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ESTABLISHMENT OF IAEA KNOWLEDGE OF INTEGRITY OF THE GEOLOGICAL REPOSITORY BOUNDARIES AND DISPOSED SPENT FUEL ASSEMBLIES IN THE CONTEXT OF THE FINNISH GEOLOGICAL REPOSITORY

Experts' Group meeting Report on Task JNT/C 1204 of the Member States' Support Programme to IAEA Safeguards

Olli Okko (ed.)

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Preface

The Geological Repository Safeguards Experts Group (Member State Support Programme tasks JNT/C1204 and C1226), agreed that annual meetings should be held to address interface issues between IAEA safeguards and radioactive waste management and to explore the use of safety and operational information to make International Atomic Energy Agency (IAEA) safeguards more effective and efficient for geological repository facilities. It has also been recognised that the safeguards measures for geological repositories are to be developed site-specifically. To address these issues to the planned Olkiluoto repository in Finland a meeting of experts in safety, geological repository operations, and safeguards from 6 States, European Commission, and IAEA was held in Olkiluoto and Rauma, Finland, during September 29 – October 4, 2003.

The pre-operational phase of the Olkiluoto repository should be efficiently used by the parties involved in safeguards. The applicability and reliability of the potential new techniques and the efficient practices must be developed and proven before their implementation as safeguards measures to be applied at the subsequent stages of the repository development. The visit to the location of the proposed Olkiluoto repository and neighbouring areas and subsequent presentations enabled the working groups to discuss the various issues with reference to actual site conditions. The working groups were thus able to identify potential measurement and monitoring techniques and research and development requirements for consideration by the Finnish authorities, in addition to making recommendations to the IAEA on planned activities for carrying out before and during the early investigation phase of the proposed Olkiluoto repository. It was understood that all parties shall take good care of the implementation of the planned activities to ensure that proven means, approaches and the required verified information is at hand at the time the projected facility will become a nuclear facility under construction. The working groups reports are presented in the Annexes of this report as discussed at Rauma and edited afterwards. The content of this report reflects the professional competence of the participants. The Executive summary was generated at the meeting. The drafting of the report was carried out mainly by Mr. Bruce Moran and Ian Upshall (Baseline requirements and knowledge-base development, Annex 3) and Tapani Honkamaa (Nuclear Material Characterization, Annex 4). This report was compiled finally by Mr. Juha Rautjärvi and Olli Okko according to the comments received from all of the participants.

Contents

1 Executive summary

1.1 Issues

A geological repository is a unique facility type from the perspective of international safeguards because of its construction in suitable geological formations, the long construction period, and the continuing safeguards requirement after facility closure. Because of these, the International Atomic Energy Agency (IAEA) should recognize that different design information verification time schedules apply than have typically been used when applying safeguards to surface facilities. These extended time frames apply not only following closure of the facility, but to the design, characterization, and construction phases. If the IAEA is to effectively and efficiently develop assurance of the integrity of the perimeter of the geological repository, the most advantageous way would be early IAEA interactions with the repository operator, the State, and, where relevant, Regional Authority to generate and evaluate design information before excavations at the proposed repository location begin. The IAEA safeguards policy statement relevant to geological repositories recommends that design information verification activities begin during this early phase.

Although the proposed repository location does not meet the definition of a nuclear facility until it receives nuclear material and does not meet the definition of being under construction until the location is qualified and licensed by the State, excavation of safeguards-relevant shafts, ramps, and tunnels begins when excavation into the bedrock is initiated. Although the generic safeguards approach for geological repositories has been generally accepted, the safeguards measures and procedures have not been applied to or tested under site-specific conditions. Finland's proposed Olkiluoto geological repository presents the first site-specific case at which the safeguards approach will be applied. Therefore, the site-specific procedures and measures need to be carefully developed and tested. Substantial baseline data regarding the integrity of the host bedrock has been collected by the operator providing a basis for the creation of the initial knowledge base. As the ability to independently verify the baseline information will be lost when the excavation operations begin, IAEA activities must be initiated soon.

In order to facilitate the IAEA meeting its safeguards goals at Finland's Olkiluoto geological repository, design information verification activities should begin immediately and testing of measures to maintain knowledge of the integrity of the geological repository boundary should begin very soon. The early evaluations will determine where the gaps are in the provided design information and verification capabilities, and allow these gaps to be closed. Effective safeguards will require a long-term commitment from the IAEA, albeit at low effort levels, for the continual verification of design information at the geological repository.

1.2 Recommendations

The experts recommend the following:

1. Finland should immediately notify the IAEA of the status of the geological repository and provide to the IAEA safeguards-relevant information on the geological environment and integrity of the bedrock, on neighbouring locations and activities, and on the proposed design of the exploratory tunnel and geologic repository.
2. Finland, Posiva (the repository developer and operator), Euratom, and IAEA should initiate interactions and planning for IAEA safeguards activities. We note that Euratom has maintained a low-level involvement at meetings related to geological repositories and that six IAEA staff attended the Geological Repository Safeguards Experts Meeting.

3. Finland and IAEA should develop top-down awareness and support for IAEA safeguards interactions and safeguards-relevant activities at the proposed Olkiluoto geological repository site.

4. The IAEA should develop its competencies to be able to evaluate information provided by Finland related to the geological repository, to determine gaps in the information, and to independently verify the accuracy of the information. These competencies could be quickly established through cost free experts and consultants.

5. The IAEA should initiate new or extend existing tasks to confirm the ability of satellite imaging, geophysical monitoring, and environmental radiological sampling to generate knowledge base of the proposed site and to be able to maintain that knowledge base.

6. Following iterative interactions with Finland, the IAEA should identify what information is safeguards relevant information to establishing knowledge of the integrity of the geological repository perimeter and document procedures and guidance to be used for future interactions.

7. The Member State Support Programs should provide expertise to the IAEA and should undertake technical tasks to develop, test and validate the verification methods.

8. The IAEA member states' support programmes should to the extent possible provide assistance to the IAEA's geological repository safeguards activities in the following areas:
   - Funding
   - Equipment
   - Expertise
   - Human resources.

2 Background

2.1 Geological repository safeguards overview

In comparison to above-ground facilities, at which the International Atomic Energy Agency (IAEA) has experience verifying design information and implementing safeguards monitoring and verification measures, geological repository safeguards present unique challenges. First, the space, into which the repository will be constructed and the underground areas contiguous to the boundaries of the repository, cannot be directly observed. Second, once emplaced, the IAEA will no longer be able to reverify the inventory of nuclear material contained in the repository because of the backfilling of the emplacement drifts. Thus, should continuity of knowledge of the nuclear material content of the repository be lost, that knowledge cannot be restored.

2.1.1 IAEA safeguards policy

International Atomic Energy Agency, Policy Series Number 15, dated June 1997, states the following policies, among others, with respect to geological repository safeguards:

"3.1.1 Spent fuel disposed in geological repositories is subject to safeguards in accordance with the applicable safeguards requirements. Safeguards for such material are maintained after the repository has been back-filled and sealed, and for as long as the safeguards agreement remains in force. The safeguards applied should provide a credible assurance of non-diversion."

"3.1.2 The safeguards system for such a repository should be based on: verification of design information during design, construction, and operation; verification of receipts and flow that no nuclear material is removed by any declared or undeclared access routes; and maintenance of continuity of knowledge on the nuclear material content."

"3.1.4 Safeguards requirements should be integrated into the repository design at an early stage in order to establish functional, non-intrusive, and cost-effective safeguards measures. Consultations between the State and the IAEA should, therefore, start at an early stage to agree on the safeguards measures in the repository."

"3.1.7 The State should provide the following information as early as possible:
- draft plans of a geological repository site;
- description of intended exploratory underground works for the geological repository;
- information on existing local mines; and
- any other information that might be identified by the IAEA as relevant for the purpose of safeguards.

"3.3.1.2 The Agency, in collaboration with the State, should establish all pertinent information about the original undisturbed site (i.e., zero-point checking), preferably before excavation begins, in order to plan for safeguards measures."

2.1.2 IAEA safeguards approach development

In 1988, the IAEA held its first Advisory Group meeting to address safeguards for the final disposal of spent fuel in geological repositories. The IAEA's Programme for the Development of Safeguards Approaches for the Final Disposal of Spent Fuel in Geological Repositories (SAGOR) was begun in 1994 and, in 1998, provided recommendations to the IAEA on generic safeguards approaches for spent fuel conditioning facilities and for operating and closed geological repositories. Nine

Member States and two international organizations contributed to the SAGOR Programme recommendations. In 1999[1], the IAEA established the Geological Repository Safeguards Experts Group to provide advice on safeguards technology development for geological repositories and on implementing the generic safeguards approach at specific facilities.

In a number of meetings this experts' group, named at Rauma ASTOR (Application of Safeguards TO Repositories) discussed specific topics: the use of geophysical techniques, the definition and establishment of baseline knowledge, and the interface between safeguards and safety monitoring activities during the construction and operation of a repository. All of the meetings arrived at the same conclusions. Namely that the final set of safeguards measures must be developed and defined for specific repository projects and that generic discussions should now be replaced with site-specific considerations. That is why this experts' meeting was held; i.e., to discuss site-specific needs for the Olkiluoto geological repository.

2.1.3 Meeting structure and objectives

The objective of the experts' group meeting was to identify what knowledge the IAEA should establish during the pre-operational phase of the Olkiluoto geological repository to have assurance of the integrity of the geological repository boundaries and spent fuel assemblies and to determine what activities are recommended to the IAEA for acquisition of that knowledge. A second objective was to ensure that the required knowledge base will exist when a repository begins nuclear material disposal operations. Through evaluating the knowledge and information base against the Finland-specific situation, actions will be identified that should be undertaken by the IAEA, Finland and Euratom, and the Member State Support Programs.

Numerous presentations were made with the objective of stimulating further discussion by the experts. The meeting agenda (Annex 1) lists the presentations made. Working Groups were formed by the participants to examine some specific issues related to site characterisation and the establishment of a knowledge base and the characterisation of spent fuel. All issues discussed were directly related to the proposed Olkiluoto facility. During the meeting, experts from the Finnish, Swedish, German, Canadian, UK, US, Euratom and IAEA delegations discussed the use of radiometric measurements, satellite imagery and geophysical technologies and their potential in support of site evaluation characterization programmes. Safeguards and information management experts separately considered two related topics; the production of Olkiluoto site baseline information and the broader data and information requirements for a knowledge-based system. In order to better understand the features of the undisturbed site, a visit to the location of the proposed Olkiluoto repository and neighbouring areas was undertaken on the first morning of the meeting. The visit and subsequent presentations enabled the working groups to discuss the various issues with reference to actual site conditions. The working groups were thus able to identify potential measurement and monitoring techniques and research and development requirements for consideration by the Finnish authorities, in addition to making recommendations to the IAEA on planned activities for carrying out before and during the early investigation phase of the proposed Olkiluoto repository.

1 The 1st Experts Group Meeting took place in Helsinki during October 19–21, 1999.

3 Baseline

3.1 Definition

Baseline information is that information which, when evaluated, can be used to create a knowledge base of the site features and characteristics against which changes can be identified, analysed and compared.

The same set of information can be used for different purposes, to establish different subordinate baselines, depending on the data used to create the information. For example, geophysical data collected by the repository developer may be used to establish a knowledge base on the geological medium to provide assurance that suitable containment will be provided for certain radionuclides over a specific length of time. These same data could also be used by the IAEA to establish an understanding of the integrity of the geological repository boundary.

3.2 Establishment of knowledge base for the repository – Annex 3

The Finnish project represents an opportunity for the IAEA to follow the State investigation and construction of the repository from almost undisturbed conditions up to the arrival of the first nuclear material items, to establish sufficient knowledge about the characteristics of the site, and to develop and test the safeguards approach necessary to ensure IAEA goal attainment.

From 1989 to the present, numerous investigations have been performed by the operator TVO, and later by Posiva, the company entrusted with the investigation and design of the national repository, and its contractors. The purpose of these investigations has been to establish a knowledge base of information on which a judgment could be reached on the suitability of the bedrock for radionuclide containment and environmental protection. The investigations focused on numerous areas such as hydrology, rock dynamics, and climate, vegetation, fauna, seismic and social factors. This work, which was supported in part by the use of approximately 25 boreholes in the vicinity of the proposed repository, will be further enhanced following the construction of an underground rock characterisation facility (Onkalo) comprising a ramp, a ventilation shaft and drifts reaching a depth of approximately 500 m. Construction of this facility will start in mid-2004.

Construction of a fifth Finnish nuclear power reactor at the neighbouring Olkiluoto site may start as early as 2005 lasting about seven years. Consequently, there exists only a relatively short time window for the IAEA to establish techniques and to study the resultant data under relatively undisturbed site conditions. This challenging timescale was recognised by the working group and as a result, it attempted to identify those activities which the IAEA should be encouraged to carry out to establish a knowledge base that may support the realization of specific IAEA safeguards goals (IAEA 1997, 2003).

The definition of baseline data in relation to safeguards was discussed together with the monitoring and measuring techniques necessary to generate the required data for the establishment and maintenance of a knowledge base. The results of the discussion are summarized below with some detailed issues presented in Annex 3.

In particular the following subjects were addressed:

1. the use of data acquired since 1989 including environmental, geological, and satellite information;
2. the selection and follow up of safeguards relevant data during the construction of Onkalo;
3. the development and testing of specific safeguards instrumentation during the early investigation phase.

3.3 Characterization of spent fuel assemblies – Annex 4

Nuclear materials characterization is a R&D priority and is likely to provide a source of baseline data of primary importance. Information leading to improved knowledge about the properties of spent fuel items should therefore be derived before they are designated for underground disposal. Bearing in mind the currently proposed timescale, the fifteen year period between now and the receipt of the first spent fuel assembly at the Olkiluoto disposal facility does not allow a great deal of time to develop and implement advanced characterization methods. It is noted that some nuclear material characterization methods and processes may influence facility design decisions. This specific issue was taken on the agenda in this meeting. Summary of discussions held in a working group B "Requirements for nuclear material characterization for final disposal" are presented in Annex 4.

4 Olkiluoto geological repository

4.1 Olkiluoto issues

In 1983, Finland began site investigations relevant to the candidate geological repository at Olkiluoto. Following the detailed site investigations at six candidate sites in 1992 – 1998, the Olkiluoto site was accepted to represent typical Finnish bedrock and was proposed to be the suitable site for final disposal of spent nuclear fuel. In May 2001, the Finnish Parliament endorsed the Decision-in-Principle to construct a geological repository at Olkiluoto. Construction of the repository is conditional on the results of site characterization. In May 2004, construction of the Onkalo exploratory underground rock characterization facility will begin at the repository location to provide data for the site characterization. In 2012, if the location is determined to be acceptable, the license application for the construction of the repository will be issued. After the construction license has been granted, construction of tunnels and drifts for the final disposal can be continued. Spent fuel emplacement operations are scheduled to begin in 2020. At present, emplacement is expected to continue for 90 years.

Until the construction of the Onkalo exploratory facility is initiated, the geological location remains undisturbed except for the boreholes used for initial site characterization. Coordination meetings between Finland, Euratom, and IAEA were initiated in 1999 to begin discussion of what information the IAEA should assess and what activities IAEA should perform to apply effective safeguards to the geological repository. The benefits of the early Finland-IAEA cooperation are to ensure that information that is required on the undisturbed repository site is collected before excavation of the Onkalo exploratory underground facility begins in 2004.

4.2 Site[2] description – ONKALO and Olkiluoto geological repository

The Onkalo underground rock characterisation facility and the planned Olkiluoto geological repository are located in Eurajoki near, and on the same island as, the Olkiluoto Nuclear Power Plant. Also located nearby, are the Olkiluoto NPP low-level and intermediate level waste repository rock cavern. These underground constructions are located in old Precambrian bedrock consisting mainly of deformed mica gneiss. Similar bedrock conditions are reported also from the site characterisation studies for Onkalo. Therefore, the experience of applying drilling and blasting techniques with reinforcement methods can be applied also for Onkalo and the safeguards approach adapted to this procedure. The island is also under review for construction of another nuclear power reactor and the spent fuel encapsulation plant. In addition to the human induced activity there is natural activity (e.g. rock quarry, waves striking the shore, ice breaking, etc.) that could affect the implementation in a conclusive manner of the required safeguards measures.

4.3 State obligations to report/provide information

It is not intended that the Onkalo exploratory facility is to be licensed as a nuclear facility. However, once the geological characterization phase is complete, and assuming that the results are satisfactory, ramps and tunnels of the Onkalo will become components of a licensed disposal facility. At present, the proposed excavation is licensed according to Posiva's application referring to the civil construction legislation (not even mining legislation) by the municipality. Therefore, the reporting towards the State is based on voluntary deliv-

2 The concept 'Site' used hereby refers to the geological conditions, not to the Additional Protocol.

ery of information with respect to the recommendations given by the State authorities. The aim of these efforts is to secure conditions for safe and safeguardable disposal of spent nuclear fuel.

4.4 Finland–IAEA Information exchange/coordination

Timely and good communication is essential, and the desired coordination of activities can be expected to happen. The information requirements are determined by the needs of the involved parties. First of all, the parties to be involved should identify themselves. Certainly these include the producers of the Finnish spent nuclear fuel, the repository development and implementing company, and the responsible authorities, in Finland, at the IAEA, and probably also at the Euratom.- What does any particular party need to know, and why?

The law, treaties and agreements, as negotiated, will identify the parties and their respective rights and obligations. The safeguards regime and, particularly, the system implementation will call for clear roles and functional responsibilities so as to ensure efficient performance.

It is evident that due to the nature of the undertaking there are information needs to enable efficient implementation of particular safeguards measures in order to build and document the assurances of the absence of any safeguards relevant undeclared excavations at the Onkalo exploratory underground tunnels.

Further to this, there are information needs associated with tasks that must be initiated to develop required reliable technique, procedures and practices as well as to obtain prove of the usefulness and the reliability of any existing ones.

Additional information requirements are associated with the activities aimed at obtaining prove of the reliability of the information provided and of the parties generating that information. Finland is obliged to establish and maintain a national system, to implement its safeguards relevant functions (SSAC functions) in a manner as to enable the IAEA to carry out its verification activities efficiently. The IAEA is therefore requested to express its interests and fit these to the repository development time schedule.

4.5 Availability of site characterization data

Engineering geological site characterization was carried out at the western end of the Olkiluoto Island for over 30 years in order to demonstrate the suitability of the site for the two NPP facilities and their accompanying installations including the underground storages for low and intermediate level waste. The site characterization, design and construction were reviewed by local and national authorities. Moreover, the site characterization for the final disposal facility was carried out by the operating companies for more than 15 years and this has also been reviewed by the national authority, STUK. In addition, international review groups are regularly consulted in the fields of engineering-geological bedrock modelling, rock stability, hydrogeological and geochemical analysis. The review groups have been supported by the site characterization data collected by the operator or its subcontractors, presenting the qualified national or international experts.

4.6 Proposed methods and technologies

The national authority started independent environmental monitoring at the NPPs one year before the operation of the first reactor. In Olkiluoto, the progamme started in 1977 with radioecological background studies being initiated as early as 1972. Continuous monitoring is carried out at the distance of 0–10 km from the power plants.

The national experts group on the safeguards for final disposal was founded in 2002. The group possesses data on seismicity and satellite imagery for national knowledge base on absence of unauthorized activities near the repository. Also, this site characterization data can be used by international review groups. The different environmental monitoring, satellite imagery and geophysical methods were discussed during the meeting.

4.7 Site-particular conditions affecting IAEA monitoring

The Olkiluoto site is located in a crystalline bed rock area where the soil cover is minimal. The final disposal facilities are planned to be constructed on the property of the operating company. The company can provide access to the territory and assist in mounting any required monitoring instruments considered relevant for the safeguards purposes. The excavation of the underground exploratory galleries will begin in 2004 and are planned to continue for several years. The preparatory works including removal of vegetation and soil cover, and construction of supporting installations for electricity and ventilation accommodation near the entrance were initiated in 2003.

The pre-operational phase will begin with the excavation of the non-nuclear gallery. The excavation work will continue through out the construction phase until the end of the scheduled emplacement operations after the required licensing. During the operation of the disposal facility, only small parts of the disposal tunnels will be kept open at a time. Tunnel construction and emplacement activities are concurrent. It is planned, that drilling for new emplacement tunnels will take place in campaigns. During one drilling campaign, which may last a year, tunnels for several years of emplacement activities are excavated.

4.8 Follow-up procedure

The editing of the minutes was agreed to be carried out by the participants during the autumn 2003. The final editorial work shall be undertaken by the Finnish Support Programme. Finally, the German delegation was asked to organise the next meeting of the ASTOR Experts Group in Germany. A visit to the Gorleben investigation mine, being under moratorium, would be desirable.

References

International Atomic Energy Agency, Policy Series Number 15, dated June 1997.

International Atomic Energy Agency, Safeguards Technical Report, STR-338, July 2003.

Annex 1 Experts' group meeting agenda

Experts' group meeting in Rauma 29.9.–3.10.2003

Initial state characterisation of Olkiluoto site for safeguards purposes: methods, techniques and procedures

Venue: Hotel Cumulus, Rauma

Chair: To be selected

Drafting group: To be selected

Sunday, September 28

Arrival – STUK can help in organizing transports from airport to Rauma

Monday, September 29

08:30 Bus leaves hotel Cumulus for transport to Olkiluoto

09:00 Arrival at Olkiluoto
-presentation by Posiva and TVO

10:30 Guided tour to repository of medium and low level waste (VLJ) and Posiva investigation area

12:30 Lunch

13:30 Transport back to Hotel Cumulus, Rauma

14:30–16:00

Opening of the meeting, *Chair, Juha Rautjärvi*

Welcome by IAEA, *Alfredo Diaz-Mosquera, IAEA*

Introduction of participants and short opening remarks, *Participants*

Introduction of the subject, Objectives of the meeting, *FINSP*

Approval of the Agenda, *Participants*

16:00–16:20
– Coffee

16:20–18:00 Status Updates & Introductory presentations

Status update by participating countries concerning spent fuel disposal and back end safeguards – projects, plans and research. Presentation + paper to be included in the report, Participants

Technological implications of safeguards requirements for geological repositories for radioactive waste. S. Hossain, IAEA

The safeguards – safety interface *J. Rowat, IAEA*

Possible features of safeguards measures at final spent fuel disposal *Y. Abushady, IAEA*

Tuesday, September 30

9:00–11:00 Introductory presentations

"Baseline"-conceptual definition and the role of the concept in implementation of safeguards (*B.Moran & P.Button*)

Information management and knowledge creation (*J. Rautjärvi, STUK*)

11:00–11:20 Coffee

11:20 – 12:30 Baseline data and information generation:

Posiva data generation and management, information technology tools (*A. Ikonen, Posiva*)

Satellite and airborne imagery for Olkiluoto (*T. Häme, VTT*)

IAEA present practices and use of satellite and airborne imagery (*F. Claude, IAEA*)

12:30–14:00 Lunch Break

14:00–16:00 Baseline data generation session cont.

Spent fuel characterisation prior encapsulation – Proposal for a good practice applicable for Finnish conditions (*A.Tiitta, VTT*)

Radiological monitoring and surveillance program at Finnish power plant by STUK (*S. Klemola, STUK*)

Seismological data collection in the vinicity of Olkiluoto (*M. Tarvainen, Institute of Seismology*)
3D Rock model for Olkiluoto as a presentation tool (*K. Jakobsson, STUK*)

16:00–16:20 Coffee

16:20–17:50 Round table discussion (Workgroup stimulation)
Satellite imagery application to Olkiluoto case
Role of seismic techniques: safety and safeguards

17:50–18:00 Dividing the participants into three groups
Groups:
A) Olkiluoto site characterisation for safeguards purposes
B) Requirements for nuclear material characterization for final disposal
C) Data and information requirements for a knowledge based system.

Wednesday, October 1

09:00–13:00 Discussions in three working groups. Preparation of draft document

13:00–14:00 Lunch Break

14:00–15:00 Guided walking tour through Old Rauma

15:00–17:00 Discussions in three working groups. Preparation of draft document

17:00–18:00 Experts Group future activities
Demonstration of electronic performance support tool for group activities, discussion
Discussion of potential member state support programme tasks necessary to assist the IAEA in further developing and testing the safeguards measures before they must be implemented in a country.

Thursday, October 2

09:00–11:00 Plenary session, sharing the results of the groups and identification of major outcomes

11:00–11:20 Coffee

11:20–13:00 Finalization by the groups of the draft documents

13:00–14:30 Lunch

14:30–16:00 Final plenary
Presentation and discussion.
Next meeting: objective, agenda, a tentative host country and location.
Closing remarks.

Friday, October 3

09:00–12:00 Finalising the meeting document (Drafting group).

ANNEX 2 LIST OF ATTENDEES

Canada

Peter Button
CNSC

Germany

Helmut Kranz
Bundesamt fuer Strahlenschutz (BfS)

Irmgard Niemeyer
Freiberg University of Mining and Technology
Institute for Mine Surveying and Geodesy

Arnold Rezniczek
UBA Unternehmensberatung GMBH

Knut Seidel
Geophysik GGD mbh

Finland

Tuomas Häme
VTT Information Technology

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Ari Ikonen
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Kai Jakobsson
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Per H. Grahn
Swedish Nuclear Fuel and Waste Management Company (SKB AB)

Öivind Toverud
Swedish Nuclear Power Inspectorate (SKI)

United Kingdom

Ian Upshall
Nirex Ltd

United States

Bruce Moran
Nuclear Regulatory Commission

European Commission

Wolfgang Hilden
DG Transport and Energy Directorate H

International Atomic Energy Agency

Yousry Abushady
Frederic Claude
Alfredo Diaz-Mosquera
Shaheed Hossain
Helgard du Preez
John Rowat

ANNEX 3 EXPERT GROUP ON APPLICATION OF SAFEGUARDS IN GEOLOGICAL REPOSITORIES

Rauma, Finland
29 September to 3 October 2003
Report by Working Groups A & C

1 Working group objectives

The objectives of working groups A and C were:

Working Group A – *Olkiluoto Site Characterisation for Safeguards Purposes and Data and Information Requirements for a Knowledge-based System*
To determine the methods and tools for characterising the Olkiluoto region.

Working Group B – *Requirements for Nuclear Material Characterization*
To determine the information required to characterise the site and to populate a knowledge database with safeguards relevant data.

The original intention was for three working groups to be formed. However, after the initial discussion and presentations it was decided to combine the membership of working groups A and C.

2 Definition of baseline knowledge

The principal precursor of knowledge is data. Data can exist in a number of forms and is derived from many sources. In isolation, raw data may have limited value as characteristics such as their provenance and accuracy may not be defined. A certain amount of supplemental, or contextual, data is therefore necessary to support the raw data and to give them a sense of value and timeliness. For example, 4000MWd/teU is an item of raw data. In its present form, it has little meaning or relevance other than the fact that we can assume that it refers to the burn-up of a fuel assembly. We do not know if it is an integrated value, an average value, if it has an accuracy of ±1000MWd/teU or ±10MWd/teU, or indeed, the identity of the fuel assembly to which it relates. We therefore need to add contextual data to give it meaning and relevance. In summary, raw data with the addition of relevant contextual data provides us with information.

The information we now have concerning the burn-up is of some use, but what is its relevance? How might this data impact on a specific scenario and what are the implications? If, by way of example, we consider its safeguards impact we can make a number of suppositions. For example, we can infer that this fuel assembly is of relatively low burn up and that it will contain plutonium. We cannot say how much because we do not know the characteristics of the fuel assembly, such as its original enrichment or material composition. However, even with the limited information available we can assume that any activity involving this fuel assembly will have a safeguards implication. It follows, therefore, that we will need to accurately determine the nuclear materials content and record any movement of the assembly.

By establishing an association between the information we have on the fuel assembly and our implicit understanding of potential safeguards implications we have made the transition between data, information and knowledge. This knowledge can then be used for the decision making process. Whilst it is not the purpose of this paper to provide a detailed examination of the creation of knowledge it is worth noting that a final stage exists and that is wisdom. Wisdom comes about through developing an understanding of the significance of knowledge and its subsequent application.

For reasons which will be expanded upon later in this paper, it is desirable to create a knowledge database related to the disposal of spent fuel in a deep geological repository. Spent fuel assemblies destined for the future repository are discharged on a regular basis and their unique data is continuously created. The purpose of the knowledge base is to help understand what safeguards relevant data and, ultimately knowledge, is necessary to safely manage the disposal of the spent fuel.

3 The repository system

This working group took generic information and knowledge and applied it to the specific scenario of the proposed development of a deep geological repository in Finland for the final disposal of spent fuel assemblies from its Olkiluoto and Loviisa NPPs.

Posiva Oy is proposing to construct an underground rock characterisation facility (URCF), named ONKALO, on the island of Olkiluoto adjacent to the two BWR units. ONKALO is not a nuclear facility but, subject to further investigation and the satisfactory outcome of tests and support of the Finnish State, the URCF could eventually become part of a larger, purpose built, licensed repository.

In order to better understand the concept of baseline information and identify sources of data and information, it is assumed that ONKALO will in time become an integral part of the final repository. However, the outcome of this study could be applied equally to any other site or facility.

This paper will make reference to "The System". In this context, the system is assumed to comprise four interrelating components: human actions, the environment, the proposed facility and institutional controls. Each component can be considered in isolation but to obtain a full and comprehensive picture it is necessary to understand that two or more components will be interacting at any one time. The nature of these interactions is not necessarily defined but their significance and impact are nonetheless relevant.

Human action around and in the repository site is inevitable at all stages: pre-operation, operation, post-operation and post-closure. All human actions must be considered including those directly related to the repository. Therefore the impact of, inter alia, neighbouring industry, daily commuting, construction and recreational activities will all impact on the system. Similarly, the environment will determine to some extent the location, layout, method of construction and lifetime of the repository. The facility is clearly a fundamental part of the system and this will have an impact on the environment and on human actions. The fourth component, institutional control, will determine to a degree how the human actions will impact on the facility operations and on the local environmental conditions.

4 Requirement for a baseline report

The working group next turned to discussing how baseline knowledge should be collated and communicated to stakeholders. It is suggested that the most accessible form would be some type of report that contained not only the data but some interpretation of it.

It should be made clear that there is no international, regional or State regulatory requirement to produce a Baseline Report. Consequently, there must be a clear purpose for such a document. After much discussion, the working group agreed that there were a number of areas to which the Baseline Report had the potential to contribute. These included:

(a) Initial identification of safeguards relevant aspects of the system

The Baseline Report could be used to identify and further expand on the features of the system that may impact on the safeguarding of the nuclear material. In this way it could highlight design features and provide a basis for discussions with the safeguarding authorities.

(b) A record of the start conditions of the system

Clearly, the Baseline Report should provide a record of the 'start state' of the repository system; in particular, the undisturbed geological, hydrological and environmental features. In addition it may describe the pattern of human activities in the vicinity of the proposed site.

It was suggested that the Baseline Report could be structured in such a way that it provides start state information on the four aspects of the system (human actions, the environment, the proposed facility and institutional controls). Alternatively it could be structured in three sections examining above surface, near surface and deep rock characteristics.

(c) Identification of weaknesses in the system knowledge base

Not all information will be immediately available and some sources of information will be less reliable than others. The production of a Baseline Report would encourage a 'knowledge stock take' to be conducted. This would enable the operator to direct future work or focus on particular aspects in order to improve the accuracy and reliability of the information.

(d) Identification of research & development needs

An understanding and recognition of the unknown is as important as stating the known. The Baseline Report could be used to identify features or characteristics where more data and information are required and thus provide a key input into an R&D plan. This is linked to the previous goal.

(e) Input into formal declarations to safeguards authorities

At an early stage and some considerable time before the first waste item is received, the State will be required to inform the safeguards authorities of its intent. It is preferable that formal notification be preceded by discussions between the two parties in order that a common safeguards and complimentary approach is adopted. The Baseline Report could be used as the basis of these early discussions and as a key input into the formal declaration.

4.1 Ownership of the repository the baseline report

The baseline report will both contain and refer to data, information and knowledge generated by a wide range of sources. However, its compilation, accuracy and comprehensiveness will be clearly the responsibility of the organisation charged with co-ordinating the system activities. In this specific case it is suggested that the Baseline Report is owned by STUK.

Ownership includes the responsibility for the contents of the report, its control in terms of distribution, its review and updating. The management of the Baseline Report should be made a specific responsibility of a team within STUK. Collection and compilation of the data is likely to be a complex and time consuming process and one that will require the application of sound project management principles. Changes to the data or the information will have to be carefully controlled and recorded.

4.2 Baseline report stakeholders

In Finland the principal stakeholders are The State, the industry regulators (STUK), the development company (Posiva) and the operators (TVO, Fortum). In addition, the Finnish community will have a stake in the report.

The IAEA and Euratom should be encouraged to have a stake in the Baseline Report although it should be made quite clear where ownership lies. Much of the information contained in the report will contribute to the development of the safeguards approach, and this needs to be reflected in subsequent versions.

In the interests of popular support, openness and transparency, the local community should be encouraged to comment on the Baseline Report.

5 Baseline report evolution

The report provides a starting point for longer term interactions between the stakeholders. It is vital that there is a common understanding of this start point. Baseline information is dynamic and is expected to change as the project develops. It is therefore necessary that the report owner employs a robust system of change control to ensure that subsequent versions of the report are properly referenced and that the changes are clearly documented.

There has been no attempt to define the end-point at this stage. However, it is expected that the baseline report will provide one of the key inputs to subsequent declarations made to regulating authorities and the safeguards inspectorate.

5.1 Means for data acquisition

The following sections provide an indication of the range of technology that has been used to date to acquire data on the site and the activities being undertaken. Many of these technologies are well established and there are examples of their use in similar circumstances elsewhere. However, their limitations are also well understood and there is a need to improve certain aspects in order to provide more accurate or conclusive data. Where this is the case, this section recognises the need for further research and/or development.

This section examines the various data collection techniques either employed in the Olkiluoto region or expected to be used to support future site characterisation related to the ONKALO facility.

5.1.1 Commercial satellite imagery

5.1.1.1 General description

The technology of satellite imagery is well proven and has been used by the military community for many years. Its use has now spread to commercial activities and is used on a daily basis for a wide range of applications from crop analysis to mineral deposit identification. There are a number of sensor systems available giving users the ability to remotely observe earth based objects in all weathers and conditions.

The increase in the use of satellite imagery has resulted in several national programmes to construct and launch satellites equipped with a wide range of sensors and to subsequently make the imagery available. Therefore, there are a number of sources from which imagery can be obtained.

From 1991 onwards, the IAEA recognised the potential of using commercially available satellite imagery to support their safeguards activities. A principal objective is to monitor the activities at declared nuclear facilities. In order to study the geological area, the resolution and imagery techniques should be evaluated owing to the site-specific targets.

5.1.1.2 Known limitations related to site specific use

The spatial resolution of commercially available optical satellite image data is presently limited to 0.58m (Nadir Quickbird PAN [initialise acronym]) and will be enhanced in the future. Since a spatial resolution of 1m seems to be sufficient for most purposes, the today's high-resolution satellites provide the relevant background information for a general site characterisation – in cloud-free and snow-free image acquisition times. In order to be independent of the weather conditions limiting the use of optical data, the improved SAR [initialise acronym] image resolution would allow similar levels of confidence.

5.1.1.3 Improvements identified and development requirements

Due to technical improvements in the near future, a better spatial resolution will be available, for optical data as well as for thermal, hyperspectral and radar imagery.

Thus, a combination of satellite imagery showing different spectral and spatial resolutions would ensure an optimum basis. Particularly, an improved spatial resolution of SAR images would guarantee detailed information of the site and its activities even in times of significant snow cover.

5.1.1.4 Safeguards-related objects to be verified using satellite imagery

For evalution of the surface conditions, satellite imagery (WGS84) and aerial imagery should be provided to the Agency (the type and quality of data will have to be discussed). Moreover, digital maps and models should be delivered to the Agency for a detailed site description: A high-resolution digital elevation model, digital maps and a digital geological map. The data should be accompanied by reports on the background of the data and their potential use with regard to safeguards-related tasks. In order to check, in particular, the limits of optical data and to consider the specific weather conditions at Olkiluoto, meteorological statistics with information on monthly cloud cover, snow cover and sun elevation should be taken into account as well.

Taking into account the improving spatial and spectral resolution of satellite imagery and regarding the lack of extended research for the monitoring of repository sites, R&D should focus on image analysis, interpretion and visualization techniques with respect to the usability for the Olkiluoto site.

1. Radar imagery
   For the use of radar (SAR) data, image analysis techniques have to be investigated concerning the improving spatial resolution. In order to simulate the future spatial resolution, airborne campaigns should be organized and carried out. The potential and use of L-band data, showing a better penetration because of a lower frequency, should be studied. Seasonal variations and impacts have also to be checked.

2. Hyperspectral data
   The use of hyperspectral image data has to be analysed in detail. An initial estimation will be possible by the analysis of HYPERION imagery (NASA). To be prepared for the future devel-

opments for satellite-based hyperspecral sensors, an airborne campaign should be carried out with hyperspectral cameras. Moreover, a field spectrometer campaign should be performed, the field spectral measurements can then result in a database of reference spectra to be used for classification purposes.

3. Thermal data
   Today, satellites like LANDSAT 7 (channel 6, 60m) and ASTER (channels 10–14, 90 m) provide thermal images data with a relatively low resolution. For the very near future, innovative improvements cannot be expected, but should not be excluded. The potential of thermal data may be determined by case studies based on ASTER image data, more detailed with airborne thermal image data gathered during a campaign over Olkiluoto.

Digital imagery has a high potential to the international safeguards of a repository. The Finnish environmental conditions (winter, frequent cloud cover) limit the use of the optical and thermal data. They are, however, the principal information source in earth observation domain for the baseline. Radar (SAR) data applications should be developed to ensure all-weather capability in the international safeguards. Airborne imagery should be part of the baseline data but it is not used for continuous monitoring purposes.

5.1.1.5 Recommendations for actions

1. Provide baseline information to the Agency
   - STUK should provide the baseline data to the Agency (copyright issues should be examined)
     - Satellite imagery (WGS84)
     - Aerial imagery
     - Digital elevation model of high resolution
     - Digital base map
     - Digital geological map
     - Research reports
     - Meteorological statistics (monthly cloud cover, snow cover, sun elevation)
2. Research for Olkiluoto repository site
   - Radar (SAR) image analysis techniques
     - concerning the improving spatial resolution
     - concerning L-band data (better penetration to canopy than present instruments due to lower frequency)
     - concerning seasonal impact
     - organization of airborne campaign to simulate future satellite instruments
   - Hyper-spectral data analysis techniques
     - airborne campaign to simulate future satellite instruments
     - field spectrometer campaign to build a reference spectra database
   - Thermal data analysis techniques
     - airborne campaign to simulate future satellite instruments
     - concerning seasonal impact
3. Involve IAEA member states' support programme
   - Funding
   - Equipment
   - Expertise
   - Human resources.

5.1.2 Environmental sampling

5.1.2.1 General description

The accumulation of environmental data over a period of several decades may be of great assistance in assessing the suitability of the land above a repository for alternative land uses.

Parameters of potential relevance are:

- meteorology;
- hydrology, drainage, water usage, water quality;
- concentration of radionuclides and other pollutants in various environmental compartments including biota, sediments and waters;
- local ecology;
- geomorphological processes, such as denudation, localized erosion, slope evolution;
- tectonic activity such as vertical and lateral earth movement rates, seismic events;
- geothermal heat flow;
- land use in the surrounding region.

Use of earth observation techniques in the safeguards of a repository with a special reference to the Olkiluoto site.

Optical data, visible (panchromatic	Optical data (multi-spectral)	Thermal IR	Radar (SAR)	Hyperspectral
Possible & potential	Possible & potential	Probably possible & potential must be shown	Possible in the near future & seems to have high potential	Probably possible & potential must be shown
Highest resolution possible (and affordable), 10 km radius from repository, principal data	Highest resolution possible (and affordable), 10 km radius from repository	May be of high potential but not yet known (underground constructions vs. thermal response), resolution presently poor	Potential not yet clear, need high due to environmental conditions. Resolution presently approximately 10–20 meters, will improve to 1–3 meters by end of this decade.	Possibly mineral detection of quarried rock
Visual analysis, possibly combined with multi-spectral data (in Finland of particular value because of vegetated/non-vegetated surfaces)	Thematic classification?	Operative instruments?	First research priority • Intensity data • Interferometric data • Ground penetration	No operative instruments?
Application for visual classification	Application to thematic classification	Research on possibilities & potential	Research on possibilities & potential	Research on possibilities & potential

For every sensor type the specific application/information should be defined later (case study)

5.1.2.2 Site specific use

Environmental monitoring has been carried out on the Olkiluoto site for 30 years. In addition, sampling has been carried out over a 10 km radius. To date, the principal requirement for this wider sampling has been to monitor the environmental impact of the two BWR NPPs.

Historic information may be used to characterise the ONKALO site.

Changes in the baseline data may be determined through the analysis of these sample results.

5.1.2.3 Known limitations of related to site specific use

The environmental information gathered to date has been focused on demonstrating the impact of the two BWR units on the Olkiluoto Island. Environmental characterisation of the ONKALO site may require a different series of samples to be taken over a different area. It will also be important to gather data throughout the entire year in order to detect seasonal variations and fluctuations.

5.1.3 Radiological monitoring

5.1.3.1 General description

Radiological monitoring is a key tool that provides assurance to authorities and the local community that nuclear facilities are being safely operated. It is a well understood technology with a large expert base. In broad terms, radiological monitoring will be carried out remotely by installed devices or other suitable means.

5.1.3.2 Site specific use

Any attempt at re-processing within the repository will release both particulate and volatile radionuclides. Particulate is likely to be contained by HEPA filters, but detectable amounts of volatile isotopes, such as ^{3}H (as a gas or as tritiated water), ^{85}Kr (gas) and ^{129}I (as an iodide) could escape from the hot cell and leave the repository in exhaust air or in wastewater. Small quantities of volatile radionuclides would also be released if a used fuel canister were opened within the repository.

Naturally occurring radionuclides will be encountered, particularly in granite and clay; elements in the ^{238}U and also ^{40}K decay chains are common. While analysis can clearly identify these naturally occurring radionuclides, it would be wise to establish a baseline. Radium-226 decays to radon gas, an alpha emitter (half-life 3.825 days), which is commonly encountered in mines, and also at the present Olkiluoto underground facilities. New excavation can lead to a significant release of radon. Any radon anomaly would be associated with new excavation possibly an illegal one. Typical radon levels and behaviour should be established.

Observations of radionuclides in the air and water should start as soon as possible during the development of the facility. While high background from natural and manmade radionuclides is not expected, early observations will ensure that any trends in background levels are well understood and future anomalies can be addressed quickly. Good knowledge of underground water movement would help in identifying critical sampling points, for this reason knowledge of hydrology is important.

Environmental sampling for radionuclides will likely be carried out to provide a baseline for safety purposes. Reports on the analysis of water and soil samples collected during the site selection/characterization phase should be provided as baseline data. Since excavation will disturb the ground water circulation, the baseline will need to be updated during development.

Instrumentation for the detection of low levels of ^{3}H (as a gas or as tritiated water), ^{85}Kr (gas) and ^{129}I (as an iodide) in the exhaust air stream should be identified or developed.

5.2.4 Geophysical monitoring

5.2.4.1 Passive seismic

Passive seismic monitoring is carried out at various frequencies. Short period (0–50 Hz) seismic monitoring is often carried out by national authorities to monitor natural seismicity. Micro-seismic monitoring (1–100's of Hz) is used to monitor rock stress during intensive mining.

Micro-seismic monitoring is a likely method for the detection of illegal excavation. If this capability is required by the Agency, its suitability for the proposed environment will need to be demonstrated.

Current passive monitoring includes the temporary installation of short period seismometers. For evaluation purposes three stations have been installed on the surface and a fourth one is to be installed shortly. Six others have been installed by the Operator (Posiva). Raw data is logged at the seismometer stations; there is no central logging or source location. The objective is to gather data on local noise patterns, which is known to include noise from turbines and generators, wave noise from the sea and breaking ice during the winter. Spectral analysis is currently carried out on the data. Future data of interest will be noise from borehole coring and drilling during excavation. It is believed that these signals can be selected by using suitable filters.

The data currently being collected is useful, but in the future we will need to focus on data needed to demonstrate the effectiveness (or non-effectiveness) of a system intended to detect drilling activity in progress. This may be more effectively carried out using higher frequencies such as those used by micro-seismic monitoring. It is recommended that higher frequency seismometer equipment be installed prior to the excavation of the exploratory shaft/tunnel. The information collected on signal characteristics and attenuation in the host rock would be invaluable in evaluating any proposed future passive monitoring system.

In a further step, the source location capability of such a monitoring system should be investigated, because this capability will be vital, if there is a need to distinguish legal from illegal activities during the operational phase. The use of seismic arrays to determine the location of the seismic or acoustic activity (with respect to direction, depth, and distance) should also be evaluated as these techniques will permit identification and tracking of activities in the zones of interest.

5.2.4.2 Active seismic

Various active seismic methods could in theory be used to image the sub-surface. It is the opinion of the experts that this method would not be capable of sufficient resolution at the depth being considered for the repository to be capable of detecting undeclared tunnelling or cavities. It is of value in determining geological details of the site to be developed and will be used by the operator for that purpose. It will contribute to geological map of the sub-surface that will assist the Agency with its general knowledge of the facility.

Reflection seismic surveying, which directly produces profiles of the sub-surface is not an effective technique due to the rocky and uneven overburden, which provides poor acoustic coupling. Vertical Seismic Profiling (VSP) is being carried out using boreholes. This data is being used to establish detailed geological knowledge of proposed repository volume, which is of interest to the Agency.

5.2.4.3 Ground Penetrating Radar (GPR)

Under favourable conditions, Ground Penetrating Radar (GPR) will detect cavities within a short distance of a rock face. The potential role for GPR is in design information verification (DIV), in particular revealing undeclared cavities or tunnels. (For this purpose, it is proposed that it should have a demonstrated ability to detect a 2 metre cubic void at 5 metres behind a rock face.) It should be noted that GPR performance will depend on the physical properties of the host rock and the radar frequencies used.

GPR data collected during site evaluation and construction (using boreholes and tunnels) could be used both to show the potential for the detection of undeclared voids in different parts of the future repository and to provide confidence that no undeclared voids are in the vicinity. A GPR baseline for the whole of the repository may not be needed, since the reference is the declared repository design.

Some GPR data has been collected from boreholes. This data is of value since it may be used to demonstrate the performance of GPR in the host rock. There will be particular interest in its performance at repository depth. It is anticipated that salinity of the rock will increase and performance/range of GPR will decrease. Opportunities to make further determinations of the effectiveness of GPR (for the detection of voids) should also be exploited when the exploration tunnel has been excavated. The data should be compiled in a report to the IAEA.

5.2.4.4 Electromagnetic and electrical

There are a variety of methods for measuring the electrical properties of the sub-surface. Electromagnetic and electrical methods may be used in site evaluation to determine conductivity at depth, which in turn can be used to assist in the development of a hydrological model for the repository. Although electromagnetic/electrical techniques could be used for detecting both non-conducting areas such as tunnels and conductors such as rails and electrical wires these techniques are not thought to be practical for safeguards purposes.

Acquisition of electromagnetic or electrical data for safeguards purposes alone is not requested. Its contribution to the development of hydrology mapping is of value to the IAEA as a contribution to its general knowledge of the site.

Passive electromagnetic techniques should be evaluated to determine the capability to detect signals from electromagnetic sources (e.g., motors, electrical wiring, etc.) located at depths. However, these methods will also be affected by the conductivity of the host geology.

5.2.4.5 Recommendations

Initial baseline from geophysical data:

Collection of passive seismic data should be extended by micro-seismic data. Report submitted should include a review of findings on noise sources, their characteristics and any information on acoustic propagation in host rock.

Recommendations for evaluation of geological conditions from geophysical data:

- Collection of passive seismic data should be extended to include micro-seismic data. Report submitted should include a review of findings on noise sources, their characteristics and any information on acoustic propagation in host rock.
- Seismic arrays should be tested to determine their ability to identify the location of a seismic or acoustic source in the Olkiluoto environment. (These techniques have been tested in the Yucca Mountain environment.)
- A geological map of the volume to be occupied by the repository
- A hydrological map of the volume to be occupied by the repository. Electrical conductivity map if available.
- Report on GPR should include a review of effective range particularly at the planned repository depth.
- Studies on passive EM to determine ability to detect EM signals generated from electrical devices at repository depths.

5.2.5 Hydrogeologic monitoring

5.2.5.1 General description

The geosphere surrounding a repository will respond in a number of different ways to the presence of the repository, e.g. hydraulically, chemically. Relevant measurable parameters are temperature, groundwater chemistry, groundwater pressure, solute chemistry and mineralogy. These parameters will often be measurable using boreholes drilled during the site characterisation and underground investigation phases. Many mineralogical changes in response to repository ventilation are likely to be confined to the immediate vicinity of the repository.

Of particular interest are changes to the hydraulic and mechanical behaviour of rock structures that may have a direct bearing on the long-term performance of the isolation system e.g. the connectivity of major water conducting fractures. Again, investigation of these features is likely to be by boreholes drilled during the site characterisation and underground investigation phases.

For repositories in the saturated zone, groundwater flow will be towards the repository while the repository remains open. However, following repository resaturation (or perhaps resaturation of part of the repository) groundwater will flow through the repository back into the geosphere. This will produce geochemical changes in the geosphere. For some repository concepts e.g. those that make extensive use of cement, the changes may be profound.

Monitoring of these effects may be difficult, in part because of problems of access to the affected rocks, but mostly because the monitoring timescales are likely to extend into the post-closure period. Nonetheless, these issues may be relevant, both to model testing and to a societal decision to close a repository.

5.2.5.2 Site specific use

Monitoring of local groundwater flow has been undertaken by the operator.

5.2.6 Open source information

The term Open Source Information is used to describe information available from a wide range of sources that has been published or is otherwise available for access by the general public and community. At one extreme the open source information can include technical reports produced by experts and made available through thesis, conference presentations or web-sites to telephone directories identifying local companies and their capabilities.

Open source literature can be used to gain a better understanding of the State or local community technical expertise and competence.

5.3 The contents of the baseline information report

5.3.1 Baseline report structure

This section provides some suggestions on the contents of the Baseline Information Report. The report should be structured and contain sufficient detail to enable a reader with a reasonable understanding of the concept to gain an understanding of the proposed facility, its impact on the environment and the interrelationships of the four components of the system.

It is expected that the report will contain a limited amount of data for the reasons expressed above (in relation to the need to develop understanding in order to gain knowledge). However, the report will reference out to the considerable wealth of data and information that has been gathered on the site and the proposed facility over many years.

For convenience, the descriptive part of the Baseline Report will be structured such that it contains the following:

- Description of system component;
- Source and prominence of data;
- Limitations in the current knowledge;
- Planned enhancements to the current knowledge base;
- Relationships to other system components;
- Identification of technical development;
- Safeguards relevance of the information.

The following section provides some suggestions concerning the type of information to be provided for each system component.

5.3.2 Human activities

- Centres of population
- Industrial activities
- Recreational activities
- Movement (i.e. commuting).

5.3.3 The environment

The report should provide a reasonably detailed description of the proposed site in as much detail as possible. It is unnecessary, however, for the report to contain measurement or monitoring data as much of this would require interpretation. It may be advantageous to describe the surface of the site, the near surface and sub-surface features.

Meteorological conditions (seasonal variations)

- Flora
- Fauna
- Rare breeds.

5.3.4 The proposed facility

- Purpose of the facility
- Method of construction
- Management and planning of construction activities
- Testing and commissioning activities
- Ownership and operation of the facility
- Principal components of the facility (e.g. receipts railhead, verification facility, encapsulation plant, transfer facility, repository)
- Facility flowsheet
- Facility throughput
- Shift patterns
- Lifetimes
- Verification Methods
- Entity identification
- Emplacement philosophy
- Monitoring proposals
- Retrievability philosophy
- Closure proposals
- Extent and Detail of Project Plans
- Ownership and Location of Project Plans
- Project Plan Change Control
- Key Events and Timings.

5.3.5 Institutional controls

- Relevant laws
- Relevant treaties
- Regulations
- Organisational structures
- Roles and responsibilities
- Security measures.

5.3.6 System Component Relationships

Controls
Triggers
Monitoring of relationships.

Annex 4 Report of the measurements working group

SAGOR II: WG on "Requirements for Nuclear Material Characterization"

Composition of working group:
Tapani Honkamaa, STUK
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Spent fuel pins (not assemblies) are the target for safeguards verification. IAEA current requirement is verification at partial defect level. Such technology does not still exist. "Advanced" methods, like tomography, would permit verification even at the pin level.

In the interim storage phase it is expected that technical means to detect partial defects will be developed. Present methods for verification – CVDs and FORK – do not detect partial defects. Advanced verification is also not performed, because such a possibility does not exist.

Nuclear materials characterization is a R&D priority. Fifteen years may not be a lot of time to develop and implement advanced characterization methods. Some facility design decisions may depend upon methods/processes used for nuclear material characterization.

Posiva's plans for operating the encapsulation plant and the repository are based on "just-on-time delivery" concept that is common in manufacturing industry. The Finnish concept for safeguarding the encapsulation process (Rautjärvi et al., 2002) is adapted to this operational concept. The concept requires that a buffer store area be created for temporary storage of about 100 assemblies at interim storages. The efficiency of transfers to encapsulation plant could be affected by nuclear materials characterization process if verification decisions get delayed down at IAEA Headquarters. It was suggested that this could be avoided if inspectors could make final verification without having to defer to IAEA Headquarters, or if alternative verification arrangements could be developed. Any reverification after emplacement of assemblies in copper casks is regarded as highly undesirable. IAEA remarked that alternative procedures for verification will likely be in place in 15 years time.

Answers to major questions:

1) Why verify? Material going into final disposal cannot be re-verified. Comprehensive verification of the fuel assemblies on the partial defect level has not been performed so far and this is the last chance to do so.

2) What to verify? Spent fuel will be verified with best possible method applicable. Pin level verification is also possible. Partial defect measurement is a requirement by the Agency criteria. Such a method is not yet available.

3) When to verify? Verification should be made as soon as characterization methods permit detection of partial defects. However, reverification would likely be required at time of transfer to encapsulation plant.

4) Where to verify? At the interim store (wet store) – although a discussion of alternatives was not undertaken.

5) How to verify? Best applicable method should be used. The tomographic method described at this meeting appears to be promising. Further development of tomographic method is to be encouraged. Also other methods should be developed. We should not bind ourselves into a specific technology.

Recommendations:
Measurement technology should be developed. Tomography seems to be a very promising method for partial defects determination in spent fuel assemblies. Other NDA methods (e.g. enhanced FORK detector) also need to be investigated to perform similar partial defects measurements. Current safeguards criteria require partial defect verification of spent fuel assemblies before placing them in difficult-to-access areas or no access areas (as is the case for final disposal of spent fuel). IAEA in collaboration with MSSPs is encouraged to develop verification methods to the pin level.

The development objective is to find a method where the equipment provides on-site analysis of measurements to permit inspectors to draw conclusions without undue delays. Therefore, a method should be found where the equipment provides on-site analysis of fuel assemblies. With respect to Finland, the measurement should permit flexible and efficient management through facilitating characterization of the spent fuel in the interim wet store. The present characterization scheme in Finland is in accord with this recommendation.

When partial defect detection equipment becomes available it is recommended that this equipment be put into service immediately in interim stores. It is recommended that the calorimetric calibration for radiometric determination of decay heat, deemed necessary for safety reasons, should be accomplished shortly before the start of the disposal activity as at that time the most reliable calibration could be achieved.