDRS will enter service and will receive the waste produced by the station's refurbishment activities.

(iii) Continuous activities of the action plan include the performance of audits to monitor compliance with radioactive waste management standards, the development of a specific employee waste management training program, benchmarking activities with other stations, and the use of reusable materials to minimize waste.

The safe storage of radioactive waste on the Gentilly-2 Station site is a priority for Hydro-Québec, and the proper management of that waste, in terms of environmental, technological and economical aspects, is therefore addressed as such.

10:30
Waste Management Practices at Cameco
Karen Chovan, Cameco Corporation

Cameco operates business units which span most of the front end of the nuclear fuel cycle, from uranium exploration and mining, through refining and conversion, and fuel manufacturing. Each operation generates various quantities and forms of radiologically contaminated materials, although all of them can be classified as low level. These materials include waste rock and tailings from mines and mills, typical industrial wastes including wood, metal, plastic and various consumables such as personal protective equipment, construction and demolition wastes, and solid and liquid hazardous and non-hazardous process byproducts. This presentation focuses on the management of low level industrial and demolition wastes and process byproducts.

Over the past 35 years, Cameco and its predecessors have found effective ways of reducing, recycling, recovering, consolidating, treating, and otherwise diverting wastes from landfills. This has required operational flexibility, ongoing assessment of available technologies and diversion opportunities, environmental pathways analyses and extensive sampling, characterization and radiological release monitoring of materials. The end product of this strong focus on waste management has been the ongoing successful operation of Cameco's Ontario fuel services division with strong chemical re-use and recovery processes, and minimal use of licensed hazardous and LLRW management facilities.

However, finding additional or new economic recycling solutions or decontamination methods which generate inert, manageable and minimal waste is becoming more difficult. All too often the LLRW disposal route is the cheapest, even for the fuel services division with its limited disposal opportunities in Canada. Unfortunately, the non-nuclear sector's knowledge and understanding of radioactivity puts limits on opportunities, even where pathways studies indicate insignificant risk. Other challenges include the length of time it takes to find, study and gain approval for diversion options, legal negotiations for cross-border management arrangements, and differing waste classification schemes and guidelines for free-release clearance.

Within Cameco's northern Saskatchewan mining division, two operations currently have licensed on-site disposal facilities, easing waste management constraints. However, in pursuit of improved waste management processes, the LLRW cleanup and diversion lessons learned within the fuel services division are now being investigated for these remote operations as well.

10:45 – 11:15
Questions and Panel Discussion

11:15 – 12:00
Visit Business Exposition

12:00 – 13:30
Luncheon, Grand Ballroom

Concurrent Technical Sessions

Trinity 1

OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 3

Session Co-Chairs: Paul Gierszewski, Nuclear Waste Management Organization and Pauline Witzke, Ontario Power Generation

13:30

Detailed Modelling for the Postclosure Safety Assessment of OPG's DGR

J.D. Avis, A. West, R. Walsh, and N. Calder, Geofirma Engineering Limited; P. Suckling, Quintessa Limited; P. Humphries, School of Applied Sciences, University of Huddersfield, F. King, Integrity Corrosion Consulting Limited

As part of the postclosure safety assessment undertaken for the proposed Deep Geologic Repository (DGR) for Low and Intermediate Level Waste (L&ILW) at the Bruce nuclear site, calculations were undertaken to evaluate the repository's potential postclosure impacts. Impacts were evaluated for a Normal Evolution Scenario, describing the expected long term evolution of the repository and site following closure, and for several Disruptive Scenarios, which consider events that could lead to possible penetration of barriers, abnormal degradation, and/or loss of containment.

The postclosure modelling was conducted using both detailed models with three-dimensional representation of the repository geometry, and with an overall (system) assessment-level model. The purpose of the detailed modelling described in this paper was to evaluate postclosure performance in terms of repository pressures, repository resaturation levels, mass flow rates of gas at various levels in the shaft, groundwater flow and radionuclide transport through the saturated geosphere and shaft seals, and capture rates of radionuclides by a hypothetical water supply well. The results of the detailed modelling were used to inform overall assessment-level (system) modelling that was performed using the compartmental modelling code AMBER and which is described in a companion paper.

Two separate detailed modelling studies were undertaken: 1) generation of gas in the repository, repository resaturation, and transport of gas through the geosphere and shaft sealing system was simulated using T2GGM, a modified version of the TOUGH2 gas transport code with coupled gas generation, and 2) transport of groundwater and radionuclides through the saturated geosphere and shaft seals was simulated with FRAC3DVS-OPG.

The gas generation model (GGM) incorporated within T2GGM was developed expressly for the L&ILW waste that will be present at the DGR. GGM calculates generation and consumption of oxygen, hydrogen, carbon dioxide, methane, hydrogen sulphide and nitrogen from degradation of the various organic and metallic waste streams.

Results from the Normal Evolution Scenario groundwater model show that radionuclide transport is diffusion dominated and very slow, with virtually no transport beyond the immediate vicinity of the repository. Results from gas modelling indicate that the repository will take hundreds of thousands of years to resaturate, and that there will be no gas flow within the shaft for the Reference Case and most Normal Evolution sensitivity cases. In the few cases where gas flow in the shaft does occur, it is restricted to lower portions of the shaft. No gas enters the shallow groundwater system. The gas modelling also indicates that in most cases, repository pressures will equilibrate near the expected steady-state in-situ pressure. In no cases do the gas pressures exceed the lithostatic pressure.

13:55

Impact Modelling for the Postclosure Safety Assessment of OPG's DGR

R. Little, R. Walke, G. Towler and J. Penfold, Quintessa Limited

As part of the safety assessment for the proposed DGR, calculations were undertaken to evaluate the repository's potential postclosure impacts. Impacts were evaluated for a Normal Evolution Scenario, describing the expected long-term evolution of the repository and site following closure, and four Disruptive Scenarios, which consider events that could lead to possible loss of containment.

An assessment-level (system) model was implemented in AMBER, a compartment modelling code, that represents radioactive decay, waste package degradation, potential contaminant transport through the repository, sealed shafts, geosphere and surface environment, and the associated impacts. The model used input from detailed models implemented in the FRAC3DVS-OPG and T2GGM codes for the repository saturation, gas generation, and groundwater and gas flow processes.

Both safety and performance indicators were calculated to assess the potential impact of the DGR. Safety indicators include radiation dose to humans and environmental concentrations of radionuclides and non-radioactive hazardous substances. Performance indicators include contaminant amounts within various spatial domains (e.g., the repository, the host rock, and the wider geosphere) and fluxes of contaminants at various points in the DGR system.

The long timescales under consideration mean that there are uncertainties about the way the DGR system will evolve. In addition to assessing alternative future evolutions through different scenarios, uncertainties were addressed through the adoption of conservative assumptions, the evaluation of variant deterministic cases within each scenario, and probabilistic calculations.

The results for the Normal Evolution Scenario indicate that the DGR system provides effective containment of the emplaced contaminants. Most radionuclides decay within the repository or the deep geosphere. The amount of contaminants reaching the surface is very small, such that the maximum calculated dose for the Normal Evolution Scenario is more than five orders of magnitude below the public dose criterion of 0.3 mSv/a for all calculation cases. In addition, maximum calculated concentrations in the biosphere are well below the criteria for protection of biota from radionuclides, and for protection of humans and biota from non-radioactive contaminants. The isolation afforded by the location and design of the DGR limits the likelihood of disruptive events potentially able to bypass the natural and engineered barriers to a small number of situations with very low probability. Even if these events were to occur, the analysis shows that the contaminants in the waste would continue to be contained effectively by the DGR system such that the associated risk criterion is met.

14:20

Preclosure Safety Assessment for OPG's Deep Geological Repository for L&ILW

N.C. Garisto, A. Ho, S. Hussain, C. Pinilla and M. Monabbati, SENES Consultants Limited; P. Gierszewski, H. Leung and K. Sedor, Nuclear Waste Management Organization

The Preclosure Safety Assessment summarized in this paper evaluates the operational safety of OPG's proposed Deep Geologic Repository facility, focusing on safety aspects associated with waste packages. The assessment addresses the safety of members of the public and workers, and includes both radiological and non-radiological (chemical) consequences. It involves an assessment of normal operations as well as hypothetical accident scenarios selected using a hazard identification process. Results indicate that credible hypothetical accidents would not produce exposures that exceed selected radiological and non-radiological dose criteria for members of the public or workers. Similarly, doses generated under normal operations would not exceed radiation dose limits.

14:45

Maximum Flood Hazard Assessment for OPG's Deep Geologic Repository for Low And Intermediate Level Waste

P. Nimmrichter, J. McClintock and J. Peng, AMEC plc.; H. Leung, Nuclear Waste Management Organization

Ontario Power Generation (OPG) has entered a process to seek Environmental Assessment and licensing approvals to construct a Deep Geologic Repository (DGR) for Low and Intermediate Level Radioactive Waste (L&ILW) near the existing Western Waste Management Facility (WWMF) at the Bruce nuclear site in the Municipality of Kincardine, Ontario. In support of the design of the proposed DGR project, maximum flood stages were estimated for potential flood hazard risks associated with coastal, riverine and direct precipitation flooding.

The estimation of lake/coastal flooding for the Bruce nuclear site considered potential extreme water levels in Lake Huron, storm surge and seiche, wind waves, and tsunamis. The riverine flood hazard assessment considered the Probable Maximum Flood (PMF) within the local watersheds, and within local drainage areas that will be directly impacted by the site development. A series of hydraulic models were developed, based on DGR project site grading and ditching, to assess the impact of a Probable Maximum Precipitation (PMP) occurring directly at the DGR site.

Overall, this flood assessment concluded there is no potential for lake or riverine based flooding and the DGR area is not affected by tsunamis. However, it was also concluded from the results of this analysis that the PMF in proximity to the critical DGR operational areas and infrastructure would be higher than the proposed elevation of the entrance to the underground works.

This paper provides an overview of the assessment of potential flood hazard risks associated with coastal, riverine and direct precipitation flooding that was completed for the DGR development.

15:10 – 15:40

Networking Break

Trinity 1

OPG's Deep Geologic Repository for Low- and Intermediate-level Waste – 4

Session Co-Chairs: Mark Jensen, Nuclear Waste Management Organization and Pauline Witzke, Ontario Power Generation

15:40

Explorability and Predictability of the Paleozoic Sedimentary Sequence Beneath the Bruce Nuclear Site

A. Parmenter, M. Jensen and R. Crowe, Nuclear Waste Management Organization; K. Raven, Geofirma Engineering Limited

Ontario Power Generation is proposing to develop a Deep Geologic Repository (DGR) for the long-term management of its Low and Intermediate Level Waste (L&ILW) at the Bruce nuclear site located in the Municipality of Kincardine, Ontario. A 4-year program of geoscientific studies to assess the suitability of the 840 m thick Palaeozoic age sedimentary sequence beneath the site to host the DGR was completed in 2010. The studies provide evidence of a geologic setting in which the DGR, excavated at a nominal depth of 680 m within the argillaceous limestone of the Cobourg Formation, would allow for safe implementation of the DGR concept. A key attribute of the sedimentary setting for purposes of assessing suitability for long-term radioactive waste management relates to its predictable nature. This paper examines the results of site-specific investigations that provide insight into the ability to characterize and understand the evolution of the geologic setting at time and space scales relevant to demonstrating DGR safety.

As part of the site-specific studies, a program of deep drilling/coring (6 boreholes) and in-situ testing through the sedimentary sequence was completed from 4 drill sites situated beyond the DGR footprint, approximately 1 km apart. Core logging reveals that the stratigraphic sequence is comprised of 34 distinct bedrock formations/members/units consistent with the known regional stratigraphic framework. These layered sedimentary formations dip 0.6 o (~10 m/km) to the southwest with highly uniform thicknesses both at site and regional scale, particularly, the Ordovician sediments, which vary on the order of metres. The occurrence of vertical discontinuities or displacement within the sedimentary sequence is not revealed through surface outcrop fracture mapping, micro-seismic ($M \geq 1$) monitoring, 2-D seismic reflection surveys, inclined borehole coring or intersection of type hydrothermal dolomitized reservoir systems. Formation specific continuity is also evident in other properties or attributes, among them, the lateral traceability of lithofacies and chronostratigraphic marker beds at decimetre scale, extremely low formation specific hydraulic conductivities, porosities and diffusion coefficients. Further evidence can be drawn from site-specific analogues that explore the preservation of anomalous hydraulic head and gradient conditions from past external perturbations and the distribution of environmental tracers in sediment that provide geochemical signatures to explore solute migration and basin scale fluid movements on geologic timescales.

This multi-disciplinary information is compiled and integrated to illustrate the predictability of this sedimentary environment. The approach provides an indication of the high degree of explorability in

the sedimentary environment, which is beneficial in providing confidence in the DGR safety case.

16:05

Hydrogeological Evidence of Low Rock Mass Permeabilities in Ordovician Strata: Bruce Nuclear Site

R. Beauheim, Consulting Hydrogeologist; R.M. Roberts, HydroResolutions LLC; J.D. Avis and D. Heagle, Geofirma Engineering Limited

Ontario Power Generation is proposing to develop a Deep Geologic Repository (DGR) for the long-term management of its Low and Intermediate Level Waste (L&ILW) at the Bruce nuclear site located in the Municipality of Kincardine, Ontario. A 4-year program of geoscientific studies to assess the suitability of the 840 m thick Palaeozoic age sedimentary sequence beneath the site to host the DGR was completed in 2010. The studies provide evidence of a geologic setting in which the DGR, excavated at a nominal depth of 680 m within the argillaceous limestone of the Cobourg Formation, would allow for safe implementation of the DGR concept. A key attribute of the sedimentary setting for purposes of assessing suitability for long-term radioactive waste management relates to its predictable nature. This paper examines the results of site-specific investigations that provide insight into the ability to characterize and understand the evolution of the geologic setting at time and space scales relevant to demonstrating DGR safety.

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16:30

Hydrogeochemical Characterization of Groundwaters and Porewaters Beneath the Bruce Nuclear Site: Evidence for Diffusion-Dominated Transport in the Ordovician

I. Clark, University of Ottawa; T. Al, University of New Brunswick; M. Jensen and L. Kennell, Nuclear Waste Management Organization; K. Raven, Geofirma Engineering Limited

Investigations of the controls on solute transport in porewater and groundwater below the Bruce nuclear site involved laboratory-scale diffusion measurements, as well as measurements of natural tracer ($\delta^{18}O$, $\delta^{2}H$, $^{87}Sr/^{86}Sr$, Cl and Br) distributions and isotopic compositions of CH_4, CO_2 and helium ($^{3}He/^{4}He$) in the porewaters and groundwaters. The analyses were performed on samples collected from drilled boreholes, DGR-1 through DGR-6, during site characterization activities and the results are summarized below.

With the exception of just a few samples from the Upper Silurian, the effective diffusion coefficient (D_e) values measured from DGR cores are all less than 10^{-11} m^2/s, which is approximately one order of magnitude lower than measured D_e values from international programs in sedimentary rock. The majority of the data are in the range $10^{-13} < D_e < 10^{-11}$ m^2/s, with Lower Silurian and Upper Ordovician shale samples representing the higher end of this range because of their relatively high porosity (7 to 9%). The low porosity of the Middle Ordovician limestone (< 2%) results in low D_e values, clustering in the range $10^{-13} < D_e < 10^{-12}$ m^2/s.

The $\delta^{18}O$, Cl, and Br profiles in the Middle Ordovician carbonates define trends of decreasing $\delta^{18}O$ with depth, and are interpreted to result from an extremely long period of diffusion-dominated transport (~300 Ma). Near the base of the Middle Ordovician carbonates the $\delta^{2}H$ data display a slight enrichment, which could represent upward diffusion of deuterium-enriched water originating in the underlying Precambrian shield. A Precambrian shield influence on the Ordovician porewater chemistry is inferred from the measured $^{87}Sr/^{86}Sr$ ratios in the Middle Ordovician carbonates, which are elevated above values expected for porewater in equilibrium with carbonate rock.

The CH_4 data indicate the presence of biogenic gas in the Cobourg Formation and in the overlying Ordovician shales, while gas of thermogenic origin is present in the Middle Ordovician carbonates below. The fact that gas of differing origin has not mixed by diffusion across the Cobourg limestone suggests that there is an effective barrier to vertical transport near the base of the formation. The presence of a vertical transport barrier at this depth is also supported by the persistence of large gradients in the isotopic composition of CH_4 and helium.

The Cambrian groundwater chemistry displays a distinct rebound in the natural tracer profiles relative to the overlying Ordovician carbonates. The rebound in the profiles is abrupt compared to the gradual decline in concentrations and isotopic compositions observed with depth through the Ordovician carbonates. Irrespective of the mechanism(s) responsible for the Cambrian fluid chemistry beneath the Bruce nuclear site, however, the fundamental hypothesis that solute migration with the Ordovician sediments is diffusion dominated is well supported by the data.

16:55

Hydrogeologic Simulation of a Deep Seated Groundwater System: Bruce Nuclear Site

J.F. Sykes, S.D. Normani and Y. Yin Department of Civil and Environmental Engineering, University of Waterloo; M. Jensen, Nuclear Waste Management Organization

A Deep Geologic Repository (DGR) for low and intermediate level radioactive waste has been proposed by Ontario Power Generation for the Bruce nuclear site in Ontario, Canada. The DGR is to be constructed at a depth of about 680 m below ground surface within the argillaceous Ordovician limestone of the Cobourg Formation. This paper describes the hydrogeology of the DGR site developed through both site characterization studies and regional-scale numerical modelling analysis. The analysis, using two computational models and four conceptual models, provides a framework for the assembly and integration of the site-specific geoscientific data and assesses the factors that influence the predicted long-term performance of the geosphere barrier. Flow system evolution was accomplished using both the density-dependent FRAC3DVS-OPG flow and transport model and the two-phase gas and water flow computational model TOUGH2-MP. Borehole logs covering Southern Ontario combined with site specific data from 6 deep boreholes have been used to define the structural contours and hydrogeologic properties at the regional-scale of the modelled 31 sedimentary strata that may be present above the Precambrian crystalline basement rock. The regional-scale domain encompasses an 18,500 km^2 region extending from Lake Huron to Georgian Bay. The analyses also included a site-scale numerical model, with a surface area of approximately 400 km^2, and an approximately east to west cross-sectional model of the Michigan Basin.

Pressure data from the DGR site investigation boreholes indicate that the Cambrian sandstone and the Niagaran Group in the Silurian are over-pressured relative to density corrected hydrostatic levels. The Ordovician sediments are significantly under-pressured. The processes commonly invoked to explain the overpressures are compaction, hydrocarbon migration, diagenesis, tectonic stress or more simply topographic effects. Explanations of abnormal under-pressures include osmosis, exhumation, glaciation unloading, crustal flexure and the presence of a non-wetting gas phase in pores. The overpressure in the Cambrian was described in the numerical modeling study by density differences across the Michigan Basin and surface topography differences. The most likely cause of the under-pressures in the Ordovician sediments is the presence of a discontinuous gas phase in the rock. The TOUGH2-MP analyses support this conclusion. Paleoclimate analyses that included mechanical loading could not describe the under-pressures.

The low advective velocities in the Cobourg and other Ordovician units, estimated in the numerical modelling, result in solute transport that is diffusion dominant with Peclet numbers less than 0.003 for a characteristic length of unity.

Trinity 2

Regulatory Considerations – 1

Session Chair: Don Howard, Canadian Nuclear Safety Commission

13:30

Introduction to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and Canada's Participation

J.L. Mecke, Canadian Nuclear Safety Commission

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) is the first and the only legally binding international instrument to address safety issues concerning the management of spent fuel and radioactive waste on a global scale. It entered into force on June 18, 2001. The Government of Canada strongly supported international efforts to bring into force the Joint Convention and was the second country to ratify it.

The Joint Convention is an "incentive instrument" that is based on peer review (similar in that respect to the *Convention on Nuclear Safety*) and devised to encourage countries that are Contracting Parties to report and to foster open and frank discussions on the safety of spent fuel and radioactive waste management. Being an incentive convention, it is not designed to mandate Contracting Parties to fulfill its obligation through control and sanction, but it is based on the common objectives of Contracting Parties to achieve and maintain a high level of safety in spent fuel and radioactive waste management, protect individuals, society and the environment from ionizing radiation and prevent accidents and if necessary mitigating the consequences of such accidents.

The following paper will provide an introduction to the Joint Convention and provide a summary of Canada's peer review at the most recent Review Meeting which was held on May 11-20, 2009, at the International Atomic Energy Agency (IAEA) headquarters in Vienna,Austria.

13:55

Decommissioning of Nuclear Facilities in Canada

S.M. Oue, Canadian Nuclear Safety Commission

This paper will discuss the Canadian Nuclear Safety Commission (CNSC) and the decommissioning work in Canada. It will provide the CNSC's regulatory framework, licensing process, requirements for decommissioning plans, considerations for decommissioning and examples of decommissioning projects in Canada and the some of the lessons learned.

The CNSC protects the health, safety and security of Canadians as well as the environment, and respects Canada's international commitments on the peaceful use of nuclear energy. It was established in 2000 under the *Nuclear Safety and Control Act* (NSCA), and was created to replace the former Atomic Energy Control Board (AECB), which was founded in 1946.

The CNSC operates and enforces regulations under the *NSCA*. Nuclear activities are carefully regulated to ensure their safe operation. The *NSCA* prohibits any person from preparing a site con-

struction, operating, decommissioning or abandoning a nuclear facility without first obtaining a licence granted by the CNSC. Under the *NSCA*, specific requirements for decommissioning planning are set out in the following regulations:

- Uranium Mines and Mills;
- Class I Nuclear Facilities;
- Class II Nuclear Facilities.

In accordance with CNSC Regulatory Guide G-219, Decommissioning Planning for Licensed *Activities*, and CSA N294, *Decommissioning of Nuclear Facilities*, the CNSC requires licensees to prepare and submit for approval, decommissioning plans in two stages: a preliminary decommissioning plan and a detailed decommissioning plan. The requirements of both plans are set out in G-219 and N294, and will be discussed in this paper.

The preliminary decommissioning plan (PDP) must be filed with the regulatory body as early as possible in the lifecycle of the activity or facility. The PDP documents the preferred decommissioning strategy and objectives at the end of decommissioning. The plan should be sufficiently detailed to assure that the proposed approach is technically and financially feasible. It must also be in the interests of health, safety, security and protection of the environment. The PDP defines areas to be decommissioned and the general structure and sequence of the principal decommissioning work packages envisioned. The plan should be revisited and updated throughout the lifecycle of a licensed facility, as necessary.

The detailed decommissioning plan (DDP) is filed with the regulatory body for appropriate licensing action prior to beginning decommissioning activities. The detailed plan normally defines and adds procedural and organizational details to the preliminary plan. The detailed plan serves as a guide for the decommissioning of a licensed activity or facility. Once the CNSC approves the detailed plan, it will be incorporated into the licence authorizing the decommissioning.

The nuclear industry is subject to federal jurisdiction through the *NSCA*. However, the CNSC would also expect that a nuclear facility comply with applicable provincial regulations. Consequently, the CNSC has established a joint regulatory process. This means that the CNSC, as a lead agency, invites other regulatory agencies, federal and provincial, who may have an interest in the operations of the nuclear facility to provide input to the CNSC on the facility's operations.

Over the years, the CNSC or its predecessor agency, the AECB, has provided regulatory oversight for a number of decommissioned nuclear facilities including:

- Tunney's Pasture Isotope Processing Facility;
- Bruce Heavy Water Plant;
- UniversityofTorontoSLOWPOKE-2 Reactor Facility;
- Beaverlodge Inactive Uranium Tailings Site.

Since 2003, Atomic Energy Canada Limited (AECL) has been decommissioning the Whiteshell Laboratories research and testing establishment, located near Pinawa, Manitoba. Recently, Dalhousie University, in Halifax, Nova Scotia, completed decommissioning of the university's SLOWPOKE-2 reactor facility.

Experience gained from the facilities mentioned above and from other decommissioning activities indicate that there are a number of decommissioning considerations to take into account. The principles of reuse, reduce, and recycle should always be considered, and occupational health and safety is sometimes the most important aspect of a decommissioning project.

Regardless of the facility type or size, decommissioning shall provide for the following:

- protection of health and safety of workers and public;
- protection of the environment;
- compliance with regulatory requirements;
- keeping radiation exposures as low as reasonably achievable (ALARA);
- management of all radioactive and hazardous materials generated;
- security;
- safeguards.

These provisions are consistent with the CNSC's mandate and the requirements of the *NSCA.*

14:20

Implementation of a Financial Guarantee Policy at the CNSC

R. Barker, Canadian Nuclear Safety Commission

The Canadian Nuclear Safety Commission (CNSC) was established in 2000 under the *Nuclear Safety and Control Act* (NSCA) to replace the Atomic Energy Control Board (AECB). Prior to the coming in force of the NSCA, financial guarantees associated with licensed activities were not prescribed in the *Atomic Energy Control Act* or its regulations. Under the NSCA, the Commission Tribunal "the Commission" was given authority to impose conditions in licences requiring financial guarantees from licensees. Other provisions of the NSCA provided information on the application of financial guarantees and for refunds when decommissioning obligations had been met.

Since 2000, the application of financial guarantees has been primarily focussed on licences issued pursuant to the *Class I Nuclear Facilities Regulations* and the *Uranium Mines and Mills Regulations*. This was to assure that the requirements for financial guarantees were initially directed at the high risk, complex facilities licensed by the CNSC. However, all licensees have not yet been required to provide a financial guarantee for all licensed facilities, activities or licence types. Additionally, CNSC expectations in relation to when financial guarantees, associated decommissioning plans and cost estimates need to be reviewed, updated and submitted, and what they should entail have been evolving, indicating a need for a clear CNSC policy on the subject.

Consequently, the CNSC is proceeding with the development of a financial guarantee policy and implementation plan to assure that generators of nuclear waste will have the financial resources available to decommission nuclear facilities, operations and devices and that this activity will not fall to government as a future liability. This program will require approval by the Commission, planned for 2012. This paper will further describe this policy and its possible outcomes.

14:45

New CSA Guideline for the Exemption or Clearance from Regulatory Control of Materials that Contain, or Potentially Contain, Nuclear Substances

M. Rhodes, A. Kwong and N292.5 Technical Sub-Committee, Canadian Standards Association

The Canadian Standards Association (CSA) guideline N292.5, *Guideline for the exemption or clearance from regulatory control of materials that contain, or potentially contain, nuclear substances*, was recently developed to address a need for guidance on approaches for clearance and of materials from facilities licensed by the Canadian Nuclear Safety Commission (CNSC) consistent with Canadian and international recommendations. This guideline is also applicable to determining if an activity associated with materials that contain nuclear substances is exempt from requiring a CNSC licence. The guideline summarizes the regulatory requirements associated with the exemption and clearance of materials and provides a graded approach to designing a survey based on the risk of residual contamination being present.

15:10 – 15:40

Networking Break

Trinity 2

Regulatory Considerations – 2

Session Chair: Don Howard, Canadian Nuclear Safety Commission

15:40

The New Canadian Standard in Decommissioning - N294-09: Decommissioning of Facilities Containing Nuclear Substances

M. Stephens, Canadian Standards Association

The N294-09 Standard was developed to provide direction to Canadian groups that are decommissioning facilities and sites that have been used for activities involving nuclear substances. The Standard is intended to be consistent with Canadian and international recommendations. It incorporates current best practices and existing regulatory requirements, and draws on the decommissioning experience of the Canadian nuclear industry.

The Standard was developed by the CSA Technical Committee (TC) on the Decommissioning of Nuclear Facilities, under the jurisdiction of the Nuclear Strategic Steering Committee (NSSC). The TC includes experts from across the nuclear industry, government and regulatory authorities, and other stakeholders.

The paper outlines the rationale behind and content of the N294-09 Standard. The Standard applies to the decommissioning of licensed facilities and other locations where nuclear substances are managed, possessed, or stored. The Standard describes requirements and guidelines for the detailed decommissioning process in terms of four phases: planning, preparation, execution and completion. Annexes provide guidance on practical aspects such as preparing preliminary decommissioning plans, estimating decommissioning costs, conducting surveys, preparing end state reports, and on handling particular situations such as decommissioning mine waste rock and tailings, complex sites, and small facilities.

The Standard is now beginning to be applied through the site licences and associated handbooks issued by the Canadian Nuclear Safety Commission (CNSC). It will continue to be improved as experience accumulates.

16:05

Observations from the Certification and Oversight of the Waste Isolation Pilot Plant

R.T. Peake, S. Ghose, R. Lee, J. Walsh, L. Bender, K. Economy, M. Eagle, E. Feltcorn and R. Joglekar, U.S. Environmental Protection Agency

The US Environmental Protection Agency (EPA) developed environmental standards for the US Department of Energy's (DOE) Waste Isolation Pilot Plant (WIPP) used by DOE for disposal of defense related transuranic wastes. EPA implements those standards for the deep geologic disposal system at WIPP, which has been operational for over 10 years. The general environmental standards applicable to WIPP are set forth in the EPA's 40 U.S. Code of Federal Regulations (CFR) Part 191 Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. The standards are established for a 10,000 year compliance period. Compliance with these standards is determined, in part, by performance assessments that develop numerical results that can be compared to a numerical limit. These standards are implemented by site-specific compliance criteria standards (40 CFR Part 194), with EPA oversight of DOE. With ten years of experience, there is a trend of increasing calculated radionuclide releases that has developed as result of multiple performance assessments.

16:30

Preparing to Construct a Disposal Facility; Posiva Approaching the Submission of a Construction License

P. Vuorio, M. Palmu and T. Äikäs, Posiva Oy

Posiva Oy's (Posiva) last leg of the journey to submit a construction license for a deep repository and an encapsulation plant at the Olkiluoto site in Eurajoki, Finland has started. The forty year´s journey towards operating a disposal facility in 2020 is about to reach the second important legal milestone towards the facility implementation, the submission of the construction license in 2012.

The starting words of Posiva's waste management programme were published in the "Activity plan and timetable for TVO's nuclear waste management" in 1982 by the Nuclear Waste Commission of Finnish Power Companies. The essence of the plan became a Government decision in 1983 stating that the disposal operations of spent fuel could be started in 2020 and a site suitable for the construction of a repository should be selected by the end of 2000. The Government's Decision-in-Principle (DiP) that was ratified by the Parliament in 2001 enabled Posiva to proceed to site confirmation studies. As a major part of these studies it enabled Posiva to construct the underground rock characterisation facility ONKALO on the site according to the regulatory requirements despite the fact that ONKALO URCF is not a nuclear facility.

Posiva's programme after about ten years of confirming site studies and learning underground construction according to regulatory requirements is currently aiming at submitting a construction license application for the Olkiluoto deep repository and encapsulation plant in 2012.

According to the Government's decision in 2003 a pre-licensing documentation was submitted to the responsible ministry TEM (Ministry of Employment and the Economy) and the state-of-the-art documentation related to the safety case for the disposal facility was submitted to the overseeing authority STUK (Radiation and Nuclear Safety Authority Finland).

Prior the decision in principle application in 1999, Posiva also carried out the Environmental Impact Assessment (EIA) programme as a pre-requisite of the application. The EIA programme and report were also pioneering actions at the time, since after Finland joined the European Union this programme was the first project for which the new EIA legislation adopted after the EC's EIA directive was applied in Finland. The EIA process was updated in 2008 for the nuclear plant expansion programmes of Posiva's owners TVO and Fortum Power and Heat. Also new Decision-in-Principle applications were submitted for the new nuclear power plant units.

Posiva now proceeds according to its latest research, development and demonstration (RD&D) plan "TKS-2009", taking into consideration the statement by the responsible ministry TEM and the comments received from STUK on the pre-licensing documentation with the 2012 goal in sight.

This paper discusses the licensing process of Posiva's facilities within the Finnish regulatory environment from the implementer's point of view.

16:55

Environmental Protection Uranium Recovery Issues in the United States

R.T. Peake, A. Cherepy, R. Rosnick, D. Schultheisz and L. Setlow, U.S. Environmental Protection Agency

Uranium recovery activities in the United States were at a standstill just a few years ago. Demand for processed uranium yellowcake has increased, as has its price, though the price is down since the Fukushima reactor accident. Interest in producing uranium has increased, too. Currently the most preferred, low-cost uranium extraction method in the United States is in-situ leach (ISL) recovery where the geohydrology is conducive to injection, mobilization and pumping. A number of applications for new ISL and conventional mills have recently been submitted or are expected to be submitted for licensing by the Nuclear Regulatory Commission (NRC). In the United States, the Environmental Protection Agency (EPA) has developed Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings under the authority of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). These standards are found in the Code of Federal Regulations, Title 40, Part 192 (40 CFR Part 192). The NRC develops implementing regulations for 40 CFR Part 192 and then NRC or delegated States enforce the NRC and EPA regulations. Facilities regulated under 40 CFR Part 192 include conventional uranium and thorium mills as well as in-situ leach operations, which are considered to be "milling underground" for regulatory purposes. However, there are no explicit standards for ISL operations in 40 CFR Part 192. In addition, EPA has determined that portions of the operations at uranium recovery operations, specifically the radon emissions from tailings impoundments, are covered by Section 112 of the Clean Air Act as a source of hazardous air pollutants (HAPs). EPA addresses these operations in 40 CFR Part 61, Subpart W. EPA is in the process of reviewing both 40 CFR Part 192 and 40 CFR Part 61, Subpart W for possible revision. This paper presents some of the issues related to uranium recovery that are being considered in the current regulatory review.

17:20

A Comparative Analysis of Managing Radioactive Waste in the Canadian Nuclear and Non-Nuclear Industries

S. Batters, I. Benovich and M. Gerchikov, AMEC NSS Ltd.

Management of radioactive waste in nuclear industries inCanadais tightly regulated. The regulated nuclear industries include nuclear power generation, uranium mining and milling, nuclear medicine, radiation research and education and industrial users of nuclear material (e.g. radiography, thickness gauges, etc).

In contrast, management of Naturally Occurring Radioactive Material (NORM) waste is not regulated by the Canadian Nuclear Safety Commission (CNSC), with the exception of transport above specified concentrations. Although these are radioactive materials that have always been present in various concentrations in the environment and in the tissues of every living animal, including humans, the hazards of similar quantities of NORM radionuclides are identical to those of the same or other radionuclides from regulated industries. The concentration of NORM in most natural substances is so low that the associated risk is generally regarded as negligible, however higher concentrations may arise as the result of industrial operations such as:

- oil and gas production
- mineral extraction and processing (e.g. phosphate fertilizer production)
- metal recycling
- thermal electric power generation
- water treatment facilities

Health Canada has published the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM).* This paper presents a comparative analysis of the requirements for management of radioactive waste in the regulated nuclear industries and of the guidelines for management of NORM waste.

Trinity 3

Aboriginal Traditional Knowledge – Panel Presentation

Session Chair: Pat Patton, Nuclear Waste Management Organization

13:30

What is Aboriginal Traditional Knowledge?

D. McGregor, University of Toronto

13:50
Applying Aboriginal Traditional Knowledge in Resource Management, Industrial Decommissioning, and Environmental Restoration
M. Duiven, Deputy Commissioner, Skeena Fisheries Commission; A. Garibaldi and J. Straker, Integral Ecology Group

14:30
An Aboriginal Perspective in Practical Experiences in Applying Aboriginal Traditional Knowledge in Industrial Development
J. Barnaby, JB Consultant

14:45 – 15:10
Panel Discussion

15:10 – 15:40
Networking Break

Trinity 3

CRL Waste Management – Program Overview

Session Chair: Paul Tonner, Atomic Energy of Canada Limited

15:40
Waste Management Program at Atomic Energy of Canada Limited
P.C.F. Wong, N. Chan and K. Hawrelluk, Atomic Energy of Canada Limited

The Atomic Energy of Canada Limited (AECL) Waste Management Program establishes requirements for waste management activities at AECL sites in Canada. It ensures that activities involving planning for, handling, processing, transporting, storage and long-term management of wastes are performed in a manner that protects the workers, the public, and the environment, and are in compliance with applicable regulatory and licence requirements. The program translates applicable legal requirements into program requirements appropriate for AECL, and assists AECL management in implementing those requirements.

The Waste Management Program was formally established at AECL in 2007 as one of the nuclear programs. The activities conducted in the first two years (2007 - 09) were mainly focused on program development. Currently the program is executing the waste management improvement initiatives based on the Waste Management Program Improvement Plan.

During the program implementation, close collaboration between the Waste Management Program and other departments resulted in improved waste management performance at Chalk River Laboratories (CRL). This included increased segregation of the waste at the source, reduction in waste generation, improved labeling and identification of waste packages, improved recyclables collection and initiating recycling of selected hazardous wastes.

In accordance with pollution prevention, the quantities and degree of hazard of wastes requiring long-term management shall be minimized, following the principles of Prevent, Reduce, Reuse, and Recycle. The annual volume of solid waste generated is one of the key indicators for waste management performance. AECL has been successful in reduction of operational waste and diversion of materials for recycling at CRL. From 2007 to 2010, the annual volume of solid waste, including inactive and radioactive wastes, generated from routine operations at CRL decreased by 26%, and the annual amount of recyclables sent to off-site recycling agents increased by 19% showing a significant amount of waste diverted from landfills. The overall refuse volume generated at CRL, including solid waste and recyclables, decreased by 14% from 2007 to 2010. This is a notable achievement in view of the fact that the workforce at CRL increased by about 15% during the same period.

The Waste Management Program continues to make improvements in waste management at AECL through implementation of initiatives. Program review and self-assessment are used to identify ways to continuously improve the adequacy, suitability, and effectiveness of the program. The current and future improvement initiatives are discussed in the paper.

16:05
Waste Minimization at Chalk River Laboratories
P. Kranz and P.C.F. Wong, AECL, Chalk River Laboratories

Waste minimization supports Atomic Energy of Canada Limited (AECL) Environment Policy with regard to pollution prevention and has positive impacts on the environment, human health and safety, and economy. In accordance with the principle of pollution prevention, the quantities and degree of hazard of wastes requiring storage or disposition at facilities within or external to AECL sites shall be minimized, following the principles of Prevent, Reduce, Reuse, and Recycle, to the extent practical.

Waste minimization is an important element in the Waste Management Program. The Waste Management Program has implemented various initiatives for waste minimization since 2007. The key initiatives have focused on waste reduction, segregation and recycling, and included: 1) developed waste minimization requirements and recycling procedure to establish the framework for applying the Waste Minimization Hierarchy; 2) performed waste minimization assessments for the facilities, which generate significant amounts of waste, to identify the opportunities for waste reduction and assist the waste generators to develop waste reduction targets and action plans to achieve the targets; 3) implemented the colour-coded, standardized waste and recycling containers to enhance waste segregation; 4) established partnership with external agents for recycling; 5) extended the likely clean waste and recyclables collection to selected active areas; 6) provided ongoing communications to promote waste reduction and increase awareness for recycling; and 7) continually monitored performance, with respect to waste minimization, to identify opportunities for improvement and to communicate these improvements.

After implementation of waste minimization initiatives at CRL, the solid waste volume generated from routine operations at CRL has significantly decreased, while the amount of recyclables diverted from the on-site landfill has significantly increased since 2007. The overall refuse volume generated at CRL (including solid radioactive waste, inactive waste and recyclables) decreased by 14% from 2007 to 2010. It should be noted that the workforce at CRL increased by approximately 15% during the same period. When considering the refuse volume data on a per capita basis, the

volume of overall refuse per person was reduced from 3.03 m^3/person in 2007 to 2.25 m^3/person in 2010. This represents a 26% reduction in refuse in three years. This paper describes the waste minimization initiatives and the achievements at CRL in details, and also the planned initiatives in future.

16:30

Integrated Waste Plan for Chalk River Laboratories

P. McClelland, Atomic Energy of Canada Limited

The core missions for Chalk River Laboratories (CRL) involve a complex suite of activities for decades to come. In order to support the core missions of Research, Development and Innovation; Isotope Production; and Environmental Management, there is a requirement to be able to model waste stream pathway scenarios and be able to make informed strategic decisions regarding the various options for waste processing, storage and long-term management (i.e. "enabling facilities"). A holistic waste management plan integrated with the decommissioning, environmental remediation and operations programs is required such that:

- Waste inputs and timings are identified;
- Timing of key decisions regarding enabling facilities is clearly identified; and
- A defensible decision-making framework for enabling facilities is established, thereby ensuring value for Canadians.

The quantities of wastes that require managing as part of the Nuclear Legacy Liabilities Program and other Atomic Energy of Canada Limited (AECL) activities is in the range of 200,000 to 300,000 m^3, with a yearly increase of several thousand m^3. This volume can be classified into over 30 distinct waste streams having differing life cycle waste management pathways from generation to disposition. The time phasing of the waste management activities required for these wastes spans several decades and involves a complex array of processes and facilities. Several factors typical of wastes arising from the development of nuclear technology further complicate the situation, including the level of detail and format of waste records over several decades varies considerably; and, wastes were put into storage over several decades without knowing what the final disposition path will be.

Prior to proceeding with any major new-build project, options assessment and feasibility studies are required to demonstrate a defensible justification of selected options. Recent experience with the "pre-project" process when applied to waste management is mixed. The reason for this is that the map of waste stream pathways from generation to disposition is not yet clear, and the time-phased inventories of wastes driving the business need for each facility reflect a high level of uncertainty. Recognizing there are gaps in this foundation information, pre-project options analysis has at times been difficult and ineffective.

Other complex nuclear programs have had similar challenges worldwide and AECL is benefitting from experience and lessons learned at various decommissioning sites to improve Waste Management business planning for CRL. The process developed by the United Kingdom Nuclear Decommissioning Authority (UK-NDA) for Integrated Waste Strategy is particularly relevant to the challenges faced with respect to planning for waste management infrastructure at CRL. This paper describes the application of the UK-NDA process at CRL and preliminary results obtained to date.

16:55

Streamlined Approach to Waste Management at CRL

L. Adams and B. Campbell, Atomic Energy of Canada Limited

Radioactive, non-hazardous, hazardous and mixed wastes have been and continue to be generated at Chalk River Laboratories (CRL) as a result of R&D and operations since the 1940s. Over the years, the wastes produced as a byproduct of activities delivering the core missions of the site have been of many types and today, over 30 distinct waste streams have been identified, all requiring efficient management. With the commencement of decommissioning of the legacy created as part of the development of the Canadian nuclear industry, the volumes and range of wastes to be managed have been increasing in the near term, and this trend will continue into the future. The development of a streamlined approach to waste management is a key to successful waste management at CRL.

Waste management guidelines that address all of the requirements have become complex, and so have the various waste management organizations with their many different processes and capabilities. This has led to difficulties for waste generators in understanding all of the requirements to be satisfied for the various CRL waste receivers, whose primary concerns are to be safe and in compliance with their acceptance criteria and licence conditions. As a result, waste movement on site can often be very slow, especially for non-routine waste types.

Recognizing an opportunity for improvement, the Waste Management organization at CRL has implemented a more streamlined approach with emphasis on early identification of waste type and possible disposition path. This paper presents CRL's streamlined approach to waste identification and waste management at CRL, the implementation methodology applied and the early results achieved from this process improvement.

17:20

Safe Dry Storage of Intermediate Level Waste at CRL

T. Sanderson, J. Lian and A. Chiu, AECL, Chalk River Laboratories

Ongoing operations at Chalk River Laboratories (CRL) generate High, Intermediate and Low Level radioactive wastes that will require safe storage for several decades until a disposal facility is available. These wastes are currently stored in in-ground concrete structures (tile holes) or in concrete bunkers or the Shielded Modular Above Ground Storage (SMAGS), depending on the characteristics, thermal and shielding requirements of the particular waste package. Storage capacity in the SMAGS is planned into the future but the tile holes and bunkers are nearing their full capacity and alternate storage has not yet been selected. To this end, work has been undertaken at CRL to design, license, construct, and commission the next generation Waste Management Area under a project identified as the New Dry Storage System (NDSS). The

NDSS will provide safe interim storage for CRL's High Level Waste (HLW) and Intermediate Level Waste (ILW) until permanent disposal is available.

These new above-ground facilities will provide safe interim storage for CRL's HLW and ILW until permanent disposal is available improving upon existing working conditions of Waste Management staff and reducing the doses to which they are exposed.

The NDSS is currently in the concept stage. This paper examines the requirements and the challenges faced as CRL moves forward with a new generation of radioactive waste storage. The waste considered for the NDSS design are classified into two broad groups: fissile waste which includes used fuel from the NRU reactor, used CANDU reactor fuel which has undergone Post-Irradiation Examination (PIE), fuel fabrication wastes, and fissile isotope production waste; and non-fissile ILW which include irradiated components and reactor parts, hot cell wastes, non-fissile isotope production wastes, resins, and filters. This paper focuses on the essential requirements and potential technical/safety issues to be considered in designing safe dry storage for CRL's non-fissile ILW. Spent fuel storage at CRL is addressed in a separate paper.

The fundamental requirements for a new facility to dry store the non-fissile ILW are to provide (1) containment of the wastes, (2) adequate radiation shielding, (3) effective decay heat removal, and (4) retrievability of the waste for eventual disposal in an appropriate disposal facility. This paper provides a brief overview of the existing waste management facilities used to store radioactive waste at CRL. Potential technical and safety issues associated with the storage of non-fissile wastes are identified and two design concepts currently under consideration are discussed.

Trinity 4

Geological Disposal - CRL Site Characterization

Session Chair: Alex Man, Atomic Energy of Canada Limited

13:30

An Investigation of the Suitability of the Chalk River Site to Host a Geologic Waste Management Facility for AECL's Low and Intermediate Level Wastes

P. Thompson, P. Baumgartner, D. Beaton, T. Chan, C. Kitson, E. Kozak, A. Man, J.B. Martino, K. Sharp, S. Stroes-Gascoyne and R. Thivierge, Atomic Energy of Canada Limited

Atomic Energy of Canada Limited (AECL) is investigating the suitability of the Chalk River Laboratories (CRL) site for hosting a Geologic Waste Management Facility (GWMF) as part of the Nuclear Legacy Liabilities Program (NLLP) funded through Natural Resources Canada (NRCan). The GWMF is envisioned to be an underground engineered-geological repository consisting of shafts, access tunnels and emplacement caverns located at a nominal depth of 500 to 1000 m in the bedrock at the CRL site.

A five-year-long pre-project study was started in 2006 to assess the feasibility of the bedrock at the CRL site to host a GWMF. The pre-project feasibility study began with a review of various previous geological investigations performed in the bedrock at the CRL site.

The 2006-2010 pre-project feasibility study involved exploring the geoscience and engineering characteristics of the bedrock to depths of over one kilometre at the CRL site through surface investigations and the drilling and testing of seven new deep characterization boreholes into the CRL bedrock. The collected information and interpretations were used to construct three-dimensional (3D) deterministic computer models of the geology of the bedrock at the CRL site and surrounding area and of the associated groundwater-flow regime.

In order to technically assess the suitability of the CRL site, the GWMF feasibility study has conservatively assumed that all of the legacy and forecast Low and Intermediate Level Waste (LILW) at CRL would report to it. The 3D deterministic models were used within a preliminary performance and safety assessment model to assess the long-term safety of a hypothetical GWMF at the CRL site on the basis of future radionuclide and toxic substance releases. Other items important to a preliminary performance and safety assessment include an inventory of CRL's radioactive wastes and other contaminants that could be placed in the GWMF, the creation of the engineered waste emplacement rooms and barriers within the GWMF.

This paper describes the technical work undertaken and the general findings of the preliminary performance and safety assessment study.

13:55

Microbial Characterization of Groundwater from Boreholes CR9 and CR18 at CRL (2007-2009) – Implications for a Possible Future Repository for Radioactive Non-fuel Waste

S. Stroes-Gascoyne and C.J. Hamon, AECL, Whiteshell Laboratories; M. Audette-Stuart, D. Beaton, K. King-Sharp, A. Festarini, M. Serran, D. McMullin, S. Kramer-Tremblay, S. Rose and L. Bellan, AECL, Chalk River Laboratories

A microbiological characterization study was carried out on groundwater samples taken from various depths in boreholes CR9 and CR18 at Chalk River Laboratories (CRL), over a three-year period (2007 – 2009), as part of the technical feasibility study for siting a proposed Geologic Waste Management Facility (GWMF) at the CRL site. The characterization included a variety of methods to determine total, viable and culturable cell counts, as well as identifications using molecular methods. Results indicated a total population of 10^4 to 10^5 cells/mL of which < 1% could be cultured. However, a large percentage of this population was in fact viable and appeared to survive in a viable-but-not-culturable (VBNC) state. The microbial results combined with geochemical observations suggested that the oligotrophic biogeochemical system in CR9 may have exhausted the process of nitrate reduction but, due to a lack of electron donors (dissolved organic carbon, DOC) and acceptors (e.g., Fe(III)), is not able to lower Eh values sufficiently to allow the occurrence of sulphate reduction and methanogenesis as major processes.

The results from a biofilm experiment in CR18 showed that most cells appeared to be suspended rather than attached. From a future GWMF perspective, the presence of a population of largely VBNC cells implies that, given an increased source of electron donors (DOC) and acceptors (e.g., metals) leached from the waste, microbial activity could increase significantly. This can have

both positive effects, such as a lower redox potential and lower radionuclide solubility, and negative effects, such as increased radionuclide mobility, and ^{14}C-containing gas production. It is expected that ultimately the biogeochemical system would return to its original oligotrophic conditions but the rate at which this would occur is, at present, uncertain because both waste leach rates and *in situ* microbial metabolic rates are unknown. The current results, limited to samples from CR9 and CR18, do not preclude the feasibility of a GWMF at the CRL site, but suggest that microbial effects need to be considered in the safety assessment of a GWMF.

14:20

Multi-Dimensional Modelling of Groundwater Flow and Contaminant Transport in Fractured Crystalline Rock of the Chalk River Laboratories Site

T. Chan, AECL, Whiteshell Laboratories; R. Guo, AECL, Chalk River Laboratories; F.W. Stanchell, Consultant

Two- and three-dimensional (2-D and 3-D) hydrogeological simulations were performed to assist in the assessment of the suitability of the Chalk River Laboratories (CRL) site for hosting a deep geologic repository to provide safe long-term management of CRL's low- and intermediate-level wastes. The modelled flow domain includes the bedrock of the CRL site and its immediate vicinity with a number of highly permeable major faults/fracture zones explicitly represented. The 2-D modelling indicates that i) a 10-km length scale is sufficiently large, ii) the predicted groundwater flow field is only weakly influenced by in situ depth-dependent natural temperature and salinity at the CRL site, and iii) advection and dispersion, rather than diffusion, are the predominant contaminant transport mechanisms. A 3-D conceptual hydrogeological model, which encompasses a 165-km^2 area, extends to 3 km below surface and includes eight faults/fracture zones, was developed based on a preliminary 3-D geological framework assembled from data available in 2009. Particle tracking analysis for nearly 500 particles released from a 20-km^2 area at 500-m below surface into the predicted groundwater flow field showed that particles from the northeastern two-thirds of the release area would discharge to the Ottawa River while the remaining particles discharge to Maskinonge Lake, with substantially shorter travel times for the former discharge area. Using this and other information the conceptual design team proposed potential footprints for a repository with an approximate area of 1.6 km^2 at either 500 m or 1000 m below surface. Advective transport through the Geosphere (bedrock) was investigated by tracking more than 500 particles from each hypothetical repository. Predicted travel times suggest a moderately strong natural barrier. A network of 10-20 linear segments was constructed to approximate the flowpaths from each hypothetical repository to surface discharge. The network geometries, head values, travel times and corresponding repository sector information were provided to the Postclosure Performance and Safety Assessment team. Sensitivity analyses were performed to investigate the influence of various model input parameters. The head profiles predicted by the Base Case simulations using two codes and the simulation with the best-fit rock-mass permeability available in 2010 were compared to the measured head profiles in four boreholes. Agreement was only poor to fair, indicating that the subsurface head distribution has not yet equilibrated and that uncertainties remain in the conceptual and numerical models, and the site-specific hydrogeological parameters. The simulation using rock-mass permeability fitted to data from three boreholes predicted significantly slower groundwater flow.

14:45

Geologic Characterization of the Deep Gneissic Bedrock at Chalk River Laboratories (Ontario) Using Oriented Drill Core and Integrated Borehole Surveys

R.I. Sikorsky, R.H Thivierge and J. Siddiqui, Atomic Energy of Canada Limited

As part of an overall feasibility study, multidisciplinary surface and borehole investigations are being conducted on the Chalk River Laboratories (CRL) property in order to characterize the rock mass and to assess the technical viability of siting a deep Geologic Waste Management Facility (GWMF) for permanently managing CRL's low- and intermediate-level radioactive waste at a reference depth of 500-1000 m. The current borehole program has included the drilling of seven cored boreholes to lengths of up to 1200 m and vertical depths of one kilometre. This paper presents some of the borehole techniques used to obtain the data required for bedrock characterization and the results of geologic interpretations.

Detailed logging of oriented core provides the most direct information on fracture and lithologic characteristics and is supplemented by data from borehole geophysical surveys that include:

1. electrical logs (normal and single-point resistivity, and magnetic susceptibility),
2. natural gamma logs,
3. fluid temperature and resistivity logs,
4. 3-arm caliper logs,
5. image (optical and acoustic televiewer) logs, and
6. flow-meter logs.

The electrical logs and natural gamma logs corroborate the visual generalization of rock types and fracturing into lithostructural domains and assemblages. Some fracture filling minerals are preferentially distributed in the broader rock units. Pyrite fracture filling occurs preferentially in a garnetiferous quartz-monzonitic assemblage, which has a low magnetic signature, whereas hematite filling occurs predominantly in a magnetite-rich and garnet-poor granitic assemblage. Graphite-bearing rocks are reflected by a markedly low resistivity. Diabase dykes, represented by positive magnetic anomalies at surface, have similar signatures in borehole intersections.

Fracture orientation patterns determined from borehole image logs are similar to those from core measurements, but are more tightly clustered. There is a predisposition for a brittle fracture set to develop along pre-existing low-dip ductile fabrics although other fracture sets also occur. The identification of open fracture locations, used to select intervals for hydraulic tests, is more confidently established using caliper and image logs as compared to drill core logging, although the core is required to determine the mineralogical character of these features. Heat-pulse flow-meter logging can

confirm the hydraulic significance of fractures. Borehole fluid properties are also used to locate open fractures in the boreholes. The core logs and geophysical survey logs supplement each other and provide independent verification of rock mass conditions.

15:10 – 15:40
Networking Break

Trinity 4

Geological Disposal – Thermal Aspects

Session Chair: Paul Thompson, Atomic Energy of Canada Limited

15:40
Calculation of the Thermal Response in a Deep Geological Repository Using the Horizontal Tunnel Placement Concept in Limestone at a Depth of 500 m
R. Guo, Atomic Energy of Canada Limited

The Adapted Phased Management (APM) approach proposed by the Nuclear Waste Management Organization (NWMO) and accepted by the Government of Canada for long term management of Canada's used nuclear fuel includes eventual containment and isolation of the used nuclear fuel in engineered excavations about 500 m deep in plutonic rock or sedimentary rock. The NWMO is evaluating the horizontal tunnel placement (HTP) method for used fuel containers in a deep geologic repository (DGR) in sedimentary rock. The approach is similar to the reference NAGRA conceptual design for the Swiss used-fuel/high-level waste repository in sedimentary rock. Some thermal-only or coupled thermal-mechanical simulations are performed using different programs for the near-field modeling. These simulations evaluate the stability of the rock around the placement tunnel for the HTP method in a DGR located at a depth of 500 m in limestone during the excavation stage and after placement of used nuclear fuel. In the near-field modeling, the thermal boundary conditions are based on a dimensionally infinite horizontal repository. The results from these simulations are only considered to be representative for a finite repository for the first 1,000 years after used fuel placement. In order to correct the near-field modeling results to be representative of a DGR of finite horizontal extent, two far-field models (i.e., infinite and finite horizontal extent) are run for the specific repository conditions and dimensions. The thermal results for the volume very near the container from this near-field modeling are modified to represent the results for a finite repository by subtracting the differences between the results from the far-field models for a finite repository and for an infinite repository. The modified results show that the tunnel wall has a peak temperature of 69.6°C at 68 years after placement and a second peak temperature of 71.5°C at 683 years after placement (compared to the original results for second peak temperature 72.5°C at 1,500 years). Modified temperatures for other selected points in the rock along the horizontal line through the container centre are also obtained for one million years to obtain a better estimate of temperature in the near-field of a finite repository.

16:05
Characterizing and Improving the Thermal Conductivity of Engineered Clay Barriers for Sealing a Deep Geologic Repository
A. Man, J.B. Martino, C-S Kim and D. Priyanto, AECL, Whiteshell Laboratories

Engineered clay barriers are important components of Canada's concepts for the isolation of used nuclear fuel within a deep geologic repository. Different clay-based materials have been proposed for various applications within a repository. These include highly compacted bentonite (HCB), bentonite-sand buffer (BSB), light backfill (LBF), dense backfill (DBF) and gap fill (GF). Characterization of the thermal, hydraulic, mechanical, and chemical (T-H-M-C) properties of these materials is required to evaluate the long-term performance of a repository. The thermal properties of these materials are required to model the dissipation of heat from the used-fuel containers (UFCs). Thermal conductivity is an important repository design parameter since it affects the UFC spacing required to prevent the development of excessive temperatures within the repository. High thermal conductivities are desired since this condition accommodates the rapid transfer of heat from the UFCs to the surrounding rock mass, and in turn allows for a smaller repository footprint.

This paper presents some recent characterization work on the thermal conductivity of the proposed engineered clay barriers. HCB (at low moisture content) and GF pellets were identified as possible insulating layers, having lower thermal conductivity than the desired range of 0.7 W/(m·K) to 0.9 W/(m·K). Preliminary work is presented on increasing thermal conductivity using admixtures such as silica sand, copper powder and titanium dioxide. At low degrees of saturation, silica sand and copper powder increased the thermal conductivity of HCB to the desired range.

16:30
Coupled Thermal-Hydraulic-Mechanical Modelling of the Canister Retrieval Test
R. Guo, AECL, Chalk River Laboratories; D.A. Dixon, AECL Whiteshell Laboratories

One of the in-situ tests chosen for examination as part of a series of numerical simulations undertaken for the Engineered Barriers Systems Task Force (EBS-TF) is the Canister Retrieval Test (CRT) carried out in the Äspö Hard Rock Laboratory. The CRT basically aims at demonstrating the practicality of recovering emplaced containers after the bentonite is fully saturated and has developed its maximum swelling pressure. The CRT also studies the thermal, hydraulic and mechanical evolution in the buffer from start until full water saturation. In the CRT, an electrically heated full-scale container is lowered into a deposition hole lined with cylindrical blocks and ring-shaped blocks of bentonite in the fall of 2000 and retrieved after five years of operation in early 2006. A large number of instruments measure pressure, temperature and other parameters during this time. Coupled thermal-hydraulic (TH) and coupled thermal-hydraulic-mechanical (THM) simulations for the CRT are conducted using the CODE_BRIGHT program in order to evaluate the effectiveness of its modelling code in matching the observed evolution of the coupled processes in unsaturated bentonite material. The measured temperatures in the bentonite materials

and in the rock are well simulated except for the measurements located in bentonite bricks because of the inadequate thermal characterization of the bentonite bricks. The simulated liquid saturation profiles at the end of the test matched the measurements very well at different layers. The simulated vertical stresses in the bentonite materials capture the trends and the value of measurements reasonably well.

16:55

Enhanced Sealing Project: Monitoring the Thermo-Hydro-Mechanical Response of a Full-Scale Shaft Seal

D.A. Dixon, J.B. Martino, B. Holowick, D. Priyanto, Atomic Energy of Canada Limited

Closure of the subsurface facilities at Atomic Energy of Canada Limited's (AECL) Underground Research Laboratory (URL) was completed in 2010 with installation of a concrete surface cap. Additionally, as part of decommissioning, seals were installed at the penetration of the shafts through the major hydro-geological feature known as Fracture Zone 2 (FZ2). The seal construction was funded by Natural Resources Canada (NRCan) under the Nuclear Legacies Liabilities Program (NLLP).

The shaft seals at the URL were based on the composite seal concept developed for application in a deep geologic repository for disposal of used nuclear fuel. The access shaft seal consists of two 3-m thick concrete segments that rigidly confine a 6-m long section of swelling clay-based material (40% bentonite clay – 60% sand by dry mass). Monitoring of the regional groundwater recovery following flooding of the lower shaft is a closure requirement and was included in the design. It was widely recognized that the installation of the seals at the URL represented a unique opportunity to monitor the evolution of the type of seal that might be installed in an actual repository but the NLLP mandate did not include any monitoring of shaft seal evolution. As a result the Enhanced Sealing Project (ESP) partnership composed of NWMO, Posiva, SKB and ANDRA was established and a set of 68 instruments (containing 100 sensors) were installed to monitor the evolution of the seal.

In the first year of operation sensors have monitored the following parameters in the ESP: thermal evolution and strain of the concrete components, thermal, hydraulic and mechanical changes in the clay component and its contacts with the rock and concrete confinement. Additionally, monitoring of the near-field and regional groundwater evolution have been undertaken. Monitoring of the short-term thermal-mechanical evolution of the concrete components was successfully accomplished and only a small temperature rise occurred due to the use of low-heat, low-pH, high-performance concrete. The temperature, moisture and pressure sensors installed in and around the clay component indicate that the groundwater pressure is quickly recovering in the vicinity of the shaft, the clay portion is providing a hydraulic disconnect between the regions above and below FZ2 and water uptake by the clay is progressing much as anticipated. The instrumentation and monitoring results up to the end of April 2011 are described in this paper.

Trinity 5

Geological Disposal – Modelling and Engineered Barriers – 1

Session Chair: To be announced

13:30

Used Fuel Container Designs and Lifetime Prediction

G. Kwong and J. Villagran, Nuclear Waste Management Organization

The Canadian method for long-term management of used nuclear fuel is Adaptive Phased Management, which consists of placing the fuel in a deep geologic repository designed to contain and isolate the fuel for an extended period of time. This method involves encapsulating used-fuel bundles in durable containers and sealing the containers in the repository which would be built at a depth of about 500 m below ground. Several used-fuel container designs are being considered. Copper and carbon steel are candidate corrosion barrier materials for the used fuel containers. Over the past 20 years, many studies have been carried out to improve our understanding of the long-term behaviour of both materials in a deep geological repository in either a crystalline rock or a sedimentary rock environment. This paper presents an overview of recent work in used fuel container design and development in the Canadian program, including anticipated container performance and lifetime estimates based on our current knowledge of the relevant corrosion processes.

13:55

Construction of Full-Scale Shaft Seals in Crystalline Rock

J.B. Martino, D.A. Dixon, D. Onagi, C-S Kim and B. Holowick, AECL, Whiteshell Laboratories

The Underground Research Laboratory (URL) was constructed to investigate concepts related to geological disposal of used nuclear fuel. This involved investigating the rock mass by undertaking in situ experiments using a multi disciplinary technical approach. The decision was made in 2003 to close the URL. Part of the closure process involved installing seals in the access and ventilation shafts at locations where they intersected an ancient thrust fault (Fracture Zone 2 – FZ2). FZ2 is an active hydraulic pathway in the Lac du Bonnet, Manitoba batholith and this feature is the dominating structural and hydrogeological feature at the URL site. Above FZ2 the groundwater has a low salinity and is dominated by surface-related processes. With increasing depth in the batholith, surface-related effects decrease and the salinity of the groundwater increases to 90 g/L total dissolved solids. The decision to install the seals was made as part of the due diligence for the site closure to ensure that the saline groundwater located at depth down strike and below the thrust fault would not enter the closed underground openings and mix with less saline shallow groundwater. The construction of each seal involved the installation of a heavily reinforced low alkalinity concrete component keyed into the surrounding rock. The concrete supported and restrained a central clay-sand component, which was capped by an unreinforced concrete component. The clay-sand component spans the exposure of the thrust fault in each shaft.

This paper describes the construction of the main shaft seal and the ventilation shaft seal. The construction of the shaft seals at the URL was part of the Nuclear Legacy Liabilities Program (NLLP) being funded by Natural Resources Canada (NRCan).

14:20

Large-Scale Backfilling Simulations at Äspö Laboratory Sweden and Applicability of Results to Repository Concepts Considered for Canada

D.A. Dixon, Atomic Energy of Canada Limited; K. Birch, Nuclear Waste Management Organization; E. Jonsson, Svensk Kärnbränslehantering AB; J. Hansen, Posiva Oy; P. Keto, B+Tech Oy

As part of the Nuclear Waste Management Organization's (NWMO's) Adaptive Phased Management (APM) approach to development of deep geologic repository concepts for the permanent disposal of used nuclear fuel, effort is being put into reviewing, assessing and where possible participating in international activities associated with repository sealing in a variety of geological host media. Of considerable interest are developments related to backfilling and closure of the repository openings following placement of the used fuel containers (UFCs).

In a host medium such as granite, the potential exists for localized inflow of water or combining of small localized inflows into larger features if flow is not managed. Under conditions of high inflow these could form channelled flow features (piping features) through backfilled rooms or tunnels. This could cause erosion of the backfill and complicate ongoing construction and installation activities within the affected room. While UFCs would not be installed in locations where unsuitable hydraulic conditions exist (i.e. high inflow rates), tunnels may pass through such hydraulic features and hence the backfill installed in those locations must be able to deal with the accumulated inflow from these and other smaller features. Posiva and SKB have been examining how water enters and passes through backfill materials at laboratory- to nearly full-scales ($1/12^{th}$ to ½–scale placement room cross-section) in order to define when water inflow begins to become disruptive to the backfill. Additionally, studies to determine the effects of varying the composition of the backfill blocks and pellets on system performance have also been examined as part of the process of design optimization.

Work by SKB and Posiva has demonstrated that backfilling of placement rooms in crystalline rock environments can be achieved using a combination of precompacted clay blocks and clay pellets using modified conventional equipment. There are hydrogeological conditions that could be potentially disruptive to newly placed backfill, in particular the inflow of water to the room and its subsequent movement through the unsaturated backfill. Tests have evaluated a number of backfill materials options, the effects of intersecting fracture features, rate of water influx and how isolated pockets of unsaturated backfill may respond to subsequent water influx.

14:45

Hydro-mechanical Modelling of a Shaft Seal in Crystalline and Sedimentary Media Using Comsol

D.G. Priyanto, Atomic Energy of Canada Limited

Shaft seals are components of the engineered barriers system considered for closure of a Deep Geologic Repository (DGR). These seals would be installed in strategic locations of the shafts, where significant fracture zones (FZ) are located and would serve to limit upward flow of groundwater from the repository level towards the surface.

This paper presents the results of hydro-mechanical (HM) numerical modelling exercises to evaluate the performance of a shaft seal using a finite element computer code, COMSOL. This study considered a variety of host geological media as part of generic assessments of system evolution in a variety of environments including five hypothetical sedimentary and crystalline host rock conditions. Four simulations of a shaft seal in different sedimentary rocks were completed, including: (1) shale with isotropic permeability; (2) shale with anisotropic permeability; (3) limestone with isotropic permeability; and (4) limestone with anisotropic permeability. The other simulation was a shaft seal in crystalline rock with isotropic permeability. Two different stages were considered in these HM simulations. Stages 1 and 2 simulated the groundwater flow into an open shaft and after installation of shaft sealing components, respectively.

Based on the conditions and assumptions defined for the host media and fracture features examined in this study, the following conclusions can be drawn from the results of the numerical modelling exercises. The installation of the shaft seal could limit groundwater flow through the shaft. A shaft that remained open for a longer time was beneficial with respect to delaying of seal saturation because it could reduce the groundwater flow rate around the fracture zone. The core of the shaft seal (i.e., the bentonite-sand mixture (BSM)) became fully saturated after 90-100 years if the shaft remained open for 100 years before a seal was installed. Only a slight difference between five cases was observed from the results of the numerical modelling exercises for different cases. This may, in part, be the result of limitations in the knowledge regarding the HM characteristics of the geological media evaluated. Defining of more site specific conditions (e.g., depth and geometry of fracture, hydraulic properties of rock and fracture feature, and mechanical characteristics of rock) was recommended in order to more effectively simulate HM behaviour of a shaft seal at the location of a fracture zone.

15:10 – 15:40

Networking Break

Trinity 5

Geological Disposal – Modelling and Engineered Barriers – 2

Session Chair: To be announced

15:40

The Role of Highly Compacted Bentonite in Localized Suppression of Microbial Activity in a Nuclear Fuel Waste Repository

S. Stroes-Gascoyne and C.J. Hamon, AECL, Whiteshell Laboratories

Highly compacted bentonite (HCB), through its inherent physical properties, is able to suppress microbial activity if dry density remains sufficiently high (i.e., preferably ≥ 1600 kg/m^3). At certain locations in a repository the HCB dry density may not be sufficiently high, which could result in increased microbial activity in these locations. An additional concern is the potential migration of microbes through dessication-induced fractures in the HCB that have not healed rapidly or sufficiently enough upon re-saturation. If microbes are able to rapidly travel through such fractures, there is a risk that they could populate the area immediately around the containers and (temporarily at least) increase the potential for microbiologically influenced corrosion of the containers. Therefore, a series of experiments were carried out to address this possibility through the examination of the movement of fluorescent polystyrene microspheres of microbial sizes (0.2 to 0.6 µm) along interfaces and through fractures in HCB plugs. Results confirmed that these microspheres were able to travel along the interfaces between the HCB clay plugs and pressure cells, but not through the intact clay matrix. In those plugs containing an induced fracture at the start of the experiment, some microspheres were found inside the healed fractures in about 50% of the experiments, suggesting that microbial intrusion into healed or healing fractures is possible, but not massive. Further work would be required with actual microorganisms to confirm these results.

16:05

Modelling of Reactive Transport in a Sedimentary Basin Affected by a Glaciation/Deglaciation Event

S.A. Bea and K.U. Mayer, University of British Columbia, Department of Earth and Ocean Sciences; K.T.B. MacQuarrie, University of New Brunswick, Department of Civil Engineering

Canada's plan for the long-term care of used nuclear fuel is containment and isolation in a Deep Geologic Repository (DGR) constructed in a suitable sedimentary or crystalline rock formation. Sedimentary basins are complex systems affected by interacting processes including density-dependent groundwater flow and solute transport, heat transfer, mechanical loading, mixing of waters from different formations and rock-water interactions. Understanding the interactions among these processes is important when assessing the long-term hydrodynamic and geochemical stability of sedimentary basins during glaciation/deglaciation events. To this effect, an enhanced version of the reactive transport code MIN3P (i.e. MIN3P-NWMO) was developed and tested. The revised model includes key capabilities required to simulate complex coupled processes that are expected to occur in sedimentary basins during periods of glaciation and deglaciation. The capabilities of the new model were evaluated by simulating reactive transport in a hypothetical sedimentary basin affected by a glaciation scenario similar to the last Laurentide glaciation event. The simulations are used to provide an illustrative assessment of the hydrogeological and geochemical stability of this sedimentary basin over a time period of 32,500 years.

Simcoe

Port Hope Area Initiative – 2

Session Chair: Christine Fahey, Port Hope Area Initiative (PHAI) Management Office

13:30

Material Management and Site Condition Challenges During LLRW Removal and Transport at the Port Granby Project

J. Fairclough, N. Rudolfo, D. Wilson, M.A. Sungaila, AECOM; G. Case, Atomic Energy of Canada Limited; T. Palmeter, Public Works and Government Services Canada

The Port Granby Project is part of the larger Port Hope Area Initiative (PHAI), a community-based program for the development and implementation of a safe, local, long-term management solution for historic Low-Level Radioactive Waste (LLRW) in the Municipalities of Port Hope and Clarington, Ontario, Canada. The Port Granby Project includes the construction of a Long-Term Waste Management Facility (LTWMF) adjacent to the subject property within the Municipality of Clarington; the transfer of approximately 400,000 m^3 of impacted material to the new facility from the existing Port Granby Waste Management Facility (PGWMF); implementation of long-term management strategies, restoration of the source site and accompanied monitoring and maintenance of the facility for a period of several hundred years.

The total volume of material can be further described as approximately 182,000m^3 of LLRW historically deposited in unlined trenches and within two naturally occurring Gorges that flank the east and west sides of the Central Plateau and approximately 197,000m^3 of associated Marginally Contaminated Soil (MCS) which includes miscellaneous impacted material and debris that will be generated during material staging and handling operations . Impacted material as well as interstitial soil and debris will be excavated and transported to the proposed LTWMF for long-term waste management purposes. Impacted Materials comprise mainly of neutralized raffinate and calcium fluoride having consistencies described as "peanut butter" and "toothpaste" respectively. These waste characteristics offer significant challenges related to material handling and manipulation, slope stability, health and safety, and environmental protection during staging, excavation, dewatering, transport, deposition, and ultimately management of the material for the long term at the LTWMF. In addition sizing and segregation of oversized industrial waste and refuse intermixed with the waste prior to placement within the Containment Mound to be constructed at the LTWMF also presents a significant logistical challenge. Available geotechnical and testing information such as Atterberg limits, shear strength, and water content have informed the design and have been used to validate that assumed production rates and implementation schedules are both practical and achievable. Existing data gaps have been identi-

fied and are to be addressed through the completion of supplemental subsurface investigative work particularly in the vicinity of the East Gorge Area where steep slopes and particularly soft waste materials exist. Due to the complexity of the Project, Contract Documents will provide sufficient information to bidders such that they allow for potential handling issues that may arise while at the same time, avoiding direction of means and methods to enable innovation within the contracting community for undertaking the remedial works.

With design completed in March 2011 and tendering scheduled for early 2012, this paper provides a brief synopsis of the finalized design, plans for additional geotechnical investigations and testing, and the design approach to be employed in mitigating potential risks related to the handling and management of these unique materials.

13:55

Procurement Vehicles for Strategically Sequencing Multi-Year and Schedule Driven LLRW Design and Construction Projects

B. Noble, and M.A. Sungaila, AECOM: T. Palmeter, Public Works and Government Services Canada

The Port Granby Project is part of the larger Port Hope Area Initiative (PHAI), a community-based program for the development and implementation of a safe, local, long-term management solution for historic Low-Level Radioactive Waste (LLRW) in the Municipalities of Port Hope and Clarington, Ontario, Canada. The Port Granby Project includes the construction of a Long-Term Waste Management Facility (LTWMF) in the Municipality of Clarington; the transfer of over 400,000m^3 of contaminated material to the new facility from the existing Port Granby Waste Management Facility (PGWMF); restoration of the PGWMF; and monitoring and maintenance of the facility for a period of several hundred years.

In addition to the LTWMF and PGWMF described above, there are several other design components required to enable the remedial waste transfer and containment including, construction of a new Waste Water Treatment Plant (construction and post-construction operation), temporary buildings, road upgrades, decontamination facilities, new and upgraded utilities, and storm water management infrastructure.

To ensure the enabling works (WWTP, road upgrades, decontamination facilities, etc.) are constructed and operational prior to the waste transfer, the implementation schedule has been prepared for strategic sequencing and procurement of these critical path tasks. To ensure the overall efficient implementation of the remedial works, special attention has been paid to mitigating risk of contractor overlap, tender packaging, pre-purchase of long lead time items, and the overall constructability of the project.

Owner supplied services, such as operation of the WWTP during the construction phase, necessitate forethought into how contracting entities will interface (or not) within their contract to complete the work with no impedance or direction of means and methods by the owner.

Other aspects such as quality testing and control, road and utility maintenance, environmental monitoring, and radiation verification protocols have been reviewed and prepared to ensure the stated objectives of the PHAI are met or exceeded, while at the same time enabling an adequate procurement vehicle for these services.

With design completed in March 2011 and tendering scheduled for November 2011, this paper will provide an update and review of decision points, factors considered, and a monitoring framework for adherence to schedule for this 7+ year remediation project.

14:20

Incorporation of Sustainable Principles into an LLRW Environmental Clean-Up – Goals and Results

D. Wilson, B. Noble, C. Cunningham, AECOM; T. Palmeter, Public Works and Government Services Canada

The Port Granby Project is part of the larger Port Hope Area Initiative (PHAI), a community-based program for the development and implementation of a safe, local, long-term management solution for historic Low-Level Radioactive Waste (LLRW) in the Municipalities of Port Hope and Clarington, Ontario, Canada. Atomic Energy of Canada (AECL) is the Project Proponent, Public Works and Government Services (PWGSC) is Managing the Procurement of services and AECOM is providing detailed design and construction oversight and administration services for the Project. The Port Granby Project includes the construction of a Long-Term Waste Management Facility (LTWMF) in the Municipality of Clarington; the transfer of approximately 400,000m^3 of LLRW contaminated material to the new facility from the existing Port Granby Waste Management Facility (PGWMF); restoration of the PGWMF; and monitoring and maintenance of the facility for a period of several hundred years.

The total volume of material can be further described as approximately 205,000m^3 of LLRW, approximately 100,000m^3 of Marginally Contaminated Soil (MCS), and approximately 70,000m^3 of potentially impacted topsoil /fill overlying the LLRW. The remaining material is comprised of a variety of material and debris. All this material as well as interstitial soil and debris will be excavated and transported to the proposed LTWMF for long-term waste management purposes. In addition to the LTWMF and PGWMF there are several other design components required to enable the remedial waste transfer and containment including, construction of a new Waste Water Treatment Plant (construction and post-construction operation), temporary buildings, road upgrades, decontamination facilities, new and upgraded utilities, and storm water management infrastructure.

The Canadian Federal Government has begun initiatives to ensure that sustainable development principles are built into the policy of all federal organizations. PWGSC has developed a Sustainable Development Strategy (SDS) that sets out principles, goals and actions for integrating sustainable development principles into policies and operations, inclusive of federally funded projects such as the Port Granby Remediation Project.

With the detailed design for the Port Granby LLRW Clean-up at completion and construction about to begin this paper reviews the design of the remediation project from the perspective of incorporation of Green and Sustainable Remediation goals and objectives and fulfillment of Federal Sustainable Development Principles. Specifically the paper reviews the Port Granby Remedial Design featuring Green and Sustainable Remediation aspects including: work sequencing to

minimize handling of materials; optimization and minimization of material use and reuse; water conservation aspects; and future land use planning encompassing recreational use and blending of storage facility design/profile into natural environmental settings.

14:45

Complex Containment Design for Long-Term Encapsulation of Radioactive Waste

M.A. Sungaila, and E.K.W. San, AECOM; T. Palmeter, Public Works and Government Services Canada

The Port Granby Project is part of the larger Port Hope Area Initiative (PHAI), a community-based program for the development and implementation of a safe, local, long-term management solution for historic low-level radioactive waste in the Municipalities of Port Hope and Clarington. The Port Granby Project includes the construction of a long-term low-level radioactive waste management facility, the transfer of the contaminated material to the new facility from existing storage, construction and operation of a new waste water treatment facility, and monitoring and maintenance of the facility for a period of several hundred years. A key component of the new long-term facility is a highly-engineered containment mound incorporating a composite base liner, a leachate collection system, and a multi-layer final cover system. Issues of interest include the details of the design, the evolution of the design, as well as the field quality assurance measures that will be specified to ensure that the design is correctly implemented.

15:10 – 15:40

Networking Break

Simcoe

Port Hope Area Initiative – 3

Session Chair: Glenn Case, Port Hope Area Initiative (PHAI) Management Office

15:40

Balancing Risk in Regulatory Decision Making: The Port Granby Project Case Study

L. Benitez, Natural Resources Canada; H. Kleb, Canadian Nuclear Association

The purpose of this paper is to review the considerations involved in regulatory decision making. Under normal circumstances, regulatory decisions under the *Canadian Environmental Assessment Act and the Nuclear Safety and Control Act* consider potential risks to the environment, human health and safety if a project were to proceed. There is only limited consideration, under such circumstances, of the risks to the environment, human health and safety if the project were not to proceed. The primary focus is on the potential adverse effects of the project, rather than on the beneficial effects. However, in the event of an emergency, the focus can quickly shift to the economic and other potential benefits of proceeding.

The Canadian Nuclear Safety Commission (CNSC) is the federal body that regulates the use of nuclear facilities and nuclear-related activities to protect the health, safety and security of Canadians and the environment. The CNSC typically employs a staged process for the licensing of nuclear facilities and activities, commencing with an assessment of environmental effects and culminating in the issuance of a licence. The environmental assessment (EA) process is undertaken in accordance with the *Canadian Environmental Assessment Act* and the licensing process is subject to the requirements of the *Nuclear Safety and Control Act* and supporting regulations.

The Port Granby long-term low-level radioactive waste management project (the Port Granby Project), a project for the safe, local, long-term management of historic low-level radioactive waste in the Port Granby, Ontario area, is subject to the EA and licensing processes described above. Approximately 0.4m^3 of the historic low-level radioactive waste that is presently located at the Port Granby Waste Management Facility is to be transported to a newly constructed long-term waste management facility. The new facility is to be located approximately 700 m north of the bluff face where the waste is located in a series of trenches and gorges.

While the Port Granby Project does not represent an emergency situation, it does represent a project that could result in a significant degree of environmental risk if it were not to proceed. Over the course of the various studies that have been undertaken at the Port Granby Waste Management Facility, it has become apparent that the facility is subject to ongoing erosion and gullying along the bluff face where the waste is situated. The potential for the leaching of contaminants from the existing waste management facility and the erosion of the Lake Ontario bluffs are recognized as ongoing risks that will continue and potentially worsen if the project were not to proceed.

The economic and other considerations that could influence regulatory decision making are particularly apparent when a project, such as the Port Granby Project, is examined from an emergency perspective. It is in the event of an emergency that the beneficial effects of proceeding, such as the prevention of unplanned, uncontrolled or accidental releases of contaminants and any resulting damage to property, come to the forefront of regulatory decision making. It is in such cases that the need to balance adverse effects against beneficial effects becomes particularly apparent.

Achieving the necessary balance between costs and benefits is not straight forward, however. In recent years there has been a growing trend towards increasingly quantitative approaches to regulatory decision making, including cost-benefit analysis. Cost-benefit analysis is recognized as having a number of advantages, such as providing a balanced perspective and a documented and transparent approach to decision making. The disadvantages of cost-benefit analysis have also been acknowledged, including a lack of flexibility, difficulty with multi-criteria decision making and the absence of ethical considerations.

When recent approaches to cost-benefit analysis were applied to the Port Granby Project, the advantages were clear. Cost-benefit analysis provides for a more complete picture of the gains and losses associated with the Project.

16:05

The Remediation and Rejuvenation of Cameco's Port Hope Conversion Facility

A. D'Agostino, Cameco Corporation

Cameco's Vision 2010/Vision in Motion project is a comprehensive redevelopment plan for the Port Hope conversion facility (PHCF),Canada's oldest continually operating nuclear facility. It entails the cleanup and redevelopment of the site, which is currently home to a number of old or under-utilized buildings, contaminated soils and stored historic wastes. Following removal of the targeted structures, the contaminated soils and stored wastes, new replacement buildings will be constructed. The project is being carried out in conjunction with the Port Hope Area Initiative (PHAI), a federal government undertaking for the cleanup and long-term management of low-level radioactive and industrial waste in Port Hope.

The demolition program will form a significant portion of the Vision 2010 project activities. There are a number of buildings on the site that are to be removed, ranging in size from small pump-houses to large former production plants. The buildings slated for demolition will first have any remaining equipment and materials removed and then be cleaned to remove surface contaminants. Once the buildings have been cleaned, they will be dismantled.

The excavation of fill and native soil underlying Cameco's PHCF is another important element of Vision 2010. The soil has been contaminated by historical operations, largely related to predecessor uranium processing and radium production activities. Soil which exceeds the remedial objectives will be loaded onto trucks and transported to PHAI's long-term waste management facility (LTWMF) for management.

Throughout these activities, hazardous materials will be encountered, primarily during the demolition of buildings and the cleaning of materials to meet release criteria. Some hazardous materials may also be encountered during the preparation or repackaging of drummed waste prior to disposal at the LTWMF and during soil excavation.

16:30

A Radiological Dose Assessment for the Port Hope Conversion Facility

N.C. Garisto, F. Cooper, A. Janes and R. Stager, SENES Consultants Limited; R. Peters, Cameco Corporation

The Port Hope Conversion Facility (PHCF) receives uranium trioxide for conversion to uranium hexafluoride (UF_6) or uranium dioxide (UO_2). The PHCF Site has a long history of industrial use.

A Radiological Dose Assessment was undertaken as part of a Site Wide Risk Assessment. This assessment took into account all possible human receptors, both workers and members of the public. This paper focuses on a radiological assessment of dose to members of the public.

The doses to members of the public from terrestrial pathways were added to the doses from aquatic pathways to obtain overall dose to receptors.

The benchmark used in the assessment is 1 mSv/y. The estimated doses related to PHCF operations are much lower than the dose limit.

16:55

Surveying and Remediation of Contaminated Small-Scale Residential Sites in Port Hope

D. Elion, SNC-Lavalin Nuclear; A. Husain and Y. Verzilov, Kinectrics Inc.

There are approximately 4500 small-scale properties in Port Hope, Ontario, Canada, a town in which there were historic radium refining operations. It is expected that 200-400 of these properties are contaminated at levels above the Port Hope Area Initiative Clean-up Criteria (PHAI CC) and will need to be remediated.

In 2010, an initiative was implemented to (1) resurvey a representative number of the 4500 properties and (2) remediate up to six of the properties where the presence of historic Low Level Radioactive Waste (LLRW) contamination was confirmed. Information from the resurvey and remediation field work was intended to be used as the basis for developing procedures feasible for the overall resurvey and remediation work to be done as part of Phase 2 of the Port Hope Project.

Thirty-five small-scale properties, selected based on historical data, were resurveyed for the presence of interior radon gas and for exterior as well as interior gamma radiation levels. Objects and surfaces were surveyed for the presence of fixed and loose contamination at various locations including those with elevated gamma radiation levels. Boreholes and hand-augered holes were drilled to obtain soil samples for analysis of PHAI CC parameters; in addition, radiation profiles were recorded as a function of depth in the drilled boreholes. Based on the results obtained, the presence of LLRW was confirmed on several properties and deemed likely on several others. One of the more extensively contaminated properties was chosen for remediation.

This paper presents an overview of the techniques employed and results obtained during the SRCA field work as well as an account of the remediation work carried out. Overall conclusions are presented and recommendations drawn for the next phase of the work.

Grand Ballroom

International Plenary Session

Session Co-Chairs: Joan Miller, Atomic Energy of Canada Limited and Kathryn Shaver, Nuclear Waste Management Organization

08:30
Introductory Remarks

08:40
The License Application for the KBS-3 System in Sweden and the Next Steps Towards Implementation of Final Disposal
Hans Riotte, Head, Radiation Protection and Radioactive Waste Management Division, OECD-NEA

In its 1998 *Nuclear Energy Outlook* the NEA reviewed the status of radioactive waste management world-wide and noted that the technology for disposal of short-lived low- and intermediate-level radioactive waste is well developed. The review concluded that all OECD countries with major nuclear programmes either operate corresponding waste disposal facilities or are in an advanced stage of developing them. By contrast, the developmental progress of HLW/SNF management programmes varies widely between countries; not to mention that there is currently no repository operating that could take spent nuclear fuel or high-level waste from reprocessing. In its collective opinion "Moving forward with geological disposal" the NEA noted that deep underground disposal in geological formations is seen worldwide as the only sustainable endpoint for the management of these types of waste, as it affords unparalleled protection without reliance on active safety monitoring and controls.

While waste management programmes in some countries are well matured and countries like Finland, France and Sweden aim to operate geologic repositories in the next decade, others need to develop their national strategies, plans and corresponding actions for managing radioactive waste further. Periodically reviewed national waste management plans, as legally required for EU member countries by a recent Directive, can provide a co-operation framework for all national institutional players and a means to measure progress.

In implementing sustainable solutions for the long-term management of HLW/SNF, specific challenges lay in establishing an efficient policy and regulatory framework that (a) defines a desired level of safety over the various time scales to be considered and (b) allows for sustainable decision making procedures by involving public and stakeholder in a flexible, step-wise implementation process. Technical confidence in the safety of a repository needs to be demonstrated in a modern safety case which goes beyond demonstrating compliance with numerical safety indicators and highlights the range of underlying evidence and methods that give confidence. Regarding long-term safety regulation, the variety of approaches in national criteria and practices that reflects the different national regulatory, legal and cultural environments needs to be made transparent.

Today, there is a clear understanding that the implementation of radioactive waste repositories is as much a socio-political challenge as a technical one. Public acceptance of the site needs to be secured and maintained over the lifetime of the repository and beyond. A durable relationship between a waste management facility and its host community is paramount to resolve conflicts and to deal with diverging interests that may come up during the long implementation and operational period of a geologic repository. Reversibility of decisions and retrievability of waste, under specified conditions, are typically two important requests from the local public that need to be taken into account when designing a disposal programme.

09:10
The License Application for the KBS-3 System as a Step Towards Implementation of Final Disposal in Sweden
Anders Ström, Director, Nuclear Fuel Programme, SKB, Sweden

The nuclear power utilities in Sweden were in 1976 given the responsibility for final disposal of radioactive waste from their power production. The utilities formed the Swedish Nuclear Fuel and Waste Management Co (SKB). A large part of the system that is needed to manage and dispose of the waste from operation of the reactors has been built up during this time. The system consists of the interim storage facility for spent nuclear fuel (Clab), the final repository for short-lived radioactive waste (SFR), plus the ship m/s Sigyn and casks for transport. What remains to be done is to build and commission the system of facilities, the KBS-3 system, needed for final disposal. This includes extending Clab with a plant for encapsulation of the spent nuclear fuel, casks for transport of spent fuel canisters, and building a final repository where the canisters will be deposited. For the low- and intermediate-level waste it will be necessary to add an extension to SFR, build a repository for long-lived radioactive waste (SFL) and casks for shipments of long-lived waste.

The site selection process for the final repository for spent nuclear fuel was initiated in 1992. In June 2009 SKB announced Forsmark as the selected site after general siting studies on the national and municipal level and finally comprehensive investigations of two sites. SKB has now submitted license applications according to the Act on Nuclear Activities and the Environmental Code for a geological repository at Forsmark and an encapsulation plant in Oskarshamn. The review by the regulatory bodies has just begun and a Government decision can be expected after roughly three years. After the necessary licenses have been obtained construction of the shafts and a ramp to repository depth (close to 500 m) can commence. The layout of the current plans is to begin construction of the Nuclear Fuel Repository and the encapsulation plant in 2015 and 2016, respectively, and some eight years later to commence trial operation. The first copper canister with spent fuel is expected to be deposited around 2025.

SKB is now ready to change the emphasis of work towards more of industrial accomplishment of a final repository for spent nuclear fuel in Forsmark. Within a few years SKB will also include a considerable construction department. The SKB organisation for the nuclear fuel programme is adapting to the new phase in the process towards final disposal. In parallel for the low and intermediate level programme, SKB plans to submit applications under the Nuclear Activities Act and the Environmental Code for the extension of SFR at the end of 2013.

09:40

A Brief Review of Decommissioning and Waste Management in the UK

Adrian Simper, Strategy & Technology Director, Nuclear Decommissioning Authority, UK

The UK's nuclear legacy is a major public liability, and arguably represents the largest, most important environmental restoration programme in Europe.

The Nuclear Decommissioning Authority (NDA) is a public body and is the strategic authority that owns 19 legacy civil nuclear sites and the associated nuclear liabilities across the UK. We have an annual budget of ~£2.8bn ($4.513bn CAD) and manage a total discounted liability of £49.152bn ($79.231bn CAD).

Our core objective is to ensure that these historic nuclear legacy sites are decommissioned safely, securely, cost effectively and in ways which protect the environment. The sites range in size and complexity of decommissioning from commercial generating stations and experimental reactor sites through to Sellafield, one of the most complex nuclear sites in the world.

In order to bring a clear focus to our mission we have identified six strategic themes under which we group all of our activities which are:

- Site Restoration
- Spent Fuels
- Nuclear Materials
- Integrated Waste Management
- Business Optimisation
- Critical Enablers

Link to the NDA strategy:

http://www.nda.gov.uk/documents/upload/NDA-Strategy-Effective-from-April-2011-full-colour-version.pdf

There are numerous examples of successful strategy implementation across the NDA estate. The Active Handling Building at Winfrith has now been fully decommissioned and that area cleared. An experimental reactor has also been fully decommissioned and the site is at present being cleared.

Challenges that remain include work at Dounreay and the progress being made taking apart the legacy after four decades of research, stretching back to the earliest days in the industry. The experimental nature of many of its redundant facilities means the clean-up and demolition requires particular innovation.

The Legacy Ponds and Silos (LP&S) programme at Sellafield poses the most significant challenge within the UK's nuclear legacy, and where it is essential that tangible, demonstrable progress is made. The LP&S programme scope comprises of the retrieval of waste from the four main plants on site which were used historically to prepare fuel for reprocessing or storage.

Nuclear site operations and successful site restoration depend on the availability of suitable waste management routes and facilities. Effective management of both radioactive and non radioactive waste is essential to the delivery of our mission and is a significant part of our programme.

The UK's approach to Waste Management will be discussed and the information on the evolution of the waste management and the importance of building on lessons learned will be shared. This includes the Geological Disposal Facility (GDF) and the importance international communication has on the development of a waste disposal facility.

10:10 – 10:30

Networking Break

10:30

The U.S. Blue Ribbon Commission on America's Nuclear Future: Status and Plans

Tom Isaacs, Lead Advisor to the Blue Ribbon Commission on America's Nuclear Future, USA

The U.S. Blue Ribbon Commission on America's Nuclear Future (BRC) was formed by the Secretary of Energy at the request of the President to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle and recommend a new plan. It is co-chaired by Rep. Lee H. Hamilton and Gen. Brent Scowcroft. The Commission and its subcommittees met more than two dozen times between March 2010 and July 2011 to hear testimony from experts and stakeholders, to visit nuclear waste management facilities in the United States and abroad, and to discuss the issues identified in its charter. The Commission delivered its draft report to the Secretary of Energy on July 29, 2011. The draft report highlights the Commission's findings and conclusions to date and articulates a preliminary set of consensus recommendations for public review and input. This talk will describe the status of the BRC its and preliminary conclusions and recommendations contained in the draft report. The Commission's final report is due to be delivered to the Secretary of Energy on or before January 29, 2012.

11:00 – 11:20

Questions and Panel Discussion

11:20 – 12:00

Visit Business Exposition

12:00 – 13:30

Luncheon, Grand Ballroom

Concurrent Technical Sessions

Trinity 1

Waste Characterization

Session Chair: Mark Gardiner, Atomic Energy of Canada Limited

13:30

Experiences of Waste Assay and Management Issues Encountered in Decommissioning Old Radioactive Facilities

I. Adsley, M. Davies, M. Green, I. Pearman, H. Beddow, N. Brown, K. Miller and R. Murley, Nuvia Limited; Y. Tur, National Nuclear Centre, Republic of Khazakhstan; A. Klepikov, Nuclear Technology Safety Centre, Republic of Khazakhstan

The history of nuclear programmes has now given rise to a legacy of radioactive contaminated facilities in the UK and elsewhere. In the

UK these facilities were associated with the initial R&D programmes, both civil and military, and subsequent reprocessing programmes to reclaim 235U and plutonium produced in fission reactors. The principle radioactive species produced in these systems are fission products, characterised by Cs-137 (Ba-137m), activation products, characterised by Co-60, and actinides, which are in general more difficult to assay as many of these do not have a characteristic gamma signature.

In addition, the UK was also the base for the Joint European Torus (JET), a pioneering fusion research facility. Several particle accelerator facilities were also designed and built, such as Van de Graaf machines and various cyclotron/synchrotron particle research systems. The radioactive waste types from these are activated materials from fast and slow neutron capture and more exotic radionuclides produced from particle-nucleus interactions.

Of the various waste characterisation methods, gamma techniques are the simplest to use because they enable a significant volume of waste material to be interrogated, whereas alpha and beta measurements are generally of limited range and are best used in laboratory measurements. Furthermore, the detection limits for neutron measurement techniques are usually so poor that they are greater than most relevant waste sentencing criteria. Nuvia has developed a range of in-situ and ex-situ gamma based systems for monitoring wastes and these will be described in detail in the paper. These include dose rate measurements in high gamma fields (g.t. 100μSv/h), gross gamma systems for mapping and bulk waste sentencing, and gamma spectrometry systems for in-situ contamination and package (200 litre drum, 1-2 tonne bag) monitoring. These systems include the Nuvia GROUNDHOG GPS-based contaminated land mapping system, a concrete core profiling system, 2D and 3D room mapping, conveyor monitoring, excavator bucket monitoring and purpose designed gamma spectrometry systems for bulk waste monitoring.

Examples of completed projects will be described; these will cover the range of radioactive wastes produced and the appropriate measurement systems used.

13:55

Characterization of the Radiochemical Activity in CANDU® Steam Generators

A. Husain, Y. Verzilov, S. Suryanarayan and A. Antoniazzi, Kinectrics Inc.

The scope of mid-life refurbishment activities at some CANDU® plants includes replacement of the existing steam generators. Shipment of the discarded steam generators for interim storage, intact disposal or for recycling via metal melting requires an assessment of the inventory of radionuclides within the components and also dose rates.

Kinectrics was contracted by Bruce Power to develop radionuclide inventory and dose rate data for steam generators from its four-unit, Station A, located in Kincardine, Ontario, Canada. Units 1 & 2 are currently being refurbished while Units 3 & 4 are planned for refurbishment in 2016. The scope of the refurbishment activities at all units includes replacement of the existing steam generators. Those from Units 1 & 2 have already been placed into interim storage at the Western Waste Management Facility (WWMF) which is also located on site but operated by Ontario Power Generation.

This paper presents the detailed methodology employed to develop radionuclide inventory and dose rate data for radionuclides within (characterize the steam generators that are) both in-service and out-of-service (in-storage) steam generators. The data were developed as follows: a) archived tube sections from various steam generators were characterized; scaling factors were derived using the detailed alpha and beta activity data obtained b) *in-situ* gamma spectrometry (using germanium and cadmium zinc telluride detectors) and dose rate surveys were performed at various steam generators and c) a detailed assessment of the tritium inventory in various primary and secondary side components was performed.

14:20

Near Real-time Characterization of Radio-contaminated Soils in France: Challenges and Methods

Y. Desnoyers, GEOVARIANCES; D. Dubot, Commissariat à l'Energie Atomique

Over the last 10 years, the French Atomic Energy Commission (CEA, Commissariat à l'Energie Atomique) has set up an innovative methodology aiming at characterizing radiological contaminations. The application of the latter relies on various tools such as expertise vehicles with embedded measurement devices and a recently developed software platform called Kartotrak. A Geographic Information System tailored to radiological needs constitutes the heart of the platform; it is surrounded by several modules aiming at (i) sampling preparation, (ii) data analysis and geostatistical modeling and (iii) real-time monitoring and data acquisition.

This paper presents a methodological framework for the follow-up of decontamination projects, from doubt removal to the verification of the decontamination process. The use of the radiological characterization methodology and its related developments leads to a better appreciation of the contamination and, most importantly, to the optimization of the waste volumes and the reduction of the global cost of the remediation process.

14:45

Assay of Plutonium Contaminated Waste by Gamma Spectrometry

I. Adsley, R. Bull, M. Davies and M. Green, Nuvia Limited

The extreme toxicity of plutonium necessitates the segregation of plutonium contaminated materials (PCM) with extremely small (sub-μg) levels of contamination. The driver to measure accurately these small quantities of plutonium within (relatively) large volumes of waste is (in part) financial. In particular the cost of disposal (per unit volume) rises steeply with increasing waste-category.

Within the UK, there has been a historical reluctance to use low energy gamma radiation to sentence PCM because of the potential for self attenuation by dense materials. This is unfortunate because the low-energy gamma radiation from PCM offers the only practicable technique for segregating PCM within the various Low Level Waste (LLW) (>0.4Bq/g) and sub-LLW categories. Whilst passive neutron counting techniques have proved successful for assay of waste well into the Intermediate Level Waste (ILW) (>100Bq/g)

category, a cursory study reveals that these techniques are barely capable of detecting mg quantities of plutonium – let alone the sub-µg quantities present in LLW.

This paper considers the use of two types of gamma detector for assay of PCM: the thin sodium iodide FIDLER (Field Instrument for the Detection of Low Energy Radiation) and the HPGe (High Purity Germanium) detector. Systems utilising these two types of detector can provide complementary information.

FIDLER measurements are conducted by careful, local, systematic monitoring of surfaces

By contrast a HPGe detector can be used to monitor entire walls, or even rooms, in one measurement. Thus, a HPGe detector placed in the centre of room (from which any radioactive hot-spots have previously been removed) could be used to demonstrate that the *average* activity remaining close to the surface of the walls/floor/ceiling is below a given limit.

The Monte Carlo Code MCNP has been used to model both FIDLER probe and HPGe detector in the measurement geometries described above.

The MCNP simulations have been validated with experimental data.

Subject keywords: ASSAY; PLUTONIUM; WASTE; GAMMA; MCNP; MONTE CARLO; FIDLER; SODIUM IODIDE; HPGE; SIMULATED SPECTRUM

15:10 – 15:40
Networking Break

Trinity 1

Cemented Mo-99 Waste Treatment

Session Chair: Mark Chapman, Atomic Energy of Canada Limited

15:40
Characterization of Surrogate Cemented Waste: A Laboratory Study
J.F. Fiset, A. Bilodeau, R. Lastra and N. Bouzoubaâ, CANMET-MMSL

Portland cement is commonly used to stabilize intermediate and low level of radioactive wastes. The stabilization/solidification process needs to be well understood as waste constituents can retard or activate cement hydration. The objectives of this project were to prepare surrogate radioactive cemented waste (SRCW), develop a comminution strategy for SRCW, determine its chemical characteristics, and develop processes for long term storage. This paper emphasizes on the characterization of surrogate radioactive cemented waste.

The SRCW produced showed a high degree of heterogeneity mainly due to the method used to add the solution to the host cement. Heavy metals such as uranium and mercury were not distributed uniformly in the pail. Mineralogical characterization (SEM, EDS) showed that uranium is located around the rims of hydrated cement particles. In the SRCW, uranium occurs possibly in the form of a hydrated calcium uranate. The SEM-EDS results also suggest that mercury occurs mainly in the form of HgO although some metallic mercury may be also present as a result of partial decomposition of the HgO.

16:05
A Preliminary Evaluation of Comminution Strategies for Radioactive Cemented Waste
M. Bilodeau, R. Lastra, N. Bouzoubaâ, CANMET-MMSL; M. Chapman, Atomic Energy of Canada Limited

Lixiviation of Hg, U and Cs contaminants and micro-encapsulation of cemented radioactive waste (CRW) are the two main components of a CRW stabilization research project carried out at Natural Resources Canada in collaboration with Atomic Energy of Canada Limited. Unmolding CRW from the storage pail, its fragmentation into a size range suitable for both processes and the collection of a representative sample are three essential steps for providing optimal material conditions for the two studies. Separation of wires, metals and plastic incorporated into CRW samples is also required. A comminution and sampling strategy was developed to address all those needs. Dust emissions and other health and safety concerns were given full consideration.

Surrogate cemented waste (SCW) was initially used for this comminution study where Cu was used as a substitute for U and Hg. SCW was characterized as a friable material through the measurement of the Bond work index of 7.7 kWh/t. A mineralogical investigation and the calibration of material heterogeneity parameters to define the sampling error model showed that Cu, Hg and Cs are finely disseminated in the cement matrix. A sampling strategy was built from the model and successfully validated with radioactive waste. A larger than expected sampling error was observed with U due to the formation of large U solid phases, which were not observed with the Cu tracer.

SCW samples were crushed and ground under different rock fragmentation mechanisms: compression (jaw and cone crushers, rod mill), impact (ball mill), attrition, high voltage disintegration and high pressure water (and liquid nitrogen) jetting. Cryogenic grinding was also tested with the attrition mill. Crushing and grinding technologies were assessed against criteria that were gathered from literature surveys, experiential know-how and discussion with the client and field experts. Water jetting and its liquid nitrogen variant were retained for pail cutting and waste unmolding while attrition milling was selected for fine grinding. Sieving and magnetic separation are among the foreseen technologies to be investigated for metal and plastic rejection. A comminution process flowsheet, to be evaluated and validated at the pilot scale, was designed for the waste site comminution. Water recycling remains the main issue to be addressed. A radioactive waste sampling and comminution laboratory was installed and successfully tested. A statistical material balance algorithm was customized for the lixiviation process for designing sampling protocol and improving accuracy of the contaminants inventory.

16:30
The Cesium Leaching Resistance of Cement Matrices for Secondary Processing and Solidification of Cemented Radioactive Waste Materials
A. Bilodeau, C. Laviolette, J.F. Fiset and N. Bouzoubaâ, CANMET-MMSL

This study is part of a broader investigation on the processing and re-solidification of cemented radioactive wastes (CRW) for the pro-

duction of stabilized waste materials suitable for disposal. One of the objectives of the study is to develop and assess various cementing matrices for the solidified material. The leaching resistance of those potential matrices has to be assessed. A series of tests on the leaching of cesium was performed and the results are presented in this paper.

Surrogate Cemented Waste (SCW), representative of the CRW, was reduced to a particle size suitable for mixing with cementing material (cement and other cementitious materials) and water to produce mortars. The mixture optimization program included several parameters such as the composition of the SCW, the cement-to-SCW (C/SCW) and the water-to-cementitious materials (W/C) ratios of the mortars, and the use of different types and proportions of supplementary cementing materials (SCMs). In this part of the study, the cesium leaching resistance was determined on a number of mortars of different compositions at various ages using the ANSI leach test. As an indicator of the durability, the calcium leaching resistance was also determined on selected specimens.

Reducing the water-to-cementitious materials ratio (W/CM) of the mixtures resulted in the improvement of the leaching resistance of the mortars, however, the effect of the use of SCMs was not clear. In general, the use of zeolites resulted in a relatively good performance in the leaching.

The amount of calcium leached from the mortar exposed to water, an indication of the long-term durability, was determined during the extended cesium leaching test. The calcium leaching appeared significant, however, the extended-test leachability index values for cesium indicate that the integrity of the cement matrix was not much affected by the longer exposure to water, at least not enough to affect significantly the cesium leaching resistance of the mortars.

Trinity 2

LILWM – Treatment and Processing – 1

Session Chair: Doug Metcalfe, Natural Resources Canada

13:30

Spent Resin Management: A Viable Treatment Approach

S. Vijayan, Atomic Energy of Canada Limited; A. Roth, Westinghouse Electric Company

Spent organic resins containing both cations and anions, generally referred to as "mixed resins", are generated by different light water and/or heavy water purification systems employed in all types of nuclear power reactors, research reactors, and decontamination and decommissioning operations. The main factors that have a significant impact on waste treatment and the overall cost of managing such wastes are (1) the concentrations of short half-life (arbitrarily less than approximately 30 years) radionuclides, (2) the concentrations of long half-life radionuclides (in particular carbon-14), and (3) toxic metals present in the wastes. The presence of even small inventories of long-lived radionuclides results in the resin wastes being classified in the US as "US NRC Greater than Class C or Class B" low-level radioactive wastes, or "intermediate-level radioactive wastes" in other jurisdictions.

A variety of resin waste treatment methods is available. Some methods have been applied to specific situations, while others are being developed for future applications to meet the need for reducing worker dose, environmental releases, and waste storage and disposal costs.

The treatment of spent resins by drying, hot super-compaction and packaging provides a waste volume reduction of up to four for long-term storage or final disposal. The additional benefit of carbon-14 removal from certain spent resins during the drying process would allow reclassification of the processed resin to "Less than or Equal to US Class C" low-level radioactive waste. The recovered carbon-14 would be managed as a low-volume "Class C or Greater than Class C", low-level radioactive waste, consisting of metal carbonates. This could be stored with or without stabilization in cement, or could be further volume-reduced in a metal carbide waste form.

This paper presents a comparison of the different waste treatment options for the management of spent resins. The application of resin drying and super-compaction is a particularly attractive option, amongst those considered, for the management of spent resins containing carbon-14 for long-term storage. This option allows sufficient flexibility in the preparation of a suitable waste form to meet applicable waste acceptance criteria for disposal or destruction. The paper also discusses resin treatment performance results from bench-scale testing, using actual spent resin samples, and experience gained with large-scale thermal drying tests, involving 400 L batches of inactive resins, performed in a facility in Hanover, Germany. The results have shown that resin volumes are reduced by a factor of about 2 by particle breakage and loss of pore water. In addition, the elevated temperature resin drying results in destroying more than 70% of the anion-exchange functional groups, which suggests that the elevated temperature drying of resins in commercially available drying equipment would allow the removal of carbon-14 held by the anion resins as carbonate/bicarbonate. The paper discusses technical performance data to show that the proposed cost of a resin treatment approach is favorable for the long-term management of spent resins.

13:55

Treatment, Conditioning and Packaging for Final Disposal of Low and Intermediate Level Waste from Cernavoda: A Techno-Economic Assessment

S. Suryanarayan and A. Husain, Kinectrics Inc.; L. Fellingham and V. Nesbitt, Nuvia Limited; L. Toro, Mate-fin; V. Simionov and D. Dumitrescu, Cernavoda NPP

National Nuclearelectrica Society owns and operates two CANDU-6® plants at Cernavoda in Romania. Two additional units are expected to be built on the site in the future.

Cernavoda's low and intermediate level short-lived wastes are planned to be disposed off in a near-surface repository to be built at Saligny. A techno-economic assessment of the available options for a facility to treat and condition Cernavoda's radioactive wastes for disposal was carried out in 2009 and recommendations made on the preferred technologies and scenario for ownership and operation of the facility. The assessment was based on projected waste volumes from four CANDU® units. The principal waste streams are IX

resins, filters, compactable wastes, non-compactables, organic liquids and oil-solid mixtures. The volumetric generation rates of the various wastes per reactor unit were estimated to be: IX resins (6 m^3/y), filters (2 m^3/y), compactables (23 m^3/y) and non-compactables (15 m^3/y).

A large number of processes for treatment and conditioning of radioactive wastes were screened to identify viable processes for further consideration. The screened processes were used to develop overall processing options for each waste stream. These were subsequently consolidated to obtain options for the entire plant by minimizing the number of unit operations required to process all waste streams. A total of 9 plant options were developed. Detailed costing was undertaken for these 9 options. Based on a techno-economic optioneering assessment, two plant options with the top ranking scores were identified. Several scenarios were considered for implementing these options. Amongst them, a contractor run operation of a facility located on the Cernavoda site was considered to be more cost effective than operating the facility using SNN personnel.

14:20

Pre-Treatment of Organic Liquid Waste Stream at Cernavoda NPP

G. Teodorav, L. Toro and A. Sandru, MATE-FIN; D. Kelley, Pacific Nuclear Solutions, D. Dumitrescu, NPP Cernavoda

The radioactive waste management system at Cernavoda Nuclear Power Plant (NPP) was designed to maintain acceptable levels of safety for workers and to protect human health and the environment from exposure to unacceptable levels of radiation.

During the ten years operation of the Cernavoda NPP a series of waste streams have been developed for waste management purpose. One of these streams is consist of radioactive organic liquid wastes: spent oils, spent solvents, liquid scintillation cocktails (LSC), flammable solids (solid-organic liquid mixture) and sludge.

Effective treatment of organic liquids waste from the initial to the final stage has been a challenge for NPP Cernavoda. All components of the organic liquid waste stream was stored in liquid form in stainless steel drums in the Solid Radioactive Waste Intermediate Storage Facility (SRWISF). This facility was originally designed for solid wastes only, the regulatory body has asked Cernavoda NPP to remove the flammable liquids from this repository as soon as possible.

As a result, at the end of 2008, Cernavoda NPP initiated the solidification of organic liquid wastes (both historical and "fresh" wastes) together with a separation of solids associated with the organic liquids. In accordance with terminology of the International Atomic Energy Agency (IAEA), this system consists of the "pretreatment" of solid and organic liquid radioactive waste.

In 2008 Mate-Fin sign a contract with Cernavoda NPP in order to treat organic liquid waste and inflamable solid waste. The quantity for the entire 4 years project was about 24 tones of organic liquid waste and inflammable waste and after 2 years Mate-Fin succesfully solidified all historical organic liquid waste.

The proposed solution to this problem is to apply proven, low cost polymers to absorb liquid compositions. The polymers may be combined to create a formula specifically designed to permanently solidify a waste stream in a simple one-step process.

Nochar polymer technology (Nochar Petrobound – N910 and Acidbound – N960) has been successfully deployed in the immobilization of organic liquids waste in Cernavoda NPP. A detailed presentation is given related to the quantities of polymer used to solidify a specific organic liquid waste, possible mixture used for a particular type of liquid, the influence of the liquid properties (ex. impurity content) on the composition (N910 versus N960) of the polymer mixture and quantity.

14:45

Plasma Torch Treatment of Low Level Waste

F. Nachtrodt and W. Tietsch, Westinghouse Electric Germany GmbH; D. Mostacci, University of Bologna; U.W. Scherer, FH Aachen University of Applied Sciences

Low and intermediate level radioactive waste is produced during nuclear power plant operation. This waste has to be processed and conditioned for final storage. To apply an appropriate treatment technology, a profound knowledge of the waste composition and properties is necessary. This paper first gives an overview of the waste characteristics of low and intermediate waste from nuclear power plant operations.

Plasma torch treatment of these wastes is an advanced technique for volume reduction by thermal treatment and is applicable to all kinds of the occurring waste. Different design variations of plasma furnaces are imaginable and few have been implemented as prototype scale plants.

Scenarios for application are based on the waste production in the nuclear power sector and the possible and expected throughput of a plasma plant. Plasma torch treatment is most economically applicable as a part of a "radwaste" treatment plant in scenarios where several nuclear power plants are located in the same area.

15:10 – 15:40

Networking Break

Trinity 2

LILWM – Treatment and Processing – 2

Session Chair: Doug Metcalfe, Natural Resources Canada

15:40

OPG Western Waste Management Facility WVRB Control Room Upgrades Lesson Learned

J. Julian, Ontario Power Generation

The Ontario Power Generation (OPG) Western Waste Management Facility (WWMF) uses a computer based Supervisory Control and Data Acquisition (SCADA) system to monitor its facility, and control essential equipment. In 2007 the WWMF Low and Intermediate Level Waste (L&ILW) technical support section conducted a review of outstanding corrective maintenance work. Technical support divided all work on a system by system basis. One system under review was the Waste Volume Reduction Building (WVRB) control room SCADA system.

Technical support worked with control maintenance staff to assess all outstanding work orders on the SCADA system. The assessment identified several deficiencies in the SCADA system. Technical support developed a corrective action plan for the SCADA system deficiencies, and in February of 2008 developed an engineering change package to correct the observed deficiencies. OPG Nuclear Waste Engineering approved the change package and the WVRB Control Room Upgrades construction project started in January of 2009. The WVRB control room upgrades construction work was completed in February of 2009.

This paper provides the following information regarding the WWMF SCADA system and the 2009 WVRB Control Room Upgrades Project:

- A high-level explanation of SCADA system technology, and the various SCADA system components installed in the WVRB.
- A description of the state of the WVRB SCADA system during the work order assessment, identifying all deficiencies.
- A description of the new design package.
- A description of the construction project.

A list of lessons learned during construction and commissioning, and a path forward for future upgrades.

16:05

The Dissolution of Metal Decontamination Sludges Stored in Tanks and their Management

R. Prokopowicz and B. Phillips, Atomic Energy of Canada Limited

The decontamination of stainless steel components is accomplished by the use of alkaline permanganate solutions, followed by an application of solutions of complexing agents such as citric acid or oxalic acid. Spent decontamination solutions comprising residues from both steps were combined in several waste storage tanks, where they have been in storage for several years. In those tanks, a reaction between residual permanganate and unreacted complexing agents produced a sludge, consisting mainly of manganese dioxide, that resides in the tanks along with supernatant liquid. In a campaign that was conducted a few years ago, the accumulated waste solution was partially treated and disposed. This treatment consisted of decanting only the supernatant liquid and transporting it to a liquid waste treatment facility that employed a Thin Film Evaporator (TFE) to concentrate the liquid and ultimately produce a bitumen-encapsulated solidified waste form for disposal. A study of treatment options for the remaining sludges is reported here. The requirement was to determine a simple means of treating the sludges using existing routine processes and equipment. This will be a significant step toward the decommissioning of the decontamination waste storage tanks. The available equipment at the liquid waste treatment facility was not designed to process sludges or slurries containing a large fraction of insoluble solids. Laboratory testing was carried out to find a means of dissolving the decontamination waste sludges, preferably in situ, and filtering undissolved solids to meet the feed requirements of the TFE in the liquid waste treatment facility. A concentrated citric acid solution was applied to sludge samples, without the use of externally applied mixing of the reagent and sludge. In all of the samples of actual decontamination waste sludges that were tested, a quantity of undissolved material remained after the treatment with citric acid. The quantities were relatively small in volume, and easily removed by coarse filtration. Tests of these residues indicated that, while they were still radioactive, the radioactivity had been decreased relative to that of untreated sludges. Processing of the sludges, following their treatment with citric acid, involved extraction from the storage tanks and filtration to remove the small quantity of undissolved residue. The conditioned liquid from the holding tank is currently being processed through the TFE where its volume will be reduced and it will be mixed with a bitumen emulsion to produce a solid waste form suitable for storage in 205 L drums.

16:30

Removal of Metal Contaminants and Radionuclides with Natural Zeolites – Competitive Sorption and Effects of Zeolite Modifications

K.V. Reddy and A. Prakash, University of Western Ontario, Department of Chemical and Biochemical Engineering; S. Vijayan, Atomic Energy of Canada Limited

Metal contaminants including radionuclides found in wastewaters must be reduced to acceptable levels before discharging the wastewater into receiving waters. These cations can accumulate in aquatic organisms causing toxicity and death, hence strict regulatory limits for their allowable discharge levels have been established over the years. This has also prompted the development of cost effective technologies that will permit the efficient removal of contaminants, while concentrating the contaminants in a form suitable for immobilization, storage and disposal. Removal requirements can be met by some inorganic zeolites, which can be natural or synthetic. The zeolites have a strong affinity for transition metal cations, and their cage-like structures offer large internal and external surface areas for ion exchange and adsorption.

In view of these considerations, investigations with two low-cost natural zeolites (clinoptilolite and chabazite) were started, with the objective of developing a cost effective technology for column operations. Sorption tests of Cs^{+}, Sr^{2+} and Cu^{2+} ions on chabazite and clinoptilolite were carried out using batch experiments in 125 mL vessels under various test conditions. Competitive sorption was studied in mixed cation solutions containing the commonly occurring non-toxic cations Ca^{2+} and Na^{+}. The presence of these non-toxic cations inhibits removal of the targeted cations. Additional pretreatments and modifications of the "as received" sorbent particles were also investigated, which are important in multiple cation systems, to enhance removal selectivity for the target contaminant cations.

Sorption tests with chabazite and clinoptilolite showed that these two natural zeolites can be effectively used to remove cesium, strontium and copper ions from aqueous solutions. The performance can be controlled by maintaining the zeolite to waste volume ratio. The contaminant removal performance of chabazite was approximately 20% superior to that of the clinoptilolite. The presence of calcium ions has an adverse effect on the removal of copper and strontium ions, and this effect is more pronounced with clinoptilolite. The role of hydrated radius and energy of hydration in the sorption process offered an explanation of the differing removal efficiencies

for the various cations by the zeolites. Conditioning of chabazite in a concentrated sodium chloride solution improved its performance by about 10%, while there was little improvement attained by conditioning with calcium or ammonium ions.

This paper also describes a research plan for optimal field-scale applications in column operations. Considerations such as fluidization and hydraulic behavior, mass transfer and mixing in the zeolite beds, and safety considerations will be investigated. These investigations should lead to the selection of appropriate particle sizes, operating mode and the design of sorption-column internals.

16:55

Likely-Clean Concrete Disposition at Chalk River Laboratories

J.A. Betts, Atomic Energy of Canada Limited

The vast majority of wastes produced at nuclear licensed sites are no different from wastes produced from other traditional industrial activities. Radiation and contamination control practices ensure that the small amounts of waste materials that contain a radiation and or contamination hazard are segregated and managed appropriately according to the level of hazard. Part of the segregation process involves additional clearance checks of wastes generated in areas where the potential to become radioactively contaminated exists, but is very small and contamination control practices are such that the wastes are believed to be "likely-clean". This important clearance step helps to ensure that radioactive contamination is not inadvertently released during disposition of inactive waste materials.

Clearance methods for bagged likely-clean wastes (i.e. small volumes of low density wastes) or discrete non-bagged items are well advanced. Clearance of bagged likely-clean wastes involves measuring small volumes of bagged material within purpose built highly sensitive bag monitors. For non-bagged items the outer surfaces are scanned to check for surface contamination using traditional hand-held contamination instrumentation. For certain very bulky and porous materials (such as waste concrete), these traditional clearance methods are impractical or not fully effective. As a somewhat porous (and dense) material, surface scanning cannot always be demonstrated to be conclusive. In order to effectively disposition likely-clean concrete, both the method of clearance (i.e. conversion from likely-clean to clean) and method of disposition have to be considered.

Likely-clean concrete wastes have been produced at Chalk River Laboratories (CRL) from demolitions of buildings and structures, as well as small amounts from site maintenance activities. A final disposition method for this material that includes the secondary clearance check that changes the classification of this material from likely-clean to clean has to date not yet been developed. This has not historically represented a significant problem because the volumes of waste concrete being generated have been low, and capacity in sand-trench storage facilities was available. Now that decommissioning has started to ramp up, and sand-trench storage is no longer available, a solution for this high volume waste stream is more urgently required. Establishing that slab concrete is likely-clean is a significant accomplishment requiring a combination of review of records and measurements of 100% of all exposed surfaces. Establishing likely-clean concrete is clean requires more effort, and based on discussions and benchmarking to date, the most promising way forward involves crushing to check for absorbed contamination.

This paper will present CRL's chosen method of Concrete Crushing as a means of both completing the clearance of this material as well as preparing it for reuse as the optimum disposition. It will also discuss the progress of implementation.

Trinity 3

Decommissioning Projects and Information and Systems Management-1

Session Chair: Michael Stephens, Atomic Energy of Canada Limited (retired)

13:30

Management and Upkeep of AECL's Prototype Reactors being Held for Deferred Decommissioning

S. Kenny and R. Parsonage, Atomic Energy of Canada Limited

AECL is responsible for three prototype power reactor sites located at Douglas Point at the Bruce Nuclear site, Ontario; Gentilly-1 (G-1) near Bécancour, Québec located on the Gentilly-2 site and Nuclear Power Demonstrator (NPD) located at Rolphton, Ontario. Each site has its own unique challenge in maintaining it in a Static State. All three sites operate under separate Waste Management Facility Licenses approved by the Atomic Energy Board of Canada which is now the Canadian Nuclear Safety Commission. Decommissioning of a Nuclear Power Reactor Generating Station in Canada is carried out in different stages due to the safety and economic considerations associated with it. An immediate dismantling and disposal of plant and equipment following shutdown is neither desirable from the point of view of keeping worker radiation exposure as low as reasonably achievable (ALARA) nor feasible until an acceptable waste disposal site has been built in Canada.

This paper details the ongoing challenges encountered during extended periods of Storage with Surveillance (SWS) and how these challenges are being addressed. It will also outline how the long-term program for the sites is being developed to allow key decision points to be made on maintaining the period of SWS and the potential strategies reflecting on the transition into decommissioning, while being cognizant of international decommissioning initiatives.

The objective of safe shutdown activities is to safely shutdown the reactor and support systems and put the reactors, systems and components along with the support buildings in a Static State where only systems required for continued monitoring and surveillance activities over the next twenty plus years would remain operational. NPD, Douglas Point and G-1 sites were safely shutdown following the same strategy.

Maintaining the safe shutdown state of the active and non active facilities of each site has been a particular challenge as the only common approach used to bring each site to Safe Shutdown State was the removal of the secondary systems and equipment.

From the time a facility is safely shutdown through to decommissioning and remediation of the site, maintenance of the site must continue. Revised maintenance plans must be developed during shutdown activities to continue or start maintaining equipment, systems or components through a defined maintenance program. Configuration management of the site must be maintained for cost estimating and maintenance purposes. Maintenance costs will escalate as equipment exceeds its normal life cycle and budget planning for upgrades, modifications and capital replacements even though the facility is shut down must be completed.

Management and upkeep of AECL's prototype reactors being held for decommissioning presents many challenges. Knowledge transfer, aging facilities that have spent their projected life cycle and records management are underestimated tasks. Maintenance of the facilities, equipment, systems and site must be kept at an appropriate level to keep the facilities in a safe state until decommissioning is completed and meet regulations.

13:55

Enhancement of Decommissioning Training in the IAEA

P.J. Dinner, M. Laraia and P. Degnan, International Atomic Energy Agency; J.R. Dinner, CANDESCO Corporation; E. Fourie, South African Nuclear Energy Corporation (NECSA)

Significant progress has been made in recent years in improving the quality of decommissioning training and expanding the training options available to those in IAEA MS with developing programmes. In this paper we examine the issues and challenges associated with such training, and the initiatives being taken to address them, especially those to improve hands-on opportunitites aimed at improving decommissioning planning and the physical execution of decommissioning activities. The important role played by the IAEA waste management Networks in providing training opportunitites and facilitating the exchange of knowledge and lessons learned is discussed. Expectations and initial steps to create a powerful web-based platform (CONNECT) providing the Network participants with efficient means of access to each other, to qualified experts on specific topics, and to high quality training materials is described. The essential role played in the success of these initiatives by the generous contributions of professionals and organizations in Member States with developed programmes is identified and acknowledged.

14:20

A Summary of the Building 107 and 204 Decommissioning Projects

P. Pottelberg, Atomic Energy of Canada Limited

This paper discusses the Advanced Decommissioning Work Packages for Building 107 Dismantling and the Building 204 Bay Water Removal and Fire Separation Project at the Chalk River Laboratories. This Paper provides a facility description, history and background. It provides a project overview; including timeline of major milestones. This paper provides a summary for the radiation dose assessment on the building 204 project and provides a high level overview of the financial costs and waste management summary. This paper also highlights some of the key lessons learned on each project.

14:45

Using Geographical Information Systems in Planning NLLP Decommissioning and Environmental Restoration Activities

R. McGregor and W. Turner, Atomic Energy of Canada Limited, Chalk River Laboratories

The Nuclear Legacy Liabilities Program (NLLP) manages Canada's nuclear legacy liabilities at Atomic Energy of Canada Limited (AECL) sites and is funded by the Government of Canada through Natural Resources Canada (NRCan). Through the first five years of the Program these two organizations have worked collaboratively to bring numerous projects to completion. In addition to the diversity of facilities and waste dealt with under the NLLP, the Program involves seven sites in three different provinces. The breadth of the Program encompasses over 20 different projects at AECL's Chalk River Laboratories (CRL) site alone, with new projects evolving as work continues.

Nuclear legacy liabilities are the result of over 60 years of nuclear research and development conducted by the National Research Council of Canada (1944 to 1952) and AECL (1952 to 2006) on behalf of the Government of Canada. The liabilities consist of outdated and unused research facilities and buildings, a wide variety of buried and stored radioactive waste, and affected lands.

Since 1952, AECL has safely and cost effectively managed Canada's nuclear research facilities and the waste generated by their operation. During this time AECL improved waste management technologies and developed expertise in best practices.

All projects undertaken by the NLLP contain a spatial, or geographically referenced, component that can be captured in a geographic information system (GIS). From the decommissioning of a single building within the plant itself (e.g. the building location itself or spaces within the building) to the process of locating a new facility within the CRL site (e.g. location within the CRL property in three dimensions and adjacency to other communities) all these projects contain spatially referenced information. This spatial information can be captured, organized and used by the GIS software to analyze and model any number of questions.

The paper will discuss projects that address a variety of GIS data sets, tools, and techniques and how the discipline of geomatics can and should be used as another tool in the decision making process. In most projects the process can be categorized into five major steps; ask, acquire, examine, analyze, and act. The presentation provides examples, and includes a discussion of the four steps in which the GIS process has been used in NLLP projects: ask, acquire, examine and analyze.

The projects to be discussed include:

- Analysis to Determine the Most Efficient Groupings for the Decommissioning of Buildings at CRL Subject to Environmental Assessments
- Proposed Geologic Waste Management Facility at CRL
- Geophysical Surveys of the Ottawa Riverbed Adjacent to CRL

15:10 – 15:40

Networking Break

Trinity 3

Decommissioning Projects and Information and Systems Management-2

Session Chair: Michael Stephens, Atomic Energy of Canada Limited (retired)

15:40

Information Management for Decommissioning Projects

A.N. LeClair and D.S. Lemire, Atomic Energy of Canada Limited, Chalk River Laboratories

This paper explores the importance of records and information management for decommissioning projects. Key decommissioning information and elements of a sound information management strategy are identified. Various knowledge management strategies and tools are discussed as opportunities for leveraging decommissioning information. The paper also examines the implementation of Atomic Energy of Canada Limited's (AECL) strategy for the long term preservation of decommissioning information, and its initiatives in leveraging of information with the application of several knowledge management strategies and tools. The implementation of AECL's strategy illustrates common as well as unique information and knowledge management challenges and opportunities for decommissioning projects.

16:05

GIS-Based Tools to Identify Trade-offs between Waste Management and Remediation Strategies from Radiological Dispersal Device Events

P. Lemieux, J. Wood, E. Snyder, D. Schulthiesz, T. Peake and M. Ierardi U.S. Environmental Protection Agency; T. Boe, Oak Ridge Institute for Science and Education; C. Hayes and M. Rodgers, Eastern Research Group, Inc.

Management of waste and debris from a Radiological Dispersal Device (RDD) will likely contribute a significant portion of the overall remediation effort and possibly contribute a significant portion of the overall remediation costs. As part of the recent National Level Exercise "Liberty RadEx" that occurred in Philadelphia in April 2010, a methodology was developed by EPA to generate a first-order estimate of a waste inventory for the hypothetical RDD from the Liberty RadEx scenario. Determination of waste characteristics and whether the generated waste is construction and demolition (C&D) debris, municipal solid waste (MSW), hazardous waste, mixed waste, or low level radioactive waste (LLRW), and characterization of the wastewater that is generated from the event or subsequent cleanup activities will all influence the cleanup costs and timelines. Decontamination techniques, whether they involve chemical treatment, abrasive removal, or aqueous washing, will also influence the waste generated and associated cleanup costs and timelines. This paper describes the ongoing effort to develop a tool to support RDD planning and response activities by assessing waste quantities and characteristics as a function of potential mitigation strategies.

16:30

Multi-Site Risk-Based Project Planning, Optimization, Sequencing, & Budgeting Process and Tool for the Integrated Facility Disposition Project

J.G. Nelson, H. Lucek, J. Huntsman and T.C. Marks, WorleyParsons Polestar

Faced with the Department of Energy (DOE) Complex Transformation, National Nuclear Security Administration (NNSA) was tasked with developing an integrated plan for the decommissioning of over 400 facilities and 300 environmental remediation units, as well as the many reconfiguration and modernization projects at the Oak Ridge National Laboratory (ORNL) and Y-12 Complex. Manual scheduling of remediation activities is time-consuming and inherently introduces bias of the scheduler or organization into the process. Clearly a well-defined process, quantitative risk-based tool was needed to develop an objective, unbiased baseline sequence and schedule with a sound technical foundation for the Integrated Facility Disposition Project (IFDP). Faced with limited available data, innovation was needed to extrapolate intelligent relative data for key risk parameters based on known data elements. The IFDP Supermodel was customized and expanded to provide this capability for conceptual planning of diverse project portfolios and multiple sites.

Trinity 4

Waste Disposal - International Experience

Session Chair: Dave McCauley, Natural Resources Canada

13:30

40 Year Experience of Radioactive Waste Disposal in France

N. Solente, G. Ouzounian, M. Dutzer and R. Miguez, Agence Nationale pour la Gestion des Déchets Radioactifs

France's experience in the management of radioactive waste is supported by forty years of operational activities in the field of surface disposal. This feedback is related to three disposal facilities:

- Centre de la Manche disposal, not far away Cherbourg, from design to post-closure facility.
- Centre at Soulaines-Dhuys from site selection to design to operation during nearly 20 years.
- Centre at Morvilliers from site selection to operation for seven years now

During the operational period of Centre de la Manche disposal facility (1969-1994), the safety concept for low-and intermediate level short lived waste (LIL-SLW) was developed and progressively incorporated in the procedures of the facility. The facility entered its institutional control period and the experience of this facility has been useful for the operating facilities.

Centre de l'Aube that took over Centre de la Manche, and Morvilliers for very low level wastes. Both facilities currently accommodate the major part of the volume of radioactive wastes that are generated in France. However disposal facilities have to be considered as rare resources. Then new waste management options are being investigated as the disposal of large components or recycling metallic wastes within the nuclear industry.

13:55

Managing the Future Swedish Decommissioning Waste - From Dismantling to Final Disposal

F. De la Gardie, SKB International AB

By Swedish law it is the obligation of the nuclear power utilities to satisfactorily demonstrate how a nuclear power plant can be safely decommissioned and dismantled when it is no longer in service as well as transporting and dispose the waste in a safe way so that the environment will not be affected.

To meet these objectives, detailed plant-specific studies have and are being performed by Westinghouse Electric Sweden AB (WSE) and TLG Services in cooperation with the utilities of Oskarshamn, Forsmark, Ringhals and Barsebäck on behalf of SKB.

The final closure of most of Sweden's NPP is far ahead but anyhow there has been a need for developing a more general decommissioning planning basis. These studies result in estimates of radioactive and conventional waste volumes and radioactivities and will be a major input in designing transport systems and final repositories for the decommissioning waste. The studies will also be used as a base for estimation of the associated decommissioning costs.

The Swedish Nuclear Fuel and Waste Management Co. (SKB) is owned by the Swedish nuclear power utilities and is responsible for managing the nuclear waste by designing, building and operating waste storage and disposal facilities.

The paper will provide detailed data of waste characterization and amounts, as well as of time schedules for the Swedish fleet and show how decommissioning will fit with the existing well-developed waste management system of the country. The standardized waste packages that are planned to be used will be presented as well as managing of the large components, e.g. whole BWR Reactor Pressure Vessels. In order to dispose the radioactive waste the ongoing project to extend SFR (final repository for short-lived LILW) and the planning for the repository for the long-lived waste, e.g. core components will be shown.

14:20

Current Status of Development of a New LILW Repository in Romania

A-I Petrescu and A. Gheorghe-Sorescu, Nuclear AN DR, Romania

The current nuclear power program in Romania includes: 2 CANDU-6 Canadian PHWR type reactors in operation since 1996, respectively 2007 and another 2 similar units projected on same Cernavoda Nuclear Power Plant site to be commissioned in 2019. For waste generated by Cernavoda NPP, the draft of the revised national radioactive waste management strategy currently under revision will include a new near surface type repository to be commissioned in 2019. The repository will accommodate the Low and Intermediate Level Waste with short lived radio-nuclides and limited quantities of long lived as accepted according to the results of the safety assessment for long term behavior of waste and repository system. The siting process of the new repository started in 1992 and has been developed following the IAEA guidelines and standards. Within its evolution, the siting process was reviewed several times by different IAEA expert missions, mentioning that the selected sites along with a proper design have a good perspective. In 1997, the Saligny site located inside the exclusion zone of Cernavoda NPP was preferred taking into consideration both technical and non-technical factors, including further acceptance of the project implementation by the local communities. In 2008, Nuclear Agency for Radioactive Waste (AN&DR), the owner of the new near surface repository project, obtained a partial siting license, representing a license issued by CNCAN with a conformance program in order to obtain the siting license. In order to issue that license, CNCAN reviewed all process and conclusive safety documentation prepared by the main organizations that supported the R&D process for the new repository between 1992 and 2007. AN&DR coordinated the actions of that conclusive work and mainly completed it asking an IAEA Waste Management Assessment and Technical Review Programme (WATRP) expert mission, acting for addressing experts' observations and recommendations and obtaining the acceptance of the local authorities and local communities that agreed for further work on the repository project. The year 2011 is a very important year in the project development and the preparation of the new investment. AN&DR is the beneficiary of 2 contracts that represent 2 Phare projects approved by the European Commission to support AN&DR to strengthen the development of the repository project. According to the scopes of work, the two contracts provide AN&DR all relevant safety and design support documentation for obtaining the siting and later the construction license for the Saligny repository.

14:45

Site Selection Process for a HLW Geological Repository In France – A Convergence Approach

N. Solente, G. Ouzounian, R. Miguez and J-L Tison, Agence Nationale pour la Gestion des Déchets Radioactifs

On December 1991, the French National Assembly passed the French Waste Management Research Act, authorizing and initiating a 15 year research program along three options for HLW long term solution: separation and/or transmutation, long-term storage, and geologic disposal.

On June 2006, the "Planning Act on the sustainable management of radioactive materials and waste" sets a new framework and new aims to the above mentioned options.

This paper deals only with the geologic disposal research program. In a step by step approach, this program has been broken down into three phases, each having intermediate objectives: site selection for an Underground research Laboratory (URL), disposal feasibility demonstration, reversible disposal design.

The first step of the research program aimed at URL site selection. From 1994 to 1996, Andra carried out geological characterization surveys in four French districts, leading to the Request for Licensing and Operation of laboratory facilities on three sites. During this phase, boreholes, 2D seismic campaigns and outcrops geologic studies were the main sources of data. The result was the selection of Bure area, the most suitable site for the implementation of an underground laboratory. Main results on Bure URL will be presented in the paper.

In the second phase the research program targeted the safety and technical feasibility of a reversible disposal site, located in Meuse or Haute Marne districts, as selected by the government in 1998. Andra

conducted geologic survey during the URL shaft sinking and experiments in drifts at depths of 445 and 490 m. This program allowed consolidating the knowledge already acquired: geological environment, stability of the rock and the regional geology, and containment properties. The 2005 Progress Report presents the results of this phase. The main conclusion is that a potential disposal facility may be safely constructed over a zone with geological characteristics similar to those investigated at the URL, called transposition zone (about 250 km^2). The paper will present the most important results in this phase.

From 2006, the third phase of the program, the activities were oriented, inside the transposition zone, to determine a smaller zone in which a potential disposal facility could be located. In 2009, Andra issued a proposal for such a zone to the French authorities. In this paper, the main results of this phase will be presented.

Finally, the next steps towards a final implementation will be described.

15:10 – 15:40
Networking Break

Trinity 4

Used Fuel Storage

Session Chair: Jim McKenna, Atomic Energy of Canada Limited

15:40
Technical Challenges for Dry Storage of Spent Fuel from Research Reactors in Canada
J. Lian, T. Sanderson and A. Chiu, Atomic Energy of Canada Limited

Research reactors have been operated in Canada to support nuclear R&D programs and medical isotope production. Spent nuclear fuel discharged from these research reactors is currently being dry stored at the storage facilities at Chalk River Laboratories (CRL) site. The research reactor spent fuels are significantly less corrosion-resistant than the Zircaloy-clad power reactor fuels during storage and are subject to unique hazards associated with their chemical and physical characteristics. This paper discusses the technical and safety issues related to the dry storage of these fuels, and presents the key safety considerations required in the design and operation of new dry fuel storage facilities at CRL.

16:05
Lessons Learned: The Effect of Increased Production Rate on Operation and Maintenance of OPG's Western Used Fuel Dry Storage Facility
L. Morton and N. Smith, Ontario Power Generation

Lise Morton (Ontario Power Generation), Nathan Smith (Ontario Power Generation)

In 2010, the Western Used Fuel Dry Storage Facility (WUFDSF) located at Ontario Power Generation's (OPG's) Western Waste Management Facility in Tiverton, ON, transferred, processed and stored a record-high number of Dry Storage Containers (DSC's) from Bruce Power's nuclear generating stations.

The WUFDSF has been in operation since 2002. The facility transfers, processes, and stores the used fuel from the Bruce Power generating stations located in Tiverton, Ontario. As per a contractual agreement between OPG and Bruce Power, an annual DSC production and transfer schedule is agreed to between the two parties.

In 2010, an increased annual production rate of 130 DSC's was agreed to between OPG and Bruce Power.

Throughout 2007, 2008 and 2009, several facility modifications had been completed in anticipation of the increased production rate. These modifications included:

- Installation and commissioning of a second set of welding consoles
- Addition of a second vacuum drying system
- Procurement of a second transfer vehicle
- Installation of a bulk gas system for welding cover gas

In 2010, the increased production rate of 130 DSC's/year came into effect. Throughout 2010, significant lessons learned were gained related to the impact of such a high production rate on the operation and maintenance of the facility.

This paper presents the challenges and successes of that operation.

The facility successfully achieved its production target with no safety incidents. This high rate of production is planned to continue for several years at the facility. Some challenges continue and these are being assessed and incorporated into the facility's business plan. In order to continue being successful, the facility must look to the future for opportunities for improvement and efficiencies to be gained.

16:30
Pre-Project Activities Related to the Remediation of Fissionable Materials Contained in Standpipes at Atomic Energy of Canada Limited's Whiteshell Laboratories
T.M. Stepanik, H. McIlwain, J. Edworthy, S.M. Alam, A.G. Man and J. Martino, Atomic Energy of Canada Limited; P. Taylor, Acsion Industries Incorporated

AECL is presently decommissioning Whiteshell Laboratories (WL), a former nuclear research site. Some Fissionable Materials (FM), arising from operation of Whiteshell Reactor-1, an experimental organic-cooled 60 MW reactor that ran from 1965 to 1985, are stored in 69 in-ground standpipes in the WL Waste Management Area (WMA). The standpipes (171 in total) were used to store mainly intermediate level waste over the period 1967 to 1986.

AECL has committed to remediate the 69 standpipes containing FM. This work, under the auspices of the Nuclear Legacy Liabilities Program, is presently in the pre-project phase, which is focussed on developing an optimum remediation strategy. It includes assessing the condition of the standpipes, the environment inside the standpipes, and possible remediation options. This paper describes the standpipe designs, approaches for determining their fitness for purpose, and steps being taken to determine what radiological or industrial issues may be associated with the stored material. In addition, potential remediation strategies identified to date, and technology that must be developed for conditioning the contents of the standpipes for remediation are discussed.

Trinity 5

Environmental Remediation – 1

Session Chair: Steve Liblong, Atomic Energy of Canada Limited

13:30

The Path to Determining a Recommended Remediation Strategy for Ottawa Riverbed Sediment

R. Silke, M. Audet, A. Ethier, D. Hartwig, D. Lee, M. MacCafferty, D. Rowan and J. Roche, Atomic Energy of Canada Limited

There are many factors that influence how a remediation decision is made. Fundamentally, a risk-based, methodical consideration of potential, or actual, impacts to human health and the environment should form the basis of a defensible remediation solution. However, in addition to evaluation of the technical aspects in an assessment, it is also imperative to success to ask the community what they perceive the risks and effects of the contamination to be. "Perceived risks are as tangible as 'real' risks as far as the decision making process is concerned".

This paper considers the factors required for an effective remediation decision-making assessment process. This process will be employed to determine a recommended remediation strategy for contaminated sediment in the Ottawa River adjacent to Atomic Energy of Canada Limited's (AECL) Chalk River Laboratories site. This is one of the legacy liabilities currently being managed by AECL under the Nuclear Legacy Liabilities Program funded through Natural Resources Canada.

13:55

Reactive Sandpacks for the Removal of Strontium-90 in Groundwater

S-W Jeen, Atomic Energy of Canada Limited, Chalk River Laboratories

Reactive sandpacks have been proposed as an alternative treatment method for Sr-90 in groundwater. In concept, reactive sandpacks are installed around the screens of dewatering wells, replacing the non-reactive conventional sand pack, such that the contaminant is altered or sorbed in the ground during the dewatering process. While the concept appears to be useful, it has not been known whether reaction kinetics are fast enough in the fast moving water near the well-screen for satisfactory retention of contamination in a dewatering application. This study tested the concept of reactive sandpacks under realistic pumping conditions, by conducting in situ column experiments. Two sets of column experiments were conducted for the period of 49-55 days, with each set composed of two 10 cm columns placed in a well at the Chalk River site. The well was screened in an actual Sr-90 groundwater plume. Columns were filled with clinoptilolite (i.e., a natural zeolite), and groundwater was pumped through the columns at the velocities expected near the pumping well (33-200 m/day). Measurements of gross beta for the effluent water showed that the columns with higher flow velocities had effluents with greater radioactivities than the columns with lower velocities. The starting time and extent of the breakthrough of Sr-90 was proportional to the flow velocity. Distribution coefficients, determined by fitting the normalized aqueous gross beta data to the 1-D advection-dispersion equation, varied inversely with flow velocity, suggesting that the sorption of Sr-90 onto clinoptilolite is kinetically-controlled in this high velocity range. Radioactivities for the solid samples, retrieved from the columns after the operation, showed that sorption fronts were advancing in proportion to the flow velocity, consistent with the aqueous data. The results showed that the concept can be applied to dewatering projects if the sandpack is properly designed.

14:20

Interception of a Groundwater Plume Containing Strontium-90

D.R. Lee and D.S. Hartwig, Atomic Energy of Canada Limited, Chalk River Laboratories

In December 1998, a vertical, permeable "barrier' of granular zeolite (clinoptilolite) was emplaced underground in the path of groundwater that was transporting strontium-90 (^{90}Sr) toward a wetland on the property of Atomic Energy of Canada Limited's (AECL) Chalk River Laboratories (CRL). The largest components of the barrier were a 30–m long, steel-sheet piling, cut-off wall and 130 m^3 of granular zeolite contained in a volume, 2-m thick in the direction of groundwater flow, 11-m wide and 6-m deep. The mass of granular zeolite was not situated at the depth of groundwater contamination. Instead, it was "hung" like a curtain 3 to 4 m above the initial position of the contaminant plume. A locally reduced elevation head in the curtain induces flow through the curtain. By ion exchange, the granular zeolite reacts with and retains ^{90}Sr. The use of a commercially available granular zeolite (clinoptilolite) has been proven suitable for long-term subsurface control and mitigation of groundwater contaminated with ^{90}Sr. The 13-year record of gross beta measurements showed no sign of ^{90}Sr breakthrough. Attempts to measure ^{90}Sr radio-chemically showed that the concentration is < 0.1Bq/L in the effluent. Hydraulic controls have performed as intended. As of February 2011, the groundwater plume continued to be intercepted.

14:45

Performance Modeling to Support Decision-Making for the Management and Disposition of Low-Activity Radioactive Waste

K.S. Czyscinski, D.J. Scultheisz and R.T. Peake, U.S. Environmental Protection Agency

The Agency has been examining the potential for the use of the RCRA-C disposal unit technology for the disposal of "low-activity" radioactive wastes (considered as a subset of Class A wastes as defined by the NRC). To determine waste acceptance criteria (permissible radionuclide concentrations in the wastes), preliminary performance modeling of the RCRA-C disposal unit was conducted for an expected case (slow degradation of the disposal unit), as well as exposures through three human intrusion scenarios and worker exposures during waste handling, treatment, storage and transportation. The expected case modeling examined disposal units in arid and humid climates and in a variety of hydrologic settings. A set of linked codes were used to assess stochastic performance within the waste unit, along the ground water travel path and the biosphere to calculate doses to a near-by off-site receptor. Results showed that arid site locations offered exceptional performance due to the low infiltration and generally deeper water tables. Preliminary modeling showed that worker

exposures and human intrusion scenarios strongly dominate the comparative dose assessments due to direct exposures to the receptors in these analyses. The robust design of the RCRA-C units can exert a significant counterbalance to the limitations imposed by the direct exposure scenarios however. Determining permissible waste concentrations for use in rule making or guidance for this potential disposal option will consider site restrictions, waste form requirements and other factors before decisions are made on final criteria.

15:10 – 15:40
Networking Break

Trinity 5

Environmental Remediation – 2

Session Chair: Steve Liblong, Atomic Energy of Canada Limited

15:40
Investigation of Strontium-90 in Groundwater Discharging to the Ottawa River
J.M. Roche, D.R. Lee and D.S. Hartwig, Atomic Energy of Canada Limited, Chalk River Laboratories

In 2007, an area of Ottawa Riverbed (about 250 m^2 in extent) was found to be a groundwater discharge zone with above-background levels of tritium (as tritiated water - HTO). The area was adjacent to the shoreline along the property boundary of Atomic Energy of Canada Limited's Chalk River Laboratories. The probable source of the HTO has been identified as a groundwater plume originating from a facility undergoing decommissioning. A discharge of strontium-90 (^{90}Sr) that occurs within a small part of the groundwater discharge zone in the study area has also been identified and is likely coming from the same groundwater plume as the HTO. Based on information from years of ongoing site and plume monitoring, a more detailed investigation was conducted to provide specific information on where the ^{90}Sr plume was emerging to the surface and to estimate contaminant flux to the river.

Work in 2009/10 revealed discharge of ^{90}Sr within a small portion of the groundwater discharge area. A land-based survey using a portable gamma spectrometer showed up to 550 total gamma counts per second above the plume's path. Based on a ^{137}Cs survey, these gamma counts were not attributable to ^{137}Cs and are likely due to the presence of ^{90}Sr and its decay product, yttrium-90 (^{90}Y). A vegetation survey of alders along the shoreline revealed gross beta levels of 1 – 70 Bq/g. Alders are known to root in wet ground and are likely pumping ^{90}Sr from the contaminated groundwater to the surface. Groundwater samples obtained from the river using mini-piezometers had gross beta levels of 3.3 – 590 Bq/L, with the highest values obtained near the area of the most contaminated vegetation. These same groundwater samples also contained elevated tritium. Seepage meters were used to calculate discharge rates to the river.

Although actions were taken to cut the source of ^{90}Sr to the aquifer, the residual ^{90}Sr plume continues to advance toward the Ottawa River. The primary goal of the current project is to quantify the discharge of ^{90}Sr that moves to the river annually at this location. The groundwater plume had been defined previously using widely spaced onshore monitoring wells 20 – 40 m from the shoreline. However, in this study, closely spaced mini-piezometers showed actual locations of ^{90}Sr discharge to the river and seepage meters provided direct measurements of discharge rates. As the project nears completion, the resulting data will be useful if remedial action is required.

16:05
Vertical Distribution of Radioactive Particles in Ottawa River Sediment Near the Chalk River Laboratories
D.R. Lee and D.S. Hartwig, Atomic Energy of Canada Limited, Chalk River Laboratories

The purpose of this investigation was to examine the vertical distribution of discrete grains or fragments of radioactive material in Ottawa River sediment near the cooling water discharge at the Chalk River Laboratories. Previous work showed above-background levels of radioactivity in the bed of the Ottawa River near the Chalk River Laboratories in an area 200 m wide by 400 m long, in water 10 to 30 m deep and associated with the discharge of the nuclear cooling water outfall. Particles of radioactive material were described as sand-sized grains of nuclear fuel and corrosion products. Although the natural sediment in the area is a cohesive, silty clay and contains less than 10% sand, the sediment near the outfall, where the radioactive particles are most numerous, is nearly 70% sand.

In this paper we report that the radioactive particles are almost entirely limited to the topmost 10 cm of the riverbed. Based on the thin slicing of sediment samples, our preliminary conclusion is that the majority of these particles were likely released during the operation of Chalk River's NRX reactor from 1947 to 1992.

16:30
Investigation of Tritium in Groundwater Around a Tritium Light Manufacturing Facility
D. Hart, R.V. Nicholson and M. Venhuis, EcoMetrix Incorporated

Routine environmental monitoring around the SRB Technologies property in Pembroke,Ontario, in 2004-05, found tritium in groundwater at concentrations above the federal/provincial drinking water limit of 7,000 Bq/L. An investigation was ordered to determine the source of these levels, and suggest strategies for source control. Point source leaks were suspected.

The investigation was undertaken by EcoMetrix from December 2005 to October 2007. The scope included gathering data on tritium levels in air, soil water, groundwater and nearby surface water, determining local groundwater uses and associated risks, identifying the tritium source as a basis for source control, predicting future transport of tritium in groundwater and estimating timeframes for improvement of groundwater quality.

Tritium in air was monitored using passive samplers, and modelled from annual emissions using the IMPACT code (CSA N288.1 model). Soil water from boreholes was analyzed for tritium, and concentrations were predicted from modelled air concentrations. Groundwater from 37 monitoring wells was analyzed for tritium, and concentrations were predicted from modelled historical air and soil water concentrations, allowing for decay during vertical transport to the well screen.

It was found that one-third of monitoring wells, mostly within the property boundary, had tritium in groundwater in excess of 7,000 Bq/L. The maximum tritium in groundwater was 50,000 Bq/L. Two water supply wells were hydraulically down-gradient of the stacks. One well at an office building (1,500 Bq/L) was used for drinking, and the other (5,000 Bq/L) was used for truck washing. The nearest residential supply well (450 m north-west) had tritium at 1,400 Bq/L, equivalent to approximately 2% of the public dose limit.

Tritium emissions to air peaked in the year 2000 (1.7E6 GBq/a) (well within licence limits) and have been declining since that time. Tritium in shallow soil water in 2007 was predictable from modelled tritium in air based on 2006 emissions, suggesting a time lag of about one year between air and shallow soil moisture. Tritium in groundwater was consistent with modelled concentrations based on previous years' emissions to air, with a depth-dependent time lag.

Since the tritium in groundwater issue seemed to be related to licensed emissions to air, the control strategy focused on reducing emissions to air. A new emission limit of 67,200 GBq/a was established, as a level that would produce soil water concentrations well below the drinking water limit at the facility boundary. Some deeper groundwater concentrations on site, produced by historical emissions, will continue to exceed the limit for decades. Tritium concentrations in groundwater are expected to be well below the drinking water limit prior to discharge at the nearest surface water body.

Simcoe

Fuel Cycles and Waste Processing - 1

Session Chair: Alan J. Melnyk, Atomic Energy of Canada Limited

13:30

Use of Enriched Uranium in Canada's Power Reactors

K.W. Dormuth and D.P. Jackson, D.P. Jackson and Associates

Recent trends in Canadian nuclear power reactor design and proposed development of nuclear power in Canada have indicated the possibility that Canada will break with its tradition of natural uranium fuelled systems, designed for superior neutron economy and, hence, superior uranium utilization. For instance, the Darlington B new reactor project procurement process included three reactor designs, all employing enriched fuel, although a natural uranium reactor design was included at a late stage in the ensuing environmental assessment for the project as an alternative technology. An evaluation of the alternative designs should include an assessment of the environmental implications through the entire fuel cycle, which unfortunately is not required by the environmental assessment process. Examples of comparative environmental implications of the reactor designs throughout the fuel cycle indicate the importance of these considerations when making a design selection. As Canada does not have enrichment capability, a move toward the use of enriched fuel would mean that Canada would be exporting natural uranium and buying back enriched uranium with value added. From a waste management perspective, Canada would need to deal with mill, refinery, and conversion tailings, as well as with the used fuel from its own reactors, while the enrichment supplier would retain depleted uranium with some commercial value. On the basis of reasoned estimates based on publicly available information, it is expected that enrichment in Canada is likely to be more profitable than exporting natural uranium and buying back enriched uranium. Further, on the basis of environmental assessments for enrichment facilities in other countries, it is expected that an environmental assessment of a properly sited enrichment facility would result in approval.

13:55

The Geological Disposal of Spent Nuclear Fuel Beneath Sedimentary Basins

B. Brunskill, Helix Geologic Consultants; M. Wilson, Petroleum Technology Research Centre

The risk of contamination of the geosphere surrounding any relatively shallow (less than 1000 m) used nuclear fuel repository increases with time due to the eventual degradation of engineered materials used to contain the waste. The potential for the vertical movement of this contaminated material further in the geosphere, and possibly into the biosphere, will be largely dependent upon the vertical mobility of the contaminated groundwater in the fractures in the host-rock surrounding the repository. The primary emphasis for absolute containment, therefore, should be on the selection of a geological environment that provides great vertical separation from the biosphere accompanied with a hydrogeological environment that would, due to significant resident-fluid density stratification, contain water that is geologically ancient, having been in-place for millions of years. Rocks beneath some deep sedimentary basins could potentially provide this environment. In appropriate locations, repositories could be developed using drilling methods such as those currently used to develop oil and gas resources throughout the world.

14:20

Russia: Results and Prospects of Liquid Solidification Experiments at ROSATOM Sites

Y. Pokhitonov, V. Babain, V. Kamachev, V.G. Khlopin Radium Institute; D. Kelley, Pacific Nuclear Solutions

Ongoing experimental work has been underway at selected nuclear sites in the Russian State Atomic Energy Corporation (ROSATOM) during the past two years to determine the effectiveness, reliability, application and acceptability of high technology polymers for liquid radioactive waste solidification. The long term project is funded by the U.S. Department of Energy's Initiatives for Proliferation Prevention (IPP) program. IPP was established in 1994 as a non-proliferation program of DOE / National Nuclear Security Administration and receives its funding each year through Congressional appropriation. The objectives of IPP are:

- To engage former Soviet nuclear weapons scientists, engineers and technicians, currently or formerly involved with weapons of mass destruction, in peaceful and sustainable commercial activities.
- To identify non-military, commercial applications for former Soviet institute technologies through cooperative projects among former Soviet weapons scientists, U.S.national laboratories and U.S.industry

- To create new technology sources and to provide business opportunities forU.S. companies, while offering commercial opportunities and meaningful employment for former weapons scientists.

Argonne National Laboratory provides management oversight for this project. More than 60 former weapons scientists are engaged in this project.

With the project moving toward its conclusion in 2012, the emphasis is now on expanding the experimental work to include the sub-sites of Seversk (SGCHE), Zheleznogorsk (GKhK) located in Siberia and Gatchyna (KRI) and applying the polymer technology to actual problematic waste streams as well as to evaluate the prospects for new applications, beyond their current use in the nuclear waste treatment field. Work to date includes over the solidification of over 100 waste streams for the purpose of evaluating all aspects of the polymer's effectiveness with LLW and ILW complex waste. Waste stream compositions include oil, aqueous, acidic and basic solutions with heavy metals, oil sludge, spent extractants, decontamination solutions, salt sludge, TBP and other complex waste streams. Extensive irradiation evaluation (up to 270 million rad), stability and leach studies, evaporation and absorption capacity tests and gas generation experimentation on tri-butyl phosphate (TBP) waste have been examined.

14:45

Treatment of Liquid Waste and Regeneration of Spent Ion Exchange Resin Using Electrochemical Techniques

J. Semmler and L. Chi, Atomic Energy of Canada Limited

Liquid waste and spent ion exchange resin are generated during the decontamination, refurbishment and decommissioning of nuclear power reactors and nuclear facilities. The liquid waste and spent resin may contain radionuclides, metals, organic chelating (complexing) agents and inorganic reagents. The liquid waste is treated at high cost, and the dewatered spent resin is transferred to containers and stored in a radioactive waste storage facility. During storage of resin waste, radiolytic and other decomposition processes can occur resulting in gas generation and release of free liquids. Therefore, storage facilities are built to allow continuous monitoring of the resin waste container for at least 50 years. It is therefore ideal to develop methods for the treatment of liquid and resin waste in order to treat the waste as soon as it is generated.

An electrochemical method is being developed at Chalk River Laboratories which has potential to be used for treating liquid waste and for regenerating spent ion exchange resin. A three compartment electrochemical cell has been designed and fabricated; the central compartment contains liquid waste or spent ion exchange resin, while the anode and cathode compartments contain electrolytes. This paper discusses the results of cyclic voltammetry tests performed in simulated spent CAN-DEREM™ reagents to determine the iron redox potential in these electrolytes. CAN-DEREM™ is a dilute regenerative chemical decontamination process developed by Atomic Energy of Canada.

Limited for use in the primary heat transport system of CANDU® reactors, pressurized water reactors and boiling water reactors. The paper also presents the results of tests to study the current efficiency of iron deposition as a function of solution pH, cathode material and temperature. The influence of three commercial cation exchange membranes on the transport efficiency of iron is also discussed.

The ultimate goal of the project is to force (under an electric field) the migration of metal ions in spent ion exchange resin through a membrane into the cathode compartment where they can be reduced to metal and deposited on the cathode. As a result, the spent ion exchange resin can be regenerated and reused, lowering the volume of ion exchange resin required. The reduced solid metal on the cathode would have a significantly lower volume and be much easier to dispose of.

15:10 – 15:40

Networking Break

Simcoe

Fuel Cycles and Waste Processing - 2

Session Chair: Ken W. Dormuth, Atomic Energy of Canada Limited (retired)

15:40

Removal of Bulk Contaminants from Radioactive Waste Water at Bruce A Using a Clay Based Flocculent System

R. Davloor and B. Harper, Bruce Power

Bruce Power's Bruce Nuclear Generating Station "A", located on Lake Huron, has a treatment system that processes all aqueous radioactive waste water originating from the station. This Active Liquid Waste Treatment System (ALWTS) consists of collection tanks for the collection of radioactive waste water, a Pre-Treatment System (PTS) for the removal of bulk contaminants and suspended solids, a Reverse Osmosis System (ROS) to remove dissolved solids, an Evaporation and Solidification System (ESS) to concentrate and immobilize solids contained in concentrated waste streams from the ROS, and discharge tanks for the dispersal of the treated water. The ALWTS has been in continuous service since 1999 and is used to treat approximately 100,000 litres of Active Liquid Waste (ALW) each day. With the exception of tritium, it discharges waste water containing near zero concentrations of radioactive and conventional contaminants to the lake.

The original design of the Bruce A ALWTS used a Backwashable Filtration System (BFS) to provide solids free water to the ROS, as measured by the Silt Density Index (SDI). During commissioning, the BFS was not successful in backwashing the solids from the filter elements. For approximately one year, a temporary solution was implemented using a Disposable Filtration System (DFS). A cationic polymer was added upstream of the DFS to agglomerate the solids. The system proved to be highly unreliable. It was difficult to agglomerate solids in the waste stream containing high amounts of detergent. As a result, DFS consumption was high and very costly. The SDI specification for the RO membrane was not always met, resulting in a quick decline of performance of the first stage ROS membranes in the treatment process. In addition, the excess cationic polymer in the RO feed caused the membranes to become fouled.

In-house station staff, together with personnel from Colloid Environmental Technologies (CETCO) Company, worked to develop and implement a clay-based flocculation Pre-Treatment System. In-service since late 2000, the system has been able to reliably treat a broad range of contaminants in the waste water before being sent to the downstream ROS. This clay-based system is unique in its application; it is able to remove bulk oil and grease, suspended solids, and metal contaminants in a waste stream that contains a high amount of surfactants originating from the laundering of plastic suits (personal protective equipment for working in radioactive environments) and other waste waters from the station. The treated water from the PTS consistently meets the strict requirements for subsequent treatment by the system RO membranes.

16:05

A Novel Canadian Solution for Processing and Disposal of Mixed Liquid Wastes

S. Suryanarayan and A. Husain, Kinectrics Inc.; C. Elwood, T. White and K. Wigle, Bruce Power

In 2009, Bruce Power contracted with Kinectrics for the disposal of its accumulated mixed liquid waste (MLW) inventory. The waste consists of solvent, PCB (Poly Chlorinated Biphenyls) and non-PCB contaminated oils and aqueous waste drums. The radioactivity in the wastes is principally due to cobalt-60, cesium-137 and tritium.

Historically, MLW drums originating from Canadian utilities were shipped to a licensed US facility for destruction via incineration. This option is relatively expensive considering the significant logistics and destruction costs involved. In addition, restrictions on importation of non-US PCB containing wastes also apply. Because of this, Kinectrics proposed a wholly Canadian option for the disposal of the MLW.

Disposal of Bruce Power's MLW was conceived to be carried out in three phases.

Phase 1: Develop an overall plan for disposal of the accumulated wastes,

Phase 2: Dispose the PCB oil waste drums (highest priority), and

Phase 3: Dispose all other waste drums

Phases 1 & 2 have been completed and Phase 3 is currently underway. A description of the key activities undertaken to date are described in this paper. This work sets the stage for the future management of Bruce Power's MLW based exclusively or largely on disposal within Canada. All key technical, regulatory and logistical issues pertaining to the receipt, handling, processing and shipment of the wastes were addressed. Equipment was installed for basic processing of the incoming wastes. Based on Pathways methodology, it was shown that the wastes can be shipped to unlicensed facilities within Canada without exceeding the 10 µSv per annum exposure to the critical individual. Despite this and for compliance with ALARA, wastes containing relatively elevated levels of radioactivity will be solidified and shipped for storage as radioactive waste.

16:30

Inorganic Sorbents for Radiostrontium Removal from Waste Solutions: Selectivity and Role of Calixarenes

S. Vijayan, Atomic Energy of Canada Limited; K. Belikov and A. Drapailo, National Academy of Sciences of Ukraine

The challenge for the remediation of ^{90}Sr-contaminated waters arises from the need to achieve very high removal efficiencies to meet discharge targets from waste effluents containing relatively high concentrations of non-radioactive cations. Low-cost natural zeolites that are not selective for strontium over other divalent cations, notably by such ions as calcium, produce low ^{90}Sr removal performance, and large volumes of spent sorbent waste. The synthesis and use of selective, synthetic inorganic sorbents could prove to be a feasible approach for high ^{90}Sr removal efficiencies, and much smaller volumes of secondary solid waste generation. The essential advantages of inorganic sorbents include their stability and resistance to radiation, and the potential for producing stable waste forms such as vitrified glass or ceramics for disposal. However, presently, the cost of strontium-specific sorbents is prohibitive for large-scale applications.

This paper is a review of the reported information on removal mechanisms and performance of Sr-specific inorganic sorbents. The analysis has revealed promising performances, efficiency and selectivity for strontium removal from solutions containing low and high concentrations of salts. The leading sorbents are crystalline silicotitanate and oxides of metals such as titanium. An initial assessment has also been made of the performance of calixarene-based macrocyclic compounds. These are known for their selectivity for strontium in solvent extraction processes.

From the initial strontium removal results in bench-scale tests using different solid substrates, impregnated with calixarene derivatives, only sodium-mordenite impregnated with calyx[8]areneamide gave an overall strontium removal efficiency in the range of 90 to 95% in the presence of 3.5 ppm calcium. There was no improvement observed for strontium- removal efficiency or selectivity over calcium in the calixarene-impregnated inorganic sorbent matrix. In several tests, the overall efficiency of the sorbent was lost by up to 50% in the presence of high concentrations of Ca (e.g., 15 ppm). Presently, the reasons for this behavior are not evident.

This paper also reports high strontium removal performance measured in column tests using the crystalline silicotitanate sorbent with actual ground waters containing low and high concentrations of calcium. The spent sorbent waste volume has been estimated to be approximately one order of magnitude less than that using a natural zeolite such as chabazite. Until costs can be lowered, the presently available selective sorbents are not attractive for large volume applications. Further development in the modification of relatively low-cost sorbents, including natural zeolites and certain metal oxides such as titanium and zirconium oxides, would be advantageous.

Sponsor and Exhibitor Corporate Profiles

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Cameco Fuel Services Division has three locations in Ontario:

- **Blind River Refinery** – Cameco's Blind River operation is the world's largest uranium refinery. The plant processes uranium concentrate from mines around the world including Canada, the US and Australia to produce a high-purity uranium trioxide (UO_3) powder. This product is shipped to Cameco's Port Hope conversion facility as well as other conversion facilities in the US and Europe for further processing.

- **Port Hope Conversion Facility** – one of the only three conversion suppliers in the western world that owns or controls about 35% of western world nameplate capacity to produce uranium hexafluoride (UF_6) required to produce fuel for light water reactors. Converts refined uranium trioxide (UO_3) to other chemical forms needed to produce fuel for electricity generation. The plant uses separate processes to produce natural uranium dioxide (UO_2) to fuel Canadian-designed CANDU® reactors and uranium hexafluoride (UF_6) to feed enrichment plants in the US and Europe that produce the fuel for light water reactors.
- **Cameco Fuel Manufacturing** – one of two Canadian suppliers of finished fuel bundles for Candu reactors. Operates with locations in Port Hope and Cobourg – CFM's primary business is the manufacture and sale of fuel bundles for CANDU® reactors. CFM is one of two fuel manufacturers serving nuclear utilities in Canada. The company also provides nuclear fuel and consulting services to CANDU® operators around the world.

Approximately half of Ontario's electricity is generated using uranium processed in these facilities.

Cameco is widely viewed as an employer of choice and is a proud, active, responsible member of each local community.

Canadian Nuclear Safety Commission

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The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and to implement Canada's international commitments on the peaceful use of nuclear energy.

The CNSC was established in 2000 under the Nuclear Safety and Control Act (NSCA) and reports to Parliament through the Minister of Natural Resources. The CNSC was created to replace the former Atomic Energy Control Board (AECB), which was founded in 1946. Under the NSCA, the CNSC's mandate involves four major areas:

- regulation of the development, production and use of nuclear energy in Canada to protect health, safety and the environment;
- regulation of the production, possession, use and transport of nuclear substances, and the production, possession and use of prescribed equipment and prescribed information;
- implementation of measures respecting international control of the development, production, transport and use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons and nuclear explosive devices; and
- dissemination of scientific, technical and regulatory information concerning the activities of CNSC, and the effects on the environment, on the health and safety of persons, of the development, production, possession, transport and use of nuclear substances.

The CNSC's Commission Tribunal has up to seven appointed permanent members whose decisions are supported by CNSC staff. These employees review applications for licences according to regulatory requirements, make recommendations to the Commission, and enforce compliance with the NSCA, regulations, and any licence conditions imposed by the Commission.

The CNSC is currently celebrating its 65th year of regulating nuclear safety in Canada.

Canberra Co.

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Canberra is the leading supplier of innovative and cost-effective nuclear measurement solutions and services used to maintain safety of personnel, assess the health of nuclear facilities and safeguard the public and the environment. Applications for Canberra offerings include health physics, nuclear power operations, Radiation Monitoring Systems (RMS), nuclear safeguards, nuclear waste management, environmental radiochemistry and other areas.

CH2M HILL Inc.

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Headquartered in Denver, Colorado, employee-owned CH2M HILL is a global leader in full-service program management, engineering, construction, and operations for government, civil, industrial and energy clients. With $6.3 billion in revenue and more than 23,000 employees, CH2M HILL is a FORTUNE 500 firm and an industry-leading program management, construction management and design firm, as ranked by Engineering News-Record. CH2M HILL delivers innovative, yet proven solutions to overcome program management barriers, providing breakthrough success—for every client, on every project, every time.

CH2M HILL specializes in the management of complex nuclear programs and projects around the globe. For more than two decades, CH2M HILL has been the nuclear operations contractor responsible for material handling and process operations, spent fuel operations, facility operations and environmental remediation and decommissioning operations for commercial and government facilities and sites worldwide. We are one of the few firms with the experience necessary to manage and operate large nuclear projects with inherent radiological, chemical, and industrial safety challenges. CH2M HILL provides program management and consulting services for some of the world's largest civil nuclear power programs through all phases, from program development through commissioning. In addition, we provide planning, permitting, and licensing of new nuclear generating stations within the 21st century regulatory environment.

CH2M HILL provides innovative clean up and closure solutions for the most contaminated sites in the U.S. DOE nuclear weapons complex and in U.K. NDA sites, while successfully and safely delivering projects ahead of schedule and under budget. In addition, we ensure the decommissioning, waste management, waste fuel strategies, and support service operations at civilian nuclear research sites in the United Kingdom and the United States result in reduced costs and improved schedule performance, quality, and safety standards.

EcoMetrix Incorporated

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EcoMetrix is an environmental consulting firm that is employee-owned and operated. EcoMetrix provides specialized knowledge-based services to the leaders of industry within the Nuclear, Energy, Forest Products and Mining Sectors, and to Government Agencies and other professional service companies.

On behalf of the nuclear industry, EcoMetrix provides a broad range of environmental services. These include modeling of radionuclides and other contaminants in air, water, groundwater and soil, analysis of transport pathways and radiation doses to biota and humans, environmental baseline studies for new facilities and environmental monitoring for existing operations, development of cleanup criteria and strategies for remediation of contaminated materials, preparation of environmental assessments, and development of decommissioning plans. EcoMetrix is frequently retained to assist nuclear facilities in obtaining licenses, and in communication with regulators and stakeholders on technical matters pertaining to environmental impacts. EcoMetrix has also completed various studies on behalf of nuclear industry associations, crown corporations, research facilities and regulators, and has been active in development of environmental standards for the nuclear industry.

The professionals at EcoMetrix have completed assessments for all major phases of the nuclear fuel cycle, including assessments for uranium mines and mills, uranium refineries, nuclear fuel fabrication facilities, nuclear power stations, and radioactive waste management facilities. IMPACT, an environmental pathways model for radionuclides and non-radionuclides, developed by EcoMetrix, has been used in many of these assessments, and is also widely used by CANDU owners for calculation of public doses and derived release limits.

Energy*Solutions*

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Energy*Solutions* is an international nuclear services company with operations around the world. Our portfolio spans the entire nuclear lifecycle from new build, operations, engineering and technology, facility decontamination and decommissioning, defueling, reactor dismantling, transportation, waste processing and recycling to complete site restoration.

Energy*Solutions* Canada, an ISO 9001 registered company, provides comprehensive, integrated services and solutions to the Canadian nuclear industry. We operate a Canadian Nuclear Safety Commission licensed facility where we safely and cost-effectively manage waste, perform decommissioning projects and meet the significant fuel cycle and waste management challenges faced by our Canadian government and commercial customers.

Energy*Solutions* brings new ideas, new approaches and real innovation.

ENVINET Pico Envirotec Group

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The strategic aim of the ENVINET Pico Envirotec Group is to supply high quality equipment, provide innovative solutions and complex services in the field of nuclear power, radiation protection, manufacturing of ionizing radiation detectors and radiometric systems, radioactive waste characterization, chemical and radiochemical measurements, laboratory technologies, industrial automation and customized information systems products.

ENVINET has been operating as an engineering, designing and supplying company for the nuclear power industry in Europe for about 20 years. The company is an expert in development and manufacturing of radioactive waste characterization equipment and unique free-release measurement technology. In recent years ENVINET has successfully completed many projects implemented at nuclear power facilities. The geography of these includes the following countries: the Czech Republic, Slovakia, Italy, Bulgaria, the Netherlands, Finland, Lithuania, Romania, Armenia, the Ukraine and the Russian Federation.

ENVINET owns highly specialized Detectors Technology Division where the plastic scintillators, NaI(Tl) scintillation crystals, scintillation detector assemblies are uniquely manufactured. These products match the portfolio of world-wide known detector manufactures and are also utilized by expert producers of the ionizing radiation detection systems.

ENVINET is certified in accordance with the international standards ISO 9001, ISO 14001, OHSAS 18001, ISO 20000, ISO 27001.

In 2011, ENVINET entered into a partnership with Pico Envirotec Inc., a Canadian Company engaged in the development and manufacturing of the radiometric equipment. The ENVINET Pico Envirotec Group was formed with a view to present its products to the North American market.

Priority of the partners is to meet the demands of the customers, and challenge the high requirements of the industrial production and nuclear energy industry, at favorable prices while respecting the environment.

GEOVARIANCES

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GEOVARIANCES is a leading provider of advanced geostatistical solutions. The company offers the most complete solution in geostatistics: innovative methodologies, experts and software packages to answer its customers' challenges in mapping, resource evaluation, volumetric estimation, risk analysis.

GEOVARIANCES also provides its customers with a full range of services including technical support, training, mentoring and consulting, to ensure optimum performances in an operational context.

GEOVARIANCES' sectors of expertise are the Environment for natural resource evaluation, and pollution estimation, Mining, Oil & Gas, as well as any field where geostatistics applies including civil engineering, fisheries, oceanology, agriculture, forestry, epidemiology, etc.

GEOVARIANCES develops and sells KARTOTRAK, the first all-in-one software solution dedicated to soil contamination characterization.

Born out of a partnership between the French Alternative Energies and Atomic Energy Commission (CEA) and GEOVARIANCES, KARTOTRAK is designed to characterize sites that are contaminated by radioactive substances before, during and after soil or structure clean-up.

KARTOTRAK is a GIS-based software which integrates a real-time data acquisition system, data analysis and modeling workflows, sampling optimization algorithms and reporting tools. KARTOTRAK embeds geostatistics to valorize data and precisely map the contamination at each step of the characterization sequence with an efficient risk assessment. That way, KARTOTRAK leads to a reduction of radiological waste with full control of related costs and deadlines.

GEOVARIANCES has also been developing and selling ISATIS geostatistical software solution for the last 25 years, regarded as the Reference in geostatistics.

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Kinectrics is uniquely qualified to provide complete waste management, decommissioning, plant chemistry and environmental-related services for Canada's nuclear industry. Our qualified nuclear experts, working in accredited, licensed facilities, can provide a full suite of specialized capabilities based on decades of experience in waste management, chemistry, materials characterization and radioactive materials analysis. The Kinectrics team offers the advantage of in-depth knowledge of CANDU® systems, source term management and the movement of radioactivity around the primary circuit . Our services include:

- Liquid and solid waste management
- Decontamination and Decommissioning
- Radioactivity Monitoring and Assay of Waste Packages
- Waste Characterization
- Condition Assessment
- Safety and Licensing

Kinectrics' capabilities for mixed liquid waste disposal cover pathways analysis and waste solidification and, we offer a unique Canadian solution for managing both PCB-contaminated and other mixed wastes.

Kinectrics' Analytical Chemistry Laboratory is a large specially-equipped facility accredited for a number of tests, including radiochemical analysis. Kinectrics also develops scaling factors for various difficult-to-measure radionuclides typically present in reactor waste.

Our clients include some of North America's largest nuclear utilities. Kinectrics is capable of undertaking large-scale field projects and has a proven track record in delivering R&D solutions for bench and pilot-scale process development. Recent major projects include:

- Resin Liner Over-packing
- Survey and remediation of contaminated properties
- Cleaning and decommissioning of large pump motors and heat exchangers
- Optioneering study for waste conditioning facility
- Development of radionuclide inventory for steam generators
- Clean-up of organic carbon contaminated heavy water
- Disposal of PCB liquid wastes
- Support and waste characterization for a Deep Geological Repository

NAC International

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NAC International (NAC) is an industry-leading provider of engineering and nuclear fuel management solutions for nuclear facility operators, fuel cycle companies and government agencies. The company offers a proven process for the design, licensing and deployment of innovative technologies to store, transport and manage nuclear materials, including waste and spent fuel. In 2009, NAC received the U.S. NRC Certificate of Compliance for the MAGNASTOR System dry storage technology, offering spent fuel storage capacity and operational advantages superior to those of any other concrete, canister-based system. Our professional staff possesses unsurpassed industry knowledge and experience, necessary for today's demanding requirements for nuclear project management and performance. NAC is also a leading provider of nuclear spent fuel transportation services and operates a commercial fleet of spent fuel transport casks.

In addition, NAC's Consulting division continuously serves the world's most prestigious nuclear organizations in providing impartial evaluation, consulting and training services in all technical and business aspects of the nuclear fuel cycle. No matter how complex the nuclear market may become, NAC's specialized consultants will be there to provide well-informed analysis. NAC's unique reputation for customer-centric service is reinforced by its diverse customer portfolio of the world's leading nuclear organizations.

Nuvia Canada

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Nuvia is a nuclear specialist across the complete lifecycle from new build, through operations and maintenance, to final decommissioning and waste management. Benefit is taken from being able to draw on radiation safety expertise that is involved in all activities from front end nuclear design, through operations to final waste disposal.

We provide all of the services needed to safely, economically, and successfully plan and undertake nuclear decommissioning and waste management projects. Our services include strategic and technical consultancy, development of engineered solutions, radiological protection, and management of field operations.

Nuclear Waste Management Organization

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The Nuclear Waste Management Organization (NWMO) was established in 2002 by Ontario Power Generation Inc., Hydro-Québec and New Brunswick Power Corporation in accordance with the Nuclear Fuel Waste Act to assume responsibility for the long-term management of Canada's used nuclear fuel.

On June 14, 2007, the Government of Canada selected the NWMO's recommendation for Adaptive Phased Management (APM). APM moves towards a goal that Canadians themselves identified: safe and secure long-term containment and isolation of used nuclear fuel produced in Canada, with flexibility for future generations to act in their own best interests. The NWMO now has the mandate to implement the recommendation.

Ontario Power Generation

Nuclear Waste Management Division
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OPG is an Ontario-based electricity generation company whose principal business is the generation and sale of electricity from its generating assets, while operating in a safe, open and environmentally-responsible manner. With an in-service capacity of 19,931 megawatts OPG operates 65 hydroelectric generating stations, two wind power turbines, five thermal generating stations, and three nuclear generating stations.

OPG's Nuclear Waste Management Division (NWMD) is responsible for the interim storage of low, intermediate and high level nuclear waste from Ontario's 20 nuclear reactors. The Division operates facilities at the Bruce, Darlington and Pickering nuclear sites. OPG is currently in the planning stages of a Deep Geologic Repository for the long-term management of low and intermediate level waste at the Bruce site.

OPG has been safely storing nuclear waste from the Bruce, Pickering and Darlington generating stations for more than 40 years and we are proud of our operating record and the progress we have made towards long-term solutions for the future.

Through employing highly qualified staff, careful planning, development of technology and equipment and the use of sound operating procedures, OPG has ensured that radioactive waste is managed safely and poses no significant risk to employees, the public or the environment.

Our facilities and transportation programs are licenced and monitored by the Canadian Nuclear Safety Commission. We comply with conditions, directives and regulations from a number of oversight agencies including: Natural Resources Canada, Transport Canada, the Canadian Environmental Assessment Agency, the Provincial Ministry of the Environment and; the International Atomic Energy Agency.

For further information visit www.opg.com or drop by Booth 106 during the conference and speak to an employee.

Perma-Fix Environmental Services, Inc.

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As a leader in the field of environmental remediation and waste management, we pride ourselves on innovations to comprehensively, compliantly and safely manage wastes to meet and exceed our client's needs. Perma-Fix is an integrated nationwide network of treatment, storage and disposal facilities; site remediation teams; on-site services; and environmental consultants that provides you with comprehensive, cost effective waste management services.

Perma-Fix provides turnkey LLW and MLLW treatment and disposal services that minimize our customers' liability with timely and compliant disposition of the most difficult waste challenges. Perma-Fix operates four fixed based radioactive waste treatment facilities and is the only commercial company in the U.S. capable of treating the full scope of low-level mixed waste.

Our clients include the U.S. federal government as well as research laboratories, medical facilities and nuclear power generators both in the U.S. and Canada.

Perma-Fix's largest onsite initiative is at the U.S. Department of Energy (DOE) Hanford Site as part of the CH2M Hill Plateau Remediation Company (CHPRC) team. The Central Plateau is undergoing cleanup from decades of plutonium production in support of the nation's defense. Perma-Fix provides project management, waste management, operation of storage and repackaging facilities, operation of onsite disposal facilities, and waste treatment to support CHPRC in its mission to perform remediation, clean-up, and waste management activities for the DOE. Perma-Fix's M&EC PRC division employs approximately 280 personnel on the Hanford Site and includes management of DOE's oldest Category 2 Nuclear Facility, T-Plant.

Promation Nuclear Ltd.

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Promation Nuclear has developed leading edge technologies for nuclear customers for many years. Promation's engineering and advanced technologies are designed to provide cost effective solutions in waste handling and management, plant life management and plant life extension. We have developed a wide range of solutions including specialty equipment and automated tooling for waste handling, reactor refurbishment, fuel handling systems and also large scale mock-ups and test rigs. Promation offers complete turnkey solutions through its innovative engineering, advanced manufacturing and superior customer support.

Promation Nuclear's strengths are its engineering applications and development capabilities. experienced team of engineers and coupled with practical development facilities.

Products

- Waste Handling and Inspection Tooling
- Lead flasks and waste containers
- Fuel Channel Replacement Tooling
- Steam Generator Maintenance
- Calandria Inspections
- Reactor Components
- Fuel Handling Systems
- Mock-ups and Test Rigs
- Robotics and Automation
- 3D Laser Scanning

Services

- Development and Testing
- Engineering and Design
- Manufacturing
- System Assembly and Integration
- Training

Promation Nuclear is committed to Quality, and is certified for the following:

- Certified to ISO 9001
- Compliant with CSA N286.2 and CSA Z299.1
- Audited to Z299.2 by CANPAC
- Certified to CSA B51 for vessels, piping, selected fittings.
- Certified to CSA N285.0 for design and manufacture of Class 1,2,3 & 4 vessels, piping systems, supports, material up-grades, and selected fittings at our plant, and nuclear item repair, modification, or replacement at nuclear field sites
- Software Class 3 as per IEC 61513 (equivalent to OASES Category 3)

Quantum Murray LP

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Quantum Murray LP (QMLP) is Canada's premier industrial decommissioning company with a full line of services including demolition, remediation, hazardous materials abatement, emergency response and training as well as the salvaging and recycling of scrap metals.

In 2007, Murray Demolition, Quantum Environmental and Thomson Metals & Disposal came together to create the strongest industrial services offering in the nation.

Through the development of a strong network of suppliers, sub-contractors and strategic partnerships, QMLP is able to offer our clients a diverse range of specialized services. Building strong partnerships in key areas allows us the flexibility to take on a variety of technically complex projects.

With offices across Canada and with more than 700 employees, the QMLP team seamlessly provides complete decommissioning, hazardous waste abatement and management, scrap metal salvage and investment recovery, environmental remediation and soil management and emergency response services to all market sectors from institutional and governmental to commercial and industrial.

Rolls-Royce Civil Nuclear Canada Ltd.

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Rolls-Royce is trusted to deliver excellence and has been delivering that excellence for over 100 years to businesses that require reliability, such as aerospace, marine and energy.

The Rolls-Royce group invests in excess of $1.5 billion in R&D every year, ensuring that it remains at the forefront of technology and innovation in everything it does.

World-wide recognition for manufacturing excellence has been won through the utilization of lean manufacturing techniques and stringent production system principles. Product integrity is assured.

Management of the United Kingdom's nuclear submarine program has given Rolls-Royce 50 years of experience in all aspects of the nuclear fuel cycle, including:

- nuclear R&D,
- reactor design, licensing, fabrication and operation,
- fuel development and fabrication, and
- nuclear waste packaging and management.

This experience is now being utilized to service the growing world-wide Civil Nuclear industry, and has led to significant supply agreements being signed with major reactor vendors such as Westinghouse and AREVA.

The Canadian footprint includes a recently acquired 100-person strong design/build business based in Peterborough, Ontario. This business has been a supplier of key equipment to the Canadian nuclear industry and the US Department of Energy. Its Canadian experience includes:

- the Fuel Retrieval and Repackaging System for AECL, Chalk River, and
- the transfer and lid clamps, stands and spares for the Ontario Power Generation Dry Storage Containers.

Whether you require a problem solved, a service provided or the cost-effective supply of high quality components, Rolls-Royce will be with you from the start of the cycle to its end.

Safety and Ecology Corporation

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Safety and Ecology Corporation (SEC) provides a wide range of environmental services worldwide including RAD/HAZ remediation; Decontamination; Facility D&D; RADCON; and Emergency Response. We specialize in the removal and remediation of hazardous materials. SEC has one of the largest RAD/IH Instrumentation labs in country where we provide rental, calibration, and repair services.

Saskatchewan Research Council

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The Saskatchewan Research Council (SRC) is Saskatchewan's leading provider of applied research and development and technology commercialization. SRC has been providing Smart Science Solutions™ to communities, governments and a variety of industries around the world for more than 60 years.

Internationally recognized for both facilities and expertise, SRC offers a broad range of research and technology services and solutions in key sectors such as agriculture and biotechnology, mining and minerals, energy and environment.

Since 1947, SRC has worked closely with clients to convert new ideas and knowledge into commercially successful products and services that increase competitiveness and boost the economy.

Operating in more than 33,500 square metres of bench scale laboratories and pilot scale facilities, SRC has over 420 skilled employees that serve more than 1,950 clients and partners.

SRC has scientific, technical and management expertise in environmental remediation, as well as experience working with regulators and interested parties such as communities, Aboriginal groups and industry.

A large-scale, multi-year, multimillion-dollar remediation project to cleanup 38 abandoned uranium mine sites in northern Saskatchewan is currently managed by SRC. Project CLEANS (Cleanup of Abandoned Northern Sites) is a fully integrated project that relies on the expertise of not only SRC's scientists, researchers and field experts, but also on key collaborations with the private and public sector.

The mining industry turns to SRC's uranium laboratories and Advanced Microanalysis Centre™ for reliable minerals analysis. One of the largest accredited secure diamond facilities in the world operates at SRC. Also available to the resource sector is the internationally acclaimed Pipe Flow Technology Centre™, which helps clients conduct commercial-scale studies on cost-effective ways to extract, transport and process waste from mineral and oil resources.

Providing environmental monitoring, measuring and reporting services, SRC Environmental Analytical Laboratories helps companies address environmental challenges. The lab offers a variety of environmental analytical services, from water quality testing to radiochemical analysis.

SNC-Lavalin Inc.

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SNC-Lavalin is one of the leading engineering and construction groups in the world and is a major player in the ownership of infrastructure, and in the provision of operations and maintenance services. SNC-Lavalin has been in business since 1911 and now employs over 25,000 staff around the world. It is celebrating its 100th anniversary in 2011.

As a founding member of Team CANDU, SNC-Lavalin's involvement in the nuclear industry parallels the development of nuclear technology in Canada over the last 40 years with areas of expertise spanning uranium mining and processing, nuclear power station design and refurbishment, decommissioning, and environmental restoration. SNC-Lavalin proudly serves sector leaders such as OPG, Bruce Power, AECL, New Brunswick Power, Cameco, and the NWMO.

SNC-Lavalin is uniquely positioned with an in-house environmental services group that has extensive experience in radioactive waste management, decommissioning, and undertaking complex restoration and remediation projects for our clients. Some of our many project highlights include:

- **NWMO** - engineering analysis to update conceptual design, schedule and costs for a Deep Geological Repository for Canadian nuclear wastes and associated facilities, and waste retrieval from current storage locations
- **Bruce "A" Nuclear Generating Station** - replacement of steam generators in Units 1 & 2 and Balance of Plant refurbishment to re-start the laid up plant;
- **Cameco** - comprehensive engineering services for Port Hope uranium conversion facility ; development of Cameco Vision 2010, a comprehensive redevelopment master plan for the Port Hope facilities that includes large scale site remediation
- **AECL** - low level radioactive waste management pilot programs for removal of contaminated fill throughout the Town of Port Hope; development of decommissioning plan for Chalk River; newly acquired licensing of CANDU technology and on-going operations and maintenance programs;
- **Pt. Lepreau Generating Station** - original siting, design and construction of this station along the Bay of Fundy and business case for two new 1100 MW plants

US Ecology / Stablex

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US Ecology operates five hazardous and radioactive waste treatment and disposal facilities in Canada and the US, including Stablex in Quebec. US Ecology and Stablex provide transportation, treatment and disposal services for hazardous, naturally-occurring radioactive material (NORM), and low-activity CNSC and US NRC licensed radioactive materials. US Ecology provides full service truck or rail transportation, including all export/import services. US Ecology has made over several hundred international radioactive materials shipments between Canada and the US, all in full compliance with all international regulations.

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Unified Engineering
30 years of turning ingenuity into practice
ISO 9001:2008 CAN Z299.3

Unified Engineering provides professional engineering services specializing in industrial applications with complementing fabrication, assembly and installation services. Our services extend to providing automated control systems, OEM custom machinery, and on-site multi-trade services including Pre-Start Health & Safety Reviews. A multi-discipline company, UE designs mechanisms and equipment from an initial concept to a design build solution. Using the latest solid modelling and FEA technology we are able to provide a turn key innovative solution.

Unified Engineering (UE) is an integrated Engineering and Manufacturing company with customers in the Nuclear, Power Generation, Steel Foundry and Automotive Industries.

For over 30 years, Unified has been recognized for its technical expertise with prototype development, product design and custom fabricated solutions.

Our project portfolio includes:

- Specialized high capacity lifting equipment
- Generator jacking systems
- Shielding structures
- Material handling systems
- Metal fabrication (Catwalks, Walkways, Mezzanine structures)
- Prototype Development
- Waste Containers
- Laboratory testing equipment
- Nuclear Tooling
- Conveyors
- Turbine Transportation & Storage Containers
- Hydraulic Presses
- Batch Style & In process Curing Ovens (Humidity, Temperature Controlled)
- Leak testing machinery
- Field Welding Repair (Wind, Rotor, Ship)
- Specialty TIG Welding (Aluminum, SS, Boral)

WorleyParsons Canada - Nuclear Energy

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WorleyParsons

WorleyParsons has been actively engaged in all phases of the nuclear power industry for over 55 years. Our involvement includes plant engineering and design, modification, construction management and providing nuclear D4+ consulting services. We have a reputation as a provider of high-quality, cost effective engineering services.

Globally, we hold world-class credentials and deliver full-service design analysis, modification engineering, extended power up-rate, license renewal, D4 consulting services, construction management, power station due diligence evaluations, and early site permitting assessments / evaluations and analyses. We also have extensive consulting expertise with decommissioning, deactivation, decontamination, demolition, strategic planning, nuclear safety analysis, planning/management tools, operational/project readiness, engineering & operations support, and environmental compliance.

In Canada, we have 7,500 employees of which 1,000 are located in Ontario. Our Markham operation is 1 of 3 nuclear delivery hubs for the global organization. WorleyParsons has a Nuclear Quality Assurance Program that has been audited and is compliant with CSA N286.1, N286.2, and Z299.1.

Author Index

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