United States
Nuclear Waste Technical Review Board (NWTRB)

Transcript

Spring 2026 Board Meeting

Tuesday
June 9, 2026

PUBLIC MEETING
In-Person and Virtual

Arlington, Virginia

NWTRB BOARD MEMBERS IN-PERSON

Peter Swift, Ph.D., Chair

NWTRB EXECUTIVE STAFF MEMBERS IN-PERSON

Bret Leslie

Jayson Bright

NWTRB PROFESSIONAL STAFF MEMBERS IN-PERSON

Hundal Jung

Yoonjo Lee

Chandrika Manepally

NWTRB ADMINISTRATION STAFF MEMBERS IN-PERSON

Davonya Barnes

Kimberly Brown

SWIFT: It's eight o'clock now, so we're going to get started. And just making sure everybody's okay there. Good morning. Good morning from Arlington, Virginia to those in other countries. Thank you for being here. And I want to welcome both the audience here and the international audience. And in particular, the speakers. We're not all here in the room, obviously. Our speakers are all elsewhere in the world and in other time zones, and we're really very grateful to them for making the time to be a part of this meeting. We are the US Nuclear Waste Technical Review Board. This is our Spring 2026 Meeting, and I'm Peter Swift. I'm the Chair of the Board. The meeting will focus on the technical lessons learned from the siting and development of deep geologic repositories in countries other than the US. So, all of our speakers are representing other countries. And we're holding the meeting in a hybrid format with a combination of both in-person, that would be us here in the room, and virtual presentation by both presenters and audience. I'm going to start off by describing briefly what the Board is and what we do. And I hope that for those who aren't familiar with the Board, which will be some of the audience, I'm sure, hope this is a useful introduction. And then, I'll have something to say at the end here about why we're holding the meeting. And I'll summarize the agenda before turning it over to Bret Leslie who will then actually introduce the technical portion of the meeting. Slide 2, please.

For a brief description of the Board. We are a separate federal agency in the executive branch. We're not part of the Department of Energy or any other federal department or agency. We serve only in an advisory role with the government, and that's worth noting. We do not have any regulatory authority. Next slide.

But here's our mission, and this is written directly in statute, in the Nuclear Waste Policy Act as amended in 1987. We perform independent objective and ongoing evaluations of the technical and scientific validity of the DOEs activities related to the management and disposal of spent nuclear fuel and high level radioactive waste. In effect, that means that we're evaluating the DOE’s activities that implement the Nuclear Waste Policy Act. That primarily limits our work to the high level waste program and the commercial spent fuel. So, Slide 4.

Yeah, the Board members. At full strength, the Board should have 11 members. And the Board members are appointed by the President from a list of nominees that are submitted by the National Academy of Sciences. And as I said, I'm Peter Swift. I'm the Chair of the Board. I'll note that all Board members serve part-time. And in my case, I'm a consulting geoscientist. I worked most of my career at Sandia National Laboratories, but I'm serving in this function in a semi-retired role. I also, and some of you are familiar with this, I am the only member of the Board at present. Of the 11 members that we normally would have, 10 positions are vacant. However, the Board is fully operational. Activities are continuing to work uninterrupted. And that is because we have a staff. The staff is primarily here at the table in front of us. Our staff is composed of full-time professionals, of scientists and engineers, and a support staff. And historically, much of the work of the Board has been done by the staff. Slide 5.

The Board provides objective, technical, and scientific information on a wide range of issues related to the management and disposal of spent fuel and high level radioactive waste. And we report that to policymakers in Congress and the administration. By statute, we report findings, conclusions, and recommendations to Congress and to the Secretary of Energy. And in the context of today's meeting, specifically, I want to make it clear that the views expressed by Board members, that would be me, and the staff during this meeting or at any meeting you might see any of us at, those are our own opinions and views, not necessarily Board positions. Board official positions appear in writing in reports and letters, and those are available on the Board's website. If you hear one of us ask a question or make an observation, do not assume that represents a position to the Board. Slide 6.

Meetings like today's are an important part of the Board's activities. The Board routinely does invite speakers from other countries, other repository programs. And that's part of informing us on additional perspectives from other programs. We aren't reviewing other programs. Of course, we're only reviewing the DOE, but it is helpful for us to be able to report to the DOE on what we've learned from other programs. Our reports are found on the website, as I mentioned. And you can also find their archive materials, past reports, transcripts of past meetings, various testimony we may have given, correspondence, our mission statement plans. And some of this information is at the table outside there, and you're welcome to pick up copies. Slide 7.

The agenda for this meeting and the presentations are posted on the Board's website. And I think they're already up. If not, they'll be up shortly. And they can be downloaded. Note that we'll have a public comment period both for those here in the room and for people online. The public comment period will be at 3:05 Eastern Time today at the close of the meeting. And those here in the room who want to provide oral comments, sign up out at the desk at the public comment register. And oral commenters will be taken in the order which they signed in. And depending on the number of those wishing to speak, we may have to put a time limit on it. If looking at the size of the crowd, I don't think that'll be a problem. But when making a comment during the public comment period, please use the microphone as available at the front of the... it's not available in front of the room, but it will be by this afternoon. And state your name and affiliation so that you'll be identified correctly in the meeting transcript. You can also submit public comments at the online viewing platform using the Comments for Record form. Comments submitted during the day of the meeting will be read into the record by Board staff during the public comment period just prior to adjournment. The Board values these comments and will read them as part of our deliberations on the meeting. We will not respond in real time to them. Comments submitted online during the meeting will be posted verbatim to the Board's website shortly after the meeting adjournment. So, write them accordingly expecting them to be posted. Written comments and other written materials may also be submitted by mail later or email to the points of contact noted in the press release. They will also become part of the meeting record and will be posted to the website. And one last note, the meeting here is being ... one last note on the meeting, it's being webcast live and is being recorded. So you'll see cameras around the room, keep that in mind. If you don't want to be on camera, figure out where that might be in the room. But generally, if attending this meeting, you should assume you will be recorded. Slide 8.

This is the... the objectives of this meeting. We're here to, basically, as I said, to learn about other countries' experiences during the site selection process for a deep geologic disposal facility. And some of the countries here have already selected a site. From them, we hope to gain insights from their experience during the licensing construction and the phase of commencing operations. We've invited speakers from implementing organizations to describe their programs, answering a series of questions we previously provided on their experiences developing their programs. It's worth noting that in the context of the US program, today's meeting is actually occurring at an opportune moment. In March of 2025, over a year ago, this Board sent Congress and the DOE a letter, which I think Bret is going to have something to say about after me. But with our finding, it's a finding, which is a fairly important statement from the Board, but not a surprise. But the Board wrote to indicate that we have found that the nation does need a deep geologic repository for permanent disposal of domestic spent nuclear fuel and high level waste. It was a very clear statement. And we also included it with a recommendation that the DOE should proceed working with Congress to develop a program that would lead to such a repository. And in January of this year, 2026, the DOE actually took some action. They issued a request for information inviting states to express interest in hosting nuclear lifecycle innovation campuses. And that was basically a proposal by the DOE to find interest in a new effort that would modernize the nation's full nuclear fuel cycle and strengthen the American's leadership in advanced nuclear energy. That was a stated purpose of the request for information. And some responses were due in end of March, beginning of April of this year from states. Many of those responses have been made public. And speaking here personally, not for the Board, but I'm very encouraged by what we've seen in those publicly available responses. And we've seen states actually expressing interest in learning more about the opportunity to host disposal facilities. That's something we haven't seen in this country in quite a long time. So, I'm encouraged by that. And I want to just commend the DOE for beginning a dialogue that includes looking for solutions for spent nuclear fuel and high level waste disposal. It's a long ways from here to there, but it's a good first step. We look forward to learning more about it. And again, that was my opinion, not necessarily a Board statement. Slide 9.

Just note that we're going to go through the agenda very quickly here. Setting up today's meeting, just note that we've got at least four different time zones across three continents. Some people are staying up quite late to be here, thank you to them. And we did have to organize the agenda with that in mind. After I have sit down, Bret will get up and give a couple of brief words. Bret is our Acting Executive Director and senior member of professional staff and a career scientist in nuclear waste disposal and management. But I'll go through the agenda very quickly. We're going to hear from the Korea Radioactive Waste Agency, from Sungbok Lee. And he'll be supported by Ms. Jane Joo from Korea... from KORAD in Korea. We'll have a brief question and answer period. We'll hear from Hiromitsu Saegusa-san from the Nuclear Waste Management Organization of Japan. And he'll be supported in the Q&A portion of it by Yoshito Kitagawas... Excuse me, I apologize, Kitagawa-san, and Hideaki Hyodo-san from NUMO... also from NUMO. And following the Q&A, we will take a short break. Then, Slide 10.

After the break, the Czech Republic's national program will be presented by Markéta Dohnálková. And following Ms. Dohnálková 's talk, we'll hear from Ms. Barbara Pastina from Posiva Oy, the Finnish implementing organization. And then we have a lunch break starting at 12:15 for one hour. And there is a list out there on the counter, on the desk table out there, I believe, of local restaurants. But it is just a one-hour break, so move quickly. After the lunch break at 1:15, we'll hear from the Swiss program, from Michael Schnellmann of Nagra. And he'll be supported in the Q&A, we believe, by Ingo Blechschmidt from the Nagra program. And then, our last talk of the day will be from Axel Liebscher from the BGE, the German program. And then, the public comment period at 3:05. And then we will adjourn at 3:20. So, last thing I want to just say here is a note that I want to thank the international speakers for their presentations today in advance. And again, thank them for working with us on time zones... across many time zones. And I want to thank the Board staff. And I'll start with Jay Santillan, who couldn't be here. But he actually put together much of the work of this meeting. Chandrika Manepally... Chandrika, Bret Leslie, Jayson Bright, Davonya Barnes, and Kimberly are in front there working at the front desk. And on this side, Jo Jo Lee and Andy Jung. So that's it. I think we can move on here. Just again, a reminder, if anybody hasn't turned off their cell phone or muted it, please do so. And Bret, do you want to come on up?

LESLIE: Thank you, Peter. As the slide says, I'm Bret Leslie. And I'll be talking about how the Board learns from national repository programs. Peter did a fine job of introducing it. I'll provide a little more context for today's meeting.

So as Peter said, the Board had a letter to the Secretary of Energy and to Congress. And what I've done here is to pull out that finding verbatim and also the recommendations so that our international audience and the members of the public here today can understand exactly what the words were. And I think the recommendation points at a really important point. It's a pathway to site, license, construct, and operate. It's not enough just to site a facility. And so, as you see, the presentations today, we will be focusing on siting, but we will also be looking at that pathway to getting to an operating facility.

So as Peter suggested, our focus is evaluation of the Department of Energy on the scientific and technical evaluation of them. But we learn from the national repository programs, and we learn from participating in meetings like this. We update a survey report of 13, and it will now be 15 national programs. And this is kind of a guidebook for Congress and members of the public to understand how these other national programs operate. We also have conducted detailed analysis of siting and I'll mention that in a second. The other thing is the Board does visit other countries and other organizations to understand really how things get implemented on the ground. And it's amazing the things that we learn when we go on these visits or when representatives come and visit us in our offices. As the diagram or the figure on the right shows, we do report our findings and information we gather from these national visits in our summary report, but also in this survey report.

So, as I said, we have done detailed analyses of other countries. Back in 2015, we looked at two dozen siting efforts over the last 50 years in these countries, some of whom you will hear today. But kind of the key point coming out of that report was siting of a repository requires a socially acceptable siting process, which reflects the norms and cultures of each country and a process to find a technically suitable site. In 2023 of August, we had an international workshop on siting of radioactive facilities, where we had Canada, Sweden, and Switzerland participate and that focused on one aspect of that, the social aspect of it.

So, this figure on the left, it kind of puts into a graphic, this idea that social acceptability and technical suitability overlap and that it's somewhat iterative in that process to find an acceptable site. So, the focus of our 2023 workshop was really on social acceptability. And we had wonderful presentations and panel discussion and captured our findings or the key messages in the proceedings. But today's meeting is really focused on technical suitability. And what you'll realize as we go through the presentations today, no one is going to talk solely about technical suitability. In fact, their presentations emphasize this point. You cannot separate technical suitability and social acceptability. So don't be surprised when you hear some things about social acceptability as well today. So, as I said in the recommendation, it's not just siting, but also getting to an operating facility. So today we're going to be hearing lessons primarily from four countries that have gone through the siting process or are just beginning. So, what we've tried to do is invite countries that are at different points in this siting process. And you'll hear from the Republic of Korea first, Japan, Czech Republic, and finally, Germany at the end of the day. In addition, it's not just getting to that site, it's getting to an operating facility. And so, there are a number of countries that have moved past siting. Two of them will be presenting today, Finland and Switzerland. So again, we're not just focused on... the country should not be just focused on just siting of a repository. It's getting one operating. So, we have to think about all these lessons as we move forward. And with that, Peter, I'll turn it back to you to introduce the first speaker.

SWIFT: Thank you. So once again, let me make sure I've got my program here. Our first speaker is Mr. Sungbok Lee from KORAD in Korea. And do we have a camera on Mr. Lee? Thank you.

LEE: Okay. Thank you for introducing me. Good morning, ladies, and gentlemen. It's night in Korea, but it's morning in the local area, so I should say good morning. Okay, let's start the presentation. First of all, I would like to sincerely thank the NWTRB for inviting me to speak today on the topic updates for high level waste management program in Korea. My name is Sungbok Lee, and I'm Director of the High Level Waste Planning department at Korea, KORAD. KORAD is the Korea Radioactive Waste Agency. KORAD is the quasi-governmental organization established to safely manage all already active waste generated in Korea. KORAD was founded in 2009. And in 2015, we began operating a disposal facility for low and intermediate level radioactive waste. Today, approximately 440 staff members are working to ensure the safe management of radioactive waste in Korea. It is truly a great honor for me to share our recent progress with you today. Today, I would like to introduce the current status and recent progress of high level radioactive waste management in Korea. Toward the end of my presentation, I will also briefly introduce the management of low and intermediate level radioactive waste in Korea. Next slide, please.

This is the outline. Let me begin with the outline of my presentation. Today, I will cover six main topics. First, I will introduce the current status of nuclear power generation and spent nuclear fuel inventory in Korea. Second, I will explain the radioactive waste management framework, including the recent enacted Special Act on High Level Radioactive Waste Management. Third, I will introduce the high level waste siting in Korea. Fourth, I will introduce the underground research laboratory project. Fifth, I will discuss R&D activities related to high level waste disposal. And finally, I will briefly introduce low and intermediate level waste management in Korea. Next slide, please.

So, Chapter 1, the nuclear power and spent nuclear fuel inventory. Next slide, please.

Let me start with the current status of nuclear power in Korea. Currently, nuclear power accounts for approximately 31.7% of Korea's electricity generation. At present, 26 reactors are in operation, two are under construction, and two have been permanently shut down and are being prepared for decommissioning. To meet future electricity demand, the Korean government plans to construct two additional large scale nuclear power plants by 2038. In addition, Korea is preparing for the deployment of small modular reactors, SMRs, which are expected to be introduced in the mid-2030s. Next slide, please.

As you can see on the map, nuclear power plants in Korea are mainly located at four sites: Kori, Hanbit, Hanul, and Wolsong. Most of the spent nuclear fuel generated from nuclear power plant is currently stored at onsite storage facilities, mainly in spent fuel pools. However, because the volume of the spent fuel from CANDU reactor at the Wolsong site is relatively large, additional dry storage facilities have been constructed there. Nevertheless, many of the existing storage facilities are approaching their capacity limits. Therefore, securing centralized interior storage facilities and the deep geological disposal facility has become one of the most urgent challenges for nuclear waste management in Korea. Next slide, please.

This is the radioactive waste management framework. Next slide, please.

Legal framework. Next, I would like to explain the legal and institutional framework for radioactive waste management in Korea. Korea established the Radioactive Waste Management Act in 2008, which provides the fundamental legal framework for radioactive waste management. More recently, in March 2025, the Korean government enacted the Special Act on High Level Radioactive Waste Management. According to this Special Act, the government plans to secure an interim storage facility by 2050 and the deep geological repository by 2060. The act also requires the development of both generic and on-site specific underground research laboratory, which will provide scientific evidence to support the safe disposal of high level radioactive waste. Next slide, please.

In terms of governance, several organizations are involved in radioactive waste management in Korea. The Ministry of Climate Energy and Environment is responsible for nuclear energy and low and intermediate level waste management policy. The High Level Waste Management Commission, established under the New Special Act, serves as the central coordinating body for high level waste management policy. KORAD is the implementation organization responsible for managing radioactive waste, including both low and intermediate level waste and high level waste. For regulatory oversight, the Nuclear Safety and Security Commission, NSSC, supervises nuclear safe regulation with technical support from KINS and KINAC. Meanwhile, research and development activities are mainly carried out by KAERI under the Ministry of Science and ICT. Next slide, please.

This slide presents the overall roadmap for high level radioactive waste management in Korea. The roadmap shown in this figure was originally developed under the National Plan for High Level Radioactive Waste Management established in 2021. Hence, this roadmap was prepared before the Special Act was enacted. The Special Act now stipulates that the geological repository should be secured by 2060. The National Plan for High Level

Radioactive Waste Management set by the ministry and updated every five years includes the roadmap. The Second National Plan stipulates that 13 years are expected for site selection process and the host community is granted veto right during the site selection process. The interim storage facility and the geological repository are planned to be constructed at the same site. Next slide, please.

This slide illustrates the high level radioactive waste management procedure. The spent nuclear fuels are generated from nuclear power plants are stored at the on-site pool, and they will be moved to on-site dry storage facility. A spent nuclear fuel generator is responsible for the management of spent nuclear fuel at the nuclear power plant site. When Korean government makes decision to move spent nuclear fuel out from the nuclear power plant site to an interim storage facility, they, will count high level waste, and KORAD will take responsibility for the safe measure of high level radioactive waste. KORAD is in charge of transportation to the interim storage facility and construction and operation of the interim storage facility and deep geological disposal facility. Next slide, please.

And Chapter 3, high level waste repository siting. Next slide, please.

Now, I would like to explain Korea's approach to high level waste repository siting. Last year, the High Level Waste Management Commission was officially established, and its first meeting was held earlier this year. In April, the Commission approved the national plan for site stability investigations. Based on this decision, Korea has now entered the implementation phase of the siting process. Korea high level waste program has transitioned from policy discussion to implementation. The Special Act established our legal foundation while 2030 storage saturation creates urgency. Our five-stage process, exclusion screening, voluntary application, basic investigation, deep geological investigation, and final selection, spends nine to 13 years. We are now moving toward the technically driven, legally supported, and socially accountable siting implementation. Next slide, please.

We are currently developing exclusion screening criteria which represent the first step of the siting process. KORAD is implementing screen first strategy using GIS-based nationwide analysis. We exclude unsuitable areas based on three categories. First, geological stability, including active faults, seismic or volcanic zones, and unstable rock formations. Second, environmental protection, such as flood-prone areas, water resource zones, and protected ecosystems. Third, social constraints, including high population density and limited accessibility. Our screening resource will be publicly disclosed before voluntary siting begins, which helps reduce future licensing risk. Next slide, please.

Now, I would like to explain our investigation framework. The detailed criteria are used as favorable characteristics for site suitability assessment. Our IAEA compliant framework has two phases. Basic investigation, of three to five years, identifies three candidate sites using a surface method like trench investigation and overall testing. Deep geological investigation, three to four years, confirms depth suitability through the drilling and THMC modeling. Six key areas guide our work: geology, rock mechanics, hydrogeology, geochemistry, solute transport, and ecosystem. These investigations provide data for comprehensive safety assessment. Next slide, please.

Now, I would like to introduce our safety assessment framework. Our safety progress is from preliminary to detailed to final stages. The evaluation metrics covers five items. Geological stability produces site describe model. And engineered barrier generates barrier performance reports. Radionuclide transport creates migration analysis. Multi-barrier performance demonstrates system robustness. And long-term safety confirms our regulatory compliance. This framework cumulates [culminates] in the final safety case required for licensing. Next slide, please.

We learned that technical justification alone is inefficient. Transparency and trust are essential. From Finland, Sweden, France, and Japan, we adopted the stepwise decision making and voluntary participation. Our governance ensures accountability. High Level Waste Committee provides the oversight, KORAD, implements, and KINS, regulate. And the local government participate with consent authority. We target interim storage before 2050 and geological disposal before 2060. Next slide, please.

Chapter 4, URL project. Next slide, please.

Now, I would like to introduce the underground research laboratory project or URL project. First of all, I would like to emphasize that no radioactive materials will be emplaced in the generic URL. The purpose of this facility is to conduct a scientific research to verify the safety of geological disposal systems. Taebaek City is selected as the site for the generic URL through an open and transparent site selection process. Next slide, please.

Taebaek City is located in a mountainous region in the northeastern part of South Korea and was historically a coal mining area. The geology of this site is characterized by the distribution of Hongjaesa Granite along with sedimentary and volcanic rock formations. The Hongjaesa Granite is considered to be the host rock for the generic URL. Next slide, please.

This slide illustrates the result of preliminary site investigation. During the investigation, the issue emerges regarding whether the site consists of single rock type.

However, the issue have been settled and a feasibility review of the project is currently in progress. Next slide, please.

The project was launched in 2023. The site was selected in 2024, and construction is scheduled to be completed by 2032. Next slide, please.

The generic underground research laboratory is a legal requirement under the Special Act, and is recognized as an important tool for implementing a deep geological disposal program. In Korea, there have been several unsuccessful attempts in the past to site high level waste management facilities. However, KORAD has successfully selected the site for the generic URL, which represents important milestone for high level-waste management in Korea. Next slide, please.

Chapter 5. R&D activities for high level waste disposal. Next slide, please.

In terms of our R&D approach, the High Level Waste Management Commission serves as the control tower for high level waste research in Korea while KORAD is responsible for implementing disposal related R&D. Our research focused on strengthening national scientific and technical capacity and applying advanced technologies, including AI-based performance assessment and geological characterization. Key research areas include geological stability evaluations, characterization of disposal system design, engineered barrier performance, and excavation technologies. The research of these activities will be applied to the generic underground research laboratory. Next slide, please.

Korea is currently developing a conceptual design for the geological repository suitable for domestic geological conditions. This work aims to establish Korean reference disposal concept that reflects the characteristics of Korea geology and engineered barrier technologies. The conceptual design includes the configuration of the repository layout, disposal tunnels, and engineered barrier system, as well as the overall disposal operation concept. Throughout this work, Korea is building the technical basis for the safe and long-term disposal of high level radioactive waste. Next slide, please.

On Chapter 6, LILW management. Next slide, please.

Now, before concluding, I would like to briefly introduce the management of low and intermediate level radioactive waste in Korea. KORAD currently operates the Gyeongju low and intermediate level radioactive waste disposal facility, which began operation in 2015.

The Gyeongju disposal site has a total capacity of 800,000 drums based on 200-liter drums. In Phase 1, a silo-type disposal facility was construct to dispose of intermediate level radioactive waste, including low-level radioactive waste. Phase 2 is a near-surface disposal system for low-level waste. And Phase 3 is planned as a landfill type facility for very low level radioactive waste. Next slide, please.

The silo-type disposal facility has been in operation since 2015 and has disposed of more than 30,000 drums so far. The near-surface disposal facility has completed construction and licensing. And preparations are currently underway to begin disposal operations later this year. The Phase 3 landfill type disposal facilities are currently under design. Next slide, please.

In conclusion, Korea is making a steady progress in establishing a comprehensive system for high level radioactive waste management, including legal frameworks, site selection process, and R&D activities. In April of this year, Korea finalized a site investigation plan with the goal of selecting a repository site within approximately 13 years. We will continue to follow a structured five-stage process to ensure successful and transparent siting outcome. KORAD will continue to contribute to protecting public health and preserving the environment through the safe and efficient measurement of radioactive waste. Thank you very much for your attention. I will be happy to take any questions. For some of the communication, we will use interpretations during the Q&A session. Thank you. [Jane Joo translated the Board questions. Director Lee answered the questions. Jane Joo translated Director Lee’s answers.]

SWIFT: So, thank you. Thank you very much for that. That was exactly the kind of information we were looking for. I appreciate it. I do have a couple of questions. I'll start with one here in just a moment. And then, I will turn it over here to the staff to ask more questions. So, my first question, your underground research laboratory, your URL, is planned in crystalline rock. Does that suggest that all of your candidate sites for a repository will also be in crystalline rock, or will you consider other media, other rock types?

JOO: So, this is the answer to your question, sir. The DGR in Korea, regarding the deep geological repository in Korea, we did not decide the type of the bedrock yet. But in the Korean Peninsula, there's enough and sufficient volume of crystalline rock. So, we consider crystalline rock as the suitable rock type, but we are open to the bedrock types.

SWIFT: Thank you. I have a second question. Your estimates of low and intermediate level waste that will acquire disposal, do those include waste from future reprocessing activities or are they based on assumption of direct disposal of spent fuel?

JOO: Currently, in Korea, reprocessing shall be considered. But still, there is no plan for direct disposal... there is no current policy for the direct disposal. So, when the policies are set, then the KORAD, which is the operator, shall follow that policy.

SWIFT: Thank you. Bret.

LESLIE: Bret Leslie, Board staff. Thank you for an excellent presentation. I'll echo Peter's compliments to your information you provided. One question I had was, you had identified the use of AI, both in geological investigations and in performance assessment. I'm wondering if you could explain a little more your potential plans. I recognize that it's early in the process, but I know many countries are moving in that direction and we haven't really heard too much yet from these other countries. So, thank you.

JOO: Well, to be honest, I have not joined the study, so I cannot give you detailed information regarding the use of the AI. But currently, in KORAD, we use some AI technology and inspection process of lower and intermediate level waste. When we receive the lower and intermediate level waste from our nuclear power plant operator, we use the AI technology to inspect those drums and packages of the low and intermediate level waste. And also, we use some IT systems to monitor whole process of the disposal of lower and intermediate level waste.

So, we expect that that kind of AI technology can be applied to the high level waste disposal process.

LESLIE: Thank you.

MANEPALLY: Chandrika Manepally, Board staff. Thank you for such a lovely presentation. I had a couple of questions. The first one was on Slide 9. You had talked about the site selection process being about 13 years. I want to know if the clock has started.

SWIFT: I had the same question.

JOO: So, April this year, the High Level Waste Commission, the governmental agency, approved the site investigation plan. So, this year marks the original year and the very first year of this site selection process. So, we are aiming at selecting the site by 2038.

MANEPALLY: Okay. Thank you. So given that it is 13 years is what was set for site selection, in case you're not able to find a site in that 13 years, do you have like a backup plan or...

I'm asking this question because you know, you've had problems in the past, and looking at other countries, sometimes you always don't, you know, make it even though you plan very well. So, I was wondering, have you considered any of the backup plans for that sort?

JOO: The year of 2060, which is for the securing the deep geological repository is stipulated in the Special Act on High Level Waste Management in Korea. We are well aware that it's very challenging mission. But anyway, it's stipulated in the law, so we will do our best to keep this date and we will follow the five-step approach that I explained just before. And also, we learned a lot from the site selection process of the generic URL. So, we're going to apply these lessons learned from this site selection process. So, what we can say is that we'll try to do our best to keep this date.

MANEPALLY: All right. Thank you so much.

SWIFT: Andy.

JUNG: This is Hundal Jung. Thank you so much for your presentation. I believe there are a lot of significant improvements for the waste management from South Korea. I heard that the plan is to co-locate both interim storage and a repository too at the same site. So, I wonder it has been decided to co-locate it or is it still possibility to make separate? Because interim storage, which is the first step, because considering the on-site storage saturation near future in the 2030s, I wonder how this co-location of interim storage and repository affects siting flexibility.

JOO: Well, we are well aware of your concerns. But the decision to put the interim storage facility and deep geological repository in the same site has been set by the Korean government's policy, which is mapped out by two times of public debates. Maybe the backgrounds that the policy has been set in this way is that the population density is quite high in Korea and the Korean Peninsula volume of the land... territory of the Korean Peninsula is quite small. So, I guess there has been some concerns about having separate sites. So that could be one of the reason that the Korean government’s map out its policy to put these two different types of facilities in one site. So, when it comes to its policy and strategy of the radioactive waste management, firstly, the spent nuclear fuel will be stored on-site in a dry storage facility. And when the centralized interim storage facility is constructed by 2050, the spent nuclear fuel will be transported to the centralized interim storage facility and in line with construction of deep geological repository.

JUNG: Thank you.

SWIFT: Thank you, Bret. Yeah, I have one more question at least, and Bret may have more also, or Chandrika. I'm curious about the criteria you've established in this or has been established for you perhaps by national policy. For site selection, the exclusion criteria, the desirability, the desirable features criteria, to what extent are those flexible? Particularly, the exclusion ones, will those be seen as absolute? We won't look further at a site if it fails one? And how will they actually be quantified? What are the metrics for determining, for example, geologic instability?

JOO: So, we set different types of criteria, and these are considerations so far. For the sites, subject to the exclusion criteria, this will be absolute standard. So, the site subjective exclusion criteria will never be the deep geological repository. But for the preferred criteria, that could be the evaluation factor. So, we mapped with different types of criteria and we are now looking into how to utilize these different types of criteria in the future.

SWIFT: Thank you. Bret, do you have any more questions?

LESLIE: Yeah.

SWIFT: Yeah.

LESLIE: So, I know you mentioned that you have looked to other countries... Bret Leslie, Board staff. I know you mentioned that you've looked to other countries in terms of some of the basics: stepwise decision making, volunteer... you know, seeking volunteers. Could you explain a little bit more about the roadmap and the updating? One of the things we have noted in the past, for instance, Sweden, every three years updates its R&D

plan. So what is the scope of this roadmap, and who makes decisions or how is it used? Thank you.

JOO: In accordance with the Special Act on High Level Waste enacted last year, the High Level Waste Commission, the Vice Ministry High Level Governmental Agency is the decision maker in regard of all the high level waste management policies and process. So, the decision maker for the roadmap is the governmental body High Level Waste Commission. And KORAD supports High Level Waste Commission to a Management Commission to establish the roadmap. The roadmap will be put into the country's High Level Waste Management Basic Plan, which is updated every five years. So, this year, the Third Basic Plan will be announced by the government. And in this Third Basic Plan, the articles and contents of the Special Act will be materialized and specified and it will be announced within this year.

LESLIE: Thank you.

MANEPALLY: Chandrika, Board staff. I was looking at your Slide 13, where you list some of the factors that you're using for nationwide screening. So, one is geological stability, environmental protection, and social constraints. So, my question was, are you giving same weightage for all these three groups of criteria or do they have different weightage?

JOO: As I mentioned before, Chandrika, we just listed all the factors and criteria which need to be considered in the site selection process. So, this year, we will set the exclusion criteria with the detailed and specified factors and variables. So, the specified and detailed variables will be set for the exclusion criteria by this year. And for the weightage, that will be applied to the preferred site selection criteria.

MANEPALLY: Okay. Thank you.

SWIFT: Well, again, I want to thank you very much for... that was exactly the kind of presentation we were looking for, a lot of good information there. We thank you very much.

LEE: Thank you.

SWIFT: And I think that concludes this portion of the meeting. Again, thank you.

LEE: Thank you so much.

SWIFT: And we have maybe a two-minute break here before the next presentation starts. Is that right?

LESLIE: Japan?

SWIFT: Yeah, the Japanese presentation. Should we wait two minutes or are the Japan speakers ready to go?

LESLIE: They're ready to go.

SWIFT: They're ready to go. Thank you. Okay. Then, two minutes?

LESLIE: Yeah. Good luck.

MANEPALLY: Okay.

SWIFT: Okay. Thank you.

Okay. I believe we're ready to go ahead now with our next speaker. And we have a camera here. I will introduce them.

LESLIE: Go ahead.

SWIFT: Are we up? Not quite. Thank you. So again, I am Peter Swift, the Chair of the US Nuclear Waste Technical Review Board, and I want to introduce our next speaker this morning. And this is Mr. Hiromitsu Saegusa-san, the Director of Science and Technology Department at the Nuclear Waste Management Organization of Japan, the NWMO... sorry, N-U-M-O, NUMO. And there'll be two other speakers joining him from the Japanese program, Mr. Yoshito Kitagawasa-san and Mr. Hideaki Hyodo-san. And they are also with the Directors of Departments at the N-U-M-O, NUMO. So, Mr. Saegusa-san, please, if you're ready. We may not have sound. No problem.

SAEGUSA: Can you hear me?

SWIFT: Yes. Thank you very much. I hear you.

SAEGUSA: Okay. So I am Hiromitsu Saegusa from NUMO. So today, I will talk about current status of deep geological repository program in Japan. My presentation material contain many, many information, but it's difficult to explain everything. So therefore, the presentation will only provide a general overview. So please refer to the later presentation for the detail on area of interest.

So, this is contents of my presentation. But first, I will introduce background information.

So, this slide presents timeline of Japan's geological disposal program. So, R&D program on geological disposal started in 1976. So based on the result of R&D, JNC, which is now JAEA, published the H12 report in 1999. After, these studies Final Disposal Act was enacted in 2000. Based on this act, NUMO was established in same year. In 2002, NUMO started to open solicitation to all of the municipalities in Japan. Now, we are performing the literature survey, which is the first stage of the deep geological disposal site selection process in four municipalities. I will introduce the status of the literature survey later.

So, the concept of geological disposal in Japan is shown here. So radioactive waste from nuclear power plants and nuclear power generation includes the high level waste, HLW, and TRU waste. The waste are disposed at depths greater than 300 meter in a stable geological setting protected by the multi-barrier system of natural rock and engineering barriers. So in the case HLW, the vitrified waste is encapsuled by overpack made from carbon steel and vitrified waste. And overpack will be emplaced with the buffer bentonite. The gas matrix of the vitrified waste, the overpack, and buffer bentonite together constitute the engineering barrier system.

This slide shows the inventory of the HLW and TRU waste. As of March 2026, about 2,500 canisters of the vitrified waste are currently in interim storage at the location facilities. And the conversion of the total amount of the spent fuel into the number of vitrified waste package is about 28,000 canisters. The NUMO plans the disposal facility for more than 40,000 vitrified waste. And the expected volume of TRU waste for geological disposal is around 19,000 cubic meters.

So, this slide presents the organization structure of the Japanese geological disposal program. NUMO is supervised by the Ministry of the Economy, Trade and Industry called METI, and is funded by the waste producers, such as electric companies and nuclear fuel reprocessors. And then, NUMO issues research and development needs to R&D organization, universities, and so on, and reflects the outcome in the disposal project. So, regarding regulator, I will briefly explain at the next slide.

The regulatory body Japan is Nuclear Regulation Authority, NRA. The Act on the regulation of the nuclear source material, nuclear fuel material, and reactors stipulates the licensing and safety regulation of the geological disposal facilities covering their design, construction, operation, and closure, while the overall disposal program framework is governed by the Final Disposal Act. Safety regulatory standard will be developed by NRA. For site selection, NRA submitted the matters that should be considered for safety assurance in the case of selecting area and online [outline] inspection area and other site for the final disposal of specified radioactive waste, we called Considerations, in 2022.

So, this table will show the consideration determined by NRA. As shown in this table, regarding fault and volcanic phenomena, the location and the condition that should be excluded to be specified. And also, regarding erosion and the mining of the mineral resources, and so on. The point to be ensured are also specified.

Next, I will talk about activities before literature survey in the site selection process.

Selection of HLW disposal site has not advanced significantly over the past 10 years since establishment of the legal system of final disposal of radioactive waste. So Advisory Committees for natural resources and energy established two expert working group in 2013 to reexamine policies for waste management and geological disposal.

Based on the deliberations from National Council, the government revised Basic Policy on the final disposal of designated radioactive wastes in May 2015. In particular, identification of scientifically more suitable regions and proposal to encourage understanding and cooperation among relevant local governments are clearly stated as governments leading laws.

In accordance with the amendment to the Basic Policy, a new process was added to the legally defined site selection process specified in Final Disposal Act. New three pathway consists of the nationwide map, the nationwide dialogue, and application by municipalities or proposal by government was set before a legal process. The legal process consists of three stage of investigation. Such as, literature survey, and preliminary investigation, and detailed investigation. In the legal process, after each investigation stage, METI will determine the acceptabilities of sites selected for the whole investigation taking account of opinion of the prefectural governor and mayor of the municipalities.

This slide shows a nationwide map. The scientific characteristics of across Japan have been summarized to contribute to the selection of suitable site and to provide opportunity and materials for general public to recognize and understand the need for final disposal and the significance of the project. The requirement and criteria for the scientific feature of the suitable regions from geoscientific and technical viewpoint viewpoints were discussed. Based on the scientific feature and criteria, area classified into four color-code categories. These requirement and criteria lead to published of the nationwide map of scientific feature relevant for geological disposal in July 2017.

This slide shows classification of the area. If there are scientific feature assumed to be unfavorable, such as the vicinity of the volcanoes, active faults, and the area within the significant uplift and erosion, and so on. The area classified assumed to be unfavorable. If none is applicable to these features, the area classified to the area assumed to be favorable. Area assumed to be favorable, with relatively high probability that favorable feature for geological disposal could be confirmed, are classified as candidates or future site-specific investigations.

So, this table shows an example of the criteria to identify the future for classification of area from viewpoint of geological environment characteristics and their long-term stability favorable to geological disposal. So, I will introduce the criteria regarding the volcanic igneous activities as an example on next slide.

So, regarding volcanic and igneous activity, consequence or impact required to be precluded is magma intrusion affecting physical isolation. The criterion to identify unfavorable feature regarding volcanic igneous activity is within an area of 15 kilometers from the center of individual Quaternary volcanoes.

Following the public publication of the nationwide map, government and NUMO have been carried out nationwide dialogue across Japan to promote understanding of the geological disposal project and the geological environment in Japan during nationwide dialogue. So, we were able to initiate the literature survey, which is the first stage of the legally specified site selection process.

Next, I will move on the status of the literature survey.

So NUMO initiated literature survey in four municipalities. In November 2020, Suttu town and Kamoenai village in Hokkaido

Prefectures. In June 2024, Genkai town is in Saga Prefectures. In May 2026, Minamitorishima Island, Ogasawara Village in Tokyo.

In 2020, we received the application for literature survey from Suttu town and Kamoenai village in Hokkaido Prefectures. Kamoenai village made the decision to accept the offer from the government for literature survey after discussion among the village council and the residents. Suttu town made the decision for the application of the literature survey after discussion among the town council and the residents.

This slide shows the location and geological feature at Suttu and Kamoenai.

So Kamoenai village located here is... Kamoenai village located near Tomari Nuclear Power Plant. And the type of rock widely distributed is Neogene volcanic rocks, hyaloclastite. So, there is volcano around the village. In the case, Suttu town is located southern part of the Kamoenai village. The type of rock is also Neogene volcanic rocks.

So, this slide shows Genkai town... about Genkai town. In June 2024, NUMO initiated literature survey for Genkai town, Saga Prefecture, Kyushu region. So Gengkai town made a decision to accept the offer from government for literature survey after discussion among the town council and the residents.

So, there is Genkai Nuclear Power Plant in Genkai town. The type of rock widely distributed is Neogene sedimentary rocks, and there are coal field in the town.

So, this slide show about Minamitorishima. On March 3, this year, METI proposed the literature survey for Minamitorishima to the Ogasawara village Mayor. And on March 14 and 21, this year, briefing session were held on the both island. Both means that Chichi-jima Island and Haha-jima Island in Ogasawara Village. On April 13, the Mayor announced his official view. After that, NUMO initiated literature survey for Minamitorishima Island. So English name is Marcus Island in Tokyo. And Ogasawara village consists of widely scattered islands with the general population resident, only the Chichi-jima Island and Haha-jima Island. So Minamitorishima Island located here. It's very far from Tokyo and very far from the Ogasawara, the main island.

And next, I will talk about literature surveys. Literature surveys to be performed based on the evaluation guideline for literature survey stage. The criteria for literature survey stage specified in the guideline, which is based on the input from legal requirement and the criteria to identify feature for classification of the area in the nationwide map, and consideration determined by NRA. And we started to support the municipal office to promote activities for their resident to learn about importance, safety, and process of our project and significant siting of deep geological repository for sustainable development of the area in parallel with our conduction of desk-top study about the geological environment of the applied area based on open document available.

So legal requirement for siting preliminary investigation area are described here. So there should be no record of significant movement in geological formation due to earthquake or a fault activity, igneous activity, uplift, erosion, and other natural phenomena. And possibility of significant movement in the future due to earthquake or fault activity, igneous activity, and so on should be small. There should be no record of unconsolidated

Quaternary deposit at appropriate depths. And there should be no record of mineral resources that are economically valuable.

So in the Act, legal requirement for three stage of the investigation. The requirement for preliminary investigation like this and for detail investigation like this. In summary, the requirement in early staging siting process are mainly for exclusion. And in later stage, for confirmation of stability.

From this slide, I will show the criteria for literature survey stage. Regarding fault, we excluded the fault plane of seismic source fault active since the Late Pleistocene, and plane of a feature in which significant rock displacement, and a large fault of a 10 kilometer in length, fault core of these faults.

Regarding magma intrusion and eruptions. The area with trace of Quaternary volcanic features such as vents, dike, and calderas, and within 15-kilometer of the active center of the Quaternary volcano, and location where it is evident or highly probable that new volcanoes could form are to be excluded.

For erosion, we excluded area where erosion over past 100,000 years exceeded the depths at which the repository is to be located, and the future erosion over the next 100,000 years would reduce the distance between the repository and the surface to less than 70 meters. The 70-meter depth is based on the tunneling practice in Japan and is required by the NRA's considerations.

So, regarding unconsolidated geological formations. Unconsolidated Quaternary sediment to be excluded, taken to account tunnel excavations. For mineral resources, for example, we excluded area with currently or recently operating mines of high economic value taking into account future potential human intrusions. For geothermal resources. For example, we check whether geothermal gradients exceeded 100 degree per kilometers and whether geothermal power plants exist within a few kilometers.

In addition, regarding geological environment characteristics. Favorable characteristics with respect to the containment function and feasibility of constructing underground facilities are confirmed. And regarding socioeconomic condition, existence of clearly unsuitable places regarding law and regulations related to land use are also confirmed.

So, this slide shows the status of the literature survey for Suttu and Kamoenai. Collecting the necessary documents and data such as the geological map and technical papers specific to the area in municipalities has been completed. And NUMO established local office for communication in each municipality as a base for various outreach activities to the resident, including information dissemination, participation in local events, small group meetings, and so on. And NUMO and municipality have jointly established the Place for Dialogue in each municipality, a meeting structure comprising 20 or so residents of the municipality and an independent facilitators.

The area has been evaluated from the viewpoint of the criteria specified in the evaluation guideline for literature service stage. The Literature Survey Report was delivered to the Mayor of the Suttu town and Mayor of Kamoenai village, and the Governors of Hokkaido Prefecture in November 2024 after confirmation by the National Council. The report described the confirmation of the existence of the area that meet criteria to be excluded, proposing candidate area for preliminary investigation, extraction of points to be confirmed in preliminary investigations.

This slide shows a result of literature survey in Suttu town. No area met the exclusion criteria in literature survey stage, but there are some matter to be specifically noted in preliminary investigation stage in detail. So fault, dike, and low-frequency earthquakes, mine, and Quaternary unconsolidated sedimentary assessment are noted after literature surveys. However, there are no place to exclude, so entire literature survey area is potential preliminary investigation area.

In the case of Kamoenai village, there was place to exclude it regarding magma intrusion. The place where protected forest for rare species population is also to be excluded. And there are also some matter to be specifically noted in preliminary investigation stage in detail.

So dike and Quaternary unconsolidated sediment are noted after literature survey. Excluding the area within the 15 kilometer from the volcano is potential preliminary investigation area among the literature survey area.

This stage outline the legal process following the completion of the literature survey report. Once the report is finalized, it is published to get the public opinion. So we have already collected over 2,000 opinions. And we currently preparing our official response to this feedback. Afterwards, the government will consult with the governors and respective mayors to determine if they wish to proceed to preliminary investigation stage.

So, this slide shows the status of the literature survey for Genkai town, same as Suttu and Kamoenai. Collection of the document has been completed. And NUMO established the local office for communications. And NUMO and the municipality have jointly established the Place for Dialogue.

So, I will share the lesson learned from our previous activities of site selection process so far. And the nationwide map has become a very effective tool for supporting dialogue with the stakeholder and proving the public understanding of geological disposal. A key point is that we established clear criteria to distinguish between favorable and unfavorable area, and then visualized there on the map. By doing so, we are able to show in concrete way that this geological disposal is feasible even in Japan despite tectonically active setting. And also, NUMO has compiled literature survey report based on the relevant evaluation guidelines. These reports were confirmed by a national council. This process have been highly effective in ensuring the appropriateness of the literature survey outcome. But it has also promoted mutual understanding throughout dialogue among the expert and has contributed to enhancing public confidence in the objectivity and transparency of the process.

Oh, I am out of time.

So regarding disseminations, the technical information. Lesson learned about these things.

So finally, I will briefly talk about the further actions. NUMO continues communication activities throughout Japan in order to have more municipalities accept the literature survey, and stepwise characterization of the geological environment, design of the repository and safety assessment. For this stepwise characterization concept of SDM development and data management are key techniques for the characterization. So, I will introduce them as topics.

So, in early stage of siting process, site where significant effect of the natural phenomena is to be excluded. After that, taken into account of geological future in Japan. It is necessary to consider the effect of the slow and cumulative process, such as uplift, and erosion, and so on. On the characteristics of the geological environment in time scale of over 10,000 years, and the area of the explosions. Whole purpose for the 4D-SDM to be developed at the regional scale, to take into account temporal and special change in the geological environmental characteristics due to the long-term topographic, climatic, and sea-level changes. This is one of our idea.

And final... this is my final presentation slide. So this slide shows about data management system for site investigation. Now, NUMO is developing the Geo-Synthesis Support System to manage extensive and diverse data generated during stepwise site investigations. Sorry, I think time is coming. So my presentation is that all. Thank you for your attention.

SWIFT: Thank you very much. That was extremely informative. It was very thorough, and it was just what we were looking for, so thank you. We do have a few minutes here for questions. And just making sure that the staff here agrees, yeah? And again, I'm Peter Swift. I'm the Chair of the US Nuclear Waste Technical Review Board. And I just want to make it clear that what we're doing here is we're not commenting in any way on other countries' programs. Our questions here, we're here to learn from you, basically. So please interpret our questions in that light. And we appreciate you taking the time to speak to us.

I'm curious about the role of underground research laboratories that you've... Japan has had a program with underground research laboratories for quite a few years. And what role do you see for your URLs going forward? And how does information gathered from the URLs help you in evaluating potential candidate sites that may come forward?

SAEGUSA: You have question about URL program in Japan and past and the future, it's correct?

LESLIE: You wanted to know if...

SAEGUSA: You can't hear?

SWIFT: Oh, I'm sorry.

LESLIE: Was your question about the role of URLs in the program?

SWIFT: Yes. My question was, about the information you have learned from URLs, how that is helping you move forward in the site selection process?

SAEGUSA: So now, in Japan... so now one URL is operating in Hokkaido Horonobe and the Mizunami underground research laboratory closed several years ago. But the information from this URL is very useful to generic safety case report published by NUMO. And so, the experience from this URL is very effective for site investigation techniques development. And in near future, we will construct underground investigation facilities. Yeah, investigation facility... not underground research laboratory, underground investigation facility in the detail investigation stage. So, in this facility, we will obtain the detail information about the physical, chemical, hydrogeological mechanical characteristics on-site information. Is this answer for your question?

SWIFT: Yeah, thank you. Do we have Bret or Chandrika?

MANEPALLY: Chandrika Manepally, Board staff. I was wondering if you had any differences in the amount of data that you had during your literature survey stage for the two sites that you finished doing? And if there was a difference, how did you account for that, especially maybe comparing the sites? And then, a follow-up to that is, the last site, the island... Marcus Island, do you expect to have a lot of data given that there is nothing there, there is no development going on? So how will you address that compared to the Suttu village and the Kamoenai site?

HYODO: Thank you for your question. And NUMO leads Japanese program has the examination guide for literature survey stage. These are the exclusion criteria. So, if the site doesn't have many information, it is assessed by just the exclusion criteria.

MANEPALLY: Okay.

HYODO: About the Marcus Island, compared to the Suttu, Kamoenai, or Genkai, it has less literature amount, I think. But I think more than 100 of the literature will be... Sorry.

MANEPALLY: It's okay.

HYODO: We are going to have the more than 100 documents.

MANEPALLY: Okay. Thank you.

SWIFT: Bret.

LESLIE: Bret Leslie, Board staff. You described how important the national map was for the dialogue process. Do you just use the map or do you have other GIS products that help communicate with the public? You know, so do you show a more detailed map of all the faults around an area, you know, a region, not necessarily right at the town? So that the public can understand where they are given... the public generally thought that with Japan being in such a tectonically active area, that, you know, we might not find a site or you might not find a site?

SAEGUSA: So nationwide map is... so the feature scientific characteristics across Japan has been summarized. But we didn't make more local map. Because how to say? There is some reason for making the data very local map. So, we need to detail information. So, data density and amount of data is heterogeneous. So, if one area can make detailed map, but another area cannot make detailed map, it is not so good for nationwide dialogue. So, we only make the nationwide map.

LESLIE: That makes sense. Thank you for the clarification.

SWIFT: This is Peter Swift again. I have one more question. Whatever you can tell us, I'm curious about the process by which communities came forward to express an interest in being included in a literature survey. And part of why I'm interested is, that this is essentially the point that the US's program is at right now. And I understand these are probably sensitive conversations that may be difficult to talk about. But somehow, three communities, four communities have come forward and said, "Consider us for further study." And what can you say about how that process worked?

SAEGUSA: So, your question is if the four municipality accept the next investigation, what will we do?

SWIFT: Well, the question is, for example, how did Genkai town identify itself to you and to METI as a community that might possibly be interested in having a literature survey done?

SAEGUSA: Yeah. Just a moment, please.

SWIFT: It may be the question doesn't translate very well.

LESLIE: They're talking also.

SWIFT: Yeah, I gather that.

SAEGUSA: Sorry. So now, we couldn't fully understand your question. Please, one more.

MANEPALLY: Say it again.

LESLIE: This is Bret Leslie, Board staff. We can follow up after the meeting in writing and we can talk to you offline so that we can have a clear understanding. Okay?

SWIFT: Yeah. Rather than have an answer that is based on a miscommunication. Thank you very much. We really appreciate the presentation. And there are many things in your presentation that, for example, the national map, that is something. We're pretty interested in that. So, thank you. Very good.

SAEGUSA: Thank you very much.

SWIFT: Thank you. We will then take a 15-minute break here in Arlington. We'll be back at 10:25 for the presentation from the Czech program, and thank you.

[Pause for Break]

[Meeting Resumes]

SWIFT: Thank you. I think we’re ready to return to the meeting and begin. Our next speaker will be from the Czech Republic. And I will wait to introduce her until we have confirmation that she’s on camera here. Ah, we’re here. Just to introduce myself again, I am Peter Swift. I’m the Chair of the US Nuclear Waste Technical Review Board. And I want to thank our next speaker who has appeared here, Markéta Dohnálková from the Czech Republic. And Markéta is a leader of the team responsible for the development of the Deep Geological Repository Project in the Czech Republic. Again, I thank you for being here and before I turn the microphone over to you, I just want to make it clear that we are here to learn from you. We’re not here to comment on your program. But we’re very curious because all programs have something to teach the US right now and we’re happy to learn. So, thank you.

DOHNÁLKOVA: Thank you very much for inviting me. So, good morning, ladies, and gentlemen. My name is Markéta Dohnálková and today I will give you a presentation about the Deep Geological Repository Siting in the Czech Republic. But firstly, okay, it looks that I have some technical problem. Yeah. So, it, it works. Firstly, a little bit more about the Czech Republic. Czech Republic, it’s a really small country in the middle of Europe. On the map you can see where the Czech Republic is placed. But even though we are really small, we have two nuclear power plants in the Czech Republic. One here in the South Bohemia in Temelín and second here in our South Moravia plant. This is the NPP Dukovany.

In the Czech Republic, it’s a state which are responsible for the safe disposal of all of the radioactive waste. We are SÚRAO and SÚRAO is a state administered team body which was established by the Ministry of Industry and Trade in 1997 according to our atomic law. And, uh, we are financed from an independent nuclear account established by law and on this account our waste producers are contribute for each megawatt-hour which was produced in our state.

Our mission is really clear. We are responsible for safe disposal of all radioactive waste. We are safely operating our national radioactive waste repositories. We are developing deep geologic repository and also, we are responsible for siting of this repository and our most important part of our job is to build public trust through the transparency and dialogue about the radioactive waste management in the Czech Republic.

So, I mentioned that we have some repositories already in operation. We have really long-term disposal operation of our intermediate and low-level waste repository. Our oldest repository Richard is in operation since 1964 and it’s mainly for industry. Now waste from medicine research and industry. We have also Dukovany repository, which is directly close to our nuclear power plant and this repository is serving mainly for the nuclear power plant since 1995. And we have also the last repository close called Bratrsvtí. This is a really small one and there are only waste with natural radionuclides.

We are also preparing the deep geological repository and our main priority is now the site selection process, which will be or should be finished in 2030 because Czech Republic would like to have our repository in operation in 2050. And why 2050? It’s because it’s in line with our European Union Taxonomy. In our previous time, we had the milestone for the operation in 2065. But because the Czech Republic has big plans, we start the constructing of new nuclear power plant. We have to be quicker and be prepared with operation in 2050. And that’s why we are in the middle of site selection process and we are also focusing on our technical design of repository and we are developing the technical design and also we have a big research and development of our engineered barrier system and also focusing on the first safety case, which is our preliminary safety case. Safety assessment, which is now underway and should be finished in 2027.

For supporting our research and development plans, we are operating Bukov. Bukov, it’s our underground research facility. It’s a laboratory, which is placed 500 meters deep and we are using facility of old uranium mine, which we already have in Czech Republic. And in this laboratory we have a lot of in situ tests for the engineered barrier system.

This states a little bit more how our DGR will look like. Our repository will be placed in crystalline host rock somewhere around 500 meters deep. And the safety of the repository is based on the multi-barrier concept from the bentonite barrier. We have a lot of bentonite in the Czech Republic and that’s why we would like to use this material. And there will be also the waste disposal package, which is the most important barrier in our concept. And this waste disposal package is double walled and it’s from steel. We have developed the design of this container in the Czech Republic.

The size of the future repository should be somewhere around 3 kilometers square underground and on the surface, 15 hectares. But it can change because each of our locality is different and we are now preparing the technical design related to the each of our possible site. In our repository will be spent nuclear fuel from our nuclear power plants and also from the future sources. And also there should be the enough capacity for other radioactive waste means low level and intermediate level waste. Because Czech Republic in the future would like to have only one repository after our operated repositories will be closed. There will be only one repository and it will be the DGR.

So, here you can see our estimated inventory. The inventory will be mainly from our existing sources. As I mentioned before, we have two NPP’s, Dukovany and Temelín. And there should be also inventory from our research reactors from the Czech Technical

University and from also Research Institute in Czech. But Czech Republic has a big plan for constructing new large reactors in the future. There should be or will be four new large nuclear reactors and DGR should have capacity also for waste from these reactors. And we would like to also construct up to six small modular reactors and also waste from the small modular reactors will go to the repository.

In total, the capacity should be in case of spent nuclear fuel more than 14,000 of tons spent nuclear fuel and more than 38,000 cubic meters of other radioactive waste. And all of this estimated inventory was described in our main documentation called Czech National Policy of Radioactive Waste Management and Spent Nuclear Fuel from 2025. On the picture you can see how the future repository would look like. There are parts for spent nuclear fuel. There are also small parts for other radioactive waste. This is the surface area and this is the underground area.

Back to the Czech Republic and our map. I would like to introduce you our four possible sites for future placing of the Deep Geological Repository. This is our candidate site. All of them are in the crystalline host rocks because we don’t have enough capacity in our clay host rocks. And that’s why the main focus are now given on the crystalline host rocks in the Czech Republic. All of our sites are in the south part of the Czech Republic. And here you can see the Czech DGR Program road map with our key milestones. First of the milestones, it’s 2020. 2020, it’s here because in 2020 four sites, which you had seen, were selected and approved by government of the Czech Republic. And government said in 2020 that we should... or we need to select our final and backup site till 2030. And that’s why there is another milestone 2030 for final and backup site selection. Between these two milestones is also the safety case one milestone because this is really important documentation which we are now providing.

After the final and backup site selection, we will continue with our program. Firstly, we decide the class of license in 2032. And after that, with 2037 with construction license. And as I mentioned before, the operation of repository should start in 2050. There is also another milestone like the ending of the operation and this is 2167. But this is not settled for sure now and it can be changed in our future.

Now a little bit more about the policy and our regulatory framework. This slide shows overall regulatory framework in the Czech Republic. The strategic direction is given by our National Policy. This National Policy is given by Czech government and also by the Ministry of Trade and Industry. SÚGB is independent regulator who is responsible for licensing and oversight. And there is SÚRAO, our organization. And we are implementer for program of radioactive waste management, which includes siting and in the future licensing processes for construction operation and also closure.

We have also legislation related to our program. The first one and primary, it’s our nuclear act, Atomic Act, which established also SÚRAO as a state organization. We have also a special decree related to the siting not only for the DGR, but for all of our nuclear facilities in the Czech Republic. There is also another act from 2024. It’s a DGR Proceeding Act and its main purpose is to define the decision making and permitting process for the Czech DGR program and to strengthen the involvement of our municipalities from our four sites and public.

There are also other acts which are really important in the site selection process like the Environmental Impact Assessment Act, also the Geological Works Act, and, as I mentioned before, the National Radioactive Waste Management Policy.

So, here is our regulatory requirements directly for the site selection process. On the strategic level, the process is defined by the National Radioactive Waste Management Policy, the Czech Program follows a stepwise approach. Reducing the number of candidates sites until a final and also the backup site are selected by 2030. Site selection is based on scientific evidence and long-term safety. And the process is transparent and involves municipalities, the public, government, authorities, and regulators.

The detail technical requirements are defined in Decree 378 from 2016 and for the DGR mainly in Section 18. And the most important requirement is long-term safety. The regulation also requires suitable hydrogeological, geomechanical, and geochemical conditions. In addition, site must be sufficiently understood to develop reliable geological and safety models. Exclusion criteria are if a site cannot be adequately modeled and cannot demonstrate long-term safety. This regulatory requirement formed the basis of our site investigation program and the evaluation of all of our candidate sites.

So, now a little bit more about the specific site selection methodology. The site selection process in the Czech Republic started somewhere after the 1990's where more than 32 areas were selected in our preliminary research. This was leading by the Ministry of Environment and Ministry of Trade and Industry. And in 1998 there was some reduction of potential sites to 13. And in 2003 only six localities or sites were proposed like for the next pass of site selection process. All of these six localities were in crystalline host rocks. After 2003 there came something like a stop to our program which was given by government and they said that there will be five years moratorium for next step and site selection process. And when this moratorium ended, the government and ministry came with proposal that there should be added more sites into the process. Two sites close to the nuclear power plant and one side close to the old uranium mine. And the purpose for this step was better understanding of the nuclear power and underground construction of the public. It means that somewhere after 2015, we had totally nine possible sites for the siting of the repository. And in 2020, these sites were shortlisted for the final four sites and this step was approved by Czech government.

And here we are, a little bit closer to the site selection strategy which we have now. When the nine possible sites were shortlisted to four, we have used some geological measurement related to the surface geological geophysics. We don’t use no drilling or holes and we apply exclusion criteria for the site selection process. And now when we have four possible sites, we would like to have more data from underground part, especially from the disposal level. And that’s why we would like to use deep boreholes, geophysical, and hydrological surveys safety case, one, and also the feasibility studies. And after this process, in 2030 we should be able to have one final and one backup site, which will be recommended by SÚRAO to the Czech government. But the Czech government is responsible for the final decision and it's up to them if they will choose recommended site or not.

For the purpose of the site selection process, we have developed a special methodology. It’s a document which is accessible on our webpage. It’s also in English and you can read. And this methodology was developed specifically for the DGR program in the Czech Republic to ensure a structured transference and evidence-based approach. This document defines clear rules, procedures, and evolution criteria for assessing and comparing of our four candidate sites. This methodology has three steps. The first step is an exclusion of risk by the legal exclusionary criteria. The second step, it’s a demonstration of potential long-term safety of our site by using Safety Case 1. And the last is a multi-criteria site comparison. This methodology was reviewed by national and international experts. And also from this methodology was involved in the site selection process special advisory panel of experts too. This is a really important part of our process because this is the independent external expert body, which is supporting the scientific robustness of our site selection process. In this panel of experts are people from Czech universities, people from ministries. There are also observers from our regulator and also observers from our potential site. And they are giving advice and reviewing the whole process.

Now we can go a little bit more into the details to the methodology. This is the step 1, the exclusion of potential risk. When we were starting with this step, there were some key questions. Firstly, is the site compatible with regulatory requirements? Are there any non-mitigatable exclusion factors? And can the site be characterized and modeled? These questions are really the most important like a first step because they can help to identify conditions that could prevent repository implementation or compromise long-term safety. This step was based on the international recommendation and also on our national legislation. You can see some examples of our exclusion criteria. It’s something like active faults and tectonic deformations in 5 kilometers from our facility. There are also criteria for a significant groundwater bodies at the risk of contamination. Our underground water sources. There shouldn’t be any volcanic activity or post-volcanic phenomena activity. There shouldn’t be any mining activities and underground structures. There shouldn’t be any geothermal energy. And we should be able to develop reliable 3D geological, hydrogeological, and geomechanical models in this step.

If we are able to fulfill all of this criteria, the next step it’s safety and the candidate site can go to the step 2. If not, if there are some exclusion criteria, which are on this locality, the locality is not possible to go to the next step. It’s excluded. So, here is step 2. This is a preliminary long-term safety plan and it’s based on our Safety Case 1, which is based on the reference concept of the Czech disposal concept for the spent nuclear for fuel disposal. This concept is applicate [applied] on the reference site. The reference site is not the real site in the Czech Republic, but it represents data from the Czech granitic host rock. This safety case on the reference site can provide some key parameters. We call it transferability parameter ranges, which could be compared to the data related from our four possible sites, from our geological model, hydrogeological model, or transport properties. And in the end, we will be able to say if the site is from the safety point of view, potentially safe or not. And how we will use it. So firstly, on the reference site, we have to be sure to ask what would a typical Czech DGR site look like? And the model for the safety case, it’s not representing the real site in the Czech Republic, but typical Czech crystalline rock condition.

In step 2, when it’s Safety Case 1 applicate [applied] we have two questions. Does the concept work? And are safety functions fulfilled over hundreds of thousands of years? And which parameters matter most for the safety? And if you are able to say which parameters matters most, we can compare these parameters with the data from our four potential sites.

This slide provides the examples of the types of transferability parameters. We are developing them directly in Safety Case 1 and the purpose is to identify which site characteristics are most important for long-term safety and repository performance. The final parameters and acceptance ranges will be defined by 2027 when Safety Case 1 is completed. And the key point is that the site comparison will be directly linked to the safety assessment.

Here is Step 3, the most important, where apply or applicate the key comparative criteria. We have six criteria related to the geological and structural properties, like degree of faulting, fracture intensity, or geological variability. We have criterion number 2. It’s related to the mechanical and physical properties like rock strength. There is criteria to the site stability like a seismic hazard or long-term geomorphic evolution or climate change. There is criterion number 4, hydrogeological and transport properties like a groundwater flow at repository. There is criterion number 5, geochemical properties of groundwater, like pH, Eh, mineralization, reducing conditions, compatibility with EBS. And the last criteria is repository size and rock mass reserve. It shows us if the repository footprint on the disposal horizon, it’s big enough or if the size of the locality is big enough and if we have enough capacity and if there is any reserve for the next nuclear resources.

In the process we have also something, which we call output studies. Output studies synthesize all site investigation data and a design data and demonstrates that each site is technically feasible, environmentally acceptable, and also safe. And these studies are preparing on all of our four sites. The first type of study is a feasibility study, which verifies that the underground and surface repository can be physically placed with the designed investigation territory. The second type of study is a safety assessment study related to our degree for placing of our nuclear facilities. The third type of study is an environmental impact assessment related to our act to the environmental impact. And this is the preliminary evaluation of DGR impact on soil, water, air, flora, ecosystem, public health, and also to the cultural heritage.

And last but maybe for the public the most important study is the social economical impact study, which is related to the assessment of economical and social demographic benefits and risks for the host region of DGR.

And the final step is a comparison of the candidate sites. So, using the key criteria from step 3, each criterion is evaluated as advantages, disadvantage, or neutral condition. And this approach helps us to identify the main risk and the strengths of each side. And at the end, we will be able to say which of our site is the best for the placing of the DGR. And if it happens that all of our sites will be on the same level, the reserve capacity of the host rock block becomes the decision factor.

So, now a little bit more about the site investigation and screening methodology. Yes, this slide shows how we move from data to our site selection process. The process that with the field investigation where we collect geological and hydrogeological data and all of this information is then integrated into the site’s descriptive models, which are provide consistent understanding of each candidate type. These models also are used as the basis for the safety assessment where we evaluate whether the site can safely host DGR.

And finally, the results are used for the site comparison and decision-making process. The key message from this slide is that we do not make decisions directly from our raw data, but we transform data into the models and models into the safety assessment and safety assessment into the evidence-based decisions.

Here you can see our site characterization program, which is based on a lot of geological works. The first is geological mapping, which we are doing for a long time of our four sites. We have already started two years ago with hydrogeological monitoring and with geophysical works. We have also the seismic monitoring and I hope that soon we will start with the drilling campaign. On each of our sites, we would like to drill seven deep boreholes. One into the 1,200 meters, two to 600 meters, and three to 300 meters. And all of the data and also into the laboratory where the laboratory testing program is prepared.

In the progress or in the program there will be a lot of site descriptive models, which will provide an integrated and predictive understanding of our candidate sites. Here you can see that we will prepare a lot of type of data and site descriptive models like the structural geological model or a hydrochemical model, hydrogeological model, and also transport model. And how site descriptive models support the siting. This slide shows how this model support all of our three steps of site selection process. In step 1, they help to understand this site and identify exclusion factors. In step 2, they provide key parameters for comparison, with transferability ranges. And in step 3, they provide quantitative indicators that allow us to compare our four sites.

In geological disposal are a lot of uncertainties and this is really normal. The goal is not to eliminate uncertainty completely, but to understand it and manage it. We consider uncertainties in data, in our geological interpretations and also in our models. And in data it could be reduced by the initial investigations or additional investigations by other monitoring and also the data collection. Conceptual uncertainty bears different interpretations of the same geological information may be possible. And in models, here we use conservative assumptions, sensitivity analysis, and also the model validation.

And the last step in my presentation is lessons learned because lessons are most important from the process. From my point of view, the safety must drive the site selection process. And it’s necessary to build the regulatory framework early and make decisions step by step. And invest not only money but also time in data and site understanding. And also involved independent expert into the process. And to the review of your work. But I can also recommend it’s the international cooperation because it can accelerate progress of the whole process. I think because lessons learned is the site selection and safety assessment cannot be separated, but they must evolve together through the whole program.

We had a lot of challenges in our Czech disposal program and site selection process. For example, the public opposition from our possible sites and how we are dealing with that is that we are transparent and we are continuing with our dialogue with public and providing the information. We have also some delays in our drilling campaign, but, you know, site selection process, it’s not based only on one data from the deep boreholes. It’s a complex dataset from a lot of measurements and deep boreholes. It’s one information but not only one.

Yeah. Here are also another key lessons learned, which I mentioned before. I think it was said. Yes. And the last slide, it’s about the lessons learned directly from our Czech DGR siting process. Firstly, it starts early and define the process clearly. I think that’s to produce the clear methodology and strategy can help to the process. And the process must be clearly communicated with all stakeholders and also with public.

As I mentioned before, uncertainties are the part of the process and especially if you are working with geological conditions. And do not attempt to eliminate it, just work with that. Also, your data and models, which you are preparing and providing, must be traceable and reviewable. And it really helps if somebody or some special advisory board can help with this review. And all of this needs a lot of time. Just plan. My big advice is to plan and take time for each of your steps and think about the safety because safety is the biggest part of the whole process and must be related also into the site selection process. So, at the end there are some acronyms and also some references, which you can see on our webpage or which are related to the Czech legislation. So, thank you very much.

SWIFT: Thank you very much. Oh, thank you. Thank you. There’s a lot of good information there. We really appreciate it. Thank you. We have... Let me check my time here. Yeah, we have some time for questions. I’ll start off by asking about the... Your emphasis there on one of your lessons learned that your data and models must be traceable and reviewable. In the US program that would basically be covered under records management and quality assurance topics. And at what point should that be introduced into the program? At what point was it introduced into your program? That you had basically rigorous recordkeeping of the collection of data and the model build... construction of models? So, the question would be when did that become an important part of your program? At what stage?

DOHNÁLKOVÁ: In what stage? It really became from our regulatory body because we have a special decree under our Atomic Law and this decree is related to the siting of all of nuclear facilities, not only for DGR, but also for nuclear power plants. And this requirement is a sign in this decree that all of our data must be transferrable, must be reviewable, and if we are not able to have reliable 3D geological, hydrogeological and geomechanical model of our site for nuclear facility, deep geological repository, this facility is not allowed to be constructed there.

SWIFT: Thank you. Chandrika?

MANEPALLY: Hey, Markéta, that was a very nice presentation. Thank you so much. I was wondering about the modelability of a site. You state that in Slide 12 that the site should be able to be modeled.

DOHNÁLKOVÁ: Mm-hmm.

MANEPALLY: As a modeler in my past life, I think any site can be modeled depending on what assumptions you can do. So, were there is specific requirements that you had when you decided whether a site can be modeled or not? Can you expand a little bit on that?

DOHNÁLKOVÁ: Yeah, you are right. Everything can be modeled and it depends how much data do you provide to the model. And if we were not able to have enough data, we'll decide what is the enough data for the model. And that's why there is a regulator in this process. And the regulator will have the final words to this. And the regulator is a part of the process from the beginning in the Czech Republic and we have some meetings with his team and we are discussing about the level of data and level of the site descriptive models. And, you know, there is no any special requirements about this level, but it came from the common discussion with our regulator.

MANEPALLY: Okay, thank you.

LESLIE: Bret Leslie, Board Staff. Again, a really nice presentation with a lot of information. In particular one of your criteria, I think, it was K6 in the repository size.

DOHNÁLKOVÁ: Yes.

LESLIE: So, in your earlier slides, I forget, it's both the inventory and size and you gave both the underground area and the surface area. What percent of that is the spent fuel roughly? If you said it was 14 hectares or whatever, 3 square kilometers underground, is half of that the high level or the spent nuclear fuel? And this question is coming a little bit from how hot that material might be and how widely spaced the packages might be. So, can you provide a little more information on that?

DOHNÁLKOVÁ: Yeah, of course. The spent nuclear fuel area in our repository will take almost 90% I think. Because another part for another type of radioactive active waste means low level and intermediate level waste will be quite small and this sixth criteria, number 6 is there because Czech Republic wants to build a new nuclear unit. And the requirements from our government is still growing and we have to be sure that we will have enough capacity for all of our sources in the future because there will be only one repository in the future and it will be DGR. And, as I mentioned before, Czech Republic is a really small country and our geological conditions are not unlimited. We have really limited geological host rock. And that’s why this calculation is a really critical part of our site selection process to be sure that the repository or the site is big enough for the repository. And there will be also some reserve. Because when you will start the construction of the boreholes, disposal boreholes, you must see that some of the boreholes, it’s not able to use because of the fractures or another geological condition. And that’s why there should be enough capacity also for all these things.

LESLIE: Thank you. That was a very clear explanation.

SWIFT: Yeah, this is Peter Swift again. I had a very similar question there getting at the question of the plan to eventually come down to one site plus one backup site. In this country that might be interpreted as two sites and, in fact, it would be if some future change in national policy led to a larger inventory than expected, you would have a second site fully qualified. Is that part of the thinking?

DOHNÁLKOVÁ: No.

SWIFT: Good. Thank you.

DOHNÁLKOVÁ: There's... Yeah, the final site is final site. The repository will be constructed there. But the backup site is there in case if something happens. Because when we will... our government will say that this is the final site, people go directly with another geological survey, with doing the deep tunnels into the disposal level. It means somewhere around 500 meters deep. And we will do there another best related to the geological conditions and we will compare if our predictions are the same like the real geological conditions because I'm sure that we will not have data from the geology. Still we will be 500 meters deep directly by the tunnel. And if there something happens and the geological predictions will be different than the real geological predictions, we will have the possibility to go one step back to the backup site. And that's why we have our backup site in our program.

SWIFT: Thank you. Andy?

JUNG: I have a quick question. To support the final site selection by 2030, I believe you must have enough or sufficient data related to the engineered barrier system as part of your conceptual design. Unfortunately, I couldn’t see any description for relate to the engineer barrier system R&D. So, will you just briefly explain what is the status and the plan and how to support for your safety assessment?

DOHNÁLKOVÁ: Yeah, it’s a really nice question. We have a really big research and development plan for the development of our engineered barrier system. We have developed a buffer and backfill from our Czech bentonite. It’s calcium magnesite bentonite from our Czech sources. And we have also the development of our waste disposal package, which is double vault from steel. Inner part of our container is from the stainless steel and outer part is from the carbon steel. And all of these engineered barriers are related to our first Safety Case 1, which should prove if our concept is workable in our Czech condition. Related to the R&D plan, we have developed also another document, which is calling R&D Plan and we are developing this plan every five years and all of our activities related to engineered barrier system development and also for the in situ testing, which is a really crucial part of the development, which we are providing in the underground research facility Bukov. It describes in this document. And you can also see the document on our website surao.cz and you can read all about our R&D program.

JUNG: Thank you.

SWIFT: Well, thank you very much. I think that’s all the time we have here. But, again, we very much appreciate the presentation and we paid attention. Thank you.

DOHNÁLKOVÁ: Thank you very much.

SWIFT: Yeah, thanks. We have about maybe one minute here before the next presentation. Is Barbara Pastina from Finland available? Is she on? Two minutes. Alright, we have a two minute break and we’ll introduce our next speaker after that, Ms. Barbara Pastina from Finland.

[Pause for Break with Music]
[Meeting resumes]

SWIFT: Thank you. I understand we're ready. So, I'm going to introduce our next speaker in just a moment. But just to reintroduce myself, I'm Peter Swift, the Chair of the US Nuclear Waste Technical Review Board. And our next speaker at today's meeting is Ms. Barbara Pastina from Posiva Oy in Finland. And Ms. Pastina has many years of diverse experience in the nuclear field, including some time here in this country. And some of us may remember working with you previously. But we're very happy to have you here speaking for Finland. So, thank you.

PASTINA: Thank you, Peter, and thank you for the invitation to present the latest news from the Finnish spent nuclear fuel repository. And today in particular I would like to talk about the iterative process of site characterization and facility design. My name is Barbara Pastina. As Peter said, I have been working 20 years now for Posiva in Finland. I am currently the development manager. But I was really hired into Posiva to lead the safety case for the operating license application. And my background is in physical chemistry.

So, the presentation will look like this. I will give a few words about the program in general, main actors, and the roadmap. And then I will mostly show a few pictures because I think those are really telling about what is happening right now at Olkiluoto. And then I will go to the main topic for the presentation, which is the site characterization and how it evolves with time and how it iterates with the design process. I will also touch upon organizational development aspects and then give you a few lessons learned and then takeaway points.

So, here’s the general context of the Finnish spent fuel disposal program. We have two... Let’s see, can you see my pointer? Let’s see if I can find the pointer here. Just a second, sorry. Here, I think it is, yeah. Here are the two nuclear utilities and two nuclear power plants. One in Olkiluoto, managed by TVO. And this is where also the disposal facility is located. And then there is another nuclear power plant located in Loviisa and it’s managed by Fortum Power & Heat. Both nuclear power plants have their own operating waste repository facilities. They are located at the depth of about 60 or 100 meters. One for Loviisa and one for Olkiluoto. That’s like 300 feet, something like that, 200, 300 feet deep into the crystalline host rock. But then both utilities came together in 1995 to create, to establish Posiva, my company, with the specific objective of disposing of their spent nuclear fuel. So, we only take care of spent nuclear fuel from TVO and Fortum and the two specific nuclear power plants.

We have a small provision in our license application to also dispose of low and intermediate level waste from the encapsulation plant. But that is the only exception to the spent nuclear fuel inventory we have.

Also, I would like to point out that Posiva is a privately owned company given that we are owned by the two utilities. So, it’s different from a governmental owned agency. For example, we have to... we operate as an industrial, commercial activity. Not commercial in the sense that we have a commercial branch, but that’s something else. But we are privately owned and that is something that is not maybe very well-known abroad.

Then I would like to also point out that our regulatory agency, STUK, is in charge of the technical review of the documentation that we submit, like license applications and so forth. And then it submits its statements to the Ministry of Economic Affairs and Employment of Finland. And this is the ministry that grants the license.

This is how the repository timeline or the spent fuel program timeline looks like. It was started in the late 70’s as in many of other countries when the need for a permanent solution for spent fuel disposal was really recognized and that geological disposal was the way to go. And Finland also opted for direct disposal of spent nuclear fuel.

So, in the late 70’s until the early 2000, the main focus was on site selection and investigation of different sites and preparation for the decision in principle. So, for the recommendation to locate the disposal facility in Olkiluoto. This decision came in 2001. So, there was a recommendation that was then approved by the government and then ratified by the parliament. And from that time on, the focus shift on underground characterization of the Olkiluoto site. We called the decision a decision in principle because the decision was based on surface data and a few boreholes. But the twist was that we had to confirm the suitability of the site after we had been underground and characterized the facility from below ground all the way to disposal level. And this is when we started to build our ONKALO or the first nucleus of ONKALO was the... today is the access ramp of the facility. But it was... it started as an underground site characterization facility. And this had a very positive impact on the overall schedule, program schedule, because unlike many other countries, we didn’t have to build another URL somewhere else. We were able to go underground and started to practice with laws and regulations that we would be implementing once we have the license to operate the repository. So, that was a very important milestone in our program and a very important decision to use the underground characterization facility as access ramp to the repository.

And with that information, we were able to submit the construction license application. We were able to first confirm the suitability of the site. And we submitted the construction license application in 2012 and we were granted the license in 2015. And since then, we have been now in phase 3. So, we have been focusing on the implementation, on construction and implementation of the facility and the production of the engineered barrier system. And with all this information, we were able to submit the operating license application in 2021.

Currently, STUK is reviewing the license application and they are almost ready to say something to the government. But we cannot just sit and wait. We have to continue working on the preparation for the operational phase. So, this means that we had to commission, cold commission the facilities, the equipment, the procedures that we will use in the actual operational phase.

So, as soon as we have the license to operate the facility, then we will move to phase 4. So, this is the actual operational phase and it will last 100 years, about 100 years. There will be safety assessments at least every 10 years as mandated by the law. And then there will be a new license to close the facility after all the spent fuel has been disposed of. So, we are really at the brink of the commissioning of the facility or the hot commissioning. Of course, now we cannot handle spent nuclear fuel, but we are very close to begin our operations.

Here's the picture of the Olkiluoto site. You can see the three reactors: Olkiluoto 1, 2, and 3. You can see the spent nuclear fuel disposal, interim disposal... No, interim storage facility, sorry. Here’s the low and intermediate level waste repository for operational waste and also there is a small provision also for the decommissioning waste of the three reactors.

And here’s our encapsulation plant. This is the plant that received the spent nuclear fuel from Olkiluoto but also from Loviisa, so it’s farther away. And in this plant we take the spent nuclear fuel from the transport casks and we transfer it to the final disposal container. And then the canister goes down by elevator and here is the access ramp. You don’t see it here in this picture, but you will see it later. There’s a small picture here. There’s the elevator. That takes the canisters down to repository level at 430 meters. It’s 1400 feet. And this is the access ramp, but that was built in 2004, started from 2004, and it was originally our site underground characterization facility.

Here's a picture of our encapsulation plant. This is the control room for remote operation. Everything has to be done remotely, of course, because we are dealing with spent nuclear fuel, a very hazardous material. This is a picture of the welding station for the welding of the disposal canister. And here’s a picture of the fuel handling cell. There’s two openings. One is for the transport cask and one for the disposal container. So, these are all actual pictures of facilities that are there, have been constructed already and are ready to operate.

And here are some pictures from underground. Three colleagues in the central tunnel. And then we have a picture of the deposition tunnel. You see the crystalline granite bedrock at Olkiluoto. And in the floor of these disposal tunnels, we are ready to bore the location of the individual vertical deposition holes. So, one deposition hole per canister. And this is called the KBS-3V design that we developed together with SKB, our Swedish counterpart.

Here's a picture of the ventilation system, heating ventilation system, and maintenance hole underground where we will take care of our equipment and machinery as we proceed into the disposal phase.

So, here’s a better picture in fact of the parts that have already been built. So, you can see again the access ramp ONKALO. This is the original ONKALO facility. Then the name was expanded to include the whole repository. We have constructed five tunnels so far and we have also some test tunnels here. And this is the trial run for final disposal tunnel, TRFD. It’s a test that we have started in 2024, the trial run for final disposal. We started in 2024 to test all the methods, procedures, equipment, the personnel. Also from the point of view of the organizational processes. How does the organization work during the operational phase? And it has been so far quite useful because, you know, we are so focused on the highly technical parts. But sometimes we realize that there are some very basic simple processes that haven’t been really thought out of and this kind of tests are very important to show what we are still missing, what needs to be improved, and so on.

So, as part of this test we have tested the transport of spent nuclear fuel from the interim storage to the encapsulation plant. This test has been completed in 2024. We tested the encapsulation. We produced five canisters of which one was taken underground and then retrieved. So, we tested the retrieval part of one of the canisters simulating the situation in which it gets damaged and the fuel needs to be repackaged. So, we took it underground and then back up. And then we have tested the whole encapsulation process. So, that was finished in January 2025. And we are getting ready to start the underground test so the disposal of actual... well, the test canisters. Four test canisters with the clay components in the 70-meter tunnel and there will be also a plug at the end of the tunnel. So, this is... we're a little bit behind schedule, but we're getting ready to start the underground test, the underground part of the TRFD.

There are six waste management organizations that are part of this test observing what really happens when you put the machinery in motion and learning at the same time as we are learning about the whole disposal process functions. There's also one regulatory authority that participates in the test and I think it's a very nice thing that also they get to see how things actually are done in practice. And there is still also room if you want to join later on or during the test.

Okay, so, this is the context. But now I’d like to talk about the challenges that are inherent to any geological disposal facility for high level radiative waste. So, spent fuel, reprocessed high level waste. These are all facilities that have socioeconomical issues to be addressed because they are about finding a site for long-lived, high level, hazardous waste. So, there’s always some socioeconomical issues. As Bret said it in the beginning, you cannot separate this from the technical issues.

There’s also an issue related to the long duration of these programs. They last over several decades. So, there’s a multi-generational implementation timeline, which means that we also have to deal with the changing of the knowledge, changing of the technology, knowledge management. And there are several issues related to this very, very long timeline for the disposal programs.

These facilities are also new types of facilities. So, we’re familiar with nuclear power plants or nuclear facilities that are above ground. But these are now deep underground, which have their own set of challenges. So, this is a couple set of challenges from the nuclear and from the underground construction perspective.

Then they are also one of a kind facilities. So, it’s not possible to just copy and paste from other programs. Although, yes, international collaboration is very important. And, yes, we definitely support the idea. But the fact remains that each facility has its own country specific context, constraints. The requirements are different. The host rock is different. The waste streams are different. So, every facility is a one of a kind. And it needs some own specific solutions.

And finally, I wanted to point out that these are technically complex systems and they require a wide range of expertise and competencies. And these expertises... this expertise evolves with time. Because in the beginning, of course, it’s very much focused on site selection, on characterization, and construction. But then it becomes more and more industrial production of engineered barrier system and encapsulation and things like that. So, the competencies evolve with time. Here's a picture of the Finnish Parliament the day of the decision in principle to select the Olkiluoto site. It was a decision that was very... with a large majority. It was supported. And this is the picture of the operating license application. It’s a thin document, but, of course, you can imagine the thousands and thousands of pages that were behind this tiny little booklet that was submitted in 2021.

And this is the title of the presentation in fact is about this slide. And what I would like to share with you is this idea that the design process, which is shown here on the lefthand side, proceeds in parallel with the site selection and site characterization process. So, these are two processes that have their own iteration, internal iterations, but also iterate between each other. So, there’s an iteration between the design and the site, the selection and characterization. And the challenge is that at the beginning when you don’t have a site or you just started to identify your site, you have relatively little information from the geology from underground. Yet you have to develop your design with your engineered barrier system to a certain level in a way that you can start planning the production. And you also have to make some preliminary safety assessments even though you don’t have the actual information from your site or from repository depth. So, there’s an issue there that has to be resolved. That is you need to have... you need to define your constraints first. Okay, so you have direct disposal. If you want to reprocess, you have reprocessed the waste, that you have your own host rock type and that defines the constraints in your system. Then you have to select your disposal method, which means that you’re starting to lock in certain parts of the system when you select. For example, KBS-3 method as we did in Finland and Sweden. We locked in certain materials, copper outer shell for the corrosion resistance. Iron for the mechanical resistance of the canister. Then we use clay surrounding the canister. So, this means that as you go along with the design, you start to lock in certain parts of the system and you have less and less degrees of freedom. And what happened in Finland, and we’re trying now to share this lesson learned with as many countries as we can, is that we ended up with quite the detailed canister design at the very early stage when we just started to learn about the Olkiluoto site. And this quite detailed canister design was taken or interpreted as a sort of like final decision on our design. But it was really a misunderstanding. We did need to have the detail because we needed it for the models. We needed enough details about our engineered barrier system and our site so that we could produce a construction license application, operating license application. But in fact, many of these details were assumptions. For example, about site properties before we actually went underground and confirmed these properties.

So, this is the difficulty that we encountered in the beginning. It was about this iteration process and how we communicated the iterative process between the site characterization and the repository or the facility design. The facility design was full of assumptions in the beginning. But we had to do to make these assumptions in order to proceed to the next phase and to plan forward. But somewhere in the communication we didn't quite succeed because then we realized as we characterized fully the site that we needed to make some changes. We needed to adapt. We needed to learn and use the information from the site and adapt our design so that we can take advantage of the favorable properties and of the... and we can design around the constraints from the site.

And at the same time, there were also implementation constraints and that became more and more important as we moved along. For example, the sustainability aspect became very prominent only when we started to produce the engineered barrier system. This is where we realized that maybe our requirements were a bit optimistic in the beginning in as far as how easy the requirements would be implemented and how sustainable this implementation from an industrial point of view were to be. And we had to make changes because we learned during this process and changes were absolutely necessary even up to the operating license application and thereafter we had to implement changes because we realized that, yes, we have a solution. Yes, we have a safe design. But, no, we cannot pay for it. And so, we had to make these changes. And this is the important lesson learned from all these years.

So, this is really... the key is to plan for safety and sustainability. Do not forget about the sustainability part because you need to have a safe design that you can also afford to produce in an industrial way reliably and you can pay for it. So, we have been working in these last few decades, I would say, toward developing a robust and streamlined design that can be reliably and sustainably implemented. This means a design that meets the safety requirements, that has less tailor made components and more off the shelf components. A design that has a well-established production process and also quality assurance, quality control methods that can be reliably implemented. A robust and streamlined design implies that there is less sensitivity to small changes in production parameters or in the production environment. For example, the supply chain may change. It may interrupt. We might have a change in a supplier, had to go find another supplier. This has happened several times during our program. So, we need to find a system or a design that can be produced in quite a robust way. So, it’s a different way of interpreting the word robustness, but the supply chain has to be robust as well.

We need a design also that is less sensitive to human error and the human factors than a design. If you can imagine, we have many prototypes of machineries and components and these are not particularly... they do not fare well with respect to human error and human factors. So, we are trying to improve all that and also, me particularly as a long-term safety assessor, I’m very interested in knowing what actually the canister looks like once it’s emplaced underground. So, it’s this as implemented state that is the beginning of the long-term safety assessment. And if I don’t have a clear view of what the canister looks like, then it’s very difficult to put together a safety case and formulate the scenarios for the long-term evolution of these canisters. So, it’s very important to have a system that can be reliably implemented. And even though it may be not as perfect as designed, but it’s important that you know what you’re working with.

So, in our view, this idea of having a robust and streamlined design fosters both safety and sustainability and that’s an important message that we like to convey.

These are the four canisters, by the way, that were produced in the TRFD test. The fifth one was destroyed because, you remember, we took it underground and then back up to the encapsulation plant. So, we only have four left. But these are the four that then we will bring down at repository level and we will make the underground part of the trial run.

The other important message is plan for iteration and adaptation. For deep geological repository programs, knowledge and experience grow at an increasingly fast pace, particularly during the implementation. So, when you’re ready to implement then the amount of data grows exponentially, not only about the EBS but also about your site. At that point you have a site. You probably have constructed some. So, this kind of knowledge, amount of data you have, it creates a very steep learning curve not only for the implementing organization but also for the regulatory body. So, we all need to iterate and adapt. And also, we all need to recognize that changes are not part of... are not a problem. In fact, they are expected during such long programs and, in fact, they are quite healthy. That means that we are learning and we are incorporating the new information... We are incorporating the new information in the overall understanding of how the site and the EBS work together, engineered barrier system, sorry.

So, in particular, during the implementation and the commissioning of the facility, the aspects related to technical feasibility and economic feasibility, so implementability and sustainability, they cannot be underplayed or their importance really grows very quickly as the program evolves. And our message would be not to delay this aspect until you are at the implementation phase because if you plan early for this kind of iteration and adaptation, then you can also plan for this need for implementability and sustainability.

Also, plan for organizational developments. Waste management organizations operate over several decades. That means that the management style needs to adapt over time. In Posiva, we've had seven major organizational changes since 1995. So, we are a 30-year-old company. Last year we turned 30. And we had to change the organizational structure and the management style several times. First, when we went from the site selection to the choice of the Olkiluoto site. Then the phase when we went from underground characterization to the construction of the actual facility or preparation for construction. Then when we moved from construction and detailed design to production and operation. Each of these phases had their own organizational and competence profiles. First, naturally, the company was very small. We started with a strong background, strong competencies in natural sciences, geology, as you can imagine, nuclear sciences, construction engineering. But then we evolved to include business management, value engineering, industrial engineering. So, aspects related more to this industrial production and sustainability. And this is something that we are still doing. We’re still evolving and we’re still learning and we expect to evolve over the next hundred years.

So, I think I have mentioned most of these things, but I have two slides about lessons learned over four decades. Posiva is 30 years old, but the whole program started 40 years ago. So, we have lessons learned since then and we have learned that the design development is iterative and adaptive. In the early phase of the program, it is acceptable and you have to use assumptions, particularly about your site, especially if you don’t have a site. But assumptions are perfectly fine as long as they’re clearly labeled as assumptions so that you can then go back to them, find them easily, and check them. And this is very... It becomes at least in our experience quite... With time some of these assumptions have somehow muted or transformed into hard facts just because they were not correctly labeled as assumptions when they were made. And they start to live their own life. And finally, we were making decisions around these assumptions until somebody went and checked the history and they said, “Well, this is just an assumption and it’s not true. And we could open other doors to different decisions, for example.” It’s something that happens quite easily, I would say.

The design should evolve to incorporate new knowledge from the site and implementation experience. So, the design should not be too detailed in the beginning because it gives a false impression that you already know everything about your site and implementation aspects, when in fact, no, the design should be very preliminary and should be communicated as such. And then for the safety assessment, yes, you do need to have some details. But then you can also communicate that part, that okay for the safety assessment we assumed that the design is like this and that and that. But then also recognize that you need to make changes. Changes are part of the process. And particularly, changes, they should aim at now achieving a robust and streamlined design that can be reliably and sustainably implemented.

I didn't talk much about requirements management, but this is something I've been working on lately very much on. Because the design does not materialize on its own. The design comes as a result of requirements. So, you have some laws and regulations that say that essentially that you should safely dispose of your spent nuclear fuel. But then it's up to the waste management organization to interpret these requirements and implement them in a way that can be actually... They can be implemented. That you could implement the design so that you achieve those goals.

And this is something, another lesson learned from Posiva. We realized that these requirements had to be managed and we were so focused on the site selection and the design development that we did not quite... did not very well track these requirements that were implicit in the head of the early developers. So, we started with our requirements management quite late in the process and, in fact, we should have started much earlier. As these requirements are very important, not only during the early phase, but also during optimization. Now we are in the phase of optimization and it's very important to know where these requirements come from, why the design is the way it looks now and what is behind, what is the thought process behind the current design? And if this is not very well and traceably and transparently documented, then it becomes very difficult to implement optimization.

Requirements are country and host rock specific. I already said that. And requirements are also developed iteratively and this is normal. It’s just that the process to update the requirements should be transparent and traceable. And also it fosters knowledge management because then it means that future generations can go back and find out what was an assumption and what is an actual hard fact. And then whether the requirement can be changed or not.

Then, of course, there are different tools to manage the different requirements. As I said, there are several sources of requirements, not just for long-term safety. There are safeguards. There are all sorts of different requirements. So, you have to have a requirements management system because you need it to design the facility, the infrastructure. You need it to manage the interfaces. You need to optimize the design and the processes and you need to communicate the information to internal and external stakeholders. So, this is something also we’re working on very much, on requirements management system.

The second slide on lessons learned is about organizational aspects. So, the organizational and management style needs to be adaptive. That means that the organization is ready to change. It’s ready to manage long-term transitions. These are key aspects to successfully evolve with time, with the program. So, it's the management of long-term transitions from one phase to the next one and to the following one and what needs to happen. In the meantime, the organization has to balance in-house and outsource the expertise. What do we need to have in-house for knowledge management? And what can be shared? Information via cooperation and so on. And what we have to have in our own country so that it's available when we need. The kind of expertise that is available when needed.

Knowledge management, development, and also know-how retention and preservation over time – that's another important aspect. Of course, we have to plan for working iteratively and incorporating new knowledge and international collaboration. This has been mentioned by my colleagues as well and this is something very important because these are all unique facilities. So, we have to discuss among ourselves.

A strong safety culture is also needed and communication skills because we have these changes that need to be safely implemented and safe and effectively communicated. It's important to do our due diligence. If we want to change a requirement or if you want to change something in the design that we have to make sure that we have turned every rock and check that we are not accidentally introducing new risks in the system. But it's really important to implement the change management or configuration management in a transparent and traceable way.

And then I did mention several times the steep learning curve not only for the implementer, but also for other stakeholders and particular for the regulatory agency. And for that we need dialogue and mutual learning because if we don't learn from each other, then it's really difficult to actually proceed. There are several types of stakeholders. Some of them are in this figure here. They're all important and they all have their own communication style and things of different importance to different stakeholders. So, it is important to understand what is important to the various stakeholders.

And finally, the takeaway points. If you can remember only a few things from this presentation, I would like you to remember this planning for safety and sustainability. Don't forget the sustainability part. Plan for iteration and adaptation. Plan for organizational development as well. And then this mutual learning and dialogue with all stakeholders is essential.

Here’s a picture of our small organization. We are about 100 people. We are a very tiny organization, but we have been able to proceed thanks to also international cooperation. I have to say this has been very important for us. But we are also ready to share our knowledge and lessons learned. We have the commercial branch. It’s called Posiva Solutions. And we have been able to help other countries that were earlier on than our current disposal system. And we have learned also from our customers.

And if you want to see some pictures from our disposal facility and the overall project, you have these QR codes. We have websites with nice videos, and we tell a lot more about our program. So, I invite you to check out our social media channels. Thank you for the attention and I hope I’ll be able to answer your questions.

SWIFT: Well, thank you very much. I should have said this at the beginning, but we are here to learn from you, from your program, and from the other programs at this meeting. This is very helpful. I have one question for you about managing basically data, but knowledge of all kinds over many decades. You collected a lot of data earlier in the program that you then had to use 20, 30 years later, I'm guessing anyway. And that's something that I'd be curious to know how you... Did you prepare then to, you know, 20 years ago when you were collecting the data? Did you know it would have to meet standards for licensing 20 years later in the future? It's a quality assurance question in general. Could you comment on that?

PASTINA: Yes, very much. Yes, yes. Especially with site characterization data, we developed a database with quality assurance criteria. But I have to say that those solutions back then, they were not very efficient. The databases were quite cumbersome and difficult to access from outside. So, yes, it has been a challenge, but thankfully now we have much better tools to manage the data and we also learned that some of the data were not properly... well, they were recorded, but there was not enough metadata. So, there was not enough knowledge about, for example, the method that was used to gather the data, the uncertainties, the quality of the data in itself. Sometimes the operator was not sure whether the number was actually correct because something happened. So, there was a lot of learning about this metadata, data about the data and how to record it so that we could go back several years later. And we had in fact to go back to some of this very early data. And, unfortunately, I had to say that we have found some mistakes and we had to reinterpret a bunch of flow. For example, data from underground because there were mistakes in the very early data. So, I think Markéta mentioned this point, that you have to have very good quality data. But sometimes, especially in the beginning, you don't know what you're dealing with until you start to form your own understanding of the site. Before you only are dealing with data and then it's only after you have the site descriptive model you can tell whether maybe this data point was not a really good quality. And then you have to go back and check the information.

SWIFT: Thank you. We have time for just a couple more questions. And Bret or Chandrika, do you?

LESLIE: Bret Leslie, Board staff. Thank you, Barbara. I always learn from you every time I hear one of your talks. So, I heard something that didn’t, you know, wasn’t completely aligned. It sounded like you wanted requirements management, but at the same time you were defining needs. So, we need to be adaptable. We need to be iterative. How do you make... Do you distinguish between what you need and your requirements?

PASTINA: Yes. Well, this, in fact, is a tension we always have in our system because we need to make a plan and to make a plan we need to have requirements. We need to have designs or implementations and move on. And at the same time, we need to make changes again, regularly make changes. So, there is this tension all the time between making a plan and at the same time having to implement changes. And that issue will not go away. We are very well aware that we will have to implement the changes again and again and again as we excavate more of the rock, or there are new technologies coming available. And the only thing we can do is to implement a configuration management program that is strong and robust enough so that we can actually change or we can check, change proposals from different perspectives, and make sure that they are still aligned. I mean, we still have the whole configuration of the facility remains and the system remains safe. It’s a bit of what happens in nuclear power plants. They have configuration management programs, so they have different interfaces. They are dealing with changes as well, but not as large changes as we are dealing with because we had to develop the facility from scratch. So, you can imagine the kind of changes we are dealing with are not the same magnitude as the changes in nuclear power plants. But configuration management is the way to go in order to look at these changes from different perspective and make sure that the overall system remains safe.

LESLIE: Thank you, Barbara.

MANEPALLY: Chandrika Manepally, Board staff. Barbara, that was an excellent presentation. Thank you. You've been talking about, you know, you've spent several decades investigating the same site. So, I was curious, if you go and look back, was your understanding of the site, say, as the conceptual flow or, you know, general things about how it happens? Again, I'm only talking about the natural system. Was this progression of you understanding the site kind of supported your general conceptual model that you had several years ago? Or there were some major changes that you had to make? Like you assumed water flow is going this way, but then you characterized the site more. And then you realize, oh, no, it’s completely different. So, what was the nature of understanding that move forward? Was it major changes or were they like, oh, it was just a minor thing?

PASTINA: I would not say major changes because, well, we’re dealing with crystalline rock and we had very strong already knowledge of what the kind of rock that we are dealing with. However, the level of detail, that’s where the like second order detail, that’s where the changes happened. Of course, a crystalline rock has one important feature, which is that it’s fractured. And it’s difficult to know where the fractures are. Of course, you know where the big fracture zones are. But then the individual water bearing fractures, those are treated stochastically in our system because it’s impossible to know exactly where they are. So, this is the kind of thing that we’re still learning about, about the site because when we construct a new tunnel, for example, we have pilot holes and then we discover new fractures that were not in our model. So, we’re constantly updating our models. But I would say these are not large scale changes. We are, in fact, we knew that this was going to happen. And it just means that we need to adapt our layout, the facility, so that we don’t emplace the canisters in an area where there could be rock shear movement, for example. So, we’re always adapting our layout as far as we construct the facility. But no major changes I would say.

MANEPALLY: Thank you.

SWIFT: I think thank you again. We really appreciate it. We’re going to have to break here for lunch though. So, thank you very much. I appreciate the presentation.

PASTINA: You’re welcome. Thank you.

SWIFT: For the audience here, we are going to take a break for lunch. We’ll be back at 1:15 for the presentation from the program from Switzerland, the Nagra program. And also remember a call that we have a public comment period at 3:05 at the end of the day. So, thank you very much.

[Music]

SWIFT: I believe we are ready to start the afternoon session here. And in just a moment, I think we'll have our first speaker online and ready to go, but… and there he is. Just to introduce myself first, I'm Peter Swift. I'm the Chair of the U.S. Nuclear Waste Technical Review Board, and we're here for the afternoon session of our meeting on lessons learned from other nations programs. And I want to reiterate that these lessons learned that we're going to try to take advantage of. This is, we're here to learn, we're here to… our job is to advise the US program, and we are definitely in information gathering and lesson learning mode ourselves right now.

Our first speaker of the afternoon is Dr. Michael Schnellmann from the Swiss program from Nagra.

And Dr. Schnellmann is the senior project manager for geosciences and has worked in the Swiss site selection program. Dr. Schnellmann, please.

SWIFT: No. There we go.

[Laughter]

SCHNELLMANN: Okay. Good afternoon, everybody. It's a pleasure for me to introduce you to the Swiss Deep Geological Repository Project, the so-called Terradura Project. I will mainly talk about the site selection phase and inform you about some lessons learned from our side. And then towards the end, I also will talk briefly about the current project development phase.

Next. At the beginning, I want to give you some national context, some context about Switzerland with regards to the placement of a deep geological repository. As you can see on the right-hand side, Switzerland is a mountainous area with the Alps basically situated in the central and the southern part of the country. And the Alps have a complex geology; you can see all the red lines. These are our faults. And also, the northern part is mountainous and quite faulted. So, the tectonically more quiet area is actually the central part, the so-called Molasse Basin and the most northern part of Switzerland. At the same time, if you look at the population density, this tectonically more stable area is actually also the area where most of the people live.

So, you can see it at the very west, Geneva, and in the center is Zurich. And for the geologic repository, that means that the suitable geological areas are actually also located in densely populated areas. And this has some consequences, actually for the, basically, the site surveys, but also for the involvement of the local people.

Next. Some other important things about Switzerland, we are a very federalistic country, so procedures and decisions are taken at three levels. We have the federal level; we have the cantonal level; so, we have 26 cantons. You can see that on the maps in different colors. And we also have the local level, the communities. And the cantons and the communities have a large degree of autonomy. That means they can, for example, raise taxes. They can make their own decisions in important matters such as education or health. This is all basically decided by the cantons.

About 20 years ago, it was decided that radioactive waste disposal is an exception, so decisions on radioactive waste disposal will be done on a federal level.

However, the fourth… the other important aspect about Switzerland is that we have extensive democratic rights at all levels. So, we have a lot of referendums. For example, 10 years ago, we voted on the energy strategy of the country, and part of the strategy is that there is a ban for the construction of new nuclear power plants. So, the existing ones are still running, but there's a ban for new power plants. And most probably, there will also be a national referendum on the on the repository. And this is expected about in the year 2032.

Next, electricity production in Switzerland. Thanks to the high relief, about 60% of the energy is produced by hydropower and about 40% is nuclear. We have a total of five reactors, and one of them is currently in a dismantling phase. We have 85,000 cubic meters packed low and intermediate level waste, and about almost 10,000 cubic meters of high level waste.

And what is special for Switzerland is that both the high level and the low and intermediate level waste have to be stored in a deep geological repository.

Next slide. So, here you can see the waste streams. On the left-hand side, you can see the nuclear power plants, they produce most of the high level waste. And then also, about 75% of the low and intermediate level waste are basically a result of the nuclear energy production. And, about 25% of the low and intermediate level waste are produced in medicine, industry, and research.

The waste is currently stored in interim storages. But, as mentioned, both high level and low and intermediate level waste will be deposited in a combined deep geological repository. Next.

Okay. Next few slides, I will talk you through the policy and regulatory framework for our siting process. Next.

So, from a worldwide perspective, in many countries, we have the voluntary approach where basically communities can apply to be involved in the site selection process. In Switzerland, the system is different. So, we have a stepwise site selection and decision-making approach that basically looks at the whole… that starts with the whole country and basically ends with selecting a site.

So, in the first phase, you see that on the right-hand side of this diagram, in the first phase, basically, the criteria and the roles and the responsibility had to be defined. And then, in the first official phase, the implementers, that's Nagra proposed siting regions. The siting region, this proposal was then reviewed by the authorities and finally approved.

In the second phase, the number of siting region has been reduced, and in these remaining citing regions we had to… at least two siting regions have to be investigated in detail, and then after these detailed investigations, we came up with the proposal for the final site. Next.

Important for the site selection is the so-called sectoral plan. So, the sectoral plan basically sets up the rules for the site selection and basically all the different, basically, actors, basically, and decided to open the process for the site selection.

So, the sectoral plan defines the process and the responsibilities and it also defines the criteria which have to be followed for the site selection. And the criteria are mainly safety and engineering-based criteria. Next.

So, the main actors in the site selection process in Switzerland are basically the Swiss Federal Office of Energy. That's part of the government. And the Swiss Federal Office of Energy defines the rules. It is actually leading the process, and in the end, it decides. Nagra is the implementer. So, at each step, Nagra proposes siting regions in the end.

And we have ENSI that is the regulator, and the regulator basically does the technical review and makes then suggestions towards the Federal Office of Energy. Next.

So, in the next slide, I will talk to you a bit more for the site selection. So, we are going to look at the safety criteria and the stepwise approach we took. Next.

So, this is the list of safety criteria we had to follow for the for the site selection. They are grouped in four criteria groups. So, the first one addresses the properties of the host rock and effective containment zone. The effective containment zone is essentially the host rock and the low permeability units above and below. And the specific criteria we had to address is, for example, the spatial extent of the host rock, the hydraulic barrier effects, or the geochemical conditions within the host rock.

The second criteria group addresses the long-term stability of the site and of the of the site properties. So, for example, there's a criteria in there called erosion, so we had to evaluate basically whether the site is stable with regard to erosion for the next million years.

The third group of criteria addresses the… essentially the uncertainties. So, the reliability of the geological findings. So, one criteria, for example, is the explorability of the spatial conditions at the site, another one is the predictability of the long-term changes.

And last but not least, the fourth criteria group advances the engineering suitability of the access infrastructure and of the repository area. Next.

And this here you see actually the different stages of the site selection process. As mentioned, we started with a white map of the country, applied the criteria for the first time, and ended up after phase one of the stage one with six siting regions. In stage two, these six siting regions have been reduced to three. And then, last but not least, in '22, Nagra suggested the final site again after evaluating the different safety criteria. Next.

Now we quickly talk about the process and methodologies we applied during the site selection. Next slide.

As mentioned, we started with a white map of the country. Next.

And in the first step, we basically looked at the tectonic, the geological tectonic conditions, and we essentially excluded the Alps and the mountain ranges in the north of the country and focused on the more simple geological areas. They are actually located in the central and in the northeastern part of the country. Next.

And in this area, we were screening all potential host rocks, and we ended up with selecting the so-called Opalinus clay. This is about 100-meter-thick claystone as a host rock, and in this tectonically suitable area, the host rock occurs at depths between 0 and about 5,000 meters.

And basically, as a next step, we basically selected the suitable depth window for a repository, which is between 400 and 1,000 meters. The minimum depth of 400 meters is determined by basically the stability for future evolution. So, for example, the protection against future erosion and the maximum depth of 1000 meters relates to the construction feasibility.

And so, we end up basically with this narrow depth window of host rock occurrence. Next.

So, a few words about the host rock. Why is it suited? So, we have a large thickness of more than 100 meters, and this claystone has a low variability. That means if you have few boreholes allowed to make good prediction for the whole volume of the host rocks. You have a high clay mineral content, and a high clay mineral content means very low hydraulic conductivity. It also means efficient self-sealing behavior due to swelling. The clay has a high sorption capacity for radionuclides. And it also, the diffusion properties which are relevant for transport are well known. Next.

So, as a next step, we looked at these depth window at the suitable depth window of Opalinus clay in more detail, and we basically excluded the areas that are regional fault zones, marked here in reddish colors, and we basically defined potential siting regions. Next.

And now in the, in the last phase of the of the sectoral plan, we had, as mentioned, three siting regions left, and these siting regions were investigated. In large detail, the detail with different methods, the most important ones being the seismic reflection data. So, all the three sites have been covered by 3D seismic data. And also, we drilled 90 boreholes in the three siting regions to calibrate the seismic data and to learn about the properties of the rocks.

Beside these two main investigation methods, we also did some quaternary investigations to get to quantify erosion rates, and we installed some long-term monitoring system, and we also profited from investigation in rock labs and also from international experience with clay rocks. Next.

So, in this slide I'm going to talk and summarize, basically, the deep exploration campaign we did in the past few years. You see here our most scenic drill site.

In total we drilled… in these nine boreholes, we drilled about 10 kilometers, and about 1 kilometer of the drillings were in the Opalinus clay.

We cored about 60% of all the borehole, and we took about almost 4,500 drill core samples, and we also did almost 100 hydraulic packer tests. Next.

And after analyzing all these data and integrating all these data, we came to the to the conclusion, which is actually the most suited of the three sites, and we had basically to simplify the argumentation so that we can easily communicate it, and we came actually, in the end we came up with three main arguments, actually for the site, Nördlich Lägern, which is the central site shown here.

So, the first argument was the quality… is the quality of the rock. So, essentially what you can see here is, is the column of the rock at the sides. And in red, you see, actually, the thickness of the effective containment zone.

And we could demonstrate that the thickness of this zone is actually largest at the Nördlich Lägern site. Next.

So, this was the quality of the rock. The next argument was the stability of the rock with regard, for example, to future erosion. And as you can see at the at the Nördlich Lägern site, the rock overburden is largest so the host rock is deepest, and that's actually why the protection against future erosion is largest at this site. Next.

So, besides, actually, quality and the stability, we had the flexibility as a third argument. And that actually addresses the width of the site, the size of the zone, which is essentially undisturbed, which is away from larger fault zones. And also, the width of this site is largest at the Nördlich Lägern site.

So, this was our simplified argumentation, actually, to choose the Nördlich Lägern site as the final site in Switzerland. Next.

But the whole argumentation is backed up with several hundreds of reports, and you can… we basically uploaded everything on the website, you can… basically, it is noted down here on this, in the title of this page. So, it's very transparent. You can basically follow the arguments, and you can get information and you can dive deeper and deeper, basically, into the argumentation.

So, that is another important aspect of our program is actually to be open and transparent and to publish basically all the argumentations and the reports online. Next.

Okay. And now, I will briefly talk about the future. So, as mentioned, Nagra handed in, in 2022, we basically… we made the site selection public. And in 2024, we also handed in the general license application for the site. And currently, next… currently we are further developing the project. So, this is summarized on the on the plot here.

So, as mentioned 2024 we handed in the documents, now the documents are under review with the regulator. And after the year 2029, the general license application will go and basically be granted by the Federal Council, by the parliament at the end, as mentioned before, by the people, by a referendum.

And while this review process is ongoing, we are working further. Next. So, currently, we are actually further developing these Terradura Project, so we have this project development phase, and we want to hand in the general… the basically, the construction license for the site in 2032. Next.

So, in this project development phase, we started with the project we handed in for the general license application. You can see that on the left. So, basically, we have we have the repository design with a low and intermediate level waste cavern on the left, and with the high level waste drift on the right.

And now the only thing we fix with the general license application is the site. So, we are still we have an exemplary project to demonstrate the safety of the site, but we are still flexible to develop it further. Next slide.

And that's what we are currently working on. So, we basically optimize the site and we changed the design, we test out different designs, different back fields, different tunnel widths, to basically get to get a better project that uses resources efficiently and that is also easily constructed.

Next. And currently, we are also doing further work at the site. So, when we actually will do a shaft exploration boreholes in the year 2028 or 2029, and we start to establish an onsite monitoring system to do some baseline monitoring, and then we prepare an environmental impact assessment for the construction license, and we acquire all the data we need actually to confirm our reference models, and to also update the safety case for the general and for the construction license. Next.

Okay. Now, in the next, after having you introduced to the program, I want to give you some takeaway points. Next.

So, one key aspect in Switzerland is certainly the process, this sectoral plan was very important, so we had agreed and accepted process before we started. And then so that the roles were clear and the responsibility were clear. Second important point, what worked well for us was the safety driven criteria for the site selection, and also the high-quality data approach.

A third important point was the effective stakeholder engagement. So, for example, we had in each of the regions, we had a so-called regional conference that is basically a group of about 100 people, from local people who basically were constantly informed and they also were involved in some decisions, for example, in the placement and in, in the placement of the surface facilities, because that's what is most important for the people living there. And these three points helped us to keep the trust in the process high, and to also get acceptance by all the participants, Next.

And how this process works, you can very nicely see in this photograph that was actually taken during the press conference when Nagra suggested the site we basically want to build the repository at. And what you can see here, is that all the different stakeholders are here. The important stakeholders are here at the same table, and everybody has different roles, but they present themselves as a team working towards a repository.

So, you can see Nagra, basically our CEO presented and the arguments for the site. We had the process owner, the Swiss Federal Office of Energy, there, we had the regulator, the ENSI there, and also the canton in which repositories plan was there, basically, and also, the relevant director of the canton was also present. Thanks. Next.

Another important aspect was actually that what we learned is that site investigation, or an actually, trust-building process. So, site investigations are a chance, because you are out there with the people and you have to communicate, and you have to talk to them, and they also learn to get to know the project and involve people. So, it's very important to inform the partners and stakeholders about your plan. And to also, you have to give them adequate time to think and to react. And it's important to talk to the people in person because they want to see the people who are behind the project. Next.

The importance of the field investigations can very nicely be seen, basically. Well, it was very nice to see, actually, during the seismic acquisition of the 3D seismic data, but you can see on the map here is actually a part of one of the siting regions. And you see all the black dots are houses. You see forests. You see industry areas. You have a lot of fields. And the red dots are actually all the measurement points for the seismic acquisition.

And we actually had for the free siting regions. We had to talk to an about 4,000 landowners, and essentially, we had to get a permit from all of these landowners. And that was a lot of work, but it was worth it, because we got between 97 and 99% of permits, actually. So, we are allowed to measure almost everywhere.

And this is not because people want the repository in their backyard, but it's because the people accepted the process. They accepted the need for a repository and accepted a science driven site selection process. Next.

Another important message we have learned is keep listening and act. So, particularly during the field campaign, it's important to listen and to offer also platforms where the people can inform themselves, where they can complain, and this is very important because you produce noise, you probably produce traffic, and people need to be able to get into contact to you as soon as possible. Next.

Next message, sharing is caring. So, we basically brought the people, and the people is that basically is the scientists and the regulators, but also the people from the regional conference and all the interested people could visit the drill site. We brought them into the core storage to look at the cores to discuss them with us, and we even brought people from the regional conference into our offices. So, at the lowermost photographs, you can see myself in front of a computer and then talk to the people or present them the results of the 3D seismic survey.

And what is also very important, particularly with the regulators, avoid surprises. So, if you always present, basically, your strategy and your findings, that is really very helpful and you also basically realize better, basically, when people don't understand or when they see need, for example, to acquire more data. Next.

So, in this slide I will summarize our lessons learned from the exploration campaign. Point one is it's important to ensure flexibility for implementation. So, we applied for more drilling locations than we actually needed to be flexible in the drilling sequence. For example, you know, in case we had legal issues, we could react, and also we could react to the findings in the first boreholes. We could adapt drilling sequence afterwards because we had enough drill sites.

Same with the work programs, we kept it rather general so that we had flexibility in changing the program, depending on the first findings. Second point, know your aims and focus the data acquisition accordingly.

So, we spent a lot of time to think about what data do we really need before we basically developed the work program. The third point, plan the drilling activities, based on agreed priorities amongst the teams. So, it's important that before you start, you know which are the most important parameters. And you also know, in case you have some troubles during drilling, you know that what you have to prioritize and which data set you may not be able to get if you have some problems during drilling.

We did some multi-purpose boreholes that can be tricky. That means we did actually hydrotesting, for example, and coring in the same in the same borehole. That is tricky because you have to choose the appropriate drilling fluid, but on the other hand, the results are easier to integrate because you have all the information in the same borehole, and you don't have to interpolate or extrapolate.

If you have opportunities for training, for example, in underground rock labs, use them. What is very valuable, if you can do that, is to have a pilot borehole to test out workflows and to also train people.

It's important to define workflows and measurement protocols early, and ideally, also to make sure that the protocols are supported by the regulator and by the experts. So, this relates, for example, to conditioning of samples or to the protocols of lab measurements. And make sure that the terminologies you use are consistent. Next.

This is just an example showing you about the focus. The focus of our drilling campaign. On the left-hand side, you can see a basically simplified geological column in the in the center in brown is the Opalinus clay. And the width of the column shows how many measurements we basically took, so you can easily see that the focus of the measurements are the host rock, but we also took some measurements above and below, because we also needed to characterize these rocks. And on the other hand, we focus on the most important parameters, which is basically the hydraulic conductivity.

So, we did a lot of hydrotests. We measured diffusion properties in the lab. We looked at and basically at the pore water chemistry. And also, the mineralogy is key because the mineralogy basically determines the key properties of the rock. Next.

So, based on all this, all this information we gathered, basically, that's the basis to do… to feed, basically, out the simulations, and at the end, for example, we came up with these basic consequence analysis showing the dose rate between of the closure of the repository and the time of the 1 million years of the present, and we could demonstrate that basically, we are several orders of magnitudes below the regulatory dose limit. Next.

But for us, it was very important not to only do modeling, but also to present the data in a way that people basically understand it. This is an example of some key data for one site. So, again you have in purple, you have the host rock in the center. And you see that the host rock, and actually, the units above and below have high clay mineral content. Because of the high clay mineral content, they have a low structural frequency, and the same units have low hydraulic conductivities.

And also, if you look at the natural tracer profiles, this is the pore water composition. We basically can confirm that we have a central area around the host rock that has diffusion dominated transport.

And so, with these kind of figures, we demonstrated the thickness of the confinement providing rock zone. Next slide. And we could then basically compare the different siting regions and demonstrate basically the differences, key differences between the site, which I already mentioned before, so that the sample site at Nördlich Lägern has obviously the thickest and basically aquitard sequence.

Next. And another key figure, which is very helpful for communication is this here. So, we plotted, for example, all the hydrotests that cost a lot of money. So, more than 90 hydrotests. We plot the results here on the ypsilon axis [Y-axis], you see the hydraulic conductivity. On the X-axis, you see the clay mineral content. And what you can see very nicely, the host rock, which is a clay mineral content of more than 40%, has a consistently very low hydraulic conductivity while, actually, if you get into the limestones, which can be fractured, you also get some hydrotests with enhanced hydraulic conductivity.

And with this plot, you can demonstrate, actually, the high quality basically of the clay rock. Next.

Also, very useful for us was the generic underground rock lab. So, we have two rock labs. One is at the Grimsel site that is actually run by Nagra, using crystalline rocks. And even more important for our project was the Mont Terri rock lab, which is run by Swisstopo. That's basically international project that is in the Opalinus clay, and it is very useful, actually, to develop and test the workflows to support our argumentation for the safety case and also, we test and demonstrate technologies at the right scale, actually in our host rock. And it's also very nice to build up international networks and to exchange and also, we use the rock labs to communicate with all the stakeholders. Next.

So, if we look ahead, a thing that helped us a lot is our midterm planning. So, we have, actually, a plan how to move ahead. We have roadmaps and we have an old RD&D plan that always looks ahead and then basically determines what we need to know at which time in future and at which level of detail. Next.

So, in summary, I can tell you what worked well in Switzerland. A key was the science-based approach, the staged data collection and confirmation and also the legitimation [legitimization] of the decision. So, at each step, basically, the regulator and the government confirmed our decision. It was very important that it was not just Nagra driving the process, but it was the whole team, Switzerland, that was basically standing behind the process and everybody was aware of their role.

What was also important is the flexibility in the location and implementation. So, have a plan B, C, and D ready. What was very helpful to us was to listen to the to the feedback of the expert, also to the local people, and to do things, as you say. And it was it was very helpful to discuss our data constantly with the people, because that also helped us not to surprise the people, because they already, by themselves they came to the conclusion in a way which will be the best site, the site that Nagra will basically suggest.

So, and the positive result of this is that we also have this clear plan is that we had no more delay since the year 2016. So, we basically went forward according to plan. Next.

So, if we look ahead, we have this Terradura project, as mentioned, we are currently moving towards a new phase. So, this is the project development phase at the selected site. So, we are basically optimizing our project at the site, we are testing different designs, different back fields, and we are preparing for the construction license.

And for that we do these multi-objective optimization of the repository, and by doing that we want at least to achieve the same level of safety. We will keep international exchange and collaboration because this has been useful in the past and this will be very useful in this in the future.

And we also will continue to use our underground research labs as a platform for international exchange and collaboration. And this will remain an internal part of our program. Next.

Okay, that was my presentation. I'm looking forward to questions. And I will try to answer them as good as possible.

SWIFT: Well, thank you very much. This is Peter Swift again chair of the NWTRB.

SCHNELLMANN: Yeah.

SWIFT: And that was helpful. That was a thorough review of the Swiss program. I want to ask a question that will take you back a little bit in time to when, I'd say, Ingo Blechschmidt has joined us. Hi Ingo.

Can you talk a little bit about how the program came to settle on the Opalinus clay as the primary unit of interest, because that's a huge selection step right there. Once you've decided that you're going to look at the Opalinus, then you've essentially preselected a small portion of the country. And what happened in that step?

SCHNELLMANN: Yeah. So, that was actually the stage one of the sectoral plan. What we actually did is we divided the country into, like, 25 geological tectonic units. I mean, Switzerland is small, so that is maybe easier than in the US. But divided the country into 25 units, and for each of these areas, we basically produced some summary sections of the geology and we went systematically through these profiles and selected potential host rocks. So, I don't remember exactly, maybe we came up with 20 potential host rocks, and then we went through some preliminary criteria, like thickness, like, clay content, or we also looked at the crystalline and hydraulic conductivity.

So, we went through all these host rocks, and then actually, after end of stage one, for high level waste, we directly focused on Opalinus clay, because also many of these host rocks occur in the Alps, and we don't have large blocks of undisturbed host rock, and for the high level waste, we needed a large block, basically, to build repository in. So, actually, after the first phase for the low level waste, we still kept some other host rock, we took some other host rock along. So, we were basically, in the second phase, we were looking at four host rocks for low level waste, but for high level waste, we directly went for the Opalinus clay, because it was really not possible to find a similar host rock with a large enough thickness and undisturbed volume in the country.

So, I didn’t show in detail, but it was a systematic approach of looking at all the regions, basically for potential host rocks, and then they were evaluated according to some preliminary criteria, and then a sub selection was looked at in more detail. And as mentioned, four of the host rocks were even taken into the second stage. Yeah. So, it was not that short as it may have seemed in my presentation.

SWIFT: Well, thank you. Are there others here on staff? Chandrika.

MANEPALLY: Chandrika Manepally, Board staff. Hi, Michael. Thank you for the lovely presentation. My question is more towards what is the relationship between the numerical models that were probably developed which kind of helped you understand the whole system while you were going through the site selection process? Did you use them to kind of help you narrow down? And can you speak a little bit more about that? Thank you.

SCHNELLMANN: Yes, for sure, we used them. But we used them in a way to inform ourselves what is relevant. And then we also used them to demonstrate that basically it's principally safe. But then for the communication, basically we identified what is relevant using the numerical models, and it's things like thickness, hydraulic conductivity, frequency of faults. And then in the communication we went directly to the thickness. That's what I tried to also visualize with some of these figures. So, in a way we didn't let the model speak in the end, but we tried to be close to the data and the findings. But to define what is, which data are relevant and which properties are relevant, we used actually the modelling.

And then, sure, for the, basically, for the demonstration of the long-term safety, for the safety case, the model placed, they were quite important. But also, there, we always tried to show some independent evidence that the modelling is also plausible; like a key data set is. And for us, it was always the porewater composition and also the groundwater chemistry, because for the model, you basically put in a geometry and properties and then you get out with a result. But it's very helpful to afterwards show that the porewater chemistry and the groundwater chemistry basically confirms that the transport was very slow over geological timescales.

So, we try to get this independent evidence that the site is really safe and that basically, for example, our host rock is diffusion dominated over long timescales. So, this does not just based on measuring the diffusion properties or basically the advective transport on core samples or in hydrotests but we also have the geochemistry that tells us how transport works over geological timescales in the past. I hope this… does this help?

MANEPALLY: Yes, thank you.

SCHNELLMANN: Okay.

LESLIE: Bret Leslie, Board staff. Nice presentation. I'm kind of… and I apologize if you didn't see Barbara Pastina on Posiva Oy, kind of to compare where they're at and where you're at; two different countries, two different approaches. You don't have a URL where you've tested the engineered barriers underground, you know. And that's fine because you have a sectoral plan that lays out what that process is. But have you thought about how you move forward in terms of communication, moving forward with repository design?

Are you thinking of like, digital twins, and, you know, that kind of stuff? Because you have this period of time before you actually submit a license application and get underground.

SCHNELLMANN: Yeah, so first of all, what is important, we have the offsite lab in the same host rock that is very important actually, that you can demonstrate basically, you know, you can look at processes, for example, at the real scale of the tunnels. And also for demonstration, also for in the future, also some of the demonstration feasibility and tests you can basically do in the offsite, you know, at the offsite in the rock labs in the end. That is very important.

To the second part of your question, the digital twins and what we are doing right now. So, indeed, we are actually working on digital twins. We are also refining our geological model, and we are building a digital twin and we also use that, actually, to optimize the repository. So, to test different designs. So, that's actually going on right now.

So, we are developing also a refined geological model, and yeah, and everything goes digital. That's clear.

And that also gives us, for the optimization, this is very valuable because you can easily play with different designs and investigate different designs. Simulations are very important there actually. To test, actually, the performance of different designs. And that's actually what's going on right now. Yeah.

LESLIE: Thanks.

SCHNELLMANN: Yeah.

LESLIE: That was quite helpful. So, again, you're moving in a logical manner from less data to more data, going to become a licensee and regulated entity. How are you controlling the data in quality management space? And how is that related to how you update your detailed models of safety and maybe your digital twins and design? So, can you talk a little bit about your information, infrastructure, and the procedures that you're using as you move forward. Again, I realize you're kind of early in the project Terradura, but it's helpful to hear your thoughts.

SCHNELLMANN: Yeah, first of all we have to do some cleaning up and basically after the license application, so we, we did also a lot of QC again. Or you know when we build up a new… so we call it the so-called integrated geological model. So, basically all the data, basically, that gets into this digital environment gets another QC round. We also do, for example, the reprocessing of the seismic data. We really go also to the next level of integration. And that also comes with a next level of also data management in this digital environment.

So, one key tool is the geological model, and then also, basically, the different designs actually. So, for example the tunnels. So, we use a building information modeling tool to also manage basically, different designs, and to bring them into the geological model.

Yes. Ingo, you wanted to add something?

BLECHSHMIDT: Yeah. Maybe shortly. Hello everyone, good afternoon. Yeah. This is one of the big issues or challenges at the moment that we are getting back to data we generated during the last decades and bring everything together. And we frame everything under the term, you know, the single source of truth. Which means we are updating our geological models, as Michael explained about the integrated geo models, and then we bring everything together with the new digital tools we have available. Which means building information models the integrated geo models. But at the next stage, we're also thinking about the use of digital twins, which will allow us to see the impact on our performance of the repository concept when we change design components, and also if we have a better understanding of the geology at the site by bringing everything together.

LESLIE: Thank you for that.

BLECHSHMIDT: That's a really important task for us.

LESLIE: Thank you for the excellent explanation and expansion of information.

SWIFT: I think we have a question here from Andy.

JUNG: Yeah, I have a quick question. On page 38, for those calculation demonstration, I assume you have utilized a reference case for reference design, including the engineering variance system.

SCHNELLMANN: Yes.

JUNG: I understand that your reference design includes a thick-walled carbon steel as a canisters, which is called super container sometimes. What is the… if true, what is the specific benefit to use of these thick carbon steel canisters, especially for… this is good for clay repository, or the only cost benefit, or other… what benefits compared to other case or materials?

SCHNELLMANN: Well, actually, what I can say here is that, actually, as part of the project development phase, we open up the materials, both of the canisters, but also of the backfill, so we basically re-evaluate. We basically re-evaluate different materials there and also different designs. So, it's really just the canister that we use now was basically for the general license application to demonstrate basically the safety of the system we basically used in this stage. But this system will change, and most probably also the canister design will change.

So, it's not just about material, it's also about thickness, you know, of the canister; everything is actually… this is up to discussion. Yeah.

JUNG: Oh. So, it can be a possibility to change the different materials?

SCHNELLMANN: This has not been with the general license application; these things are not basically fixed. So, what is fixed is the site. So, basically, the site of the surface facility and the underground area, that is actually where the repository will be built. So, everything else is still open.

And this is… in this actual phase here now, the project development phase, this can be re-evaluated. And this is easily evaluated. Yeah.

JUNG: Thank you.

SWIFT: Well, thank you very much I think that concludes our time here for this session. And I want to thank both of you for helping us, for supporting our meeting, and I wish you all the best. Congratulations. And thank you.

SCHNELLMANN: Okay, thank you. Bye-bye.

LESLIE: Thank you.

SWIFT: And I believe we have the next presentation. Is that ready to start? One minute.

[Music]

SWIFT: I believe we're ready to restart now. And once again, I'm Peter Swift. I'm the Chair of the Nuclear Waste Technical Review Board, and I'm introducing here our last session of the meeting, and this is Dr. Axel Liebscher, representing the German program.

And so, if you could just… Dr. Liebscher has a PhD in geology and has worked as well as in… he's worked in CO_2 sequestration as well as in geologic disposal, and he's here to tell us about the current status of the German site selection program and lessons learned that might be useful to us.

And before you get started, I just wanted to note that, as I've said to other speakers, we appreciate your being here. We, the U.S. Nuclear Technical Waste Review Board. We're in a learning mode here. We're here definitely to listen and to develop lessons that we can pass on to the American program. So, thank you.

LIEBSHER: Yeah, thank you very much, Mr. Chair. And thanks to the Board for inviting me to present you the current status of the German site selection procedure, and also some of the lessons we have learned so far. Next slide.

So, you see a rough outline of the talk. So, I will start with a very brief look on the history of the German site selection procedure, then present some main principles and requirements, have a slightly more detailed look on the representative preliminary safety analysis. This is the work that we are currently doing. And I will end with a few slides on the current status of our site selection procedure and then end with lessons learned.

Next slide please. So, first of all, history of the site selection procedure in Germany. And also, a brief look on the inventory that we have. Next slide.

So, you probably know most of this. In 1977, there was a selection of the town of Gorleben as a disposal or nuclear center in Germany, also containing a final repository at that state. Unfortunately, due to public opposition, the Gorleben site finally failed, and we had a moratorium in 2000 regarding Gorleben.

Then, after the Fukushima event or accident, there was a decision to phase out of nuclear power by 2022. Then in 2013, we had our first Repository Site Selection Act, and one part of this first Site Selection Act was the founding of a so-called Repository Commission that should directly evaluate this act. And based on the recommendation of this commission, we had a reorganization of the responsibilities and also the German actors.

In 2016, we had a reorganization of the financing, so we created a repository fund in 2017. And then finally in 2017, also, there was an amendment of the StandAG or the Site Selection Act and we started with the repository search for the procedure itself. And this amendment of the StandAG from 2017 defines our regulatory framework. This is supported by two safety ordinances, I will show a little bit later, that were failed in 2020.

And then finally, not in 2022, but in 2023, there was a final shutdown of the last three nuclear power plants in Germany. On the map, you see our current interim storage facilities in these red, yellow circles, and in the blue dots, you'll see our three repository mines currently operated by BGE.

The Asse mine, we have to retrieve the waste, the Morsleben mine this is the mine of the former GDR [DGR]. And the Konrad Repository is currently in construction. It will be the repository for low and intermediate level waste in Germany. Next slide.

Due to the phase out of nuclear power, we have a roughly precise knowledge of our inventory. And you'll see on the left-hand side that we are talking about roughly 1,750 CASTOR containers. These are the interim storage containers. But we also have a little bit of vitrified waste for reprocessing. And important when I talk about high level radioactive waste, Germany, it combines both. We have spent fuel, but also these waste from vitrified and reprocessing. Next slide.

A more closer look to the inventory. As you can see on the left side, we have the spent fuel elements. Then in the middle we have the canister from vitrified waste. And on the right-hand side we have a diverse inventory of spent fuel elements from research, experimental and also prototype reactors. What is important you can see on the left column, most of our spent fuel elements come from uranium oxide, several come also from mixed oxide, and roughly equal amounts coming from pressurized reactor water reactors or boiling water reactors. Next slide. So, coming to the main principles and also requirements according to the Site Selection Act. Next slide.

So, basically, when this Site Selection Act entered into force, we started with the so-called white map. So, the entire area of Germany was within the procedure.

The act defines three potential host rocks: claystone, crystalline rock, and rock salt. All three has to be investigated by BGE.

Clearly, the repository site has to be located in the Federal Republic of Germany, and we are looking for a site that provides the best possible safety for a period of 1 million years.

Based on the outcome of this Repository Commission, I mentioned before, reversibility of the entire procedure, but also of the repository facility itself is a key requirement. And in Germany we distinguish between what we call retrievability, that is during the operation phase, and recoverability, which has to be ensured for 500 years after closure. The entire procedure should be participative, science-based, transparent, self-questioning, and also learning. And although not deeper defined in the Site Selection Act, if permissible, also, final disposal of low and intermediate level radioactive waste that is not going to the Konrad mine should be disposed of at the same site. Next slide, please.

So, this is the overall regulatory framework in Germany. There are other acts like the Atomic Act or the Strahlenschutzverordnung, Radiation Protection Act, but these are the acts or ordinances that are relevant for us. So, we have the overarching Site Selection Act itself. This is underpinned by two ordinances that are already mentioned.

So, we have ordinance on the safety requirements, and we have ordinance on the safety investigation, or safety assessment activities. And you can see, also, for these ordinances, these will be regularly updated. So, it's an adaptive process. And they define how the preliminary safety assessments has to be implemented. And also, and this might be different from other countries, the safety requirement ordinance defines two safety requirements. One, the lowermost part is the additional annual dose for the expected evolutions must be below 10 microsievert. So, this is a criterion well-known from other programs, although the numbers might be different.

But in Germany we also have another safety requirement. And this is the so-called mass release requirement. So, we have the concept of containment within a containment providing rock zone, and this containment providing rock zone only 10 to the minus 9 per year, or 10 to the minus 4 during the entire assessment period of 1 million year is allowed to leave. And these numbers refer to both the mass and also the amount of the initially deposited radionuclide inventory. Next slide, please.

So, what tools do we have in the site selection procedure to, at the end, finally come to our site? We have four here in blue criteria, and minimum requirements that are defined in the Site Selection Act itself. These are exclusion criteria, minimum requirements, geo scientific weighing criteria, and also planning scientific weighing criteria. And then we have these preliminary safety analysis or assessments, they are mentioned in the Site Selection Act but defined in more detail in the corresponding ordinance. And the next slides I will show you these. First, how these four blue criteria and requirements are, and then after that, I will return to the green one for the preliminary safety analysis. Next slide.

So, the exclusion criteria, we have, in total, six of them defined in the Site Selection Act. So, these are large vertical movements, active fault zones, influences from current or past mining activity, seismic activity, volcanic activity, and groundwater age. And if an area fulfills one of these criteria, it is termed unsuitable and is no longer within the site selection procedure. And these maps that are shown here, and also in the next two slides, show you the area of Germany and the results of the execution of these exclusion criteria, or the other criteria showing in the next slides, based on the interim report we published in 2020. Next slide, please.

So, the minimum requirement, there are five of these. So, first of all, the hydraulic conductivity of the host rock or the containment providing rock zone should be below 10, to the minus 10 meter per second. The thickness of the effective containment rock zone should be larger than 100 meters. The minimum depth of the top of this containment providing rock zone should be 300 meters below ground surface. Or, if deeper, which is better, then clearly the containment providing rock zone or the area of emplacement should provide sufficient areal extent to… for the inventory that we need, and we have to show that the integrity of the barrier system should be guaranteed over 1 million years.

And on the right-hand side, again, you see this area in Germany that fulfil all minimum requirements. So, if an area does not fulfil all requirements, it is out of the selection procedure. Next slide.

Whereas these exclusion criteria and minimum requirements are basically, yes, no decisions. The third category are the geo scientific weighing criteria. And those are no/yes decision criteria but they are used to rank between different areas or to compare also between different areas. But there are no criteria that end up with not suitable, and you can see we have 11 of those. Unfortunately, the left icons are in German, but I think it's really clear.

So, we have radionuclide migration. We have the overall geosphere. We have long term stability. We have temperature resistance, or temperature behavior. We have the tendency to gas migration, the tendency to forming fracture or fluid pathways. We have geomechanical aspects to this area. We have the containment potential. We have the groundwater chemistry. And also, we have to look at the overburden or the caprock to the repository, or to the containment providing rock zone.

And on the right-hand side, you can see the areas that we defined in this interim report. In purple you see claystone host rock areas in yellow potential crystalline host rock areas. In green, it's hard to see, but this is in the northern part of Germany these are steep rock salt formations/ And the light blue colors, these refer to stratiform rock salt formation that all passed the exclusion criteria, the minimum requirements, and were termed suitable based on the geo scientific weighing criteria. Next slide.

Oh, one too much. Yeah, there.

And then we have this planning scientific weighing criteria. These are optional criteria, and they only apply to areas where we have the same level of safety because the other three types are mostly or exclusively safety driven. Whereas these planning scientific weighing criteria are not necessarily safety driven. So, we have three classes: one, two, and three. We should weigh them accordingly from class one to class three.

But again, these are optional, and they are probably only relevant either to compare two areas for the same safety, or if we have a really large or huge area where we can state identical safety for the entire area, then we can use this type of weighing criteria to reduce or narrow down the area. So, next slide please.

And this is the overall sequence of the procedure steps. So, we have three phases according to current Site Selection Act. We are in phase one. And in step 2 of this phase one, and this will end with the definition of so-called siting regions for surface exploration. In phase two, we will perform the surface exploration, and then at the end come up with a proposal of so-called sites.

For the underground exploration in phase three, this underground exploration is foreseen and at the end of phase three, we will come up with a proposal for the final site. You can see each of the phase will end with the decision, and this decision is done by parliament, so by law.

And you can also see below that for the different phases we use different types of criterion or requirements. So, the three criteria and requirements I mentioned, they will apply throughout the entire procedure. The planning scientific weighing criteria are optional but can be applied now in our step 2, but also in phase two and three. And the preliminary safety analysis are not valid for step 1, but only valid for step 2 and phase two and phase three. And you can see they will increase in detail from representative of what we are doing now to further develop in phase two and comprehensive in phase three. Next slide, please.

And the next slides will show you how these representative preliminary safety analysis or assessments are done. Next slide. So, this is for phase one.

So, the step 2 of phase one, which we are currently working on this is from subareas. So, the interim report from 2020 to the siting regions. And you can see, first of all, we will apply the representative preliminary safety analysis or procedure to all subareas identified in the 2020 report. We will categorize these areas or parts of these areas into four main categories: D, C, B, A, with A being the best suited parts; then all these category A areas, you will again apply the geo scientific weighing criteria. And then, after that, we will start to compare all category A areas and also rank them, and yes or no, applying the planning scientific weighing criteria, we will come up with a final proposal of siting regions. Next slide, please.

Here you see the building blocks of the representative preliminary safety analysis as laid down in the safety ordinance.

So, for each area and for each of these safety assessments we have to perform a geo synthesis, we have to define preliminary safety concepts and design of the repository. We also, to an extent possible at the current stage, have to optimize the repository system. Then there is the analysis of the repository system. Then again, after a very comprehensive evaluation of the repository system, but then also part of these safety assessments, we have to estimate the uncertainties, and we also have to derive the exploration research and development requirements.

So, this is as it is laid down in the safety ordinance, but to make this building blocks really operational, we had to define our own methodology how we execute these safety analysis. Next slide, please.

And this shows you the methodology we developed for this procedure. You can see it's a kind of four-step process with what we call hurdles that getting higher. So, we have step 1, just looking at the data and looking at the, again, looking at exclusion criteria and minimum requirements. Then step 2 is a qualitative, safety-oriented approach testing the suitability of the repository system. Then in step 3, we again look at the specific limits for mass and substance discharge. So, the release requirement in the regulation. And then step 4 is divided into step 4a and 4b. But basically, step 4 is then the overall assessment of an area or the remaining area in terms of suitability.

And at the end, we end up with the category A areas. And throughout the process, areas that basically fall directly in category D or C are out of the procedure and will not go further in the process. Next slide, please.

I mentioned that we had to make a methodology and also to make these requirements operational, so what we did, we defined a catalogue of safety-oriented criteria, and we defined these catalogues for each of the host rocks. And you can see on the left figure we did it for clay rock, for crystalline rock, and we did it for two different types of salt or rock salt, one in steep formation and one in stratiform formation. Because we realized in the first attempts that we have to distinguish between these two types of rock salt.

And you can also see down there, we had this criterion catalogue for the step 1, step 2, step 3, and also step 4. Next slide.

So, the first steps again are more or less basic geo scientific characterization or based on such kind of characterization where step 3 and step 4, based on a more detailed geo scientific characterization and the level of knowledge and also the depth of the assessment increase from step 1 to step 4. Next slide.

So, here, again, you can see how this refers to the regulatory framework and what we done by ourselves. So, step 1 and step 2, 3, here we use thresholds or definitions given by the regulation. So, in step 1, mostly from the Site Selection Act, whereas in step 3 we refer to the safety ordinance. Whereas step 2 and step 4 are more technical oriented and based on the definitions that we use or we defined within our methodology to really be able to narrow down the areas, because we realized that by just relying on the regulatory requirements, it will be very hard to narrow down the areas to, at the end, citing regions. Next step.

And here you see for the safety criteria that we defined, we basically looked at four different main categories: long term stability and integrity. We looked at containment properties of the host rock, spatial characterization, and reliability of the safety statement, and also on the operational reliability and technical feasibility of the disposal concept and system. Next slide, please.

And how this works will show you the next four slides on an example in brief. So here, we look at glacial erosion that refers to main category one of our safety criteria long term stability and integrity.

So, schematically shown on the right lower part, you'll see a block diagram of an assumed geology with this potential host rock at the bottom. And I also, I mentioned we have a minimum requirement of 100 meters thickness of the containment providing rock zone. So, we first, in step 1, for example, in this example, applied the minimum depth criterion, which is 300 meters, and you can immediately see that if you look at the glacial valley or glacial overdeepening, these may reach deeper than 300 meters. So, we perform the research project and added the additional depth amount to this minimum requirement. And then we would end up with the dark blue area which would be suitable for a siting region. Then, next slide, please.

In step 2, we used our own defined criteria. In this case we added kind of safety margin to these requirements given by the regulation. And in this case, we simply added a 100-meter safety margin to this lower or the needed depth interval of the containment providing rock zone. And you can see on the right-hand side; this already reduced the area where we may have a potential siting region. Then, next slide please.

We returned to the requirements in the ordinance. We did it by what we call event method. So, basically this is on the one hand side, in claystone, we did really radionuclide migration calculations, but we also did what is based on the FEP catalogue that we have. So, we looked at additional erosion, additional effects, other processes that might happen and that may even require deeper top of the host rock formation. And this is step 3.

And finally, in step 4. Next slide, please. We then defined the deposition area. So, not the containment providing rocks on itself, but really the deposition area within this rock zone, shown by this dark blue line. And then we defined the difference or the distance of this deposition area to this deepest line. In this case is called a channel basis, so what we did in step 1, 2 and 3, and then we defined, based on the distance to this channel base, we defined categories like poor, satisfactory, good, very good and excellent. And at the end only in this case, those areas that fulfil the requirement excellent or the assessment excellent, that would be then, finally, our A category sites.

This is the way we did it for the preliminary safety assessment. Next slide, please.

And what is the current status of our work right now? Next slide.

So, this is our last published status. This is published in November 2025. We will do the next publication of our status in November this year. So, rather soon.

But what you can see here, at that date in yellow, these are areas that are assessed as category C. In orange you see areas that are assessed as category D at that date. In grey, and this is a really large portion at that time, these are areas where we were still working on these steps 1 and 2. And only the small blue areas, these are areas that already passed steps 1 and 2 and now will go into step 3 and 4. Next slide, please.

And you see here, a timeline. So, in 2020, as already mentioned, we published the interim report just relying on the regulations, and then we developed our methodology for the safety assessment. And in 2024, that was our first publication of the results. You can see on the diagram below, we roughly estimated 18 to 20% of the entire area, but 80% are still not assessed. But then already one year later, in 2025, we were able to assess more than half of the entire area, and half of it was assessed as category D and C. And 3% already passed these steps 1 and 2, and the still remaining grey part that we are still working on.

And then finally, this year, in November, we will publish the next status report and we'll also present category B data. So, based on the outcomes for the blue part, maybe also for the still grey part, then we will also publish category B.

And then, finally, in 2027, at the end of 2027, we will publish or propose the siting regions based on the category A areas and the comparison between the different areas. Next slide, please.

So, lessons learned. Next one, please.

First of all, for the safety assessment criteria with thresholds, these are either defined by regulations or are developed by BGE based on the regulatory framework detailing it a little bit. These criteria that we defined, and also the methodology that we defined, led to an increase in detailed analysis of the area and the thresholds becoming stricter as the suitability of areas increases. Remember, we are looking for the site that provides the best possible safety.

And what is very important, at least in the German procedure. And based on the Gorleben experience because we defined these criteria beforehand and published them, this led to a very transparent narrowing down and evaluation of the areas. And at the end, we hope that with this, we will define the area with the highest safety reserves. Next slide.

So, these are more the lessons learned so far, the requirements and regulations laid down in the Site Selection Act that really provide a systematic and robust framework for the German site selection procedure.

However, as these are mostly generic host rock independent criteria, they need to be specified to adequately narrow down areas to siting regions. And these narrowed down, and this specification had to be done by BGE. So, we developed really host rock dependent criteria for our work.

The next step in terms of methodology is that we have to develop a methodology for the final comparison of the A category areas, and then to narrow it down and really to come up with those areas that are the best, also in comparison to others, and this work is still in progress.

And with this, I thank you, and I'm happy to take any questions.

SWIFT: Thank you very much. That was very helpful. And again, I'm Peter Swift, the Chair of the NWTRB. And I do I have a question for you. I realize that your site selection process is driven by the national law and the governing policies of the country, but I'm curious as to where it goes going forward, when eventually you will come down to a rather small area of the country that is essentially optimal. And at what point, then, do you… does political and social acceptance become a factor? And what happens if the best, or the set of best sites, those that meet your high standards are not available for one reason or another? How does how does the process work at that point?

LIEBSCHER: All different points. Maybe, let's start with the definition of best possible site in the German Site Selection Act. This is not defined on a purely technical basis, but this is basically defined on a procedural basis. So, in the act it states the best possible site is that site that comes out at the end of the process. So, even if we, as BGE, as implementer, propose, maybe site A or B, then it might be that based on the parliament decision or also on the argumentation by the regulator, we may end up with another site.

But this, again, according to the act, would be the site with the best possible safety because it's the site at the end of the process. So, it's not technically defined. Not purely technically defined. I have to say, regarding the participation, so I focus in the slides more on the technical part of the work, geo scientific work that we do at BGE.

The participation aspects are with the regulator in Germany, so with the BASE. And when we propose the siting regions, next year, BASE will establish a so-called regional conference in each of the siting regions. And this regional conference then will act until the area is either the site or until this specific area is out of the procedure.

And the idea is that by establishing these type of regional conferences, to get the people informed, to get the people of the regional people, regional communities, and governments, not only informed, but also participated. And by this, to create a kind of acceptance, or at least acceptability, for the potentially or eventual final site selection.

SWIFT: Thank you.

LESLIE: Yes, Bret Leslie, Board staff. A really fine presentation with a lot of information. And Peter's question helped bring out something which is the role of the regulator in this, in developing the regional conferences. I don't think you mentioned… you did say that the host dependent criteria were developed by BGE, did BASE have any part in reviewing those criteria, or did you communicate with them as you were developing them? Again, from a… I know we asked you to focus on the technical aspects, but as we stated at the very beginning, you can't really divorce yourself from the social aspect. So, can you provide a little clarity on BASE's role prior to them establishing the regional conferences?

LIEBSCHER: Yes, we are definitely. So, we are in an exchange with BASE, and when we developed this methodology, we presented that to BASE. But we also presented it to the general public, I would say. So, we have formal or informal activities or BASE has a kind of biannual conference they organize. We have biannual, what we call days of site selection. So, there are a lot of fora where we can present our ideas and also methodology. So, we have a kind of discussion with BASE. But BASE is very how to… how to say it? So, we have no formal approval of our methodology in this way, I could term it. But we would have an exchange, and I would say that if we would run in a completely wrong direction with our methodology and also the criteria that we defined, then we would get a hint from BASE. But we do not get any formal approval prior to the submission of our siting region proposal.

LESLIE: Thank you Axel. That clarified things quite well. And as a former regulator here in the US, I know how the regulator can be with the implementer, and while not having a formal role, it can certainly make their voice heard in the process. So, thank you.

MANEPALLY: Chandrika Manepally, Board staff. Axel, thank you so much for such a wonderful presentation. My question is more towards how can… what were the challenges did you foresee, or you've already taken into account that you make a very fair and objective comparison between sites that are located in three different kinds of host rock. I understand that you have developed, you know, specific criteria for that particular host rock, but then if you're comparing one site which is located in salt, versus one site that is located in, say, you know, crystalline rock, how can you stay objective and make sure that you are being fair to both the options?

LIEBSCHER: That's a very good question. I mentioned that the methodology for the comparison between different regions or the different category A areas, and this also include comparison between the different host rocks, is under way, and this will be not an easy task. And I expect that most or the highest difficulties to do it in a fair manner is in the current phase one of the process. I mentioned that we are not allowed to gather new data. We do have to rely on the existing or the legacy data that we get from geological surveys or from universities or even companies. But that makes it very hard to really have a sound qualitative, but especially also a sound quantitative basis for the comparison.

I think it's getting much easier when we progress in the procedure, because then we get exploration data, and we can really explore the different sites according to our needs. For the current phase one, this probably will be getting very difficult and we probably have to rely on what you may call qualitative argumentation or even expert judgement.

But I think that because the entire procedure is by narrowing down, so we may end with, I don't know exactly… so, we will have to see next year, but you can imagine that we may have between six and 12 siting regions, and they probably cover at least two of the different host rocks, potentially all three.

And then we move in phase two where we get exploration data, and then we have a much more sound basis for the comparison.

MANEPALLY: Thank you.

SWIFT: Do we have any other questions, Jo Jo, Andy?

JUNG: This is Andy. Just a quick question. On slide number 4, the history of site selection procedure in Germany. I understand that you started in 1977, which is very long history. I just wonder, because I believe there is a lot of set of data, and the experience is it still for your site selection, did you start consider like a knowledge management from the previous data or experience to utilize that? Or no, is it a totally new approach?

LIEBSCHER: First of all, this 1977 was a decision for the Gorleben site as an integrated nuclear center, including also a repository. And then they started to explore the Gorleben site. So, this was in a steep salt formation. And then we had, due to the public opposition in this moratorium in 2000, a lot of the aspects that were developed during this Gorleben time, in my understanding are still, maybe not guiding, but a little bit like guiding the current site selection procedure. For example, especially the idea of the containment providing rock salt, which is really central to the German procedure and approach.

And this comes from the former idea to use salt deposit as repository. So, this is one of these general aspects, but overall, the Site Selection Act was put on completely new basis, and there were put a lot of learnings from the Gorleben time into the new Site Selection Act. Geologically, we still depend on many of the data gained during the Gorleben exploration. This is clear if it comes to salt host rock, there are a lot of data and knowledge gained during that time where we can rely on. But from the procedure, it's completely different, I would say.

JUNG: Okay, thanks.

LESLIE: Bret Leslie, Board staff again. In phase three, the underground exploration, is it envisioned under the act that you would have, if at that point you still had a siting regions or areas in each of the rock types? Would you have to develop an underground siting characterization facility for each of those rock types?

LIEBSCHER: So, first of all, what I have presented is the current legislation. So, that is because we are currently… there are ongoing discussions in Germany whether this Site Selection

Act might be modified in the next year. And all what I have heard from the ministry is that they think about combining phase two and phase three to just one phase and make this underground exploration optional.

But this is the ideas for the evaluation or the amendment of the Site Selection Act. So, according to current legislation, it is clearly stated within the act that during phase three, we have to do a comparison of at least two sites with underground exploration. And in my understanding, and I guess this is, I would say, all in Germany agree on this interpretation, that would mean that in two different sites, we have to really do a kind of exploratory mining activity. So, not just drilling, drilling is in the surface exploration included, but really to go underground.

But the Site Selection Act does not require that these two sites in phase three must be from different host rocks. So, it would be completely fine with the Site Selection Act if we would end in phase three with either two claystone, or two crystalline, or two salt. But we can also end up with a salt and a clay as host rock.

LESLIE: Thank you for that clarification and explanation of where policy is now and where it might go. Thank you. That was helpful.

SWIFT: If there are no further questions from the staff, I think that concludes the presentation. And I want to thank you again very much more, and I thank you for working late, for your time zone there. I appreciate it.

LIEBSCHER: You're welcome.

SWIFT: And with that, I think this meeting is ready to adjourn. To the best of my knowledge, there are no public comments from people in the room. No, I don't see any. And there were none signed up. We will check the ones on the, on the website. And with that, we're adjourned.

Thank you very much.

[End of Recording]