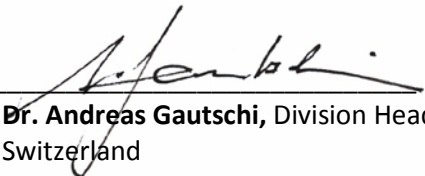


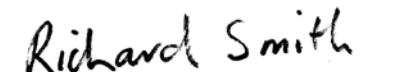
2012-2013 Report of the NWMO Adaptive Phased Management Geoscientific Review Group (GRG)

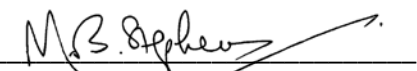
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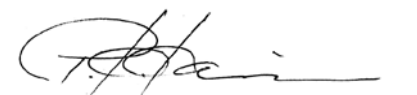
October 2013

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2012-2013 Report of the NWMO Adaptive Phased Management Geoscientific Review Group

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Summary

This report provides a summary of the work completed by the Adaptive Phased Management Geoscientific Review Group (APM-GRG; abbreviated to GRG) during the period of 2012-2013. The GRG activities included reviews of: (1) the approach, methods and criteria being used by NWMO to conduct desktop geoscientific assessments for eight of the 21 communities involved in NWMO's site selection process; (2) the approach, methods and criteria used by NWMO to identify and assess geoscientific uncertainties that would need to be addressed in subsequent stages of the site evaluation process; and (3) a generic preliminary field investigation program planned for Phase 2 of the preliminary assessments.

The GRG is impressed by the approach adopted by the NWMO and the progress made during 2012-2013. The NWMO team and its consultants have undertaken high quality work that allowed the GRG to carefully assess approaches and conclusions.

The GRG has systematically reviewed the processes and has advised NWMO on means to strengthen them. Throughout 2012-2013, NWMO has systematically tracked and commented on the GRG's recommendations and responded to all requests in a satisfactory manner. The GRG reviewed the findings of the desktop studies for eight communities and concluded that the resulting geoscientific assessments, despite the obvious remnant uncertainties, are sound and form a reliable basis for the identification of potentially general suitable siting areas in each community.

The GRG agrees with NWMO that all eight communities contain potentially suitable siting areas. However, there are varying degrees of geoscientific uncertainty amongst the communities.

For this purpose, NWMO has developed a process for the identification and assessment of residual uncertainties. The GRG has reviewed the methodology for this assessment and found it to be appropriate for supporting a decision on which communities warrant further consideration in Phase 2. The GRG recommends that, to the extent possible, the NWMO considers selecting communities that cover a variety of geological settings. For future decision-making, systematic selection criteria must be developed and should be applied once reliable data become available during Phase 2.

The GRG has reviewed the scope of work for the Phase 1 Geoscientific desktop preliminary assessment for sedimentary sites and the generic work program for Phase 2 of the geoscientific preliminary assessment and provided preliminary advice for the implementation of these programs. The GRG has also been informed of the generic geoscientific work plan for the remaining communities.

A high standard has been achieved at this early desktop stage of the site assessment process and, based on the experience of the GRG members, the adopted approach follows or exceeds best international geoscientific practice.

Introduction

The Adaptive Phased Management Geoscientific Review Group (APM-GRG; abbreviated to GRG) was established by NWMO management to provide advice and review comments on the preliminary geoscientific assessments being conducted as part of NWMO's site evaluation process to identify a suitable host community for a deep geological repository for Canada's used nuclear fuel. The suitability of communities is assessed using a staged approach including Initial Screenings, Preliminary Assessments and Detailed Site Characterization, considering both technical and community well-being factors (NWMO 2010).

Mandate of GRG

The mandate of the GRG is to provide advice and to review NWMO findings during both the desktop and preliminary field investigation phases of the preliminary assessments. The review group provides comments and recommendations on the adequacy of the:

- Findings regarding the location and potential suitability of siting areas identified for each community during the desktop study;
- Preliminary assessments of relative geoscientific suitability of potential siting areas identified in the communities considered in the site evaluation process; and
- Generic, preliminary field investigation programs proposed to further assess and increase confidence in the potential suitability of siting areas identified for each community.

A brief biography of the five GRG members for the term 2012-2013 is provided in Attachment 1.

Objectives of geoscientific preliminary assessments

The overall preliminary assessment is a multidisciplinary study integrating both technical and community well-being assessments, including geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic and cultural considerations.

The objective of the geoscientific preliminary assessment is to assess whether communities contains areas that have the potential to meet NWMO's geoscientific site evaluation factors. The preliminary assessment is conducted in two phases:

- **Phase 1 - Desktop Study.** For all communities electing to be the focus of a preliminary assessment. This phase involves desktop studies using available geoscientific information and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the preliminary assessment.
- **Phase 2 - Preliminary Field Investigations.** For a subset of communities selected by the NWMO, to further assess potential suitability. This phase involves preliminary field investigations that include high resolution geophysical surveys, geological mapping and the drilling of deep boreholes.

The subset of communities considered in Phase 2 of the preliminary assessment will be selected based on the findings of the overall desktop preliminary assessment considering technical and social, economic and cultural considerations.

As indicated below, the mandate of the GRG is entirely focussed on the geoscientific suitability assessment component.

Purpose of this status report by the GRG

The purpose of this report is to summarize the activities of the GRG and the review comments provided by the review group during the period 2012-2013. During this time, the GRG's review activities focused on the following:

- Approach, methods and criteria being used by NWMO to conduct desktop geoscientific assessments and identify potentially suitable siting areas in each community;
- Approach, methods and criteria used by NWMO to identify critical uncertainties that are relevant for identifying a subset of communities suitable for further geoscientific characterization during Phase 2; and
- Generic, preliminary field investigation program planned for Phase 2 of the preliminary assessments.

At this stage, the GRG systematically reviewed the findings of the desktop studies for eight communities.

Review Activities of GRG during 2012-2013

NWMO completed preliminary assessments for eight of the 21 communities involved in the site selection process. These are: English River First Nation, Pinehouse and Creighton in Saskatchewan; and Ear Falls, Ignace, Schreiber, Hornepayne and Wawa in Ontario (Figure 1). Preliminary assessments for the other communities are still ongoing and will be reviewed by the GRG as they are nearing completion.

During the review period 2012-2013, the GRG met three times in Toronto (March 5-6, 2012, August 23-24, 2012 and April 25-26, 2013) and held two teleconference calls (August 17, 2012 and April 18, 2013). Review activities included the following:

- Review of scope of work documents describing the approach, methods and criteria for conducting the desktop assessments in both crystalline and sedimentary bedrock;
- Review of final draft desktop preliminary geoscientific suitability assessment reports, as well as supporting documents (geophysical interpretation report, lineament interpretation and terrain analysis) for each of the eight communities;
- Review of the process for the identification and assessment of residual geoscientific uncertainties relevant to each community; and
- Review of the summary document describing a generic preliminary field investigation program planned for Phase 2 of the preliminary assessments.

The review findings of the GRG were discussed during the meetings in Toronto with NWMO staff and consultants involved in the preliminary geoscientific assessments (AECOM, Golder, Geofirma, and their sub-consultants PGW, JDMA, SRK, Stott Geoconsultants and Mira Geoscience).

The review process progressed as follows:

- An initial presentation was made by NWMO staff to provide an overview of Adaptive Phased Management, the NWMO site evaluation process, the scope of work for the desktop geoscientific assessments, and a summary of initial screening findings;
- NWMO shared with the GRG the findings of the desktop geoscientific assessments as they became available;
- Workshops and teleconferences were held to discuss GRG review comments; and

- Final products were reviewed to ensure that previous review comments were addressed by NMWO to the satisfaction of the GRG.

Overall Assessment of Progress

A systematic, iterative process was developed and followed by NMWO for review by the GRG.

The GRG is impressed by the adopted approach and the progress made over the last two years. The NMWO team and its consultants have undertaken high quality work that allowed the GRG to carefully assess approaches and conclusions. The GRG has made many suggestions for process improvements and it is pleased to report that NMWO has responded to the identified issues in a timely and transparent manner.

Specific contributions of the GRG include:

- Guidance on the reporting of the desktop studies being undertaken for each community bearing on the improved comprehension and completeness of geoscientifically relevant matters such as metamorphism, uplift and erosion, in-situ stress and thermal conductivity, hydrogeological significance of dykes and topography, etc.;
- Advice on the identification and appropriate documentation of geological and geophysical data sources and their quality;
- Technical advice on the appropriate characterization, adopted nomenclature, and process of analysis for the interpretation of surficial and geophysical lineaments; and
- Systematic review and quality assurance of draft documents to ensure achievement of high international standards.

As a consequence, NMWO has assembled public data relevant for the Phase 1 Desktop Assessment Phase. A high standard has been achieved at this early stage of the site evaluation process and, based on the experience of the GRG members, the adopted approach follows or exceeds best international practice at this early phase of assessment.

The GRG has reviewed systematically the assessment process and, as described previously, has advised NMWO on means to strengthen the process. Throughout 2012-2013, NMWO has tracked and commented on the recommendations and responded to all requests in a systematic and satisfactory manner.

Potential Suitability of the First Eight Communities

All eight communities are located in the Canadian Shield and are underlain by crystalline rocks of Precambrian age. All potential siting areas have been affected by the last glaciations ending approximately 10,000 years ago and by subsequent surface uplift. All areas are located in parts of Canada with a low seismic risk. Good quality digital elevation and satellite data, used in the terrain and surficial lineament interpretation, are available for all eight areas.

At this stage of the assessment, there is a general lack of information from boreholes penetrating the bedrock to relevant depths, particularly site specific hydrogeological and geotechnical data. However, information collected in other parts of the Canadian Shield has been used (e.g., in-situ stress, geotechnical parameters, hydrogeological or hydrochemical scenarios).

Furthermore, there are differences between and within the eight communities with respect to data availability and quality; e.g., the scale of geological bedrock and surficial cover mapping, resolution of geophysical surveys, and coverage of different geophysical data types. This introduces differences in the level of uncertainty between the eight communities.

The GRG has emphasized and noted that NWMO is fully aware of the subjective character of the interpretation of lineaments. GRG is satisfied that NWMO has responded to the GRG's comments on lineament interpretation work at an early stage in the feasibility study. As a consequence, the NWMO have worked to develop, as much as possible, a sound approach to limit inconsistencies between different interpreters and different data sources (digital elevation, satellite and aeromagnetic data mainly).

The GRG reviewed the findings of the desktop studies for eight communities and concluded that the resulting geoscientific assessments, despite the obvious remnant uncertainties, are sound and form a reliable basis for the identification of potentially suitable siting areas in each community. The GRG agrees with NWMO that all eight communities have the potential to contain suitable siting areas. However, there are varying degrees of geoscientific uncertainties among the communities.

Approach for Assessment of Residual Uncertainties

Although the GRG agrees with NWMO that, from a geoscientific perspective, there are potentially suitable siting areas in all the eight communities studied so far, there are certain features in several communities that introduce some uncertainty concerning the identification of potentially suitable siting areas. These uncertainties are inherent to the early stage of the assessment and would need to be addressed during subsequent site evaluation stages through field investigations and more detailed studies. Examples of these features include the density of lineaments interpreted from magnetic data after corrections have been made for data resolution, the occurrence of dyke swarms in some communities that lead to conspicuous bedrock heterogeneity, the occurrence of some potential siting areas inside probable major ductile shear belts, the limited size of some potential siting areas due to the limited exposure of potentially suitable bedrock, the occurrence of some potential siting areas close to areas suitable for mineral exploration, etc. The GRG is satisfied that NWMO agrees to highlight these uncertainties in the executive summary and conclusions of each community geoscientific report.

The identification of potentially suitable areas and the assessment of residual uncertainties relevant to each community were achieved using key geoscientific indicators that can be realistically applied at the desktop stage of the assessment. These were derived as a subset of the safety functions and site evaluation factors published in NWMO's site selection process document (NWMO 2010) and relate to: the size of a potentially suitable geological formation and general siting areas; proximity to major structural features such as brittle faults and ductile shear zones; surface constraints; fracture and dyke characteristics such as density, orientation and intersections; potential for mineral resources; and predictability and amenability to site characterization. These geoscientific indicators were reviewed in a systematic and consistent manner for each community.

At this stage of the preliminary assessment process, the developed approach was reviewed by the GRG and found to be helpful for the identification and assessment of uncertainties and their impact on identifying a subset of communities for Phase 2. The GRG agrees with the choice of evaluation factors selected to assess uncertainties. Furthermore, the GRG agrees that only a restricted number of the evaluation factors identified in each of the five safety functions can be utilized at this stage of the assessment due, for example, to the total absence of relevant data at repository depth and the site-

specific character of such data. The GRG is impressed with the approach adopted by the NWMO for the assessment of uncertainties.

The GRG has identified several critical features that require closer attention by NWMO in future comparative work between different communities during subsequent stages of the site evaluation process. These include:

- The geoscientific and geotechnical significance of diabase dyke swarms;
- The interplay between topography and hydraulic gradients; and
- The inconsistencies, previously discussed, resulting from the interpretation of lineaments inferred from geophysical data to be brittle structures.

Due to the highlighted remnant uncertainties from desktop studies, the GRG recommends that, in order to improve the basis for future decision-making, variation in the geological setting represented by the eight communities, encompassing geological age range, tectonic setting, lithological variation, metamorphic history and structural style, is included during Phase 2. Furthermore, NWMO needs to develop geoscientific selection criteria that should be applied during future decision-making, once additional data have been collected during Phase 2. These criteria will also assist in streamlining Phase 2 geoscientific activities.

Geoscience Work Plan

The goal of future work is to reduce or diminish residual uncertainties. The proposed framework for planned field investigation program for Phase 2 of the Preliminary Assessment was reviewed by the GRG and found to be feasible and to focus on the highest priority items. The GRG provided feedback for future consideration, discussion and refinement during future meetings.

References

NWMO, 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel, Nuclear Waste Management Organization. (Available at www.nwmo.ca)



2013-05-14

Figure 1 – Status of Communities Interest

Attachment 1

Brief Biographies of the GRG Members

Dr. Alexander (Sandy) Cruden, Professor and Head, School of Geosciences, Monash University (Australia). Sandy has more than 25 years of geoscience experience related to structural geology, analysis and characterization in both crystalline and sedimentary rock settings. Sandy completed a fault reactivation analysis and structural characterization of Southwestern Ontario as part of site characterization activities for OPG's proposed Low and Intermediate Level Waste DGR at the Bruce site.

Dr. Andreas Gautschi, Division Head Geology, Safety at NAGRA (the Swiss National Cooperative for the Disposal of Radioactive Waste). Andreas has more than 25 years of geoscience experience related to the planning, coordination and implementation of site evaluation programs for deep geological repositories in both crystalline and sedimentary rocks. He coordinated successful geoscience activities that contributed to the selection of the Opalinus Clay formation as the preferred geologic setting for long-term management of high-level waste in Switzerland.

Dr. Peter Kaiser (GRG Chairman), Director of the Rio Tinto Centre for Underground Mine Construction, formerly Founding Director of the Center for Excellence in Mining Innovation (CEMI), Professor of Mining Engineering at Laurentian University and Chair for Rock Engineering and Ground Control. His interests lie in geomechanics, underground excavation stability, mine design, mechanized excavation and the applications of other emerging technologies that increase mining safety and productivity. Dr. Kaiser is the author of more than 300 technical and scientific publications. He is a Fellow of the Engineering Institute of Canada and the Canadian Academy of Engineers.

Dr. Richard Smith, Professor in the Department of Earth Sciences at Laurentian University, Industrial Research Chair for Geophysics; exploration geophysicist with expertise in the application of geophysical methods generally and airborne methods specifically to investigate the geosphere at depth. Richard brings over 20 years of experience working in the exploration business.

Dr. Michael (Mike) Stephens, Senior State Geologist with the Geological Survey of Sweden in Uppsala. Mike has been actively involved in the Swedish site evaluation process including country-wide reconnaissance studies conducted in Sweden to identify potentially suitable regions for hosting a deep geological repository, geoscientific feasibility studies, and the detailed characterization of the Forsmark site which was selected by SKB as the site for the deep geological repository for used nuclear fuel in Sweden.