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Monitoring and the Risk Governance of Repository Development and Staged Closure: Exploratory Engagement Activity in Three European Countries

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MoDeRn

Preface

This report is the product of research activity within the EC Seventh Framework Programme "Monitoring Developments for Safe Repository Operation and Staged Closure" (MoDeRn) Project. This project aims to further develop the understanding of the role of monitoring in staged implementation of geological disposal to a level of description that is closer to the actual implementation of monitoring.

MoDeRn's view on monitoring is that it provides operators and other stakeholders with in-situ data on repository evolutions, to help manage construction, operation and/or closure activities, and may allow for a comparison with prior safety assessments. The project focuses on monitoring conducted to confirm the basis of the long term safety case and on monitoring conducted to inform on options available to manage the stepwise disposal process from construction to closure (including e.g. the option of waste retrieval). It thus provides information to inform necessary decisions. If, in addition, monitoring activities respond to stakeholder needs and provide them with understandable results, they will contribute to transparency and possibly to stakeholder confidence in the disposal process.

The project is structured into six work packages (WPs). The first four WPs are dedicated to (i) analyse key objectives and propose viable strategies, based on both technical and stakeholder considerations; to (ii) establish the state of the art and provide technical developments to match specific repository requirements; to (iii) conduct in-situ monitoring demonstration experiments using innovative techniques; and to (iv) conduct a case study of monitoring and its integration into staged disposal, including specific scenario analysis aimed at providing guidance on how to handle and communicate monitoring results, in particular when these provide "unexpected" information. The fifth WP regroups all dissemination and outreach activities and the sixth WP is dedicated to consolidating project results into a reference framework on how monitoring may be conducted at the various phases of the disposal process.

This report is to be situated within WP1 and investigates, based on an exploratory exercise, the **potential of citizen stakeholder engagement** in the **identification of monitoring objectives** and the **development of monitoring strategies** for geological disposal of high level waste (HLW) or spent nuclear fuel (SNF). As such, it builds on a former MoDeRn report (deliverable D1.3.1), based in literature study and monitoring expert interviews, describing monitoring the safe disposal of radioactive waste as a socio-technical activity (Bergmans, Elam, Simmons and Sundqvist 2012). Figure 1 offers

a schematic overview of the content of both reports, and how they fit within the social sciences research of MoDeRn.

Figure 1 Content of and relationship between MoDeRn reports D1.3.1 and D1.4.4

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1 Introduction

Geological disposal of higher activity radioactive waste presents many technical and societal challenges, not least because of the timescales involved. Research on geological disposal has been carried out in different countries for about half-a-century but it is only in the past decade or so that monitoring has become a specific focus of political, policy and research & development activity. This has been particularly the case for environmental monitoring and monitoring in view of the long-term behaviour of the repository. From our earlier document analysis and interviews with technical monitoring specialists (cf. Bergmans, Elam, Simmons and Sundqvist 2012) it became clear that the waste management community understands monitoring of a geological repository to consist of at least the following components, divided according to place and time (Table 1):

		Monitoring for …	
		Operational safety	Environmental impact
During …	Site characterisation		√
	Construction and operation	√	√
	Before and during closure	√	√
	After closure		√

Table 2 Content of and relationship between MoDeRn reports D1.3.1 and D1.4.4

Waste management agencies and their technical partners consider monitoring, both within the repository and of its environment, during construction and operation as a relatively routine operation, not demanding specific new techniques, challenging research or specific regulations. Such activity is seen as comparable to that in other nuclear installations, where the handling of the waste is concerned, and to mining activity, when it comes to the construction of underground facilities. Techniques and procedures for this are well known and regulated.

The particular challenge of a high level waste or spent fuel disposal facility is its final and long-term character. The ultimate aim of a geological repository is to reach a passive stage, in which the stored waste is completely isolated from the environment through a multi-barrier system. This aim is still valid today, but the road towards it is accepted as less straight forward than originally assumed. The original idea of a smooth progression from licensing and constructing, through operating to immediate full closure, leaving a maintenance-free facility, has come to be challenged as the concept of geological disposal became more concrete. One reason for this is that, in several cases, the estimated operational lifetime and the period after emplacement but before final closure

of the repository is now assumed to be at least several decades to a century. In Finland, for example, this is due to the fact that not only the spent fuel of the existing nuclear power plants (NPP), but also that of more recently planned NPPs must be placed in the facility planned at the Olkiluoto site. The initial decision in principle about the construction of a geological repository for the spent nuclear fuel produced in the four nuclear power plants in operation in Finland at the time (Loviisa 1 and 2, and Olkiluoto 1 and 2) dates from December 21st 2000. Two years later, on January 17th 2002, another decision-in-principle was taken regarding the spent nuclear fuel of the new Olkiluoto 3 plant unit; followed on May 6th 2010 by another decision-in-principle concerning the extension of the still-to-be-built repository to accommodate the spent nuclear fuel of yet another new plant (Olkiluoto 4).[1] These last two decisions extend the operational life-time of the future repository by at least 40 years, making a total time span from construction to closure of over a century (see diagram in Posiva 2008: 14). To take another example, in France the plan is to dispose a first batch (about 5%) of the total amount of waste to be disposed of, and observe it for a period of about 50 years before emplacing the rest (see ANDRA 2013). French legislation furthermore obliges a geological repository to remain reversible for at least 100 years. Only after this period, a decision on final closure of the facility can be taken by parliament.[2]

Not only will it take more than a human lifetime to accomplish a fully closed facility, this facility will have to remain intact and perform as planned for at least several hundred thousands of years in order for it to serve its purpose of containing its radioactive load. As many people are concerned over whether long term safety claims will indeed hold after final closure of a geological disposal facility, and environmental organisations and other civil society groups challenge the predictability of repository behaviour over such a long time frame, the demand for monitoring and surveillance has become more prominent in most countries on their way to implementation. In France and Switzerland, this seems closely related to the legal requirement for reversibility[3] and retrievability[4], respectively. The demand for retrievability, even if restricted to a dedicated period before closure, and the idea of a test-batch (cf. France) or a pilot facility (cf. Switzerland) furthermore adds another dimension to our table above. Now it also becomes important where to monitor, not just in view of operational safety and the behaviour of the facility today, but also in view of future behaviour and long-term safety. Technical research programmes, such as MoDeRn, have therefore been put in place to investigate options for in-situ monitoring.

[1] Information provided by the Finnish Ministry of Employment and the Economy: http://www.tem.fi/index.phtml?89521_m=109105&l=en&s=2471 (consulted 06/02/2013).

[2] Loi n°2006-739 du 28 juin 2006 de programme relative à la gestion durable de matières et déchets radioactifs.

[3] Ibidem.

[4] Nuclear Energy Act of 21 March 2003 (*Kernergiegesetz*, *vom 21. März 2003*).

A growing concern with monitoring strategies thus appears to coincide with a move from *risk analysis* and the production of safety cases in support of specific repository designs to *risk management* and the actual implementation of geological disposal. Therefore monitoring can be seen as central to the development of managerial control systems for safely implementing geological disposal: as both a means of internal managerial control over repository development and a support for evidence-based decision-making for staged closure. Monitoring then becomes a kind of 'moral technology' (Spreng, Marland and Weinberg 2007) enabling implementing bodies to respect established principles of nuclear safety such as the imperative for vigilance during implementation, but also to help produce and maintain stakeholder confidence during implementation and closure.

But the degree to which monitoring can contribute to establishing stakeholder confidence in a functioning repository is dependent on the confidence various stakeholders have in that monitoring system. So far in this introduction, we have mainly used the term 'monitoring' to refer to the gathering of technical data about the way in which a repository and its surroundings develop. However related societal processes of making sense of the technical data, and putting the act of monitoring in a context of responsible care or continuous vigilance are also part of a monitoring system (Hocke, Bergmans, and Kuppler 2012). Monitoring can thus refer to a range of different activities and arrangements, which raises the questions of what is meant by monitoring and what is its purpose?

In this report we explore what monitoring could mean for citizens living near a potential repository site, what expectations they could have vis-à-vis monitoring activity and the use of its results. For that purpose, workshops were set up involving volunteers from communities which host existing nuclear facilities who have had varying degrees of engagement with radioactive waste management projects in Belgium, Sweden and the United Kingdom. A subset of these volunteers was subsequently invited to visit two underground research laboratories (URLs) in Switzerland and discuss monitoring issues with their foreign colleagues and some of the MoDeRn consortium partners.

The research involved a relatively small number of participants and generated qualitative data. Our analysis cannot therefore claim to provide a representative categorisation of different opinions regarding monitoring in relation to geological disposal, either at a national or a European level. Nevertheless it provides insight into the understandings, concerns, reasoning and preferences of potentially affected citizens. Before we report the views of citizens who participated in our workshops, however, we outline briefly the context in terms of geological disposal in each of the three countries.

2 National Contexts of Geological Disposal

In this section we provide a brief overview of the ambition regarding geological disposal and the state of the programme in the three countries from which we involved citizens in our research work. We describe the main components of the concept, its maturity and the extent to which monitoring is foreseen in the proposed concept and/or called for by concerned actors.

2.1 Belgium[5]

Belgium has two nuclear power plants (NPP), with a total of 7 reactors, providing for about 54% of the country's electricity. At present, the policy is to face out and to shut down the nuclear reactors once they have reached a life span of 40 years. A scenario that has been on and off the political agenda for some time now, is to prolong these life spans with a certain period. However, today no official decision has been taken on this.

Up until the beginning of the 1990's, spent fuel was send for reprocessing to La Hague (France). Since 1993 a moratorium exists on reprocessing, and spent fuel (currently not declared as 'waste') is stored on site at the NPP's, remaining the property, and thus responsibility, of the electricity companies owning the NPP's. All radioactive waste, including the reprocessed waste is the responsibility of ONDRAF/NIRAS, the Belgian radioactive waste management organisation (RWMO), and stored on the site of its industrial daughter company, Belgoprocess, in the municipality of Dessel. Wastes are categorised as Category A (conditioned low and intermediate level, short lived waste), Category B (conditioned low and intermediate level, long lived waste) and Category C (conditioned high level waste containing large quantities of long-lived radionuclides – mainly waste resulting from the reprocessing of spent fuel).

2.1.1 A Waste Plan for high-level and long-lived (category B&C) waste

In September 2011 ONDRAF/NIRAS adopted a national waste management plan for the country's high-level and/or long-lived waste (cat. B&C). With this plan, ONDRAF/NIRAS is seeking a decision in principle on geological disposal from the Federal Government. The 'Waste Plan' was published in the Official Bulletin that same month[6], but no decision has

[5] For more detailed information on the situation in Belgium, see: Bergmans, Van Steenbergen and Verjans 2006; Schröder and Bergmans 2012.

[6] Déclaration relative au Plan Déchets en application de la loi du 13 février 2006 - Plan Déchets pour la gestion à long terme des déchets radioactifs conditionnés de haute activité et/ou de longue durée de vie et aperçu de questions connexes - Moniteur Belge 30-09-2011: 61518 – 61580.

yet been taken by the Federal Government, leaving this plan without political validation. Therefore, no concrete steps have so far been taking yet in view of site selection.

The RWMO's preference for poorly-indurated clay would in essence limit the options to the north of the country, the Flanders region, where either Boom or Ypresian clay is available at suitable depths. At present, Belgium has one URL in operation (Hades) in Boom clay, and this already for over 30 years, at the site of SCK•CEN, the Nuclear Research Centre, in the municipality of Mol.

Category B waste and category C waste are considered together for their long-term management because the risk that they present extends over similar timescales, from several tens to hundreds of millennia (NIROND 2011: 48). As reprocessing came to a halt in 1993, ONDRAF/NIRAS takes into account the possibility of geological disposal of both reprocessing waste and non-reprocessed irradiated fuel, even though it does not currently manage any spent nuclear fuel from the Belgian nuclear power plants (NIROND 2011: 49).

The geological repository concept put forward by ONDRAF/NIRAS consists of a network of horizontal galleries, with shafts leading to a main gallery which gives access to the smaller disposal galleries. The disposal galleries are divided into several sections dedicated to groups of wastes with similar characteristics (e.g. thermal output or chemical composition). Category C waste will be emplaced in supercontainers, while category B waste will placed in concrete caissons and subsequently embedded in mortar to form monoliths. Both supercontainer and monolith are to provide radiological shielding to protect workers during operation and closure of the repository. After emplacement of the waste, empty spaces in the disposal galleries are backfilled. All access galleries and shafts are backfilled and sealed at the end of the underground operations, though the option of an additional period for in situ controls is still left open. (NIROND 2011: 126)

ONDRAF/NIRAS makes itself strong that the solution of geological disposal in poorly indurated clay is flexible enough to adapt to additional conditions to which its implementation could be subjected, and to potential variations in B&C waste volumes to be managed. Concerning these conditions, the RWMO already received indications, during the public consultation on the Waste Plan, that various actors attach importance to the aspects of (a) reversibility and retrievability (R&R), (b) monitoring and control, and (c) knowledge transfer and maintaining institutional memory of the repository. How this could be worked into ONDRAF/NIRAS's disposal concept for future examination, which, according to the RWMO should be done within the context of a societal dialogue

and addressing scientific, technical, ethical, financial and safety aspects. The following elements are mentioned in the current Waste Plan regarding these three conditions:

Reversibility and Retrievability

Although reference is made to the NEA's 'diagram of a disposal system's evolution over time', showing the evolution in the degree of retrievability and passive safety, the terms reversibility and retrievability have been conceptualised somewhat differently by the Belgian RWMO and regulator, than seems to be the case at the international level. Reversibility is defined in the Belgian Waste Plan as 'the technical possibility of safely retrieving waste packages placed in disposal galleries that are not yet sealed using means identical or comparable to those used for their emplacement'. Reversibility is thus related to the industrial operation of the repository and as such considered to be provided for in the current repository design. Once a gallery is sealed, the situation is no longer considered reversible. (NIROND 2011: 129). Retrievability is defined as 'the technical possibility of safely retrieving waste disposed of in sealed disposal galleries, if necessary using means other than those used for its disposal'. In its most extreme case this would imply the full mining out of a completely closed repository. (NIROND 2011: 129)

For the Belgian RWMO, both concepts are 'technical in nature and must not be confused with the concept of "adaptability", which is specific to the proposed decision-making process' (NIROND 2011: 129).
It is furthermore suggested R&R should be the starting point for the societal dialogue ONDRAF/NIRAS plans to launch. While the RWMO thus seems to leave the option of R&R open, stating that it will undertake 'to ensure reversibility during operation, and to review the measures that could facilitate the potential retrieval of waste after the partial or complete closure of the repository for a period to be defined' (NIROND 2011: 129), at the same time it does set a number of strict boundary conditions within which the discussion on R&R should take place, among which a restriction of this option in time, and a reminder that the essence of final disposal remains the explicit intent not to retrieve (NIROND 2011: 130).

Monitoring and control

ONDRAF/NIRAS recognises that in addition to the controls provided for in the regulatory framework (related to licencing, security aspects or safeguards) additional controls are required by society during operation and/or closure, potentially also after complete closure of the repository, in order to verify the proper functioning of the disposal system. Examples are given of what such controls could imply (NIROND 2011: 132):

- verify the proper implementation of the backfill and seals
- verify that the physicochemical phenomena taking place in the repository are as expected

- verify that the potential impact of the repository on its environment (temperature in the clay and surrounding aquifers, ground elevation, etc.) remains acceptable or within the standards.

Knowledge transfer and maintaining institutional memory

Knowledge transfer and maintaining institutional memory are seen as encompassing: (a) the "marking" of the repository location, and (b) the transfer of knowledge and know-how relating to the disposal system, the waste and its characteristics, etc. In the Waste Plan, it is therefore closely linked to controllability and retrievability (NIROND 2011: 133).

2.1.2 Monitoring issues raised regarding the category A programme

For the siting of a low and intermediate level waste (LILW) surface repository a participatory approach was initiated, by setting up local partnerships in communities willing to investigate the feasibility of hosting such a repository and by giving the local community the opportunity to integrate their conditions (social, technical, economic, …) into the repository project. This led to the municipality of Dessel (neighbouring community to Mol) being chosen (by decision of the Federal Government) as the host community. One of the conditions to accept the facility was a continuous programme for participation. Therefore, the partnership approach was continued and both the partnership of STORA (Dessel) and MONA (Mol) remained in place, to allow for further participation and close interaction between the RWMO and the local community in further developing the repository project (the cAt project). Apart from following up the developments of the cAt-project, both partnerships have also taken the decision to follow any evolutions regarding the research and policy in relation the management of HLW.

With regard to this LILW repository project, the local citizens involved in the partnerships have, from early on in the process been expressing an interest in the question of monitoring, and have been closely involved in the development of the monitoring programme during the design phase of the repository (Landström and Barbier 2012). Of great concern to the local community was the importance of the broader area around the potential site as a fresh water reservoir for the Flemish region. They therefore wanted more guarantees that any leakage from the facility - which could potentially lead to contamination (radiological as well as chemo-toxic) of the groundwater - could be detected and contained as quickly as possible. Therefore, they showed to have more faith in a safety strategy based on containment, then on dispersal. Starting from the idea of an intensified monitoring programme and the ability to capture potentially contaminated water coming out of the repository, the local partners investigated different options to realize this and asked the repository concept to be

amended to accommodate for this. This led to the introduction of an inspection gallery in the design of the repository (Bergmans and Barbier 2012). Also considered to be a monitoring issue for the local citizens, was the introduction, on their demand, of a programme of prototypes, such as a demonstration test - reconstructing different building blocks of the repository before the actual construction - , a subsidence test - monitoring the subsidence of the underground before actual construction - and a test cover. The test cover comprises of a real scale simulation of the final cover, to monitor and study the behaviour of the covering layers during several decades (NIROND 2010: 48-51).

2.2 Sweden

Today Sweden has 10 nuclear reactors in operation. After a national referendum in 1980 – a time when nuclear power was the most controversial issue in Swedish political life – it was decided by the parliament, due to the strong conflict, that nuclear power should both be expanded and phased-out. The nuclear power programme should be developed from six to twelve reactors, but all reactors should be phased out by the year 2010. However, in 1997 the parliament removed the date 2010 and decided to have a flexible end-point for the phasing-out process. In June 2010 a parliamentary decision on nuclear new build was taken allowing for the replacement of old nuclear power plants on existing sites, reversing the 1980 decision and removing a 30-year ban.

After the referendum in 1980 an integrated waste disposal system, with a clear organization and legislation of its own, began to take form in Sweden. The Swedish Nuclear Fuel and Waste Management Company (SKB) planned for and received permission to construct a central interim storage facility for spent fuel (CLAB), where it will be stored for at least 30 years, at the reactor site in the municipality of Oskarshamn. This facility has been in operation since 1985. A sea transportation system, including a specially designed vessel (called Sigyn) and harbours at all four reactor-sites, was also constructed at the beginning of the 1980s. In 1986, SKB presented the idea of developing an underground research laboratory (URL). The laboratory was planned to be a dress rehearsal for the final repository for spent nuclear fuel and it was decided to be located at Äspö, in close proximity to the reactor site in Oskarshamn. The URL was completed in 1995. Contrary to the situation in most other countries these facilities were not politically controversial in Sweden. A final repository for low-level nuclear waste was also established at the Forsmark reactor site (SFR) in Östhammar municipality, and has been in operation since 1988.

In the early 1980s SKB formulated a systematic geo-scientific research programme of test drillings across Sweden with the aim of supporting the site selection process for finding a proper location for the last missing part of the Swedish waste system, the final

repository for spent nuclear fuel. The drillings were conducted without informing residents and engaged groups about the activities or the purpose of the drillings. This strategy of not involving people, and defining the drillings as research of interest only to the company itself and its geo-scientific experts, turned out to be unfortunate for the nuclear industry. A network of local protest groups against the drillings received widespread public support. The industry was forced to change its narrow technocratic siting strategy to become more socially sensitive and include the opinion of local residents in their future activities.

In 1992, after the earlier failures, SKB presented a completely new siting strategy, which meant that feasibility studies should be carried out in only those municipalities, which 'through their own initiative, display an interest in having a closer examination made of their potential for hosting a deep repository'. SKB sent a letter to all 286 municipalities in Sweden, inviting them to take part in feasibility studies. Two years later only two studies had been carried out, and since SKB pledged to carry out five to ten feasibility studies, they invited specifically the communities already hosting nuclear facilities and their neighbours. This resulted in an additional six studies. From these eight studies, SKB, in 2000, selected the sites in the three municipalities of Östhammar, Oskarshamn and Tierp as of most interest. The two most important nuclear sites in Sweden, Oskarshamn and Östhammar accepted to take part in the next step, detailed investigations. In June 2009 SKB announced, after several years of bedrock examinations in the two municipalities, that the geology of the Östhammar site was more favourable for the construction of a geological repository. In March 2011 SKB submitted to the Swedish Radiation Safety Authority and the Environmental Court, an application to build a spent fuel repository in Östhammar municipality close to the Forsmark reactor site.

During the siting studies the involved municipalities built up their own organisations and competences. Before the site investigation started, the municipality of Östhammar signed a contract with SKB where 15 separate conditions were set down. These determined, for example, that SKB alone shall carry out the site investigation; that the municipality is not bound to accept further studies/investigations in connection with the siting of a deep repository; that the municipality shall be granted unlimited access to the results of the site investigation; that highly technical aspects of SKB's investigation shall be summarized in a fashion understandable by local citizens; that the municipality's reference group shall be kept well-informed about the progress of the site investigation in a fashion that enables them to pass on information to local citizens; that the municipality's reference group's own ideas and perspectives shall be given due attention by SKB; that SKB themselves maintain a high level of ambition to inform local citizens about the progress of their site investigation paying special attention to young people, summer residents and those living close to a proposed repository; and that municipal

expenses in connection with a site investigation shall be reimbursed through the Nuclear Waste Fund. It was also decided by the municipality that the reference group set up already in connection with the feasibility study should continue its duties during the site investigation. Their task would be 'to follow, to review and to inform' about SKB's work both in relation to the municipal council, and local citizens in general. A local Environmental Impact Assessment Group was also formed composed of eight local politicians and four local civil servants. Their primary task was to represent the municipality in the regional Environmental Impact Assessment (EIA) forum coordinated by the County Administration and other EIA events organized by SKB.

Today, the organization in Östhammar consists of two review committees, one focusing on long-term safety issues and one on environmental issues. The members of the committees are local politicians. In addition, there is a reference committee, with representatives from all political parties, including representatives from neighbouring municipalities and the Åland Islands (Finland), as well as representatives from local NGO's and interest groups. There is also a group of four civil servants working full time with the different aspects of a final repository.

Participants taking part in the MoDeRn project engagement exercise are recruited among members of the community groups in the municipality of Östhammar, the candidate site for a geological repository for spent nuclear fuel in Sweden.

2.3 The United Kingdom

The UK has 19 nuclear power stations on 14 sites; 10 of these stations, all of them operating first generation Magnox reactors (with most stations having two reactors), have closed and are preparing for or undergoing decommissioning. The one remaining Magnox station is due to cease operation in 2014. Seven of the other stations each operate twin advanced gas-cooled reactors (AGR) and are currently due for closure between 2018 and 2023; the last station to be built operates a single pressurised water reactor (PWR) and is due for closure in 2035. The operator of these sites is seeking life extensions of five years for each of the AGR stations, two of which have already been approved, and 20 years for the PWR.

Current UK Government energy policy supports the construction of new nuclear power stations and eight locations, all existing nuclear sites, are currently designated as potential sites for development. This policy does not include Scotland which, as a devolved administration, sets its own energy policy and currently rejects the construction of any new nuclear facilities. It is not yet clear whether new nuclear power stations will be built or at how many sites.

The UK also has several other facilities involved in different stages of the nuclear fuel cycle, from uranium enrichment to fuel production and reprocessing plants, as well as research reactors. Some of these are already closed or are scheduled for closure; others will close over coming decades; all will generate a variety of waste streams. Spent fuel reprocessing, which produces the UK's high level waste, is expected to continue at the Sellafield site until 2021. There are also a variety of medical, industrial and research wastes. In addition to its civil nuclear facilities the UK has various military sources of radioactive waste including 27 nuclear-powered submarines, of which 18 are now out of service, defueled and in floating storage; the intermediate level waste that they will generate on final dismantling is expected to go to the planned national geological disposal facility.

The latest published UK inventory of radioactive waste, produced in 2010, which included an estimate of future waste arising, includes 1,020m^3 of high-level waste and 287,000m^3 of intermediate level waste.[7] The UK does not classify spent nuclear fuel, uranium, or plutonium as wastes; all of these are currently designated as resources that can be used to produce reactor fuel. Future changes in policy and practice - for example, the cessation of reprocessing - may lead to these materials being re-categorised.

Following failures in the 1980s and 1990s to gain local agreement to investigations of potential sites for the disposal of high and intermediate level wastes, in 2001 the Government initiated a new programme, Managing Radioactive Waste Safely (MRWS), and appointed a Committee on Radioactive Waste Management to advise on long-term management options that would ensure the safety of the human population and the environment, and which would inspire public confidence. This resulted in the adoption of a new policy committed to geological disposal of high, intermediate and some low-level wastes, with robust intermediate storage until that can be achieved, and based on a volunteer approach that entails local partnerships and the provision of community benefits packages. [8]

Only in one region, West Cumbria in the northwest of England, which is home to the large Sellafield nuclear complex and to the UK's national low-level radioactive waste facility, have elected local government bodies so far registered a formal expression of interest in the possibility of further investigations being carried out. The West Cumbrian MRWS Partnership, comprising representatives of Allerdale Borough Council, Copeland

[7] An updated inventory with a stock date of April 2013 is due for publication in February 2014.

[8] *Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal*, June 2008, A White Paper by Defra, BERR and the devolved administrations for Wales & Northern Ireland. Scotland has a different policy, having rejected geological disposal, and is currently committed to near-surface monitored and retrievable storage of these wastes, close to the sites at which they are produced.

Borough Council, Cumbria Country Council and a wide range of local stakeholder organisations, was established in March 2009 and undertook a review of expert evidence and an extended period of consultation with local citizens, stakeholder groups, and parish and town councils about whether or not the region should move to a Decision to Participate. At the time that the MoDeRn stakeholder engagement exercise was being organised this process had not yet been completed and the Partnership was at a critical stage of formulating its recommendations. The Partnership completed its work in July 2012 and published its final report in August 2012.[9] In January 2013 the three elected local government bodies each voted on whether to proceed to the next stage of the process: Copeland and Allerdale Borough Councils voted in favour but Cumbria County Council voted against. Since unanimity had been a condition for proceeding, Cumbria County Council's decision halted the MRWS process in West Cumbria. Government subsequently initiated in May 2013 a four-week consultation on the site selection aspects of the national MRWS programme. This was followed by the publication in September 2013 of a consultation document outlining proposed changes to the siting process that aim "to revise and improve the site selection process for a GDF, while maintaining an approach based on voluntarism and partnership".[10] The consultation on these proposals closed in December 2013 and the Government's response is awaited.

[9] *The Final Report of the West Cumbria Managing Radioactive Waste Safely Partnership*. August 2012. Whitehaven: Copeland Borough Council.

[10] *Consultation: Review of the Siting Process for a Geological Disposal Facility*. September 2013. London: Department of Energy and Climate Change.

3 Citizen Stakeholder Perspectives on Monitoring

In this chapter, we present an analysis of the results from focus group discussions held in three countries (Belgium, Sweden and the UK), and collective discussions during a joint field trip with some of the focus group participants and a delegation of MoDeRn partners to the underground research laboratories (URL's) of Grimsel and Mont-Teri in Switzerland. The focus group discussions were held with volunteers from communities which host existing nuclear facilities who have had varying degrees of engagement with radioactive waste management projects in Belgium, Sweden and the United Kingdom. In the case of Sweden, a number of volunteers from regional and national stakeholders in programmes of geological disposal also participated. During at least part of the discussions, these volunteers interacted with representatives from implementing bodies and associated developers of monitoring technologies.

We did not strive for representative groups, as it was not the intention to draw general conclusions on perception, behaviour or expectations of the (local) public in general. We specifically aimed to recruit participants who already had an interest in nuclear issues and were more knowledgeable about the problem of radioactive waste than average, in order to be able to start the discussions at a more specific level. The people who took part in the workshops were therefore drawn from the relatively small group of engaged citizens, rather than from the 'general public'. In that respect, the outcome of this exploratory engagement exercise can be seen as indicative of the opinions and expectations of particular groups in society.

Where possible, interviews and group discussions were recorded and fully transcribed to facilitate thematic content analysis. A common protocol with discussion topics was developed, to increase comparability between the three different exercises. Interpretation of the results was supported by reference to relevant research literature (see Bergmans et al 2012). The research methods employed generated qualitative data the analysis of which cannot be claimed to provide a representative categorisation of different opinions regarding monitoring in relation to geological disposal, either at a national or a European level, but which provide insight into the understandings, concerns, reasoning and preferences of experts and affected citizens.

What emerges from the analysis are different societal demands upon monitoring in the making, but also demands for different degrees and styles of managerial control. Then there is negotiation of those demands for monitoring which are technically feasibly

versus infeasible and possible or impossible to reliably develop. The latter negotiations link to the discussion on how far one can go in making the implementation process transparent and visible without undermining the repository's core mission of isolating the waste from the biosphere. How transparent can/should disposal be?

In what follows, we describe the set-up and results of the focus group discussions in each of the three countries. A fourth section is dedicated to the Swiss field trip.

3.1 Exploratory engagement activity in Belgium

In Belgium, volunteers were recruited among the members of the local partnerships MONA and STORA in the municipalities of Mol and Dessel[11]. Not as representatives of their partnerships, but as interested individuals to contribute to this research project. Both partnerships have been active since the turn of the century and encompass representatives from the municipal authority, political parties, civil society, as well as interested members of the public. The partnerships were initially created to investigate and debate the technical and social feasibility of hosting a low and intermediate level waste (LILW) repository in their communities, and advise their respective municipal councils on whether or not, and under which conditions, to volunteer to host such a facility (see also 2.1). In that respect, they had experience with the issue of monitoring and discussing principles and approaches of a repository's monitoring programme. Since the allocation of the facility to the municipality of Dessel, the partnerships have taken on the role of following up from close by the concrete development of the facility (including the licence application) and the realisation of the local conditions they had put forward. Some of these conditions were related to monitoring requirements. Given the presence of other nuclear activity in the area, including the underground research laboratory, HADES, for research on geological disposal of high level waste, the partnerships also extended their operations to staying informed about that activity, and advising the municipal council if deemed necessary[12].

3.1.1 Three evening workshops and one round-up session

An invitation letter was sent to all members of MONA and STORA (about 170 people in total), to which 14 volunteers responded. As mentioned above, we did not seek representation of the broader public, and opted to gather a more knowledgeable group of citizens on a voluntary basis. We did not set any selection criteria for gender, age, education, profession, or other factors, but simply welcomed all who responded

[11] www.monavzw.be and www.stora.org

[12] For more detailed information on the local partnerships and their mission, see for example: Bergmans, Van Steenbergen and Verjans 2006; Bergmans 2008.

positively. The Belgian group was composed of 13 men and 1 woman; all participants were over 30, the majority in between 50 and 65, four participants were over 70; most had a higher education (college or university).

During an introductory session, the MoDeRn project and the purpose of the exploratory engagement activity were presented and following the volunteers' preference, a series of 3 evening workshops and one 'round-up session' was planned (the first in December 2011 and the last in May 2012). The workshops took place in Mol, as this made it easiest for the local participants to attend. In each workshop, 12 to 14 volunteers participated, together with the research coordinator for geological disposal from ONDRAF/NIRAS (the Belgian waste management agency) and a EURIDICE researcher from MoDeRn. The round-up session was attended by 10 of the local volunteers. Two collaborators from the University of Antwerp (UA) organised the workshops and provided the workshop minutes. The minutes were distributed to all participants via e-mail and discussed/approved at the next meeting. The minutes of the round-up session were distributed and approved via e-mail. When referred to "the participants", or "the group" below, we refer to the 12 to 14 volunteers from the local partnerships.

The first workshop (15/12/2111) started with a free association by the volunteers from STORA and MONA around the notion of monitoring for geological disposal. It continued with a structured discussion, led by UA, about the participants' own experience with discussing monitoring issues for an LILW surface repository project (the cAt-project). Over the second and third workshop, the participants' views on monitoring for geological disposal were gradually elaborated in more detail.

The second workshop (02/02/2012) was built around two presentations. One from ONDRAF/NIRAS providing general information on the agency's generic plans for geological disposal, some examples of more concrete concepts in other countries, international (IAEA) guidelines on monitoring and surveillance, and the role the agency thinks monitoring can play in a Belgian context, referring to some foreign examples. The Swiss concept was deliberately introduced as an example, because of the planned field trip to the Swiss URLs (see below). Where the ONDRAF/NIRAS presentation focused primarily on monitoring objectives and broad implementation strategies, the other presentation from EURIDICE addressed monitoring in practise. It started from general examples from the field of construction and geo-techniques, continuing with examples from active monitoring in the HADES facility, and ending with specific challenges and promising new technical developments for monitoring a geological repository. Most of the topics listed in the workshop protocol were touched upon spontaneously by the participants through questions asked or points raised during the discussion around the presentations.

The third workshop (12/04/2012) continued with topical discussions: remaining issues were addressed and some issues revisited that seemed in need of further discussion/clarification. This was done through a structured discussion, led by UA, and based on the common protocol. Part of the workshop was dedicated to the specific questions of how to interpret threshold or trigger values (*alarmdrempels*) and the appropriateness of making raw monitoring results publicly available (in real time). This discussion was instigated by a number of real and fictitious examples of situations such as one-off measurements beyond trigger values and perturbations in measurements due to maintenance work.

During the round-up session (24/05/2012), the 5 volunteers that took part in the field trip to Switzerland (see infra) reported back from their experience. Based on an overview prepared by UA (drawn from the minutes of the 3 workshops), the participants formulated their conclusions and recommendations to the MoDeRn consortium regarding questions such as: Why, what and how to monitor? How to engage (citizen) stakeholders in the development of a monitoring programme? How to communicate about monitoring results?

3.1.2 A mind map on monitoring for geological disposal

The Belgian group started out with a free association on monitoring for geological disposal. Apart from a general introduction to the MoDeRn project and explanation on the purpose of the workshops a month beforehand (03/11/2011), no further detail was provided before this exercise took place. Given their history as volunteers in the local partnerships, the participants had previous knowledge of the different types of radioactive waste, and of the general concept of geological disposal, which had been discussed as an option for the LILW waste a few years back.

Each participant was asked to write down as many things he/she would associate with monitoring in relation to geological disposal during about 20 minutes. These collected thoughts were subsequently discussed with the group, by using a mind mapping technique. A schematic translation of this, as represented in Figure 2, was discussed in the second workshop and considered to effectively represent the participants' collective view on monitoring for geological disposal.

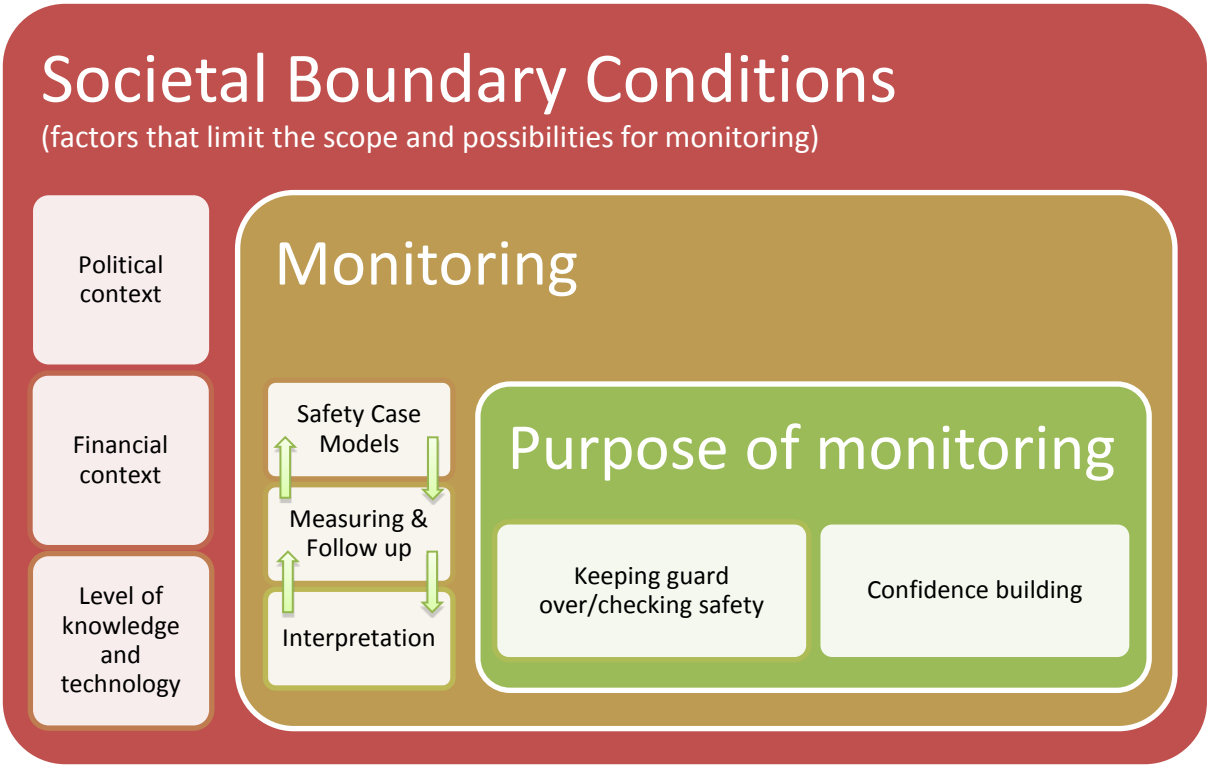

Figure 2 The Belgian participants' collective view on monitoring objectives

While there was agreement that the disposal concept must be credible and durable, monitoring was defined by the group as a way of checking if a project, facility or activity develops, performs or runs as expected; it is a way to find out what is happening, taking into account potential distortions, due to potential changes in the conditions of the measurement devices and techniques that are being deployed.

The main objectives for monitoring according to the Belgian group are checking the safety of the facility, and to assist in building confidence in its management and potential for providing long term safety. Monitoring for the participants means remaining on guard, and being prepared and capable to respond in case of unexpected results. A monitoring programme should therefore include alarm thresholds, early warning systems and response plans. If there is no room or willingness for adjustments or corrective actions, monitoring was considered useless. Later on in the discussions during the following sessions, the group specified that an unexpected result in their minds did not automatically equal that something would be wrong. They saw various degrees of responses or follow-up actions in case of such an unexpected result, the first being to find out why an anomaly in the data occurred, whether it is a one-off or a more consistent deviation, etc. Retrieval of some or all the waste in the repository, they considered at all times to be a last resort action, after all other possible options had been considered. It was stressed that any corrective action would have to be evaluated on its technical, financial and societal feasibility.

With regard to the potential of monitoring to contribute to public confidence in a repository system, the group linked this strongly to the issue of checking that the facility behaves as expected (pre- and post-closure), to the building in of flexibility to allow for optimisation in the design during construction and operation, and to data gathering in the entire period before closure that allows an informed decision on closure (or not) to be taken. It was furthermore explicitly pointed out that public confidence will not be built by setting up a monitoring programme alone. The broader question of the governance of the repository, from siting to closure is at play here. Specifically for monitoring, this would include clarity on who is responsible for monitoring, how and by whom monitoring results are interpreted and how monitoring results are communicated.

3.1.3 Issues raised during the Belgian workshops

On the scope of monitoring

For the participants a monitoring programme should be as **comprehensive** as possible and should include the monitoring of repository system conditions, environmental conditions, socio-economic conditions, as well as evolutions in knowledge and technology. A monitoring programme should furthermore have a **broad scope in both space and time**. Surveillance was seen as an essential part of such a programme.

According to the workshop participants, **technical monitoring** should be based on the models that are used to support the safety case. Monitoring is in that respect seen as a reality check and therefore there should be a possibility to adjust the models if need be. This stimulated a discussion on the extent to which that is feasible. Similarly, the participants agreed there should be room for adjustment, improvement and optimisation in the repository design, though some doubt was raised on how realistic such expectations could be.

In the pre-closure phase (that is from site characterisation to closure) the participants saw monitoring as a tool to check if everything worked according to plan and to establish whether the models used to assess the long term safety are correct and remain valid over time. Here they saw a clear role for near-field monitoring, though not exclusively. They anticipated both near- and far-field monitoring to be needed and emphasised the need for continuous research into new monitoring techniques. Final closure of the facility they only considered possible and acceptable after sufficient demonstration (through a diverse range of monitoring activity) of 'good behaviour' of the facility according to the models.

Both before and after closure, monitoring was seen by the participants as a tool for continuously making sure nothing unsafe is happening. This is not to say that they expect monitoring in itself to contribute to the robustness and safety of the facility. They see it as a means to exercise control.

Clear expectations were raised regarding post-closure monitoring, but no strong opinion resonated from the group on the value of repository monitoring at that stage. Near-field monitoring in a post-closure situation was seen by many as relatively unrealistic, although not all participants agreed one could do without.

In general, the group agreed that monitoring at all times should be performed as close as possible to the object or process one wants to monitor. If, for any good reason, that were not possible, then alternatives should be sought to provide the same, or similar, information. If any parameters worth following through near-field monitoring after closure would exist, it should be made a priority to search for good alternatives for the near-field option. A hypothetical suggestion given was the use of parallel monitoring galleries around the repository.

The group had no strong opinion on exactly which 'technical' parameters should be measured, but were clear it should be broader than radiation levels. Chemical compounds and geology were explicitly mentioned as important. Basically the participants thought it necessary to measure everything that could be relevant to know, to measure all critical parameters (which led to the rhetorical question: "What is critical?") in order to critically assess and follow-up the following things: (a) all material going into the repository, (b) the behaviour of that material inside the repository, (c) any impact of the repository on its environment, (d) any impact of the environment on the repository.

On the notion of performance confirmation

When presenting the IAEA (draft) guidelines on monitoring and surveillance of radioactive waste disposal facilities, the ONDRAF/NIRAS representative described the role of monitoring in the pre-closure phase as one of performance confirmation, of confirming that no conditions exist that could influence in a negative way the safety of the facility after closure. Several participants questioned the use of the term confirmation, as they didn't see that possible: How could one guarantee no problems could occur in the future? During the concluding session, the group therefore recommended to speak of checking the safety of the facility, of showing through monitoring that currently nothing unsafe is happening and what models then predict for the long term.

In that regard a discussion was held on what would be a sufficiently long time to monitor before enough data would be collected to corroborate the safety case, and to provide some confidence in its long term projections. The question was raised where the seemingly international standard of 100 years of measurement before closure came from and whether 100 years could at all be representative when dealing with timescales of at least several thousand times more. The explanation by the ONDRAF/NIRAS representative that a period of 100 years has meaning because within that time span the peak in heat generation will have been passed was considered reasonable. Nevertheless, people found it difficult to accept the claim that scientific proof could be provided of repository behaviour for 100,000 years, based on behaviour over 100 years. Or as one participant observed: "This is more about faith and religion, than about science. It is about whether you are willing to believe the situation will evolve in that way."

On monitoring as a process

During his introductory presentation, the ONDRAF/NIRAS representative showed a diagram of the approach the waste manager envisaged for developing a monitoring programme for geological disposal. It presented the programme to develop in a stepwise manner, attuning technical and scientific requirements with 'boundary conditions' set by the national and international regulatory framework, and by expectations from different stakeholders (referring explicitly to the regulator, local actors, the scientific community and the waste producers). The group appreciated the fact that this at least suggested openness towards stakeholder engagement, as well as a focus on flexibility of the process, with room for permanent adjustments. However, they pointed out that such a monitoring programme cannot be separated from the repository itself. If setting up any engagement activity, this would have to encompass that whole range.

With regard to roles and responsibilities, the participants considered it self-evident that the implementer would be responsible for setting up and taking care of the monitoring programme. But this work would have to be scrutinized and reviewed, in first instance by the regulator, which was considered important in assuring long term continuity in the follow-up of the repository.

There was clear consensus that the affected community would have to be engaged in the process of siting and design, and follow-up of a geological disposal facility, thus including the development of a monitoring programme. There was less agreement on how to define this affected community. Some saw the whole population as a stakeholder; others preferred this notion to be more spatially delineated, with more emphasis on the people living closest. Still all agreed a geological disposal of high level waste and/or spent fuel would affect a wider region than is now the case for the cAt surface repository project for LILW. Another point on which no agreement existed within the group, was

the question if active engagement of citizens in monitoring activity would be able to build trust and give people confidence in the repository system (indications of which were found in published literature, see Bergmans, Elam, Simmons and Sundqvist 2012). Some thought this could have a positive effect, others were less optimistic and feared it could make people feel uneasy. Regular information about monitoring results and transparency regarding monitoring activity, conversely, was something everybody indicated as essential.

One participant raised the question if it would be good if one could rely on an international group, organisation, or consortium to review and check on a regular basis the monitoring programmes in different countries. The group concluded a minimum of supra-national oversight could definitely contribute to public confidence in a monitoring programme, however, they did not think at present a reliable international oversight organisation or network existed. Organisations such as the IAEA, NEA, or EC-EURATOM administration were seen as being led by the nuclear industry. Still it was recognised that international cooperation could help prevent the disappearance over time at the national level of knowledge and know-how.

On how to engage (citizen) stakeholders in developing a monitoring programme

As indicated above, the group considered this an integral part of the siting, design and implementation of the repository. The way this was done in the cAt-project, through regular interaction between the implementer and the local community, and in a later stage also the regulator, was considered exemplary. Defining the exact content of the monitoring programme (which parameters, how and where to measure them, frequency, …) the group considered food for specialists. But this should be presented, explained and discussed with concerned stakeholders, and their concerns should be taken into account. For some participants, the emphasis lies on sharing concerns, for others it is also about making the process transparent and providing information on what one is planning to do, how, and why. All stressed that an atmosphere of openness throughout, and the ability to pose critical questions at all times about all aspects of the repository is an essential basis for creating a relationship of trust and for building confidence.

On communicating monitoring results

In first instance a majority of the participants insisted that monitoring results should be made available at all times and for all parameters in real time. After having discussed a number of real and fictitious examples (presented by the ONDRAF/NIRAS and EURIDICE representatives), most agreed this may not be the best approach. However, this did not change the group's opinion that all monitoring data should be made publicly available.

How to put that principle in practice is something that needs further consideration. The following elements were put forward by the group as a starting point:

- Frequent periodic reporting of aggregated data, put within the proper context;
- Both the implementer and regulator have a responsibility to communicate about these results;
- Various levels of reporting are needed to inform different audiences; while the level of detail may differ, the key message must remain the same;
- Raw data must be kept and made available on demand, to allow for third-party review;
- A certain delay in the availability of raw data could be considered, to allow for seeming anomalies to be checked and explained, and to avoid unnecessary concern.

3.1.4 Lessons from the cAt-project

During the workshops, the participants made reference to their experience with the cAt-project, thus identifying a number of lessons learnt that could be of value to take into account when engaging citizens in a geological disposal project.

Frequent interaction, public scrutiny and 'co-design'

Monitoring and control, and in particular making sure to keep the repository dry were issues of great concern to the local citizens participating in the partnership discussions on the cAt surface repository project. This led to a number of changes to the repository design to offer more protection against water infiltration in a country with a wet climate, at a location where groundwater levels are very high. Also a stronger emphasis was put on containment as a safety strategy, rather than dispersal in case of leakage, due to the role of the area as one of the most important fresh water reservoirs for the Flanders region. We will not elaborate further on the particularities of this repository concept here[13], but consider it important to mention, as this process of frequent interaction and 'co-design' or 'collective design' (NIROND 2010: 7, 24) is what shaped the perspective of the participants in our workshops. In general, they hold very dear to their participatory concept and value highly the input they had on the technical features of the repository and a more 'monitored' approach (see infra) for its implementation.

With that in mind, during the last workshop, the group insisted stakeholder engagement should be seen as a continuous process of critical reflection during all stages, from preparation (including siting) and design, over implementation and operation, to closure and post-closure follow-up. As recommendations for engaging stakeholders in developing a monitoring programme, it was suggested that this should be part of a

[13] For more details see Bergmans 2005; Bergmans, Van Steenberge & Verjans 2006; Bergmans & Barbier 2012.

broader approach of co-design, in which the implementer presents a proposed approach, explains why, allows the local community the time and resources to scrutinise these plans and engage expertise of their own for review, enters in discussion, and shows flexibility and a willingness to re-examine options. The group considered an atmosphere of critical reflection and 'healthy suspicion' to be the most fruitful, with the local community in the position to keep asking questions until they were satisfied with the answers. They recognised this to be a demanding process, needing time, resources and effort from all sides.

As most important characteristics of an effective stakeholder engagement process, the group put forward:

- giving people an actual voice in decision-making on various steps in the process;
- giving them the means to have access to different types of knowledge and expertise of their own choosing.

Flexibility as a precondition and experimental set-ups as part of a broader view on monitoring

Among the conditions set by the partnership for the cAt-repository, was the question to investigate a number of construction related issues in more detail, which led to the introduction of a programme of prototypes, comprising of (NIROND 2010: 48-51):

- a demonstration test, reconstructing different building blocks of the disposal modules, including an inspection area;
- a subsidence test, monitoring the subsidence of the underground under a weight comparable to that of a filled module;
- a test cover, a real scale simulation of the final cover, to monitor and study the behaviour of the covering layers during several decades.

During the workshops, the participants referred to these experimental set-ups as an essential part of what they considered monitoring, and also saw potential for that in relation to a geological disposal facility. The Swiss concept of a pilot facility thus attracted their attention.

Within the same logic, the group stressed the need for an ongoing science & monitoring programme to allow for optimisation and adaptation, following lessons from experience and evolutions in knowledge, technology and know-how, societal needs and expectations, etc.

Elements contributing to 'confidence building'

We asked the participants which elements had contributed to them having had enough confidence in ONDRAF/NIRAS' plans for the cAt repository project to advise their municipal council to declare the community prepared to host that project. The group

was firm in stating that participation was key in building trust and confidence; that trust has to be earned and that this goes both ways. In that respect, they referred to ONDRAF/NIRAS gradually putting more trust in the partnerships and their members, and to the partnerships having continued their work for over a decade with the support of their respective municipal councils, regardless of which party or parties formed the political majority at the time.

Of great importance for them had been the preparedness of ONDRAF/NIRAS to pass on all the information and allowing for critical questions to be posed. The principle of 'co-design' had allowed the partnerships to discuss all details and to actively contribute to the shaping of the repository project. Furthermore the group pointed to the diversity of the partnership members, composed of people with 'a nuclear background', but also critical actors, such as local environmental NGOs, and people with various types of expertise that allowed them to pose critical questions.

The most crucial element, according to the participants, was the aspect of checking (*"controleerbaarheid"*[14]) in its broadest possible sense, encompassing:

- continuous follow-up of further project development;
- checking that the conditions set by the local community are respected;
- following-up, as part of that, if remaining questions and uncertainties are being addressed;
- monitoring of the facility once it will be in place;
- …

The group acknowledged nevertheless that it will be a challenge to keep these practices alive, and that new generations need to be prepared for this task. As they have experienced that trust is very much linked to personal characteristics of individuals, they feared this could easily change when old familiar faces (both on the side of the implementer and on the side of the local community) are being replaced by new ones.

3.2 Exploratory engagement activity in Sweden

3.2.1 Planning the Swedish Focus Group Discussion

The MoDeRn research team decided to approach the Municipality of Östhammar and together with them select a Swedish focus group for discussion of monitoring issues. The reason for this was that the Swedish Nuclear Fuel and Waste Management (SKB) in March 2011 applied for a license to construct a final repository for spent nuclear fuel in

[14] This translates literally as 'verifiability'.

Östhammar. Therefore, in this municipality we expected to find people with an interest in the topic of monitoring nuclear waste.

The researchers from the University of Gothenburg contacted the head of the administrative unit for nuclear waste in Östhammar. The idea of a focus group discussion as part of the MoDeRn research project was presented and was positively received. It was then decided to have a meeting in Östhammar to discuss this further. On November 23rd, 2011 the two Gothenburg researchers met the politicians responsible for the three municipal groups on nuclear waste and two civil servants from the administrative unit. The Östhammar group had discussed the set up in advance and proposed to have the focus group activity as part of their regular activities during the spring 2012. This meant that they did not want to select a small group of people to take part in an activity outside of the formal meetings organised by the municipal organisation. On the contrary, they wanted the whole municipal organisation to be engaged and also to advertise the event to the general public. "Nothing should be outside the process", they argued.

In addition, monitoring was assessed as a topic not much discussed in the municipality but nevertheless of interest to know more about and thereby possible to include in the ongoing review of SKB's work. We did not need to convince them of the importance of monitoring even if this was not a prioritised topic for the municipality this far.

This meant that the event in Sweden became larger than we first planned, and it also meant that it was not possible to have several meetings in a row, but just one larger event. It was decided to have the focus group discussions as part of a one-day event.

The organisation of the focus group discussions in Sweden is in contrast to the situation in Belgium and the UK, where the invited participants are volunteers, even if in the Belgium case they are, as in Sweden, invited from experienced people taking part in a formal organisation, i.e. the partnerships. However, in Belgium it was made clear that participants in the focus group activity did not represent the partnerships, while in Sweden this was assessed as not possible to achieve, at least not suitable for the municipal organisation.

The Municipality of Östhammar has had a formal organisation on nuclear waste since the year 1995 when the council decided to accept an invitation from SKB to carry out a feasibility study of the possible suitability for hosting spent nuclear fuel within the Östhammar territory (Sundqvist 2002; Elam and Sundqvist 2007). This organisation, slightly reorganised during the years, has been following and reviewing the work of SKB from a feasibility study over a detailed investigation including extended drillings, to

today's work for planning the construction of a final repository. The main task of the municipal organisation, since its establishment, has been to review and comment on the work carried out by SKB and to prepare the consultation responses the local council regularly submits to public authorities and the government.

Today, two working committees form part of the municipal organisation. One is focusing on long-term safety issues and one on assessments of environmental impacts. Each of the groups consists of 11 members, all of them local politicians. In addition to these two committees there is a reference committee, consisting of 27 members and focusing on communication to the local council as well as to the general public. This group is presented as the link between the council and the inhabitants of the municipality. The reference committee consists of representatives from the political parties in Östhammar, from neighbouring municipalities, and from local NGOs and interest groups. In addition there is an administrative municipal unit of five civil servants, working full time with the nuclear waste issue. Quite many of the local politicians have been working on the issue of nuclear waste since 1995, so there was no lack of experience among the people invited to participate in focus group discussions. However, it is of interest to note that the three working groups are presented on the Östhammar website as lay people. They are reviewing the work of SKB, but from a lay perspective.

It was decided to have the event on February 29th, 2012, at a conference centre in the neighbouring village of Gimo, not far away from the town of Östhammar. It was also decided to start with background presentations by the MoDeRn researchers from the University of Gothenburg, as well as from SKB, the Swedish Radiation Safety Authority (SSM), and the Swedish National Council for Nuclear Waste (an independent committee under the Ministry of the Environment), to let them present how they view and assess monitoring. These expert presentations were designed to be resources for the focus group discussion. After these presentations the participants were divided into three groups discussing the same "protocol" used in all of the three countries. Finally, there was a summing up session where the results from the three groups were presented and reflected upon in the larger group.

All the members of the three municipal groups were invited to take part in the one-day event. Among the general public very few responded. However, two people from SKB's local organisation in Östhammar wanted to attend. In total 29 people accepted the invitation. The event was presented as an activity organised by the municipal organisation during spring 2012.

3.2.2 Background presentations by experts

MoDeRn Researchers

The Gothenburg social scientists started by presenting the overall aim of the MoDeRn project, the social science part of the project, the parallel focus group activities performed in Belgium and the UK, and the plan for a joint study trip to rock laboratories in Switzerland.

A short historical background of the concept of monitoring was given. It was stressed how not only a focus on technical measurements but also on social assessments and political decisions explains why monitoring can be considered important and how it can be variously performed and used. The current definitions of monitoring used by the IAEA, the European Commission and SKB were presented and the differences in how monitoring is understood and applied within the nations in the MoDeRn project was discussed. Finally it was argued that it is important to think broadly on important but general questions such as: "How should a repository be monitored?"; "How could it be monitored?"; "For how long time?"; "Who should be responsible for monitoring?", "Who should be informed about the results?"; and "How should monitoring results be evaluated, summarised and presented?".

The Swedish Nuclear Fuel and Waste Management Company (SKB)

SKB started by presenting their own definition of monitoring in connection to final storage of nuclear waste. This framed monitoring as "continuous observations or measurements in order to increase the scientific understanding of the site and the repository to show the fulfillment of requirements and conditions, and for gradual adaptation of the prepared plans".

This definition is useful for the work of finding the best site and for giving feedback to the construction work, including the best location of the waste in the repository. The focus is on the construction phase, not on the performance of the repository after closure.

SKB explicitly argues that monitoring will be performed only during operation. No monitoring of closed tunnels will be done. No monitoring of barriers after closure as this conflicts with the main goal of achieving passive safety. On the other hand SKB admitted that no final decision had been made regarding post closure monitoring.

SKB did also present their work within the MoDeRn project, and stated that the involved nations are very different, concerning societal requirements and geological conditions. It is important to SKB that these differences are acknowledged when comparing what is done in different nations.

The monitoring experiments on the buffer, the rock, the backfill and the seals, which are performed at the SKB Hard Laboratory in Äspö were also presented. Finally, the environmental monitoring at the site in Östhammar, on meteorology, hydrology, ecology (wild life), groundwater and seismic activities were also accounted for.

The Swedish Radiation Safety Authority (SSM)

The person representing SSM stated that monitoring is the responsibility of the waste producers, i.e. the owners of the nuclear reactors. However, in a long-time perspective, when the granted authorization of the repository has been resolved, the responsibility is expected to be transferred to the state.

SSM guidelines (regulations) for monitoring state that "monitoring should not be needed from a safety perspective", but if monitoring is performed "the effects on safety should be negligible". In general, not much is said in regulations about the need for monitoring. The focus is instead on possible negative consequences of monitoring if monitoring is performed. These consequences should be presented and how they may effect and threaten safety. SSM's opinion is that monitoring could be motivated from the perspective of information preservation, and in order to prevent risks for human intrusion. SSM is taking part, together with SKB, in a project organized by OECD-NEA on information preservation.

Monitoring, according to SSM, could be something good, but only if it is not intervening in safety. However, according to Swedish legislation, the planning for nuclear waste disposal should be made so monitoring is not needed.

The Swedish National Council for Nuclear Waste

The representative from the Council for Nuclear Waste quoted from its review of the latest SKB R&D Programme recently submitted to the Government. In this the Council argues that "SKB has to develop a monitoring programme, which makes it possible to study the development of the buffer and tunnels during the processes of closure… From the current status of monitoring technologies such studies are considered to not interfere with the safety function of the components".[15]

It is, according to the Council, of crucial importance to follow the development of the buffer, and the tunnels after closure. SKB should develop a monitoring programme of this kind. It is false to argue that this technology does not exist (existing technology does not interfere with safety), or that it is not of necessity to perform this monitoring.

[15] The Swedish National Council for Nuclear Waste's Review of the Swedish Nuclear Fuel and Waste Management Co's (SKB'S) RD&D Programme 2010. Translation of SOU Report 2011:50. The Swedish National Council for Nuclear Waste: Stockholm, 2012.

Reflections on the Expert Presentations

These four background presentations showed the existence of different opinions among the experts. For this reason they could be used as a resource for the group discussions. The existence of alternatives among experts gave possibilities for lay stakeholders to engage, intervene and make their own assessments and reflections. This far, however, monitoring has not been an issue in the municipality of Östhammar. It has been delegated to SKB. However, this view is harder to maintain when there are different opinions among Swedish expert organisations, and, as could be shown from MoDeRn experience, that European nuclear nations hold different views and plan for monitoring in different ways.

3.2.3 Themes and Issues Addressed by the Three Discussion Groups in Östhammar

Surveillance and Monitoring: Similarities and Differences

In the planning of the Östhammar workshop and in initial contacts between the social scientists from the University of Gothenburg and Östhammar municipality it was decided to use the term *övervakning* as the most appropriate translation of the English term 'monitoring' for a lay Swedish audience. While *övervakning* is an accepted Swedish translation of monitoring, it also carries with it meanings of surveillance, inspection and even policing. For this reason SKB expressed some dissatisfaction with the use of the term *övervakning* and preferred themselves to mint a new Swedish word *monitering* to more faithfully represent what the activity of 'monitoring' implies in the context of nuclear waste repository development and closure. Given this initial uncertainty over whether or not repository monitoring can or should be discussed as equivalent to a matter of *övervakning* in Sweden, the discussion groups started out by trying to discern the extent to which monitoring/*monitering* and surveillance/*övervakning* can be considered to distinct activities.

For example, it was suggested that monitoring may be closer to scientific and technical research while surveillance is more of a political and regulatory activity. Both monitoring and surveillance are about gaining powers of observation, but monitoring might be more dedicated to measuring people and things while surveillance is more unequivocally concerned with policing and controlling. It was argued that you surveil people and things which are considered to be dangerous and a real threat (e.g. criminals and foreign spies) while you monitor people and things you value which are perceived to be at current risk (e.g. patients in the hospital or a grandchild in the swimming pool). It was also reasoned that you practice surveillance when dangerous and threatening elements are uncontained and still 'on the loose', while you monitor these same elements after they have been contained and are more or less under control. You surveil

people and things still beyond your control and monitor those you have more or less learnt to manage.

One discussion group, however, refused to distinguish between monitoring and surveillance insisting that both are about observing and measuring people and things in order to gain control over them. In both cases, the task is to design and implement expert control systems. We both monitor and surveil to reduce uncertainty, build confidence and provide assurances that things are under control and that unexpected events can be successfully handled if and when they arise. For this group developing the ability to monitor things also implied a commitment to developing the means to act on what might be seen.

All groups associated both surveillance and monitoring with three inter-related types of issues: (1) deciding on what skills and technologies to develop for doing monitoring/surveillance (2) deciding what/who exactly to monitor/surveil including the issue of whether monitoring/surveillance itself needs to be monitored/surveilled and (3) deciding what to do with all the monitoring/surveillance data collected including how it should be communicated and stored. All groups also acknowledged the extraordinary challenges for monitoring/surveillance connected with the unprecedented time-scales ruling over the geological disposal of high-level radioactive waste and spent nuclear fuel.

All three discussion groups were able to discuss prior experience of surveillance and monitoring deriving from the history of nuclear activities in the locality. Both the history of nuclear power generation and the existence of a final repository for short-lived radioactive waste in the municipality were seen to provide useful food for thought concerning the challenges of monitoring the geological disposal of spent nuclear fuel. It was argued that people are concerned that monitoring and surveillance programmes are in existence, but that few are bothered to know how they are organized and what the latest readings are until something is perceived to be wrong. So some monitoring data may be regularly published in newspapers about background radiation in the locality but no one pays much attention as long as no problems have been reported.

The story of the discovery of the Chernobyl accident in Western European through readings taken in Östhammar was considered to be an interesting case to reflect over. The immediate reaction to monitoring data showing releases of radioactive material in Östhammar was that people thought the accident must be local and this led many to jump in their cars and flee the locality. When it became apparent that the nuclear accident had occurred elsewhere without being immediately acknowledged by the Soviet authorities to neighbouring countries and populations this was seen as

confirming the combined technical and political superiority of nuclear monitoring/surveillance activities in Sweden. At the same time, the incident was discussed as demonstrating that it is not always immediately clear what you are measuring and that the misinterpretation of monitoring and surveillance data can itself lead to problems. It was discussed how the Chernobyl accident had given rise to a new concern with monitoring background radiation in Sweden and how new monitoring technology had been developed which could also be used for monitoring radon in Swedish homes, technology which has subsequently been exported to other countries.

The ability of Greenpeace activists to break into the Forsmark nuclear site and evade immediate capture was also discussed by one group as a failure of nuclear monitoring and surveillance. However, this incident was also seen to be beneficial as it pointed to security problems which have been subsequently addressed.

Monitoring Technologies and the Problematisation of the Geological Disposal of Spent Nuclear Fuel in Sweden

An important theme addressed by all three discussions groups was the role of monitoring and surveillance programmes and technologies in relation to the historical framing and institutionalization of the geological disposal of nuclear waste in Sweden. The government of nuclear waste in Sweden encompasses a particularly pronounced division of institutional responsibility dating back to the 1977 Nuclear Power Stipulation Act. This legislation established the responsibility of the Swedish nuclear industry (the owners of nuclear reactors in Sweden) for developing and implementing a safe solution to the domestic nuclear waste problem. The industry-driven research, development and demonstration programme for the geological disposal of Sweden's spent nuclear fuel (the so-called Nuclear Fuel Safety Project - KBS Project) has been reviewed and audited by government authority every three years since the introduction of the Swedish Act on Nuclear Activities in 1984. The executive responsibility of the Swedish nuclear industry for implementing geological disposal is intended to last until the closure of a KBS repository at which point a state of passive safety should have been realised freeing future generations from having to actively manage Swedish nuclear waste.

Given this set of institutional principles and arrangements ruling over nuclear waste management in Sweden, the question of the need for, and feasibility of post-closure monitoring and surveillance becomes particularly challenging to discuss. The Swedish nuclear waste management agency SKB is committed to 'designing out' the need for post-closure monitoring as the ruling institutional arrangements as good as oblige them to do so. If post-closure monitoring and surveillance were deemed necessary by SKB then their delegated responsibility for securing Nuclear Fuel Safety (KBS) would be acknowledged as remaining undecided and incomplete upon repository closure. Thus,

during the course of their presentation in Östhammar and in discussion groups the representatives from SKB attending the workshop confirmed their understanding of repository monitoring as an activity of no immediate regulatory significance and as a set of practices already encompassed by the scientific and technical research already being pursued within the KBS project. As a form of technical research monitoring (monitering) is something to be carried in connection with the testing and refinement of the KBS concept of geological disposal, for example at the Äspö Hard Rock Laboratory in Oskarshamn. It is also something to be deployed as a tool of performance confirmation under the construction and operational phase during the staged implementation of geological disposal in Östhammar. However, it is not envisaged by SKB as a tool of any scientific or technical relevance in the post-closure phase when institutional responsibility for nuclear waste management in Sweden will be relinquished by industry.

So it was discussed by all groups that some form of post-closure monitoring and surveillance may be necessary to introduce even if SKB and the Swedish Radiation Safety Authority (SSM) continue to judge it technically and scientifically superfluous. The municipality hosting the KBS repository was also seen as a key actor in mediating public demands for post-closure monitoring and surveillance. It was discussed and acknowledged by representatives from SKB and SSM that the development of monitoring technologies facilitating post-closure monitoring has not been pioneered in Sweden. All discussion groups expressed the opinion that openness to the question of post-closure monitoring might help to boost confidence in designs for geological disposal in Sweden even if current institutional arrangements do not promote such openness. Monitoring and surveillance in general before and after closure were seen as potential resources for securing and consolidating public confidence and undergirding an evidence-based consensus on the integrity of any repository design.

One group discussed the Swiss plans for a pilot facility in immediate proximity to the main geological repository facility where a representative sample of the waste could be subject to a dedicated programme of monitoring and surveillance. Many thought this sounded like an option worth exploring in the Swedish context and even a SKB representative suggested something similar may be feasible to introduce into Swedish plans. All groups considered it important to remain informed of the development of monitoring technologies globally and the potential usefulness and reliability of wireless technology for example for remotely monitoring/surveilling a repository in the post-closure phase. The issue of limited battery life powering monitoring equipment was also discussed and the future possibilities of using the waste itself as an energy source for recharging this equipment.

The need for a greater Swedish interest and concern with monitoring and surveillance in general and during the post-closure phase in particular was linked to the shifting expectations and confidence commanded by the KBS project. Representatives from environmental NGOs at the workshop discussed how they have also historically supported a passively safe mode of geological disposal which should not require long-term monitoring and surveillance and a solution not encompassing an option for the retrievability of the waste. Nuclear waste management in Sweden in the past has coincided with a stepwise phasing out of nuclear power which should not burden future generations with the task of actively managing the risks and dangers attending legacy wastes. The ambition of permanently breaking the association of Sweden with nuclear power generation has led environmental groups to support the option of geological disposal in deep boreholes where isolation of the waste from the biosphere is imagined to be more unequivocal and irreversible.

However, given the new uncertainties concerning copper corrosion potentially bringing into question the validity of SKB's KBS concept and the difficulties of establishing the reliability of any current technical concept guaranteeing long-term safety, representatives from environmental NGOs at the Östhammar workshop discussed monitoring and surveillance technologies as potentially commanding great relevance for the future of Swedish nuclear waste management. The KBS project currently acknowledges the need for many 'decision-points' in the stepwise implementation of the geological disposal of spent nuclear fuel in Sweden, but it was discussed by all groups how new 'decision-points' could potentially arise in the post-closure phase contingent upon the successful development of technically reliable and scientifically validated monitoring and surveillance technologies.

The discussion groups expressed an interest in international research on monitoring and surveillance technologies funded by Euratom and the IAEA alike. It was appreciated that different countries and different governments may view the monitoring and surveilling of geological disposal differently depending upon how nuclear waste management is institutionalized. Sweden has an established tradition of openness, transparency and public participation in nuclear waste management and all groups were positive to discussing how new monitoring and surveillance technologies and practices might be able to enlarge and extend upon this tradition. It was also emphasized that openness and transparency are not features of Swedish nuclear waste management that have been achieved without the imposition of political demands upon decision makers. Therefore, the future development and expansion of monitoring and surveillance activities in Sweden was appreciated as not something that could be expected to take place without committed local and national stakeholder involvement and participation sustaining public interest and concern in the matter.

If trust has been hitherto placed in government authority to 'monitor' the need to strengthen Swedish nuclear waste management through the development of new monitoring and surveillance technologies all three discussion groups envisaged some form of post-closure monitoring and surveillance becoming an inescapable feature of the future of nuclear waste management in Östhammar if repository development proceeds as currently proposed by SKB. It was emphasized how such monitoring and surveillance activity would need to be unequivocally science-based and how considerable effort would need to be made to ensure that the data generated by such activity was readily comprehensible to the general public.

Discussion of the Challenges of Post-Closure Monitoring and its Institutionalization

All three discussion groups had much to say about the benefits and challenges of post-closure monitoring. It was argued that even if SKB and SSM see no practical need for such monitoring, public demands and expectations that the waste be not simply buried and forgotten would need to be taken into account. One group in particular discussed collected monitoring and surveillance data as providing a means for communication across generations and as a resource for future scientific research. At the same time, it was argued that the data and information could also be misused and serve to advertise the existence of the waste to malign interests such as terrorist organizations and 'treasure hunters'.

It was discussed how new institutional arrangements would have to be introduced to support post-closure monitoring and surveillance. It was not seen as an activity that industry could be held responsible for co-ordinating. National or international government bodies were seen as best equipped to organize post-closure monitoring. This monitoring would still be concerned with 'checking-up' on the performance of the repository but also serve as data collection for more basic and fundamental forms of scientific research. So while continuing to respect the long-term hazard presented by the waste, monitoring and surveillance could also be concerned with informing future generations about nuclear power as part of Sweden's/Europe's cultural and industrial heritage.

Given the extremely long time period under which the waste will remain hazardous the durability of different existing institutional arrangements was discussed for co-ordinating monitoring. Rather than a church-like organization supporting a priesthood of monitors, universities and scientific disciplines were discussed as the most appropriate types of institutional models to connect with long-term post-closure monitoring and surveillance. The oldest universities have been around for approaching 1000 years so they could serve as a starting point for thinking about the institutional

bases for long-term monitoring. The established values and norms guiding university research were also seen as appropriate to guide post-closure monitoring. It was considered conceivable that the national organization of scientific and technological research including repository monitoring might give way to more international and global institutional arrangements in future.

Given the nature of geological repositories they were also seen as constituting 'time capsules' we bequeath to future generations; capsules that would eventually be opened regardless of whether or not they are purposively designed as reversible solutions. So the option of leaving other items in repositories in addition to the waste was discussed. Like messages in bottles cast into the sea, repositories could also contain other messages than nuclear waste for future generations to discover. In the first instance other artefacts and information relating to nuclear activities were discussed but it was even suggested that additional items could be buried alongside the waste.

All the discussion groups moved from addressing the practical significance of monitoring and surveillance for guaranteeing repository safety to reflecting over the cultural and symbolic significance of repositories as unique man-made structures which are being designed to remain intact for an eternity. By addressing the challenges of post-closure monitoring and surveillance the historical significance of geological disposal programmes became something engaging all three discussion groups. Given the identity of repositories as cultural monuments in addition to technical solutions it was considered important that government authority start addressing how they will be remembered and commemorated in future even if they may not need to be actively managed. While nuclear industry and regulators are immediately concerned with the performance of repositories in relation to a safety case, communities hosting repositories appear destined to think about them more broadly in order to feel comfortable about adopting and accepting them. Post-closure monitoring appealed to the discussion groups as an activity recognizing and doing justice to the cultural significance of geological repositories which is a broader matter than their immediate technical functionality. Respecting the cultural significance of repositories such groups as historians and archaeologists were seen as relevant experts to involve in discussions of post-closure monitoring and the design of repositories and associated surface monuments. In addition to the question of what symbols should be used to mark where repositories are sited, it was discussed how monitoring data should be formatted in order to allow it to remain legible to future generations. These sorts of issues were discussed as matters that government authority should start discussing sooner rather than later.

3.3 Exploratory engagement activity in the UK

3.3.1 Organisation of the workshops

As noted above in Section 2, at the time of the MoDeRn stakeholder engagement exercise in late 2011 and early 2012, West Cumbria was the only location in the UK where local government authorities had submitted a formal Expression of Interest in the possibility of engaging in the Managing Radioactive Waste Safely (MRWS) process. The West Cumbria MRWS Partnership was subsequently formed in March 2009 by local authorities and other stakeholders in order to consider and advise on the implications of proceeding to the next stage of the process. In the intervening period it had been reviewing expert evidence on the issues and consulting extensively with local citizens and interest groups.[16] As the UK stakeholder group that was most directly engaged with the question of repository development, it was the members of the West Cumbria MRWS Partnership who were first invited to participate in the MoDeRn stakeholder engagement exercise. The Partnership had not, at that time, agreed upon its recommendations. Given the controversy and conflict that had surrounded an earlier attempt, in the 1990s, to develop a siting programme in West Cumbria, it was important that the Partnership gave no suggestion of prejudging the outcome in any way. In addition members themselves were under considerable pressure at this time due to the intensity of Partnership activity as it worked towards the completion of its task. It was therefore decided by organisations within the Partnership that to participate in an exercise on repository monitoring, and one that, even though intended to be purely a research activity, involved the NDA's Radioactive Waste Management Division, would be inappropriate at that time.

As a consequence, although initial responses were received from six individuals, a preliminary briefing session organised in February 2012 to coincide with a full meeting of the Partnership attracted only one potential participant. Of the six individuals from West Cumbria who had initially responded, only two eventually chose to participate in the MoDeRn stakeholder workshops. These participants had been involved in stakeholder discussions about monitoring and retrievability that took place about twelve years earlier. They had also, as part of a West Cumbria MRWS Partnership fact finding mission in October 2011, visited the underground research laboratory operated by Andra, the French radioactive waste management organisation, near Bure in north-eastern France. Both were consequently familiar with geological disposal and with some of the issues around facility monitoring.

[16] *The Final Report of the West Cumbria Managing Radioactive Waste Safely Partnership*. August 2012. Whitehaven: Copeland Borough Council.

In light of the difficulties that had been encountered it was decided to extend the invitation to engaged stakeholders in geographical areas other than Cumbria. An email was therefore sent to the network of Site Stakeholder Groups (SSGs) at NDA sites inviting participation in the MoDeRn engagement activities. This drew expressions of interest from nine SSG members at sites around the United Kingdom, two of whom subsequently decided not to participate. Although these SSG members had not been involved directly in discussions about repository development and monitoring, they included Chairmen and Deputy Chairmen of SSGs who were involved in the oversight of operational and decommissioning civil nuclear sites, were familiar with site-level questions of radioactive waste management, had participated in National Stakeholder Group meetings, and had some knowledge of UK policy for higher activity wastes.

A preliminary meeting was held on the evening of 28 March 2012 at Cockermouth, Cumbria to introduce MoDeRn to potential participants and to answer any immediate questions that they might have before they committed to participating further. Nine community stakeholders attended, along with a member of the Environment Agency's Nuclear Waste Assessment Team and two representatives of the NDA, one of them a member of the MoDeRn project consortium and the other the Partnership Engagement Manager at the NDA's Radioactive Waste Management Division. The NDA representative gave a short introduction to the project; this was followed by a presentation from the UEA researcher about the aims and organisation of the engagement exercise.

Following this, participants asked questions about the project and the stakeholder engagement exercise but also about current UK developments in radioactive waste management policy and geological disposal, seeing questions about monitoring as inevitably being linked to these wider issues. There was considerable interest among those participants from other parts of the country in the progress of the MRWS process in West Cumbria, in the consultation and deliberations that had been taking place, and in the consequences for MRWS and for their own nuclear sites should a decision not to proceed be taken in West Cumbria. There were also questions about why more people from that area, which was so deeply engaged with the issue, had not taken part in the MoDeRn project. When discussing the proposed visit to the underground laboratories in Switzerland, some of the participants emphasised their lack of technical expertise. There was nevertheless agreement on the importance of involving community stakeholders in discussions about monitoring, its aims and objectives, and participants quickly began to raise questions for discussion in the subsequent workshops.

Following the initial briefing meeting, two half-day workshops were organised and held in Birmingham, which was chosen as a location with good transport links that participants from around the country would be able to reach relatively easily. The first

workshop was held on 19 April 2012. This was followed by the field trip to Switzerland from 23-25 April, described below, in which four of the British stakeholders participated. At the second national workshop, which took place on the 23 May, the members of the group who had visited the URLs at Grimsel and Mont Terri reported back on their experience and there was further discussion of geological disposal and repository monitoring. The following section summarises the main issues raised during the UK workshop discussions.

3.3.2 Issues discussed by participants

It has already been noted that most of the participants had no prior involvement in discussions relating to the development and monitoring of a geological repository. However, participants drew analogies with their knowledge of waste management and environmental, health and safety monitoring at nuclear sites, as well as monitoring in other contexts. The discussion in the workshops was not, however, confined to monitoring as participants returned repeatedly to the broader issue of long-term management of higher activity wastes. They had many questions both about current UK policy and also about various technical aspects. This reinforced the view developed by the social science research team prior to the workshops that questions relating to the specific issue of monitoring need to be viewed and addressed in the context of the overall issue of long-term management of higher activity wastes and of the geological disposal programme (see Bergmans et al 2012, p. 79).

The presentation about the MoDeRn research and the subsequent field trip to the Swiss URLs provoked considerable discussion about the situation relating to geological disposal in the United Kingdom. Descriptions of MoDeRn research on monitoring in three host media (salt, clay, granite) raised questions about the nature and differences of these geologies (asking, for example, about the form of salt) and

One of the broader issues discussed was the waste inventory and the implications for monitoring and staged closure that might follow from adopting a requirement for retrievability of emplaced materials, either because of uncertainty about whether some of those materials might in future be considered as potential assets to which access would be sought, or because treatment technologies might become available which could be applied to the wastes to reduce the hazard.[17]

[17] The comments relating to uncertainty about the future waste inventory need to be understood in the context of current UK policy, which does not classify spent fuel or plutonium as wastes but as resources.

Why monitor?

A repeated response to the question 'Why monitor?' was "checking"; specifically, to check whether anything had changed. Drawing on their previous experience of monitoring or of dealing with monitoring data, participants identified three reasons why this would be necessary. The first reason was to ensure that the performance of whatever was being monitored complied with regulations or expected standards. A second reason was for what was described by one participant as quality control; this was based on the idea that continuous refinement and improvement of the process would be a goal and that the data collected through monitoring would help to achieve that. The third reason for monitoring that they identified was for stakeholder confidence in the safety of the repository; this last motivation for monitoring placed rather more emphasis on the sense of 'checking' as something one does to reassure oneself that all is well. In this sense it was not simply about confirming technical performance but about, as one or two participants put it, 'keeping an eye' on the waste.

When considering the question of how to monitor a geological repository, there was a detectable tension between arguments for the importance of monitoring in order to know what is going on in the repository and that everything is still safe, and the recognition that monitoring activities have the potential to compromise safety by affecting the integrity of barrier systems designed to achieve it. Here there was discussion of the potential for the development of non-intrusive monitoring techniques of the kind that the MoDeRn project has been studying.

Who should monitor? Roles, responsibilities and trust

The discussion of when and how to monitor led into discussions of who should be involved in the overall monitoring process and of who could be trusted to monitor effectively and to communicate the results of that monitoring without bias. Several members of the group felt that this should be a role for the regulators but discussion highlighted some differences of view, with some feeling that the regulators had performed their role well in other, more familiar contexts and could therefore be relied upon to ensure effective monitoring of a repository, while others questioned whether this was – or was always – the case. To some extent this difference could be traced to views on the independence of the regulator. There was in general a view that monitoring data had to be independently collected or independently validated if they were to be seen as credible: for several participants this validation role was performed by the regulator. An alternative, if minority, view was that the independence of the regulator could not always be assumed. This led to discussion of the role of citizens themselves.

When the discussion focused on the role of citizens, some participants did not see them as having a 'hands-on' role in monitoring itself but one member of the group felt that it

was important for citizens to be able to check and validate independently the results given to them by site operators or even by the regulator. The participant in question pointed to experience with community radiation monitoring at a UK nuclear power station site, where community representatives had obtained their own monitoring equipment and had been careful to seek expert advice and to calibrate their equipment to ensure that the data which they collected would be seen as valid, commenting that: "it's important to have your own equipment". This turn to carrying out their own monitoring reflected a lack of trust in, or at least scepticism towards, the responsible organisations but also an insistence on being empowered and on developing the skills and capacities necessary to reassure themselves of the radiological safety of their environment. It was also pointed out that local citizens were not necessarily 'lay' stakeholders at all but that community members could possess scientific and technical knowledge. The argument that local citizens should themselves engage in monitoring was contentious, with arguments that they lacked the necessary training and expertise being countered by examples of the careful way in which both volunteers and equipment had been prepared to ensure that recognised standards were met, in a way that echoed examples described in our basis report (Bergmans et al 2012; see, for example, Ottinger 2010).

The arguments that were levelled against direct citizen participation in the monitoring process were not only about their lack of professional training and competence but also about their lack of accountability and of any responsibility for the consequences of their decisions to which they were party. In contrast, it was argued that licensed site operators and the nuclear workers employed by them, in addition to possessing the requisite technical knowledge and skills, were held directly accountable and responsible both internally to the company and externally by the regulator. The fact that they were also citizens and local residents with families living nearby, it was suggested, was motivation enough to ensure that the site maintained the highest level of safety, so they should be trusted, it was argued, to carry out safety monitoring.

As the discussion of roles and responsibilities continued the question of who monitors the monitors was raised. For many participants this was clear: monitoring data was collected by the operator and the quality was checked by the regulators, who had sanctions at their disposal to ensure that the required standards were achieved; for others it required communities to draw on counter-expertise or to develop their own.

There was no overall consensus on the question of "who should be involved in monitoring?" but the discussions highlighted that views of who could or should be trusted to monitor or on who should monitor the monitors depended on standpoint, relationships and experience. Nor however was there an assumption to which everyone

subscribed that citizens would always and everywhere assume such a role themselves, with it being noted that the role of stakeholders in different countries is not directly comparable, as there are different levels of trust in government, scientific experts, etc.

Views on experts

The question of who should monitor also prompted a long discussion about the role and authority of experts and about confidence in their expertise. The bases that were offered for placing confidence in an expert's contributions included the suggestion that qualifications are an important indicator of competence but there was also reference to organisations whose auspices also seemed to offer guarantees of objectivity and independence, with specific reference being made to the Royal Society and to the British Geological Survey. In addition to these institutionalised sources of reassurance, a number of comments made it clear that personal knowledge of the individual competence, experience and integrity of a particular expert was also an important component in the judgements that participants made about their expertise. This combination of formal and informal criteria that underpin confidence may have implications for the design and implementation of monitoring programmes.

One question raised was whether the expertise claimed by some self-designated experts was necessarily relevant to the problem, with comments alluding to the failings of some experts that were clearly based in past experience, focusing in particular on the expertise claimed by critics of the nuclear industry. Nevertheless another participant endorsed the argument that communities could employ independent experts by pointing to France where some local information committees, lacking confidence in the 'official' radiation monitoring data that were produced at nuclear sites, had commissioned their own monitoring programme with the help of an NGO specialised in radiation monitoring (cf. Bergmans et al 2012, pp. 43-44).

Expert disagreement was also seen as a significant and perennial problem by several participants, with one commenting that "the definition of an expert is a conflict of opinion". In these circumstances it was argued there is a risk of accepting the expert opinion which confirms one's own view. Nevertheless, the value of having someone who challenges established or 'insider' assumptions was recognised, although some also insisted that such criticism should be *constructive*, in their terms, a point directed at representatives of local environmental groups. .

These discussions around expertise highlight a number of issues. The first is the problem of unresolved uncertainties in knowledge and the way in which these uncertainties may be fought over in knowledge-based conflicts around long-term radioactive waste management issues. The problem for the non-expert of adjudicating

expert disagreement also drew attention to the potential for self-confirming bias in the evaluation of knowledge. All of these have implications for confidence in monitoring programmes and more generally in geological disposal.

Monitoring data and its interpretation

Even if not involved in the collection of monitoring data, it was nevertheless agreed that community stakeholders should be involved, or represented, in the monitoring system. The importance of openness and the transparency of monitoring again was emphasised, with the point being made that secrecy and obscurity breeds rumours and myths. Nevertheless it was recognised that it would be challenging to design and operate a monitoring system effectively. How, it was asked, should the results of monitoring be communicated?

Despite the call for complete openness, experience of being presented with monitoring data at nuclear sites led to concerns being voiced about the possible problem of being swamped with data. The contrasting problem was also raised, of being presented with data in which there is little or no variance from expectations for a very long period of time. Both issues identify challenges for the design and implementation of monitoring programmes but although questions were raised about these problems, no clear solutions were identified for either of them.

Science & technology

The current state and future possibilities of science and technology were a recurrent theme in the group's discussions. Participants agreed that the work of NDA's Radioactive Waste Management division should be informed by state of the art research and sought reassurance that this was in fact the case, not simply in relation to monitoring, which was the focus of the workshops, but also of waste management options. There was interest, having been introduced to the work that was being carried on in URLs in other countries, in whether any experimental work was being done in the UK. For example, one participant referred on more than one occasion to research into the transmutation of waste in a plasma environment, asking whether this could be used to reduce the volume of long-lived higher activity waste and whether this option had received serious consideration. Although there was reference by the NDA representative to the NDA's R&D programme, it was clear that some, particularly after the trip to Switzerland, felt strongly that the UK should construct its own URL in order that it would be able to carry out R&D on a scale similar to countries like Belgium, France, and Switzerland. Others however were less convinced of the need, arguing that the results emerging from the URLs in other countries would inform the development of the UK's repository programme.

One other source of difference that became apparent was in participants' views of technological advance, which was a recurring theme during the workshops. Essentially the division was between those who took an optimistic perspective and those who were sceptical of what technological change might bring. While some took the view that science and technology can only *improve* on today, others argued that future technological improvement cannot be relied upon and may bring its own problems. This difference in degrees of confidence in technology was not confined to the development of monitoring technologies but extended to views on long-term radioactive waste management and the concept of passive safety through geological disposal. Although in general participants seemed to find geological disposal to be in principle the way forward, there were different views on the extent to which we should be delegating safety to the combination of technology and geology that forms the repository or delegating it to future generations of people. Again, this highlights fundamental differences in outlook and in attitudes that are likely to have implications for the acceptance of geological disposal and of monitoring as a source of reassurance; they also have implications for repository closure and the post closure period.

Repository closure

There was repeated discussion over the course of the workshops about when monitoring of a repository would be desirable – and when it would be possible. Some argued strongly that monitoring was necessary not only during the operational phase but also during the closure period and even the post-closure phase, this led to discussion of the problem of intrusion into the repository. Participants recognised the benefits and the potential risks associated with monitoring and although they acknowledged that some sort of balance would need to be achieved, this issue was not resolved.

One fundamental question that was debated was whether to close and seal the repository forever or to be prepared to retrieve the waste later. This remained an open question for several reasons. Firstly, although a pragmatic view was that we cannot anticipate the wishes of future generations so we must do the best we can now, as noted above there were concerns about the implications of the inventory, and of the potentially changing status of materials as waste or assets, for repository closure. Secondly there was some concern about the possibility of something going wrong inside the repository, with one participant maintaining repeatedly that it would be irresponsible to "seal it up" and "walk away". He argued that there was a need not only for continued monitoring, at least for a period after closure, to alert us to such an eventuality, but also for a strategy ("a Plan B") in place to be able to respond and intervene in some way. The differences identified would inevitably have implications for repository design and for long-term monitoring requirements.

3.4 A joint field trip to Switzerland

In the spring of 2012 (April 23-25) five Belgian, two Swedish and four UK stakeholders embarked on a field trip to the Swiss underground laboratories of Grimsel and Mont Terri. They were accompanied by the four authors of this report and five other consortium partners in MoDeRn. When referred to "the participants" in the sections below, we refer to the 11 citizen stakeholders.

The trip was hosted by Nagra, providing logistical support, guided tours of the URL's and detailed explanations about the work done. An introduction to the Swiss programme, the Sectoral Plan for site selection, the disposal concept, and the specificity of the pilot facility was provided at the beginning of the field trip, with input from the Swiss regulator and the president of one of the regional conferences set up in view of the Sectoral Plan.

3.4.1 Visit Grimsel

The visit to Grimsel started with a presentation from Nagra sketching the history and geological conditions of the Grimsel test site. Particular attention was given to the projects and experiments currently running in the lab, so that people would have an idea about what to encounter during their visit. Some specific questions were raised regarding the graphs that were shown. Some participants for example asked why a

certain drop or why a particular peak appeared in a graph. This led to a short discussion on the presentation of data, about the need to keep trace through logs, and about how to filter out misreadings (so they don't interfere with the analysis) in a well-considered and well-documented manner, and to keep record of all raw data. Apart from that, questions were mainly related to the relationship between the lab and the real thing. The Nagra hosts stressed in that regard that once they would have a real site, these kinds of demonstrations would have to be done over again, but this time "on the spot".
With that in mind, the group went for a tour in the mountain.

In the afternoon following the visit, participants reflected on their experience in a three hour session. The discussion was conducted around four main questions:

- What struck you the most?
- Do visits such as this give you a better understanding and do they influence your views?
- What did you learn/What questions did this raise concerning monitoring and the communication of monitoring results?

3.4.2 Visit Mont-Terri

A similar approach was followed for the visit to the Mont-Terri laboratory, where the participants were welcomed with introductory presentations by Nagra on: the specificity of the URL as an international rock laboratory with different partners, the geological conditions and construction of the lab, and the various projects Nagra is currently involved in. One presentation focused on the full-scale emplacement experiment, FE, which started in 2011 and is accompanied by an extensive monitoring programme. Only a handful of questions for clarification were raised by the participants this time.
Before going down in the lab, the participants also explored the Mont-Terri visitor centre, which presents information through a combination of text, visual images and interactive displays.

In the lab, the group was split up in two smaller groups, each receiving detailed explanations about various MoDeRn experiments and having the opportunity to read about others in the posters displayed throughout the lab.

There were opportunities to explore the detail of these experiments …

...and to observe the excavation of a new tunnel.

After the visit, the group sat down once more for about two hours to connect impressions from this visit to the visit and discussion of the previous day, and to see if any key messages for the MoDeRn partners were to be identified. Also, a short presentation was given by Brendan Breen (NDA) of the basic elements of the MoDeRn workflow. The purpose was to check the extent to which participants saw potential in such a schematic presentation and where in this process they would see themselves come in. However, the discussion quickly drifted in another direction, and not much tangible feedback was obtained on the workflow as such.

In the section below, we give an overview of what, after further analysis of the transcripts from both discussion sessions, seemed the most pertinent elements raised. These are grouped by topic, irrespective of whether they were raised during one discussion sequence or recurred intermittently throughout one or both of the sessions.

3.4.3 Main messages to retain from the Swiss field trip

During both discussion sessions, there was a good interaction between the technical consortium partners and the other participants. The four authors of this report maintained the position of moderators. Keen as they were on obtaining direct feedback

from the participants, the other MoDeRn representatives often put explicit questions on the table, which inspired some lively discussion. The discussion was conducted in English and although this may have limited the contributions of some community representatives, it was usually clear whether or not they agreed with positions taken by their colleagues.

Throughout the visits and the discussions afterwards, people most often inquired about the link between what they saw or had seen and the real situation they knew. The UK participants for example wondered about whether one can say anything about a potential host rock without a rock characterisation facility in the area. The Swedish participants particularly wondered about the practical implications of implementing some of the monitoring experiments they saw in a real disposal situation.

One clear observation is that the visits made a strong impression on the participants, with a number of them commenting that they were "very impressed" by the science, the intensity of the effort, and the scale of the facilities. This was particularly the case for those who had not been in a URL before, which included three of the four UK stakeholders, but others also made similar comments.

On the whole, the feedback from the participants related to URLs in general, to monitoring and what they retained from the experiments they saw, and to issues of science communication and communicating monitoring results.

General impressions on URLs and URL visits

All participants agreed that these visits gave them a better understanding. Some pointed out that as a consequence this then gave rise to new questions, not all of which were subsequently shared with the group. This, however was seen as a good thing.

Looking back at the discussions, it seems there were two tendencies in the reactions from the participants about what to take with them and how to take that further. A first was to interpret it as a form of testimony or demonstration of geological disposal as a solution (e.g. *"To me, what I've seen today was a safer option for it to be below ground."*). A second position was to explicitly place the lab work and visits to these facilities in a **context of dialogue and exploration** of that solution (e.g. *"… there is somebody in the UK who is saying that geologically Cumbria is not the best place for it, so I would have been very interested to see what his slant would have been on today's proceedings, what he would have said amongst other things."*). The **importance of confrontation** was acknowledged by various participants, indicating that bringing in opposite views and second opinions should be an integral part of the demonstration. Someone in that

respect also referred to the desirability of opening up URLs to researchers outside of the respective programmes.

With regard to the question of building trust and confidence, the participants stressed the **importance of being able to *"see things with their own eyes"***. They recognised it would be impossible to arrange for this on a large scale, but nevertheless insisted to recommend a continued effort in creating openness and transparency, and inviting people into the labs. Somebody threw in the suggestion of giving the notion of *"nuclear tourism"* some serious consideration, since tourism does make people travel, go and see things, but also exchange experiences and ideas, as research has established. The group didn't immediately pick up on that, but pointed out that some **mediation** was considered necessary between those visiting and the rest of the public. One participant furthermore remarked that openness becomes even more meaningful if directed also at people with a sceptical view regarding the nuclear industry: *"I think there is an advantage if you have people who come to see this facility who start off from the point of view of not being terrible pro-nuclear, because … if I go back and I say what I've found was very reassuring, they're more likely to believe me, the people who are sceptics, than if you send somebody who is already convinced before they come."*.

Several people remarked that a prerequisite for an open and transparent approach is that one is also **open about the different problems that occur and their nature**. Trust, it was argued by some participants, comes very much with being clear about what you know and - even more so - about what you do not know, and with a **willingness to discuss possible solutions with a wider group**: *"the implementer has identified the problems and then hopefully has some suggestions on the solutions. But the solutions should be worked out together with the audience in these consultations."*. One participant was somewhat uneasy about leaving the public to deal with solutions and stressed the role of experts in these matters. As a counter argument, it was stated by one of his colleagues that: *"the public is not one mass that has one sort of view and one sort of education. There are people in the public that might be helpful."*.

More specific feedback regarding monitoring

The term monitoring in itself caused some reflection on what it actually means. Eventually the group agreed that this was a broad enough term with an overall meaning and therefore able to include all kinds of issues. There also appeared to be general agreement that the main purpose of monitoring would be to provide **reassurance checking**. Or as one participant put it: *"I find it difficult to separate monitoring from reassurance. Because everything you do with monitoring is all about reassurance: for those with an expert knowledge to have reassurance to make sure that their work is actually being delivered properly ; for the public reassurance that the solution they're going to put*

in place is one that works and can be monitored, can be controlled". It was explicitly stressed that this checking should not focus solely on radioactivity, but had to include all elements relevant to the long term safety of the repository: *"It's about the gas, it's about the water, it's about the containment … about reassurance in difference fields."*

At the end of the visits, several participants indicated they brought them a clearer view on what monitoring is and what it can be. With regard to their own expectations concerning monitoring, participants indicated they wanted **meaningful things to be monitored**, things that potentially could cause problems and influence the long-term safety of the facility, **not parameters that simply happen to be easily measurable**: *"if you're going to measure something you should measure something that could be a problem and not something that's easy to measure and something that's easy for people like me to understand".* One participant remarked that this, however, would not relieve the responsible organisation from presenting easily understandable data that everybody could sign up to.

What was furthermore insisted upon, was that time and effort should be invested in helping stakeholders such as them to understand the **underlying mechanisms**, to have a basic understanding of how the system functions and what parameters can be of influence. If parameters are suggested as important to be monitored, it was of equal importance to the participants that **clear tipping points** could be indicated and a **system of early warning** be put in place. To illustrate this, the example of temperature was given: if your safety case is built on an average of 90°C at some point in time, and your measurements indicate it's 120°C, then it wouldn't help in terms of confidence building to claim that 120°C is just fine and wouldn't cause any problems[18]. Participants also indicated the notion of monitoring to them included knowing what to do in case measurements pointed towards **unexpected behaviour**.

The Swiss concept of the **pilot facility** was something that most participants indicated as an idea to take home and reflect upon. It was seen as something that could help reassure people, because of the presence of checks and controls. Most participants therefore seemed to understand it as a sort of test-run at the actual site: *"If you show that you can store radioactive material in a repository safely for a certain length of time I think it will give people more confidence. I think with most things you usually have a pilot study or something or other …"*.

Some of the technical MoDeRn partners brought on the issue that monitoring data may turn out to be quite boring material, as in all likelihood nothing will happen for many years. They thus wondered what monitoring results could be convincing enough. Would

[18] The authors' own synthesis of a number of arguments raised.

people feel reassured if they didn't see anything for years, confirming nothing more than that processes are so extremely slow? A few people responded that may still be problematic, as it means that deciding now or in a 100 years about closure may not make that much difference ; there will still be 10,000's and 100,000's years to follow. They nevertheless considered this first period of observation to be important, and pointed to the fact that further decisions should be taken at the end of such a stage, which calls for a strong obligation to transfer information and data to future generations.

Along the same lines, one participant picked up on a brief discussion among technical experts on monitoring for the confirmation of the models underpinning the safety case. He linked this to the work one in the URLs and the continuation of that work: *"getting confidence in the models can be done partly by using experiments in rock labs as many organisations do, so this is where we can get confidence and we try to show that we understand what's going on, and that we can show confidence in our systems. We usually have models, we develop models for these experiments. We make measurements and we compare, and in the best case we also improve the models, and we come up with a better one in the end"*.

Finally, contemplating on how something like a pilot facility would fit into their own national programmes, the participants started reflecting on the advantages of **international interactions**, not only among experts in URLs, but, also among citizens from concerned communities. Participants found it useful to learn about the situation and research in other countries, and were interested in understanding the differences between national options.

Reflections on science communication and communicating monitoring results

On a general level several participants after the visits stressed the need to **communicate more explicitly about the science** that goes on in the labs. Again the importance of bringing people to the labs was highlighted, as comprehensible summaries of scientific reports were in themselves not considered to be enough. One participant suggested an annual conference at the national level as a way to keep all concerned stakeholders and interested parties informed and up-to-date with the state of knowledge. However, some doubts were raised regarding the funding for such an event, as well as the ability to attract a broad audience. Another participant referred to popular science magazines as a way to create awareness and to spread basic knowledge about this type of issue.

Particularly with regard to the experiments feeding into the safety case and future monitoring results, several participants indicated the wish to have **free access to the**

raw data behind the reports. That way these data could be checked and validated by others, not involved in the programme and used by anyone who wanted (or needed) to review the concerned reports, e.g. in the case of a licence application. Some discussion followed on the extent to which raw data today are already available, but as contributors had different national backgrounds, this issue was not resolved. In general, the citizen stakeholders in the group were less convinced of the availability of data than were some of the representatives from RWM agencies. In any case it was acknowledged that **different levels of information** should be available to serve different publics, but that everything should be available for those wishing to know more.

After seeing all the experiments in both URLs, one participant remarked that he had been struck by of the sheer amount of data that is being produced and therefore concluded that **an intermediary** of some sort would be needed *"**to filter out the most relevant results** for the general public and represent them in a clear way"*. When asked who he would see as such an intermediary, he considered that to be **a mixed group, consisting of different types of stakeholders**: *"a team of people consisting of people who know the data, so the people who produce the data and the regulators who can double-check, and maybe the lay stakeholders also, because they can tell... okay, in this way... if you present it this way, then I can understand it"* ; a suggestion that was widely approved by the rest of the group.

4 Conclusions

Repository monitoring is now widely seen as a necessary part of programmes for the geological disposal of radioactive waste. However, we find competing perspectives on how to specify the significance of monitoring. Probably the most striking observation is the clear difference in viewpoint between technical specialists in the field and the citizen stakeholders we encountered. Among technical experts monitoring is viewed as a matter of "performance confirmation", a tool for validating the safety case underlying repository construction. The view among (potentially) affected citizens, however, is that of monitoring as enabling the "critical assessment" of safety, an instrument for checking to provide reassurance, for detecting uncertainties and emergent problems in a repository.

In this concluding section, we link the observations from our exploratory engagement activity with the material we gathered from the monitoring experts and from the theoretical reflections in the D1.3.1 report.

4.1 The need for monitoring

The role of monitoring for public confidence building, highlighted in high level international documents developed by technical experts (cf. EC 2004; IAEA 2001; IAEA 2006) was echoed in the workshop activities with local stakeholders in Belgium, Sweden and the UK. The Belgian group came to the conclusion that confidence building and 'keeping guard' over the safety of the facility were the main reasons for monitoring. The UK group also identified stakeholder confidence in the safety of the repository as one of three reasons to monitor, the other two reasons being verification of compliance with prevailing regulations or standards, and 'quality control' to support continuous refinement or improvement. Informing both the Belgian view on 'keeping guard' and UK views on verification of continued safety is a notion of maintaining a watch over the repository, something to which we return below. Both local and national stakeholder representatives in Sweden discussed the importance of the timing and placing of monitoring activities, such as the question of whether monitoring programmes carried out in underground laboratories or pilot facilities (referred to by the implementer as 'dress rehearsal' laboratories) during repository development can reduce the need for monitoring of the 'real' repository during implementation?

Analysis of the focus group discussions leads to the conclusion that citizen stakeholders generally see two main reasons for monitoring:

- Checking the safety of the facility (throughout the entire lifetime of the facility, i.e. including post-closure)
- Providing evidence that the safety case holds and that LT safety is (to the extent possible) demonstrated (i.e. pre-closure)

Both are needed if monitoring is to assist in building confidence in the repository, its management and potential for providing long term safety.

Confidence building through compliance monitoring and quality control thus seems to be the key reason for monitoring put forward by implementers, regulators and citizens confronted with a geological repository programme. However, as pointed out above, some subtle but significant differences can be detected between the viewpoints of these different actors.

4.2 Performance confirmation versus checking behaviour

An important difference in the positions taken by regulators and implementers and their monitoring experts on the one hand, and (potentially) affected citizens on the other hand, is the emphasis put by the former on performance 'confirmation', while the latter emphasize quality control and 'checking' expected behaviour. This difference in view is particularly evident where the question of long-term safety is concerned.

During the MoDeRn 'expert stakeholder workshop' with implementers and regulators[19], it was stressed on several occasions that the focus should be on performance confirmation, and not on checking performance (see MoDeRn 2011). Because these actors rely heavily on the safety case as 'the principal method for demonstrating confidence in the safety of the disposal system', they consider that checks on whether or not the system provides adequate safety come from the development of the repository design, and from the site selection and site characterisation activities. Obtaining a licence for constructing and operating a repository, they argued, is proof of a high degree of confidence in the safe performance of a repository, and hence 'there would not be reliance on monitoring as a basis for *ensuring safety*' (recorded in MoDeRn 2011, p.18, *emphasis added*). If monitoring is dedicated to helping stake out a path to inherently safe waste packages, facilities and sites then it must be dedicated to progressively reducing the need to repeatedly 'check-up' on safety. It must be dedicated to verifying the needlessness of continuing to look.

However, drawing on research on risk and trust (e.g. Giddens 1991, Simmons and Wynne 1993, Irwin 2008) and on an analysis of published accounts of the relationship

[19] MoDeRn 'Expert Stakeholder Workshop' – Oxford – 4-5 May 2011.

between stakeholders and monitoring activities focussed on the field of radioactive waste management (see report D1.3.1: Bergmans et al. 2012, p.31-53), it seems clear that in many situations, stakeholders expect a more critical assessment of safety. For that reason, they do not only require operator and expert assurance of safety, but also the additional assurance of (independent) monitoring for any evidence of exposure to harmful releases. They may not expect the monitoring activity in itself to contribute to the safety of the repository, but do expect it to assess, or check that safety is ensured. This distinction between 'checking' and 'confirming' may therefore seem to be largely a question of semantics. As we argue below, however, there is more to it than that.

The only 'lay' participant in the 'expert stakeholder workshop' referred to above observed that the focus on confirmation, rather than on checking, of expected behaviour came across as 'rather arrogant, since the system might not perform as expected'. He furthermore pointed out that 'implementers should not assume that monitoring will only confirm their expectations' (cited in MoDeRn 2011, p. 18). Similar arguments were made by participants in the Belgian, Swedish and UK workshops with community stakeholders. In the Swedish discussions, the idea that the performance of, for example, waste packages could be confirmed through experimental monitoring in an underground research facility, distant from the actual repository site, was questioned. When discussing this point with the Belgian group, the use of the term 'performance confirmation' in a presentation by a waste management organisation representative was questioned, as participants considered it inappropriate to take as a starting point the assumption that no problems can occur in future. They pointed out that in the case of geological disposal one will never be able to reach full certainty that all will go well in future before starting implementation. Monitoring was thus considered a necessary action to remain 'on guard', but was only seen as effective if accompanied by a proper 'response plan' or what UK stakeholders referred to as a 'Plan B' should anything unexpected be detected. This raised the concern that designing monitoring programmes for performance confirmation is likely to lead to implementers prioritizing different measures to those which might be most appropriate for registering more unlikely and unexpected events. This difference in approach was once more clearly illustrated during the discussion sessions after the visits to the Swiss URLs. Here too, the participating technical experts were inclined to focus on confirmation monitoring, whereas the citizen stakeholders stressed the need to consider what to do in case of unexpected results and wondered how one could claim to be a 100% sure about future behaviour over such a long period of time.

4.3 What and where to monitor

Based on the impressions of lay-stakeholder concerns expressed by the experts that we interviewed (see Report D1.3.1: Bergmans et al. 2012), it seems that there is a widely

held perception in the expert community that public and stakeholder expectations are likely to focus on environmental monitoring in order to protect against human health impacts. A review of literature on citizen and stakeholder engagement with monitoring, within the nuclear sector and in other contexts (idem), seems to corroborate this perception, as most of the activities reported did involve some sort of environmental monitoring. In several cases this monitoring was commissioned or conducted by local institutional stakeholders, particularly local governments, including some examples that integrate this with monitoring of the socioeconomic environment (e.g. Conway et al 2009). Dissatisfaction with or distrust of institutions has also led members of some communities to demand or even initiate participatory environmental monitoring, which involves local citizens in data collection (e.g. Vari, Ferencz 2007; NEA 2009). In the field of radioactive waste and other nuclear industry facilities, there is considerable evidence of stakeholder and citizen involvement in facility monitoring activities (e.g. NEA 2003, 2010). This demonstrates the desire of citizens and communities in many different contexts for active engagement with facility monitoring programmes.

From our own engagement exercises, we learned that local citizens were less concerned about the "What?" and "Where?" questions in terms of which parameters or at which exact location to monitor. What they did insist upon, was that a monitoring programme for geological disposal should be as comprehensive as possible (including, but not restricted to, monitoring of the socioeconomic environment), that it should aim at measuring meaningful parameters (not simply the once that are easiest to measure), and that it should have a broad scope, including both near-field and far field-monitoring. Both the Belgian and UK groups acknowledged the potential tension between potentially intrusive near-field monitoring and the integrity of barriers and seals that is required for passive safety. It was also considered to be important, most notably by the Belgian group, to continue searching for alternative parameters or techniques for processes that would be difficult to monitor with current technology, and to consider laboratory simulations as alternatives to near-field monitoring (e.g. in a post-closure situation). The role of URLs in relation to monitoring, taking measures and comparing, in order to further evaluate and improve the models on which the safety case is based, was something that was also mentioned during the discussions in Switzerland.

4.4 How long to monitor?

On the question of how long to monitor, the views of technical specialists and concerned citizens again tend to differ. As was pointed out in Report D1.3.1 (see Bergmans et al. 2012), post-closure monitoring is something that was considered by technical experts to be unnecessary, as they did not expect anything to be detected once a situation of passive safety had been ensured by properly closing a facility. For them, monitoring is an activity dedicated to advancing and facilitating repository closure and confirming

that the conditions outlined in the regulatory safety case have been achieved. Near-field monitoring in particular was said by many of them to be unrealistic and even potentially counterproductive insofar as the techniques used could contribute in any way to compromising barrier integrity. Nevertheless, many experts interviewed thought that there could be value in post-closure monitoring if it were needed to reassure other actors such as local communities, a position that was also expressed in technical opinion documents (e.g. IAEA 2006). It was furthermore noted by our respondents that although there may be little evidence of statutory requirements for post-closure monitoring for reasons of radiological protection, it seemed likely that they would be introduced in some countries in the future in response to societal demands.

Evidence from the Belgian, Swedish and UK workshops confirmed that constructively engaged citizens do have expectations and concerns regarding post-closure monitoring, and are not likely to accept the issue being ignored. What was less clear is the type of monitoring (near-field, far-field or the surface environment) they would be expecting in the post-closure period. In the Swedish workshop it was pointed out that even if post-closure monitoring is considered desirable, the technological innovation required to enable such monitoring is hardly likely to take place without the purposeful allocation of funds to related research and development. Community stakeholders were therefore concerned about post-closure safety but, unlike the technical experts, tended to see continued monitoring of some sort as being necessary not merely to confirm that the evolution of the repository system conforms to technical expectations, but to ensure that it continues to do so and is not affected by unanticipated events or evolutions, a concern to which we return in our final section.

4.5 The role of monitoring in the (risk) governance of geological repositories

For several decades now, one of the key principles informing the management and regulation of nuclear safety has been that of constant surveillance. This is firstly a political and moral principle which informs the practical design and development of nuclear activities: this principle is therefore an expression of what societies interpret nuclear safety to mean. Monitoring programmes focused on different types of nuclear activity are therefore ways of putting the moral principle of tireless vigilance into technical practice. This is particularly the case for nuclear installations such as power plants, fuel production or reprocessing plants, and storage facilities, as pointed out by nuclear scientist Alvin Weinberg, when he referred to the unusual degree of vigilance which of necessity had to be exercised over all programmes of nuclear power generation during the entire course of their development in order to guarantee safety (Weinberg 1972). Deep geological repositories, incorporating the technical - and moral - principle of passive safety, can be understood as a way of trying to renegotiate the need for unremitting vigilance by delegating responsibility for safety to an engineered geological

disposal system. The question then is how should the gradual transition from active human vigilance to passive safety without human intervention be organised?[20] Weinberg believed that effective geological disposal reduced the need for vigilance to a minimum, in line with current expert thinking that all that will be needed of society to ensure safety is surveillance to avoid intentional or unintentional human intrusion into the repository system. However, our exploratory engagement suggests that more is expected by many citizens.

These are, as Weinberg reminds us, societal questions that cannot be answered from a technical-expert perspective alone (Weinberg 1972). Society will therefore have to decide what kind of human vigilance is needed and for how long it should continue. Nevertheless, for society to relinquish direct control of the wastes will require confidence in the repository system and trust in those responsible for designing, implementing, overseeing and regulating it. It may therefore be easier for national and local decision-makers – and the communities that they represent - to commit to taking successive steps in repository siting, development, licensing, construction and operation if the contingent nature of their trust and commitment[21] at each and every stage is acknowledged and the opportunity to re-evaluate or even veto plans is upheld.

Throughout the focus group discussions it was explicitly emphasised by the participating citizens that involvement of concerned parties is essential during each and every one of these successive steps, with monitoring as one element to provide information on which to base evaluations and decisions. The accessibility of information in general and monitoring results in particular was seen as crucial in view of building trust and confidence. Different levels of information, including the raw data, should be available to serve different audiences. An institutional framework of checks and balances, was deemed necessary, as well as an atmosphere of openness, in which remaining or emergent problems are overtly communicated and discussed with all concerned, including the affected public. Open communication about what is monitored and why, whether that takes into account different stakeholders' expectations and concerns, and the extent to which and in what detail monitoring results are publicly reported was repeatedly referred to by all participants as key in supporting public confidence and trust in those responsible. Engaging different types of stakeholders, including members of the so-called 'lay public', to play an intermediary role in filtering out the most relevant monitoring results and to indicate how to present these in an understandable way, was suggested as a possibility to create such openness.

[20] This is excepting, of course, any external safeguards monitoring, most likely involving remote sensing technology, against human access in order to prevent the proliferation of nuclear materials.
[21] On the provisional nature of social trust see, for example: Lewis and Weigert 1985; Giddens 1991; Jones and George 1998; Walls et al. 2004.

Finally, the reflections from the participants during the exploratory engagement activity also pointed indirectly to another way in which monitoring can support public confidence. This is by helping to demonstrate that the implementer of a disposal programme is aware that there are always systemic uncertainties involved and that it is necessary to take a precautionary approach[22], although this potential role of monitoring was not emphasised explicitly in our workshops. Such open acknowledgement of uncertainty is not without its risks, of course, in that it may appear to bring into question the premise of passive safety as the technological solution to the socio-technical problem of guaranteeing unflagging vigilance over long-lived high-level radioactive waste. By introducing the notion of retrievability or reversibility into law, however, countries such as Switzerland and France are already moving towards an adapted socio-technical solution, one still directed towards achieving passive safety, but which recognises that this end point may be further away than initially planned, subject to a longer chain of socio-technical decision-making, and may not be final.[23] Such evolutions remind us that we may inevitably pass the burden of decision about final closure to subsequent generations. Acknowledging this requires that we think more specifically about the type of information, knowledge and skills that need to be passed on to future generations, and the role that monitoring might play in meeting the needs of future operators, regulators, decision-makers and affected citizens, an issue that was briefly touched upon during the discussions after the Swiss URL visits by the citizen stakeholders recognising the inevitability of passing on decisions to future generations.

[22] On uncertainty, precaution and the governance of technology see, for example: Stirling 2006.
[23] For a discussion of the adoption of the principle of reversibility in French radioactive waste policy, see Barthe 2009.

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6 Appendixes

6.1 National workshops

6.1.1 Workshop protocol

Set-up:

- ⇨ workshops could be organised as a one day event, two half-day meetings, a number of evening sessions spread out over a period of one or two months, … (*to be decided in consultation with the participants*)
- ⇨ number of participants: minimum 6 - maximum 20

Content:

General introduction to the subject of monitoring

Free association on the concept of monitoring

Discuss previous experience with monitoring issues – if any *(focus on the issues)*

- ⇨ Belgium: monitoring programme for planned LILW surface repository
- ⇨ Sweden: incidents and how they were responded to at the existing SFR facility
- ⇨ UK: Nirex Monitoring and Retrievability workshops (early 2000s); some LLWR monitoring issues

Discuss previous experience of interaction with experts (from RWM agency, regulator, ...) on technical issues as part of a radioactive waste related decision making process *(focus on the interaction)*

- ⇨ In all cases, the volunteers will have some experience with dealing with technical issues in view of (local) decision making, e.g. on taking evidence from experts, on gathering pro and con perspectives
- ⇨ We will discuss here who they see as experts, who they consider able to make authoritative statements, who they rely on for information and why, …
- ⇨ Discuss views on the value of stakeholder engagement (and the difficulties from their perspective)

Move focus of discussion to geological disposal

- ⇨ Discuss (on a fairly general level) issues of trust and confidence
  - in RWM being conducted in a fair and competent manner
    - What reassures them?
    - What gives them confidence in the RWM system (the institutions involved, the technical solutions put forward, …)?
    - How to achieve this?
  - in geological disposal
    - more specific requirements?
- ⇨ What could in this respect be the role of:
  - implementers, regulators, ...
  - science programme and URL's
  - monitoring
  - stakeholder engagement

- ⇨ Elicit participants' expectations on
  - what monitoring should achieve (objectives)
  - stakeholder engagement in defining and following up a monitoring programme
  - their interest in discussing details of a monitoring programme and the level of technicality they would demand or would be willing to endure (strategies)
  - how monitoring results should be communicated; questions relating to access to and transparency of information
  - what would be the benefits of independent scrutiny of monitoring programmes?
    - can this build trust?
    - what does independent scrutiny mean to them?
    - who/what would be considered sufficiently independent and competent?

Focus on repository monitoring for LT safety and MoDeRn

Introduction from ONDRAF/Euridice – NDA – SKB on:

- status of local GD programme, and how monitoring is addressed + other examples from "MoDeRn countries"

- the technical work in the MoDeRn project

If useful also a presentation from the regulators/safety authorities: what are their expectations from monitoring? Why would they want to know that?... [if not regulators, then maybe reference to 2011 IAEA safety guide on repository monitoring]

Observe interactions: how participants respond to this information

- ⇨ What types of questions were asked?
- ⇨ Did people find this information useful, reassuring, scary, difficult, sufficient, …
  - e.g. through a mind mapping exercise

Continue discussion (now more specific) on issues of trust and confidence, now focussed on geological disposal

- ⇨ Unpicking the basis for confidence
  - What aspect would they find reassuring?
  - What is seen as a basis for confidence: the concept or design, the (decision-making) process, its long term performance, … ?
  - How do they think about experts, and different responsible institutions?
- ⇨ The role of monitoring:
  - What should the role of monitoring be in this context? What would you find worth knowing?
  - Multiple roles may be attributed to monitoring. What about potentially conflicting ones?
  - Can monitoring help in building confidence? To what extent will they put their trust in people, in models, … ?
  - Probe about the leap from data on the short term to conclusions on long-term safety.

Discussion about value-based issues (e.g. about what is important and what one is willing to do to achieve that): how do participants see "trade-offs" taking shape between

what is expected from monitoring (objectives) and what is technically feasible: should objectives be guided by what is technically feasible (today):

- ⇨ Implications for strategy, flexibility/adaptability, resource allocation and, of course, for the structuring of the step-wise decision process
- ⇨ Role of stakeholder engagement

Reflections on interest of lay stakeholders in discussing technical choices, and on their requirements for making that meaningful. Also discuss if in that respect science programmes and URLs have anything to offer.

Closing meeting (in each country – after visit to Switzerland) to reflect on experience with this activity and on outstanding issues

Feedback from Switzerland to the rest of the group

Rounding-up exercises: lessons learned from this exploratory engagement activity with focus on issue of confidence building and what type of mediation they expect, and from whom, between them and the data

Reflections on whether or not engagement activities provided an opportunity to discuss monitoring objectives and their practical translation into technical applications in a way that was meaningful for lay stakeholders:

- ⇨ what they thought worked well,
- ⇨ what they think was missing or could be improved,
- ⇨ what expectations they have on further communication on this subject,
- ⇨ how they would see that brought into practice in their own national programmes, …?

6.1.2 Participants in Belgian workshops

	Member of	Participated in … out of 4 meetings
Local Partnership participants		
Nick Bergmans	MONA	4
Lieve Bisschops	MONA	2
Hugo Ceulemans	MONA	4
Hugo Draulans	STORA	1
Jos Draulans	STORA	3
Geert Lauwen	STORA	4
Willy Melis	STORA	3
Carlo Meynants	STORA	3
Paul Meynants	STORA	4
Karl Ooms	STORA	4
Jos Proost	MONA	3
Herman Sannen	STORA	4
War Smeyers†	MONA	2
Charles Van der Vorst	STORA	4

Moderation and reporting		
Anne Bergmans	UA	4
Jan-Willem Barbier	UA	4
Other MoDeRn participants to provide technical explanations when necessary		
Maarten Van Geet	ONDRAF/NIRAS	4
Jan Verstricht	Euridice	4

6.1.3 Participants in Swedish workshop 29th February 2012

Name	Affiliation
Bertil Alm	Local Environmental Impact Assessment Committee
Inger Arvidsson	Local Environmental Impact Assessment Committee
Sune Berglund	Local Environmental Impact Assessment Committee
Reinhold Delwall	Local Environmental Impact Assessment Committee
Sanne Eriksson	Local Environmental Impact Assessment Committee
Ingrid Gustavsson	Local Environmental Impact Assessment Committee
Christina Haaga	Local Environmental Impact Assessment Committee
Harri Lundgren	Local Environmental Impact Assessment Committee
Sune Pettersson	Local Environmental Impact Assessment Committee
Allan Krukka	Local Reference Committee
Gunnar Lindberg	Local Reference Committee
Ylva Lundh	Local Reference Committee
Anna-Lena Söderblom	Local Reference Committee
Barbro Andersson Öhrn	Local Safety Committee
Tomas Näslund	Local Safety Committee
Rune Nilsson	Local Safety Committee
Arno Unge	Local Safety Committee
Gunnel Wahlgren	Local Safety Committee
Miles Goldstick	Milkas – Environmental NGO
Berit Jansson	Norrtälje Municipality
Anders Bergman	Nuclear Waste Repository Division, Östhammar Municipality
Marie Berggren	Nuclear Waste Repository Division, Östhammar Municipality
Hans Jivander	Nuclear Waste Repository Division, Östhammar Municipality
Vio Szabo	Nuclear Waste Repository Division, Östhammar Municipality
Kenneth Gunnarsson	Oss - Environmental NGO
Christina Larsson	Oss - Environmental NGO
Susanna Andrén	SKB
Ann-Kristin From	SKB
Assen Simeonov	SKB/MoDeRn

Jan-Olov Stål	SKB
Clas-Otto Wene	Swedish National Council for Nuclear Waste
Georg Lindgren	Swedish Radiation Safety Authority (SSM)
Carina Wetzel	Swedish Radiation Safety Authority (SSM)
Mark Elam	University of Gothenburg/MoDeRn
Göran Sundqvist	University of Gothenburg/MoDeRn

6.1.4 Participants in UK workshops

John White	Bradwell Site Stakeholder Group, Essex
John Kane	Copeland Borough Council, Cumbria
David Brazier	Environment Agency, Cumbria
Peter Kane	GMB trade union, Sellafield, Cumbria
Terry Joslin	Harwell Local Stakeholder Group, Oxfordshire
Mervyn Brown	Hinkley Site Stakeholder Group, Somerset
Michael Caswell	Hinkley Site Stakeholder Group, Somerset
Rita Holmes	Hunterston Site Stakeholder Group, Scotland
Brendan Breen	NDA Radioactive Waste Management Division, Oxon.
Jay Redgrove	NDA Radioactive Waste Management Division, Oxon.
Michael Hawkins	Oldbury Site Stakeholder Group, Gloucestershire
Jayne Ashley	Springfields Site Stakeholder Group, Lancashire
Peter Simmons	University of East Anglia, Norfolk

6.2 Field trip Switzerland

6.2.1 Programme

Monday 23rd April 2012	
11:00 – 12:00 am	Arrival by plane at Zurich airport
12:00	Pick up by bus and travel to area "Lägern Nord" (meeting and stay over at Hotel Mövenpick, Zürich-Regensdorf)
12:30 – 13:30	Lunch
13:30 – 15:30	Introductory meeting between Belgian, Swedish and UK participants: who, why here, what expectations from the visits and discussions? Discussion on the MoDeRn workflow and its usefulness for different stakeholders
15:30 – 16:00	Coffee + arrival of Swiss stakeholders

16:00 – 18:00	Meeting with Swiss lay stakeholders * ⇨ intro on MoDeRn and why this visit (Brendan Breen – NDA & Anne Bergmans - UA) ⇨ presentation on the Swiss concept for geological disposal and the role of the pilot facility (Dr. Ann-Kathrin Leuz - ENSI) ⇨ presentation on the participation process and the point of view from the siting area Nördlich Lägern (Hanspeter Lienhard – President regional conference, local stakeholder) ⇨ interaction between participants
19:00	Dinner

Tuesday 24th April 2012	
7:00	Breakfast
7:30	Travelling by bus to Grimsel rock laboratory
10:00	Arrival Handeck cable car (or bus tour directly to GTS)
	Departure cable car (special dept. time) (0:12)
	Pick up by GTS minibus (1 – 2 tours)
10:30 – 12:30	Visit of **URL Grimsel** incl. coffee break with Gipfeli
approx. 12:30	Transfer to crystal cave (GTS minibus)
	visit at crystal cave
	Transfer crystal cave > cable car (GTS minibus)
13:00	Dept. cable car Gerstenegg (0:12) (special dept. time)
13:12 – 13:30	Transfer to Guttannen (0:08)
13:30	Lunch Hotel Bären
14:30 – 17:00	Reflection on visit, Hotel Bären
17:00 – 19:30	Transfer to St-Ursanne (Mont Terri) (2:08)
19:30	Check in hotels: Demi-Lune ; Couronne ; Du Boeuf
20:00	Dinner Hotel Demi-Lune

Wednesday 25th April 2012	
7:30	Breakfast
8:30	Transfer to Visitor Centre of Mont Terri rock laboratory (by coach or short walk) (0:15)
9:00 – 9:30	Introductory presentations to the visit
9:30 – 11:00	Visit of **URL Mont Terri** (2 minibuses of URL)
11:00 – 12:00	(back to Visitor Centre) Wrap up discussions: outstanding issues, particularities Mont Terri versus Grimsel+ general appreciation of this trip
12:00 – 13:00	Light lunch at Visitor Centre & visit of exhibition
13:00 – 15:30	Transfer to Zurich airport by bus

6.2.2 Participants

	Country	Organisation
Invited citizen stakeholders		
Nick Bergmans	BE	MONA
Anders Bergman	SE	Östhammar Municipality
Mike Caswell	UK	Hinkley Point Site Stakeholder Group
Hugo Ceulemans	BE	MONA
Rita Holmes	UK	Hunterston Site Stakeholder Group
Terry Joslin	UK	Harwell - Chiltern Campus Local Stakeholder Group
Thomas Kaiserfeld	SE	Kärnavfallsrådet (Nuclear Waste Council)
John Kane	UK	Copeland Borough Council
Geert Lauwen	BE	STORA
Carlo Meynants	BE	STORA
Paul Meynants	BE	STORA
MoDeRn partners		
Anne Bergmans	BE	UA
Brendan Breen	UK	NDA
Mark Elam	SE	UGOT
Bernd Frieg	CH	Nagra
Stefan Mayer*	FR	Andra
Peter Simmons	UK	UEA
Göran Sundqvist	SE	UGOT
Maarten Van Geet	BE	ONDRAF/NIRAS
Jan Verstricht	BE	Euridice

* on April 24th (for visit Grimsel and discussion)

The Swiss delegation consisted of:
Philippe Senn (Nagra), Anne-Kathrin Leuz (ENSI) and Hanspeter Lienhard (president Regionalkonferenz Nördlich Lägern) - meeting in Zurich
Thomas Spillmann (Nagra) - Grimsel visit
Tim Vietor and Herwig R. Müller (Nagra) - Mont Terri visit