EIA 08 | Environmental Impact Assessment 2008

Expansion of the Repository for Spent Nuclear Fuel

Environmental Impact Assessment Report

POSIVA

Foreword

Posiva Oy has started an environmental impact assessment procedure (EIA procedure) concerning the expansion of the spent nuclear fuel repository in compliance with the act governing the assessment of environmental impacts (the EIA Act).

The plan regarding the assessment of environmental impacts of the project and organisation of the flow of information, i.e. the EIA programme, was completed in May 2008. The EIA programme was available for public viewing during the period 27 May to 25 July 2008. The Ministry of Employment and the Economy, the coordinating authority for the EIA procedure as referred to in the EIA Act, issued its statement regarding the programme on 22 August 2008.

The environmental impacts of the project have been extensively studied. The focus has been on those impacts that are considered and felt to be significant. Information about issues deemed important by citizens and various interest groups has been obtained in connection with public communications, interaction and international hearing procedures, among other things.

The significance of environmental impacts has been assessed on the basis of, for example, the settlement and natural environment of the observed area as well as by comparing the tolerance of the environment with regard to each environmental burden.

The results of the environmental impact assessment have been collected in this Environmental Impact Assessment Report (EIA report). All relevant existing environmental data, as well as the results of the prepared environmental impact assessments, are presented in the EIA report. The EIA report also includes a plan for the mitigation of detrimental environmental impacts.

Assessing the environmental impacts of the project has been a challenging task, because most of the environmental impacts of the expansion of the spent nuclear fuel repository will only start materialising after several decades, on the 2070s at the earliest.

At Posiva, the EIA procedure has been the responsibility of the EIA project group. Mr. Markku Friberg, Safety Manager, has acted as the project manager.

Posiva commissioned the preparation of the EIA programme and EIA report to Pöyry Energy Oy. The project managers for the consulting company were M.A. Päivi Koski (the EIA programme stage) and M.Sc (Tech.) Pirkko Seitsalo (the EIA report stage). B.Sc. (Tech.) Tiina Kähö (deputy to the project manager), Lic.Sc. (Tech.) Jaakko Savolahti (assessment of environmental impacts), M.A. Mirja Kosonen (assessment of social and health impacts) and M.Sc (Tech.) Janna Riikonen (implementation of theme interviews, assessment of social impacts) have also participated in preparing the EIA report. Experts of Pöyry's geo-scientific consultancy services have also contributed to the assessment process.

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Posiva Oy

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Summary

Posiva Oy (hereinafter "Posiva") started the environmental impact assessment procedure (EIA procedure) concerning the expansion of its repository in spring 2008. Posiva is thus preparing to take into account the disposal of spent fuel of the possible new nuclear power plant projects of its owners Teollisuuden Voima Oyj (hereinafter "TVO") and Fortum Power and Heat Oy (hereinafter "Fortum") on the Olkiluoto island of Eurajoki.

The EIA programme was submitted to the coordinating authority in May 2008, and it was available for public viewing during the period 27 May to 25 July 2008. The coordinating authority issued its statement regarding the programme to Posiva on 22 August 2008.

The impacts of the project have been extensively studied in the EIA procedure. The focus has been on those impacts that are considered and felt to be significant. Information about issues deemed important by citizens and various interest groups has been obtained in connection with public communications, interaction, theme interviews and international hearing procedures, among other things.

The organisation responsible for the project is Posiva, a company wholly owned by TVO and Fortum. Posiva is responsible for conducting research for the disposal of spent nuclear fuel of its owners, building and using the repository and closing the repository after operations. In addition, Posiva provides its owners and other companies with expert services regarding nuclear waste management.

The Ministry of Employment and the Economy is the coordinating authority for this EIA procedure. The EIA report was produced by Pöyry Energy Oy.

Interaction

The participants to the briefing and public debate meetings associated with the environmental impact assessment procedure have had an opportunity to express their opinions and receive information about the project and its environmental impacts.

Theme interviews were carried out in conjunction with the EIA procedure, and they provided information regarding the attitudes and confidence of the interviewees regarding the project and Posiva. Information on the EIA procedure has also been provided by means of press releases, Posiva's internet site, brochures and various public events.

Purpose, location and time schedule of the project

In Finland, the plan is to place the spent nuclear fuel of TVO and Fortum in final disposal facilities quarried at a depth of 400–700 metres inside the bedrock. The final disposal of spent nuclear fuel is scheduled to start in 2020.

Posiva is studying the expansion of the repository for spent nuclear fuel to be located in Olkiluoto so that the repository will have space for 12,000 uranium-tons of spent nuclear fuel instead of the previously planned 9,000 tons of uranium.

The project's EIA procedure is to be concluded early in 2009. The expansion of the repository is subject to a decision-in-principle issued by the Government and ratified by Parliament as well as licence and permit decisions pursuant to a number of laws. If the project proceeds to a stage where a decision is made to apply for a decision-in-principle and the required licences, the environmental impact assessment report will be appended to the decision-in-principle application and to the licence applications, when required.

The study and design stage aimed at preparing for the construction of the repository will continue until 2012. During 2013–2020, the detailed implementation design required by the repository will be made and the repository will be constructed. The final disposal of spent nuclear fuel is scheduled to start in 2020. The final disposal of spent fuel from the seventh plant unit that necessitates the expansion now undergoing the EIA procedure would begin in the 2070s and end approximately in 2120.

Alternatives and defining parameters of the project

The expansion of the repository so that the the repository will have capacity for 12,000 uranium-tons of spent nuclear fuel instead of the previously planned 9,000 tons of uranium is studied as the main option in the environmental impact assessment. The expansion mainly concerns the underground final repository.

The EIA report also includes descriptions of facilities where 6,500 tU or 9,000 tU, respectively, of spent nuclear fuel would be placed in. The environmental impacts have been assessed for the entire extent of the repository, taking into account the expansion of the facilities. This means that the EIA report shows the environmental impacts of the final disposal facilities in a situation where 12,000 tU of spent nuclear fuel is placed in the repository. In order to compare the alternatives, the environmental impacts are shown for situations where either 6,500 tU or 9,000 tU of spent nuclear fuel is placed in the repository.

The environmental impact assessment only concerns the repository in Olkiluoto. Olkiluoto was chosen as the place for the repository from among several alternatives on the basis of extensive research involving many stages in 1999. In December 2000, the Government made a decision-in-principle based on Posiva's application, according to which the construction of the repository in Olkiluoto in Eurajoki is in the overall good of society.

The zero option to be studied is a situation where Posiva's repository will not be expanded and a maximum of 9,000 tons of uranium can be disposed of in the repository. In the zero option, the spent nuclear fuel of six nuclear power plant units can be disposed of in the Olkiluoto repository. As a result, spent nuclear fuel from the seventh nuclear power plant unit will be stored in water pools in the interim storage for spent nuclear fuel, until a decision is made regarding the treatment of fuel or its permanent disposal.

Links to other projects and plans

TVO's nuclear power plant units OL1 and OL2 are located on the west side of Olkiluoto in Eurajoki. Both plant units have a rated electrical power of 860 MW (net). Furthermore, a the third plant unit, OL3, is under construction and it will have a rated electric power of approximately 1,600 MW (net). It is scheduled to start commercial operation in 2011.

The current Loviisa nuclear power plant units LO1 and LO2 are located on the Hästholmen Island in Loviisa, approximately 80 kilometres east of Helsinki. The rated electrical output of both Loviisa plant units is 488 MW (net).

Both owners of Posiva, TVO and Fortum, carried out environmental impact assessment procedures in 2007–2008 concerning the construction of a new nuclear power plant unit. TVO studied the expansion of the Olkiluoto nuclear power plant by a fourth plant unit and Fortum examined the expansion of the Loviisa nuclear power plant by a third plant unit. These nuclear power plant units would both produce an electrical output of 1,000–1,800 MW (net). On 25 April 2008, TVO submitted an application to the Government for a decision-in-principle regarding the construction of a fourth nuclear power plant unit in Olkiluoto. Fortum is also in the process of preparing documents that would allow an application for a decision-in-principle regarding the LO3 plant unit. The need to carry out a fresh EIA procedure is due to the LO3 plant unit. If required, the repository expansion can also be used as the final disposal facility for the spent nuclear fuel from other plant units belonging to the owners of Posiva.

Description of the final disposal solution

The intention is to place the spent nuclear fuel originating from TVO's nuclear power plant units in Olkiluoto and Fortum's plant units in Loviisa in the repository for spent nuclear fuel in a manner intended as permanent. The disposal facilities will be quarried at a depth of 400–700 metres inside the Olkiluoto bedrock. By placing the spent nuclear fuel deep inside the bedrock, encapsulated in leak-tight metal containers, it is isolated from living nature. The depth of hundreds of meters also ensures sufficient isolation regarding the effects of future ice ages.

The long-term safety concept of the final disposal solution is based on the multi-barrier principle (i.e. several release barriers securing each other) so that the deficiency of one barrier will not compromise long-term safety. The release barriers include a copper & cast iron canister, bentonite barrier, disposal tunnel backfilling and intact bedrock around the disposal facilities.

Verifying study stage

The study stage mainly intended for surveying the properties of bedrock at the repository site to be used as the basis for detailed design and planning is called the verifying study stage. For this purpose, a research facility called ONKALO, reaching to the same depth as the actual repository facility, is being built in Olkiluoto.

ONKALO covers a spiral-shaped access tunnel, passenger and ventilation shafts, research, testing and demonstration facilities and technical facilities. The surveys at the disposal depth will begin in 2010. Bedrock surveys are carried out in parallel with excavation work from the

access tunnel. The results will be utilised immediately in excavation and construction work.

Construction stage

The disposal facilities and ONKALO are designed so that ONKALO can act as part of the disposal facilities when the disposal of nuclear waste canisters will begin in 2020. Some of the construction work for the disposal facilities will be carried out during the construction of ONKALO. The work methods and materials used in the construction of ONKALO have been selected so that they are also acceptable for the disposal facilities. The facilities will be expanded at the operating stage of disposal by excavating more disposal and central tunnels.

The full repository will consist of facilities above and under ground level. The underground facility will consist of access routes leading deep inside the bedrock, tunnels and deposition holes inside the bedrock where the final disposal canisters will be disposed of, and of any underground facilities and access routes required. The surface and the repository are connected by an access tunnel and a sufficient number of vertical shafts for ventilation and personnel and canister transportation.

Operating stage

Spent nuclear fuel will be stored in interim storages of Fortum's Loviisa nuclear power plant and TVO's Olkiluoto nuclear power plant for at least 40 years before the final disposal. Spent nuclear fuel will be transported from the interim storages to Posiva's repository located in Olkiluoto in special containers as special transport. Transportation from Loviisa to Olkiluoto can take place by road, rail or sea. The transportation of spent nuclear fuel is strictly regulated by national and international regulations and agreements. A licence for transporting spent nuclear fuel must be acquired in Finland from the Radiation and Nuclear Safety Authority (STUK). STUK will inspect the transportation plan, the structure of the container, the qualifications of transportation personnel and the provisions made for accidents and malicious damage.

The most important building of the aboveground facility will be the encapsulation plant. It will be designed so that it will be able to facilitate the processing of spent fuel from the owners' current nuclear power plant units and those under planning and construction. Spent nuclear fuel delivered from interim storages of nuclear power plants to the repository will be packed into copper canisters in the encapsulation plant and transported to the repository using a lift or the access tunnel. According to the current designs, the repository will be located on one floor at a depth of about 420 metres from the surface.

The designs of the disposal facilities are based on the vertical disposal solution of canisters (KBS-3V). The horizontal disposal solution (KBS-3H) where canisters are disposed of in horizontally drilled tunnels may also be used.

In the vertical disposal solution, vertical deposition holes are drilled in the floor of disposal tunnels where the tight and corrosion-proof canisters will be placed. In both options, the space left between a canister and the bedrock will be filled with bentonite blocks. As a result, the canister will be completely surrounded by bentonite blocks that will expand strongly when becoming wet, thus sealing the deposition holes.

Closing stage and retrievability of disposed nuclear fuel

Disposal sections will be sealed continuously during the disposal operations as canisters are disposed of. When all spent nuclear fuel has been finally disposed of, the encapsulation plant will be dismantled, the tunnels will be backfilled using filling material, and all connections above ground will be sealed off. When the party responsible for nuclear waste management has sealed off the final repository in an acceptable manner and paid the state the fee due for the future surveillance and monitoring of nuclear waste, the title of and responsibility for the waste materials will be transferred to the state. According to the Nuclear Power Act, the final disposal must in its entirety be implemented in such a manner that no monitoring will be required afterwards in order to ensure its safety.

However, the retrieval of nuclear fuel disposed of in the bedrock to the surface will be possible if sufficient technical and financial resources are available. Retrievability will provide future generations with the possibility of assessing the solution on the basis of their future knowledge. The retrieval will use the same regular work methods that were used in the excavation and construction of the repository. The retrieval of the canisters from the repository to the surface will be possible at all stages of the project, i.e. before sealing off the deposition hole, after sealing off the hole before the disposal tunnel is sealed off, after sealing off the disposal tunnel before sealing off all facilities, and after sealing off all facilities.

Environmental impacts of construction and operation

During the EIA procedure, both the anticipated impacts and the impacts of potential environmental accidents have been considered.

Impacts of transportation and traffic

Traffic to the Posiva repository facility represents only a small portion (some 5 percent) of the total volume of traffic on the Olkiluoto island, and it has little effect on traffic volumes or traffic-related impacts. Expansion of the repository facility will not affect the day-to-day traffic volumes.

Besides Olkiluoto, spent nuclear fuel is also brought to the repository facility from the Loviisa nuclear power plant. The plan is that the fuel from Loviisa will be transported to Olkiluoto as road transport; however, railway and sea transport and their combinations have also been studied as alternative transport methods. The volume of fuel transportation depends on the volume and type of fuel, burn-up, cooling time and size of transport vessel. At most, there will be ten transports per year. For transport, expansion of the repository means that the operation will continue as before but there will be transportation for a longer period of time. Due to the small transport volume, the environmental impacts due to exhaust gas emissions in case of all the transport alternatives will be insignificant.

The risk of serious cancer cases caused by radiation from normal transportation is fewer than 0.00007 cases/year along the inspected routes, and the cancer risk as a consequence of accidents is even lower. This means that transportation is not expected to cause a single death due to cancer. The health risk caused by radiation related to the transportation of spent nuclear fuel is smaller than that caused by regular traffic accidents.

Impacts on land use, cultural heritage, landscape, buildings and structures

The normal operation of the repository, anticipated operational malfunctions or accidents do not pose any limitations on the land use outside the aboveground repository area.

Land use restrictions to be entered in appropriate registers can be prescribed when granting a closing licence for the repository. Such limitations may apply to, for example, excavation or drilling activities in the area.

The impacts of the repository on the landscape will be minor. There are no nationally or regionally valuable buildings or other objects of cultural history in the repository area. No historical monuments have been found in the Olkiluoto area.

Impacts on the soil, bedrock and groundwater

The area required by the underground repository for 9,000 uranium-tons of fuel to be disposed is about 190 hectares. The expansion of the repository from 9,000 tU to 12,000 tU will increase the area required by final disposal by about 50 hectares. The expansion of the underground disposal facilities can be seen above ground as new shaft buildings of about 20 m^2. Other aboveground buildings will already be built before starting the expansion stage for final disposal operations.

The increase in the volume of disposable fuel from 9,000 to 12,000 tons of uranium will increase the amount of rock waste by 410,000 m^3 increasing the total volume of rock waste from approximately 1,670,000 m^3 to 2,080,000 m^3. Approximately 20,000 m^3 of quarried materials will be generated annually. Some of the rock waste will be used as backfilling material in the disposal facilities and the excessive waste can be used for other purposes, e.g. it can be sold as such or crushed into filling or building material.

The decay heat of spent nuclear fuel will expand the bedrock and elevate the ground surface in the middle of the repository by a maximum of 7 cm in more than a thousand years from the final disposal.

Groundwater will leak into open tunnel facilities and will be pumped to the ground surface. This will drawdown the groundwater pressure head around the tunnel system and may also cause the groundwater level in the Olkiluoto Island area to decrease. The volume of leakage water and the extent of impact will be reduced during construction work by sealing the bedrock around the tunnel.

The volume of groundwater flowing into the expansion of the repository area and the impact of the expansion on the level of groundwater has been assessed using a numerical flow model. The flow model has been updated to correspond to the observed and measured data compiled until the end of 2007.

According to the numerical model, the construction of the expansion will increase the volume of water flowing into the entire tunnel system by approximately 20 percent when both the ONKALO facility and the entire repository are assumed to be open at the same time. In practice, the tunnel system will be built in stages and only a part of the tunnel system is open at the same time, which will reduce the estimated impacts.

The increase of leak water will cause an average groundwater surface level drawdown of 2–4 metres in the studied area, depending on the success of the sealing. The reduction will be higher locally in parts where rock with better conductivity than the average is located close to the surface.

The chemical and gaseous composition of deep groundwater will correspond closely to the basic status that existed on Olkiluoto Island before starting to construct ONKALO. There have not been any major changes. However, the hydrogeochemical monitoring period is still short and the hydrogeochemical changes caused by the construction of ONKALO may only become visible after several years. The hydrogeochemical impact of the expansion of the repository cannot be assessed reliably at this stage, but they are assessed not to deviate significantly from the impact of operations preceding the expansion.

Impact on air quality

Civil engineering work, site traffic and separate functions (such as rock crushing and deposition of rock material) will generate dust locally. Vehicles and machinery will cause atmospheric emissions. The volume of these emissions is small and they will not have an impact on air quality outside the area.

Noise and vibration impacts

Civil engineering work, blasting, treatment and crushing of quarried materials and the use of vehicles and working machinery will cause noise and vibration. These operations that cause noise and vibration will be performed so that they will not cause any significant impact on the environment.

The repository for spent nuclear fuel will be constructed as required when spent fuel is disposed of. The noise generated by the excavation of the disposal facilities will not extend outside the plant area. At the construction stage, the crushing of quarried materials will cause noise during the day. There are no noise-sensitive objects in the noise zone created by rock crushing. The impact will not be significant because of the short duration of the operations and the small size of the affected area. Crushing of quarried materials will end when all the fuel to be placed in the Olkiluoto bedrock has been disposed of.

In practice, the volume of disposable fuel will not have an impact on the noise zone: If the amount of fuel to be disposed of increases, the repository will simply remain in operation for longer. Some noise may be caused by the excavation of any new shafts required. The impact will be minor, because of the raise boring technique and the short duration of operations.

Impact on vegetation, animals and objects of protection

The impacts of the project on flora and fauna are primarily related to the land areas required for buildings and structures and to construction work. No major impacts will occur during operation and shutdown of the repository facilities.

Most plants take water from soil water above the bedrock. Thus, the drawdown of groundwater table level due to the underground facility will not influence the plants. A significant decrease in the water level is not expected in the soil layers.

The impacts of final disposal on the Liiklankari Natura area have been studied and assessed in conjunction with the preparation of the Olkiluoto partial master plan for land-use. As a result of the Natura assessment, it has been established that the projects (including the repository) enabled in Olkiluoto through the master plan will not have a significant impact on the natural values, because of which the Liiklankari area on the southern shore of Olkiluoto belongs to the Natura 2000 conservation programme.

The utilisation of natural resources, such as mushroom and berry picking, hunting, fishing and forestry, can be continued as before outside the area reserved for the repository operations.

Impact on people and attitudes towards the disposal of spent nuclear fuel

Emissions of radioactive substances taking place in a normal situation from the repository through the encapsulation of spent nuclear fuel will be insignificant. The volumes of radioactive substances handled at any one time at the encapsulation plant will be small compared to the corresponding volumes at nuclear power plants.

The dose for a person belonging to the population caused by normal one-year emissions, calculated over a period of 50 years, will be less than 0.01 mSv in the immediate vicinity of the plant area. The dose will be at least one order of magnitude smaller at a distance of five kilometres than in the repository's immediate vicinity. The dose farther away is even smaller. As a result, dose caused by normal emissions will be insignificantly small compared to natural radiation (about 3 mSv/year).

As the volume of spent nuclear fuel to be disposed of increases, so the operating stage of the repository will also be extended. The increase in the volume of fuel to be disposed of or the expansion of the operating stage will not have any relevant effect on the radiation doses that a member of the general public will receive as a result of the normal operation of the plant. But the total dose received by the general public as a result of the operation of the plant will increase roughly directly proportional to the increase in fuel volume. Hence the increased amount of fuel will not increase the health risks due to the normal operation of the plant on the individual level. Looking at

the health risks of the entire population, they will increase roughly directly proportional to the increase in fuel volume.

The attitudes of Finnish people towards nuclear waste have been studied as part of the annual Finnish Energy Attitudes monitoring survey. Nuclear waste has been previously stated to arouse clear suspicions. In a survey conducted in 2007, one-third of all respondents (32 percent) considered the final disposal of nuclear waste inside the bedrock to be safe in Finland. There were more of those who had their doubts, almost half (46 percent) of the population. Reserved attitudes are explained by the impression of two-thirds (68 percent), according to whom nuclear waste comprises a continuous threat to the lives of future generations. Only one respondent in seven disagreed (15 percent). The attitudes have not become more neutral during the entire research period of 25 years.

According to the survey, the attitudes toward nuclear waste in municipalities containing a nuclear power plant continued to be more positive than the average in the country. Confidence in the safety of final disposal was more extensive in these municipalities. The difference between power plant municipalities and the nation's average has, however, reduced in the recent years.

The survey conducted during this EIA process in winter 2007–2008 examined the trust of Eurajoki residents in safe disposal of spent nuclear fuel. A query was mailed to 400 randomly-selected Eurajoki residents. Furthermore, the ideas of 18 Eurajoki residents were identified using theme interviews.

On the basis of the results from the query, approximately 40 percent of the responding Eurajoki residents had a positive attitude towards the final disposal of spent nuclear fuel and 12 percent a neutral attitude. The location of the repository in the home municipality was regarded as alarming by about 45 percent of residents. A special risk mentioned was fuel transport, and this is why Eurajoki was deemed a suitable final disposal site. Based on the interviews, the most major concern connected with final disposal was the import of spent nuclear fuel from abroad to Finland and to Eurajoki for disposal.

The interviewees deemed the activities of Posiva stable and not surprising. According to the interviewees, Posiva does not put safety at risk and cares for the residents of Eurajoki and every Finnish citizen by prioritising safety factors. The interviewees regarded Posiva and its personnel as competent, honest and able to handle the final disposal of spent nuclear fuel in a safe manner.

In June 2008, the opinions, attitudes and concerns of Eurajoki residents concerning final disposal were studied using theme interviews. A total of 21 people were interviewed and they were divided into two groups: those living in Olkiluoto and its immediate surroundings and a group of young Eurajoki residents, half of whom were 18–19-year-old upper secondary school students and half under 30-year-old parents of small children.

The interviewees did not consider the impacts of the expansion of the repository to be significant compared to the situation that the repository will be, nonetheless, built in the municipality. The final overall view was that the attitude of most of the interviewees toward the repository was neutral or fairly positive. Bedrock disposal was deemed the best alternative among the potential final disposal alternatives. Safety risks were mentioned, however, mostly for the longer term. None of the interviewees had actual fears relating to final disposal, even though there were some concerns, such as the risks related to the transportation of nuclear waste. A matter deemed positive for the municipality was the repository's impacts on employment and tax income. None of the interviewees felt that the concerns related to final disposal would cast a shadow over their lives or cause stress. Only one of the interviewees thought that the final disposal could endanger their personal safety.

However, the expansion of the repository compared to the fact that a smaller plant will be built in any case was a neutral or positive factor regarding safety according to nearly all interviewees. The expansion was deemed an issue awakening worry mainly because several of the interviewees thought that the expansion project was connected with a plan to start importing nuclear waste.

Impacts on social structure, regional economy and the image of the municipality of Eurajoki

According to the report entitled "The impacts of final disposal of spent nuclear fuel on regional, social and municipal economy", prepared in 2007, the decision on the location of the repository, Posiva's relocation to Eurajoki, the renovation of the Vuojoki Mansion, the renewed operations and the start of the repository's research stage, and the construction of ONKALO have had a positive impact on the development of regional, social and municipal economy in Eurajoki and the entire region in the early 2000s.

The project's impact on employment is expected to be approximately 550 man-years per year at most. During the operational stage, the immediate annual employment impact has been estimated to be about 130 man-years. The employment impacts of the repository are major for the entire region: at most approximately 220 man-years per year. The employment effect on the municipality of Eurajoki and the region will have a significant positive impact on employment in the municipality and region.

The construction and operations of the repository will have an impact on the municipal economy of Eurajoki. Real estate tax paid by the plant will slowly strengthen the municipality's income tax base as the real estate tax increases until 2020 at least. This will enable a strong annual balance and exceptional possibilities for the municipality compared to other municipalities, resulting in an increase in the attractiveness of the municipality for potential residence-movers compared to the rest of the region.

People in the region's municipalities are satisfied with the project's positive impacts on regional economy. An impact deemed especially positive impact is the fact that the construction and operation of the facility will take place over a long period of time, and the impacts can be reasonably well anticipated and will occur during a long period of time. The potential negative externalities associated in advance with the repository have not been realised. On the basis of the information available, the plant project has not disturbed the residents or companies, and the visibility and image of the municipality of Eurajoki have become stronger.

Impact of malfunction and accident situations

Malfunctions differ from accidents in that the consequences of malfunctions are milder than those of accidents but they can occur more frequently. In malfunctions, radioactive substances are released to the encapsulation plant facilities or the devices located there. Malfunctions and accidents resulting in releases of radioactive substances in the repository facilities are extremely improbable.

The maximum dose caused by a single malfunction for a person belonging to the population over a period of 50 years will in all probability be less than 0.001 mSv. Therefore, the doses caused by transients remain substantially smaller than the prescribed annual limit of 0.1 mSv.

The structures of the repository will be implemented so that accidents related to fuel at the handling stage that lead to significant damage to the fuel will not cause any immediate danger to the health of the personnel or the residents in the surrounding areas.

It is very probable that the maximum dose caused by an assumed accident situation, which refers to situations used as design criteria for safety systems, for a member of the general public will be less than 0.5 mSv during the first year and less than 0.8 mSv in 50 years. Doses caused by postulated accidents remain thus smaller than the required annual limit 1 mSv. The largest dose will be generated immediately next to the plant area, provided that there are permanent residents, agricultural operations and self-produced products are mainly used for nutrition. The main dose is accumulated from radionuclides settled on the ground, with intake through the food chain as in the case of operational transients. The dose will be clearly smaller at a distance of five kilometres from the plant.

Radioactive substances released in accident conditions and the radiation caused by these substances could be detected in the environment through measurements. The extent and shape of the impact area will depend on the quantity of release and the prevailing weather conditions.

Detection would be made difficult because of the existence of natural radioactive substances and artificial radioactive substances originating from other sources. The affected zone of a postulated accident would, in the spreading direction, extend to a distance of about five kilometres, whereas the annual dose of 0.1 mSv is considered to be the limit value (an average of about 3 mSv/year from natural radiation).

As the volume of spent nuclear fuel to be disposed of increases, so the operating stage of the repository will also be extended. The increase in the volume of fuel to be disposed of or the expansion of the operating stage will not have any relevant effect on the radiation doses that a member of the general public will receive as a result of expected malfunctions or assumed accidents. But the probability that a malfunction or accident will occur during the whole operating stage of the plant will increase roughly directly proportional to the increase in fuel volume. Hence the increased amount of fuel will not increase the health risks due to malfunctions or accidents on the individual level. Looking at the health risks of the entire population, they will increase roughly directly proportional to the increase in fuel volume.

The aboveground encapsulation plant will be structurally designed for any anticipated external incidents. Such events include a light aircraft crash, earthquake and flooding.

Long-term safety

The mechanically-strong and corrosion-resistant canisters that will be located in the steady bedrock and surrounded with bentonite clay will most likely hold all radioactive substances inside for at least several million years. However, the possibility of individual canisters breaking during this time cannot be completely excluded. In such cases, radioactive substances could be slowly released into the environment. Canister leakage could result from the emplacement of an originally damaged canister to the disposal facilities, the breakage of a few canisters placed in poor locations in earthquakes that may take place as the ice originating from the ice age withdraws, the erosion of

the bentonite clay around the canister caused by melting waters and the resulting corrosion of the canister.

However, only a few cases of canister damage are expected, even in the worst case. Releases of radionuclides caused by such damages would only have a minimal effect on people and the living environment. Safety assessments have also considered the uncertainties affecting the release and transport of radioactive substances. Clarification of safety relevant issues continues to reduce uncertainties. The feasibility and adequate quality of technical solutions will be proven with testing. The full-scale safety case to be submitted in 2012, supporting the repository construction licence, will be based on these tests.

Monitoring environmental impacts

Any long-term changes in the surrounding bedrock and groundwater flow system caused by the construction of ONKALO will be monitored in accordance with the programme prepared for the purpose. The scope of the programme includes rock-mechanical, hydrological and hydrogeochemical monitoring and the monitoring of the environment and foreign substances. Environmental impact monitoring during the construction of ONKALO will help to foresee the environmental impact resulting from the construction, operation and expansion of the repository.

Load and impact monitoring will be performed during the operations of the repository. The monitoring aims at:

- provide information about the project's impacts
- investigate which changes have resulted from the project implementation
- investigate how the results of the impact assessment correspond with reality
- investigate how the measures for mitigating adverse impacts have succeeded
- initiate the required measures if significant unforeseen adverse impacts occur.

Monitoring of radiation effects is based on the measuring of radioactive releases and concentrations and radiation dose rates. Concentrations and dose rates are also assessed by means of calculation, using information such as release and weather information as it is assumed that, due to the small amounts, radioactive substances cannot be detected in the environment. The expected radiation impact will be so small that special monitoring of the population's health is not considered to be necessary: eventual health hazards could not be detected among normal morbidity rates. As necessary, it is possible to compare the health of people living in the area with people from a more remote area with the help of, for example, information from the National Public Health Institute.

In the final disposal stage, the releases of radioactive substances to the environment are monitored. Typical measuring points include ventilation air and wastewater discharge routes. Measurements of concentrations and dose rates already started will be continued.

The environmental impacts will be monitored by means of a monitoring programme. Presented here is a tentative list of topics to be included in the programme:

- radiation effects in the environment
- concentration of natural radon gas in rock facilities
- groundwater table level in the area around the rock facilities
- vegetation distribution in the groundwater impact areas
- levels of vibration caused by overburden excavations in the nearby buildings
- image of Eurajoki
- occurrence of radiation fears
- socio-economic impacts.

Other monitoring obligations may be imposed on, for example, noise and dust in connection with later licensing processes.

Monitoring measurements carried out by Posiva will be finished once the plant is closed in a manner approved by STUK. In the closing stage, Posiva will draw up a proposal of a monitoring programme for the time following the closing, and pays the state a lump-sum settlement. This money will be used by the authorities for the monitoring and control they deem necessary. However, final disposal must be performed so that it is safe without any later monitoring.

The objective of monitoring following the closing stage is to identify how the bedrock qualities can be retrieved to the status preceding the construction stage. Monitoring of bedrock conditions has been examined in several international projects.

Monitoring following the closing stage may include the measurement of radioactivity on ground surface and in deep drilled holes. The holes may also be used to monitor groundwater levels, currents, chemistry, temperature etc. On the ground, geophysical measurements could be used to monitor micro-earthquakes. Compromising the integrity of nuclear material by illegal actions would require actions that are visible aboveground. The actions would be detected and internationally monitored from, for example, satellites.

Contents

Glossary

Access tunnel An inclined driveway (ramp) with an inclination of 1:10 running inside the bedrock from the surface to the disposal level. The main access way of the underground research facility, ONKALO.

Activity The number of spontaneous nuclear disintegrations occurring in a given quantity of radioactive material within a certain time. The unit of radioactivity, becquerel (Bq), equals one disintegration per second.

Barrier The purpose of a barrier is to prevent radionuclides from drifting in the disposal system. The barriers include canisters, bentonite barrier and the bedrock. Barriers are also called release barriers.

Becquerel (Bq) The unit of radioactivity, which equals one disintegration per second. The content of radioactive substances in foodstuff is given in Becquerel per mass or volumetric unit (Bq/kg or Bq/l).

Bentonite Bentonite is a natural type of clay created as a result of volcanic ash transforming. A special feature of bentonite clay is its expansion as a consequence of moisture (wetting). Bentonite has been planned to be used as a barrier material between the canister and bedrock and as a backfilling material in repositories.

Burn-up Burn-up is a variable that indicates how much thermal energy fuel has produced per one uranium-ton. The unit of burn-up is MWd/tU (megawatt days per uranium-ton).

BWR Boiling Water Reactor. The reactor type of Olkiluoto 1 and Olkiluoto 2.

Canister A technical release barrier intended for the disposal of spent nuclear fuel assemblies and built of a copper shell, bottom and lids and a cast iron insert.

Decibel (dB) The unit of sound volume. An increase of ten decibels in the noise level means that sound energy is increased tenfold. A-emphasis is typically used in environmental noise measurements dB(A), which aims at emphasising such frequencies to which the human ear is the most sensitive.

Degree of enrichment The relationship between uranium isotope U-235 and the total volume of uranium. The percentage of isotope U-235 in natural uranium is 0.72. The degree of enrichment for the fuel of light water reactors is 3–4 percent.

Diffusion A phenomenon where molecules attempt to move from a more concentrated content to a more diluted one levelling any differences in content over time.

Dose equivalent The dose equivalent is the product of absorbed dose and radiation type, and its unit is Sievert (Sv). Dose equivalents can be used to compare the radiation doses caused by different ionising radiation types.

Dose rate The dose rate expresses the radiation dose received in a given length of time.

EIA Environmental impact assessment. Statutory procedure, the EIA procedure.

Encapsulation plant A plant where spent nuclear fuel is placed into a disposal canister and sealed.

EPR EPR (European Pressurized Water Reactor) is an advanced version of the third generation pressurized water reactor, to which safety issues have been paid special attention. The reactor type of the Olkiluoto 3 nuclear power plant unit.

EURATOM The European Atomic Energy Community of the European Union (EU). Finland is a member.

Fuel assembly A fuel assembly consists of fuel rods where the uranium used as nuclear fuel is placed. The fuel rods are assembled using spacers and tie plates. In certain fuel types the assembly is surrounded by a metal casing called a flow channel.

Gray (Gy) The unit of an absorbed dose indicating the volume of energy transferred by ionising radiation to the target substance. 1 Gy = 1 Joule/kg. Multiple units mGy = 1/1,000 grays and µGy = 1/1,000,000 grays.

Hydrogeochemical model A modelled description of the chemical features of groundwater and affecting processes.

Hydrological model A modelled description of the physical features and conditions of groundwater and groundwater flow.

IAEA International Atomic Energy Agency.

ICRP International Commission on Radiological Protection.

Ionisation Changes in an atom's electron structure that can cause changes in molecules, such as DNA.

Ionising radiation Electromagnetic radiation and particle radiation causing ionisation directly or indirectly.

KBS-3 A principle solution for final disposal developed by SKB, which is a company responsible for nuclear waste management in Sweden. KBS is short for KärnBränsleSäkerhet (nuclear fuel safety).

KBS-3H A principle solution for disposal based on the multi-barrier principle. The first release barrier (i.e. canister) is placed inside the bedrock in a horizontal position (H=horizontal).

KBS-3V A principle solution for disposal based on the multi-barrier principle. The first release barrier (i.e. canister) is placed inside the bedrock in a vertical position (V=vertical).

KPA Store Interim storage facility for spent nuclear fuel.

KTM Ministry of Trade and Industry, the tasks of which were transferred to the Ministry of Employment and the Economy which started operating on 1 January 2008.

Mansievert (manSv) The unit of a collective dose. If, for example, every person in a group of 1,000 people receives an average radiation dose of 20 millisieverts, the collective dose is 1,000 x 0.02 Sv = 20 manSv.

Megawatt (MW) The unit of power (1 MW = 1,000 kW).

Multibarrier principle Disposal is carried out so that radionuclides must penetrate a number of successive independent barriers before being able to access living nature.

Natura 2000 A network of conservation areas in accordance with the EU's Habitats Directive, the particular purpose of which is to protect endangered, rare or natural environments, animals and plants in European nature.

Natural background radiation Radiation originating from natural radioactive substances and the space.

NT Near Threatened (conservation status).

Nuclide A nuclide is the nucleus of an atom which has a defined proton number (Z) and a defined neutron number (N).

ONKALO An underground rock characterisation facility for the final disposal of spent nuclear fuel.

PWR Pressurized Water Reactor.

Radiation dose Radiation dose is a variable used to represent the adverse effects of radiation on people. The unit of radiation dose is sievert (Sv). Radiation dose is often just referred to as 'dose' for brevity.

Radioactive A radioactive substance contains atom nuclei that can transform or decay into other nuclei. Decay generally creates ionizing radiation (e.g. alpha, beta and gamma radiation). See radioactivity.

Radioactivity A feature of the atom nucleus (nuclide) to transform by itself into another nucleus (nuclide). A radioactive nucleus can send an alpha or a beta particle transforming into another nucleus that can send electromagnetic radiation. The transformation is called radioactive decay. Each atom nucleus (nuclide) has a characteristic decay constant (half life).

Radionuclide A radioactive nuclide. See nuclide.

Radon Rn-222. A radioactive gas that does not have any stable isotopes. Rn-222, which is created as degradation product of uranium existing in the bedrock, causes the majority of natural radiation exposure in Finland.

Reprocessing Separation of useful nuclides from spent nuclear fuel. Fission products and part of transuranic elements remain in spent nuclear fuel.

Richter scale A mathematical logarithmic scale used to measure the magnitude of earthquakes.

Sievert (Sv) The unit of dose equivalent. A variable used to represent statistical adverse effects of radiation (radiation dose) for people. Sievert is a very large unit. That is why either millisieverts (mSv) or microsieverts (µSv) are used when referring to actual doses. One sievert is 1,000 millisieverts or 1,000,000 microsieverts.

Spent nuclear fuel Nuclear fuel is referred to as spent when it has been removed from the reactor. Spent nuclear fuel emits high doses of radiation.

SR-Can A safety assessment published by the Swedish SKB in 2006 which focuses on the KBS-3V disposal solution and two different location options. The main part of the safety report is also largely applicable to the Olkiluoto repository, as the technical solution and the main characteristics of the final disposal location are similar.

STUK Radiation and Nuclear Safety Authority.

TEM Ministry of Employment and the Economy that took over the duties of the Ministry of Trade and Industry on 1 January 2008.

Town plan A town plan compliant with Land Use and Building Act presents detailed definitions for organising the use of an area.

Transportation container A radiation-protected custom-made container intended for the transportation and short-term storage of spent nuclear fuel. In addition to radiation protection, the container provides mechanical and thermal protection during transportation, handling and storage of spent nuclear fuel. The term 'transport cask' can also be used.

tU Tons of uranium, or uranium-tons. Refers to the amount of uranium in fresh fuel. 95–96 percent of this uranium remains in spent nuclear fuel. The rest has been converted into fission products, plutonium and other transuranium elements.

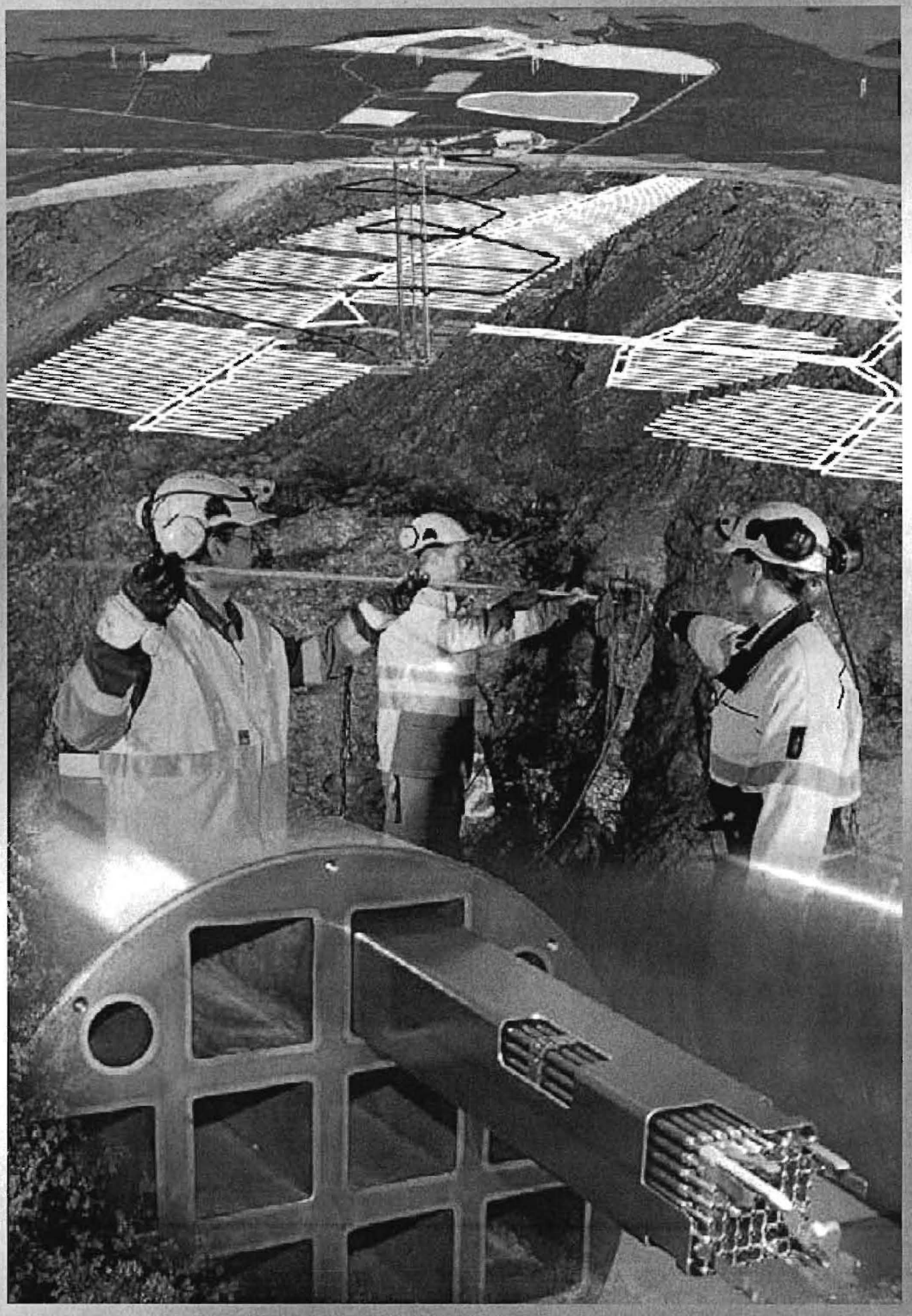
Uranium An element with the chemical symbol U. Uranium comprises 0.0004 percent of the earth's crust (four grams in a ton). All uranium isotopes are radioactive. Natural uranium is mostly in the form of isotope U-238, which has a half-life of 4.5 billion years. Only 0.72 percent of natural uranium is in the form of isotope U-235, which can be used as nuclear fuel. Its half-life is 700 million years.

VLJ Repository A repository for low- and intermediate-level operating waste.

VU Vulnerable (conservation status).

VVER-440 The reactor type of Loviisa 1 and Loviisa 2 (pressurized water reactor).

YVL Guide An authority guide published by the Radiation and Nuclear Safety Authority describing the requirement levels for radiation and nuclear safety control. The safety requirements for the use of nuclear energy are described in the YVL Guide.



1 Project

1.1 Project description

Posiva Oy (hereinafter "Posiva") is investigating the expansion of the repository for spent nuclear fuel to be built in Olkiluoto so that the repository will have space for 12,000 uranium tons of spent nuclear fuel instead of the previously planned maximum volume of 9,000 uranium tons.

Posiva started the environmental impact assessment procedure (EIA procedure) concerning the expansion of its repository in May 2008 and is preparing to take into account the disposal of spent nuclear fuel of any new nuclear power plant projects of its owners Teollisuuden Voima Oyj ("TVO") and Fortum Power and Heat Oy ("Fortum"). By taking into account the plans concerning the construction of new nuclear power plants for TVO and Fortum in addition to the currently operated units or those under construction (Olkiluoto 4 and Loviisa 3), the total volume of spent nuclear fuel is estimated to increase to approximately 12,000 tons of uranium. The expansion of the repository requires that an EIA procedure is carried out.

According to Section 4 of the EIA Act (468/1994), projects to be assessed in the environmental impact assessment procedure are prescribed in more detail by a Government decree. According to Section 7 d) of the project list in Section 6 of Chapter 2 of the EIA Decree (713/2006), the assessment procedure is to be applied to facilities intended for the final disposal of spent nuclear fuel.

A transboundary assessment procedure is applied to the project where the states belonging to the scope of the Espoo Convention (67/1997) will be provided with the option to take part in the environmental impact assessment. The parties to the Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland if the project is likely to have significant transboundary environmental impacts. Correspondingly, Finland is entitled to take part in an environmental impact assessment procedure of a project located in the area of another state if the project's impact is likely to extend to Finland.

Any decisions regarding construction have not been made and the actual design process for the expansion project has not been initiated. The expansion of the repository will be a current issue in 2070 at the earliest. The expansion of the repository is subject to a decision-in-principle issued by the Government and ratified by Parliament. The EIA report must be completed before the possible application for a decision-in-principle concerning the expansion of the repository can be submitted.

The environmental impacts of Posiva's repository were last assessed comprehensively in connection with the repository's EIA procedure in 1999, covering the disposal of 9,000 tons of uranium. In spring 2008, Posiva has prepared an updated report on the repository's environmental impacts with emphasis on the environmental impacts of the disposal of spent nuclear fuel from the sixth nuclear power plant unit (FIN6) of Posiva's owners. The report acts as one starting point for this EIA report.

1.2 Organisation responsible for the project

Posiva is an expert organisation specialising in nuclear waste management, established in 1995. Posiva's task is to define, plan and conduct the required research, development, planning and construction work and implementation of the disposal. Posiva is owned by TVO (60 percent ownership) and Fortum (40 percent ownership).

Posiva is responsible for conducting research for the disposal of spent nuclear fuel of its owners, building and operating the repository and sealing the repository after operations. In 2007, Posiva had about 70 employees. The company's annual turnover amounted to EUR 47 million in 2007. The company operates in Olkiluoto, the municipality of Eurajoki.

1.3 Purpose and justification for the project

The Nuclear Energy Act (990/1987) prescribes that nuclear waste generated in connection with or as a result of use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland. According to the act, licence holders shall be responsible for all procedures related to the maintenance of the waste they have produced, and their appropriate preparation and related expenses.

Both owners of Posiva, TVO and Fortum, have carried out environmental impact assessment procedures in 2007–2008 concerning the construction of new nuclear power plant units in their plant areas. On 25 April 2008, TVO submitted an application to the Government for a decision-in-principle regarding the construction of a fourth nuclear power plant unit in Olkiluoto. Fortum is also in the process of preparing documents that would allow an application for a decision-in-principle regarding the LO3 plant unit. If implemented, these would be the sixth and seventh plant units of Posiva's owners in Finland.

The EIA procedure carried out by Posiva in 1998–1999 covered the disposal of spent nuclear fuel for six plant units. The need to carry out a fresh EIA procedure is due to the Loviisa 3 plant unit. If required, the repository expansion can also be used as the final disposal facility for the spent nuclear fuel from other plant units belonging to the Posiva owners. By carrying out an EIA procedure that takes into account the possible seventh nuclear power plant unit, Posiva is preparing for the eventuality that Fortum may submit an application for a decision-in-principle regarding the LO3 plant unit. The seventh power plant unit is estimated to produce spent nuclear fuel amounting to some 3,000 tons of uranium. At the beginning of 2008, Posiva decided to start the environmental impact assessment procedure for expanding the repository, after which the repository would have space for 12,000 tons of spent nuclear fuel instead of the previous 9,000 uranium tons.

1.4 Background of the project

Posiva has carried out an EIA procedure for the repository in 1998–1999. In its statement (1/815/98, 5 November 1999) on the assessment report, the Ministry of Trade and Industry stated that Posiva has inspected the project and its options in accordance with the statement issued by the ministry regarding the EIA programme. Any changes in the accumulation of the nuclear fuel to be disposed of were taken into account in the assessment so that its maximum volume corresponded to 9,000 tons of uranium (tU).

The basic solution used in the assessment was the disposal of spent nuclear fuel produced by the Olkiluoto 1 (OL1) and 2 (OL2) and Loviisa 1 (LO1) and 2 (LO2) plant units over 40 operating years, meaning a total amount of about 2,600 tons of uranium. The assessment also considered a situation where the life span of the aforementioned units would be 60 years. In this situation, the total accumulation of spent nuclear fuel would be about 4,000 tons of uranium. Furthermore, the assessment took into consideration a situation where the spent nuclear fuel produced by two new plant units to be built in Finland (FIN5 and FIN6) would be disposed of in the repository in addition to the spent nuclear fuel produced in the four aforementioned plant units, after which the volume inspected in the environmental impact assessment procedure was the aforementioned maximum volume of 9,000 tU.

In May 1999, Posiva submitted its application for a decision-in-principle to the Government concerning the construction of the repository in Olkiluoto in Eurajoki. The maximum volume of disposable fuel stated in the application was 9,000 tU. In December 2000, the Government made a decision-in-principle based on Posiva's application, according to which the construction of the repository in Olkiluoto in Eurajoki is in the overall good of society. The Government stated that the requirements of the principle-in-decision were fulfilled because the municipality of Eurajoki had, in January 2000, issued a licence to build the repository in Olkiluoto. In addition, the Radiation and Nuclear Safety Authority (STUK) was in favour of the project in its preliminary safety assessment. According to the decision-in-principle, an amount of spent nuclear fuel corresponding to a maximum of 4,000 tons of uranium can be processed and disposed of in the repository. Through the decision-in-principle prepared by the Government and ratified by Parliament in May 2001, Posiva has concentrated its research in Olkiluoto.

A decision-in-principle concerning the fifth nuclear power plant unit, Olkiluoto 3 (OL3), to be built in Finland was made in 2002. At the same time, a decision-in-principle concerning the construction of the repository for spent nuclear fuel as an expanded facility was made, based on Posiva's previous application, so that spent nuclear fuel from OL3 can be disposed of in the repository. By virtue of the decision-in-principle, final disposal facilities for a maximum of 2,500 uranium-tons of spent nuclear fuel can be built. On this basis and together with the Government's decision-in-principle issued in December 2000, a maximum of 6,500 uranium-tons of spent nuclear fuel can be processed and disposed of in the repository in question.

The extended decision-in-principle states that the EIA procedure carried out for the repository in 1998–1999 covers the project to such an extent that the spent nuclear fuel produced by the operations of the four plant units and the possible two new plant units can be processed and disposed of in the repository.

In its letter dated 29 May 2007, Posiva requested the Ministry of Trade and Industry to express its opinion regarding whether Posiva must carry out a fresh EIA procedure pursuant to the EIA Act for its project regarding the final disposal of spent nuclear fuel because of the possible sixth nuclear power plant unit of its owners. The Ministry of Trade and Industry provided its statement regarding the necessity of the EIA procedure on 25 October 2007,

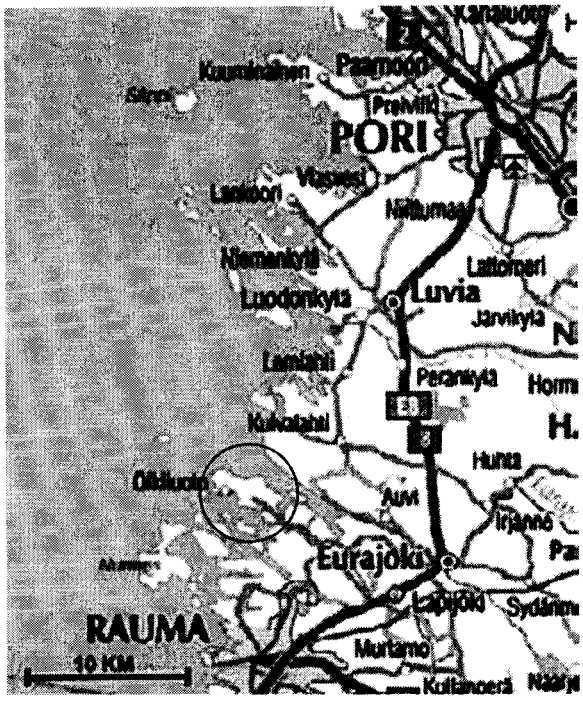


Figure 1-1 The location of Eurajoki and Olkiluoto. Eurajoki is located along highway 8.

Figure 1-2 Olkiluoto's location in Finland.

stating that the EIA procedure carried out by Posiva during 1998–1999 does cover the environmental impact assessment of the final disposal of spent nuclear fuel coming from the sixth nuclear power plant unit. However, the condition is that the total amount of fuel to be finally disposed of must be less than 9,000 tons of uranium.

The spent nuclear fuel from the sixth plant unit assessed in the EIA procedure in 1998–1999 is not covered by the disposal volume enabled by the already made decisions-in-principle. Instead, a separate decision-in-principle must be made for the final disposal according to the Nuclear Energy Act. For considering the decision-in-principle, the Ministry of Trade and Industry required that an up-to-date report on the repository's environmental impact is to be enclosed with the decision-in-principle application. On 25 April 2008, Posiva submitted its decision-in-principle application to the Government concerning the disposal of spent nuclear fuel from Olkiluoto 4 (FIN6) in Olkiluoto in Eurajoki. An up-to-date report on the repository's environmental impact was enclosed with the application.

The decision-in-principle is not the only decision on building the facility as it will require a construction licence granted by the Government. According to the decision issued by the Ministry of Trade and Industry in 2003 *(9/815/2003)*, the process for the final disposal of spent nuclear fuel must progress so that the material required by the construction licence application will be complete by the end of 2012. In the same decision, the Ministry of Trade and Industry set a new interim objective for 2009, by which time a status report of the construction licence application material must be presented. An up-to-date report of the repository's environmental impacts must be enclosed with the construction licence application.

Posiva will carry out an EIA procedure for the expansion of the repository, covering 3,000 uranium-tons of spent nuclear fuel. The said fuel amount is estimated to be produced by the FIN7 unit during its life span. The final disposal of spent nuclear fuel of the new nuclear power plant unit will begin in the 2070s at the earliest.

1.5 Location of the project and need for land

Posiva's repository is located on the west coast of Finland, on the Olkiluoto island in the municipality of Eurajoki (Figure 1-1). The distance from Olkiluoto to the nearest town, Rauma, is approximately 13 kilometres, 25 kilometres by road. The distance by road from Pori to Olkiluoto is approximately 54 kilometres. The distance from highway 8 to the repository is approximately 14 kilometres. The neighbouring country closest to the repository is Sweden, where the mainland areas closest to the repository are located about 200 kilometres west of the repository (Figure 1-2).

The repository area for spent nuclear fuel is located in the middle of the Olkiluoto island (Figure 8-1). The above-

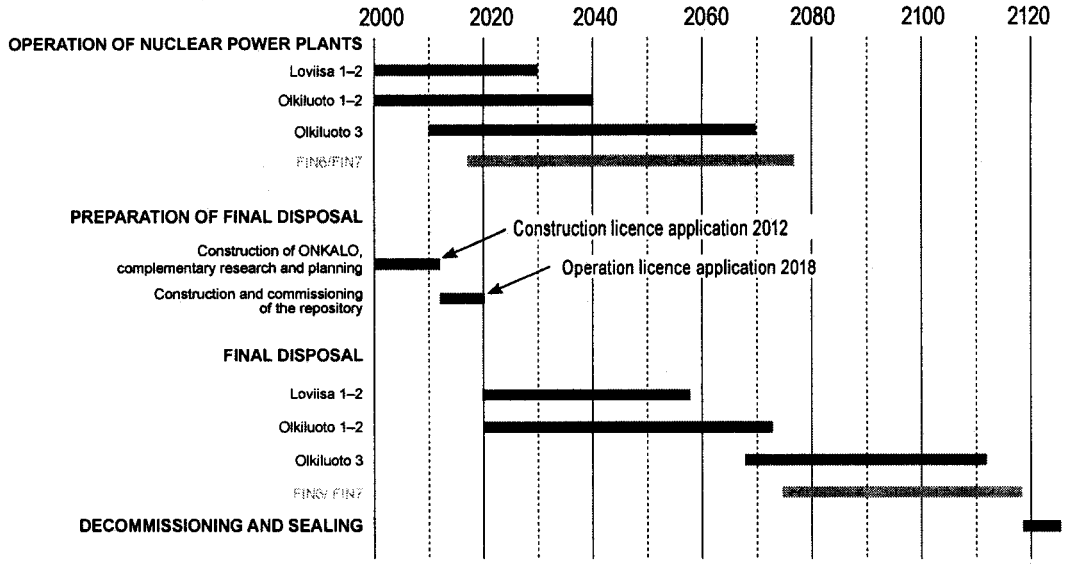


Figure 1-3 The planned operating periods for TVO's Olkiluoto and Fortum's Loviisa nuclear power plant units and the schedule of final disposal operations for their spent nuclear fuel.

ground construction area in the repository area (i.e. the area of buildings, roads, storages and fields) is a total of 20 hectares. The area required by the underground repository for 9,000 tons of uranium to be disposed of is about 190 hectares. The expansion of the disposal facilities from 9,000 to 12,000 tons of uranium will increase the area required by final disposal by about 50 hectares,

1.6 Project schedule

A decision regarding the expansion of the repository or submitting an application for a decision-in-principle to the Government has not been made.

The research, development and design stage aimed at preparing for the construction of the repository will be continued until 2012. During 2013–2020, the detailed implementation design required by the repository will be made and the repository will be constructed. The final disposal of spent nuclear fuel is scheduled to start in 2020.

Figure 1-3 shows the final disposal schedule based on calculations, including the impact of the plant units in operation and that of the OL3 unit under construction. In addition, the figure shows an estimate of the impact of the new planned plant units on the disposal schedule. The encapsulation and disposal of spent nuclear fuel from the new nuclear power plant unit will begin in the 2070s at the earliest.

1.7 Links to other projects, plans and programmes

TVO's Olkiluoto nuclear power plant

TVO has two boiling water reactors in Olkiluoto, Eurajoki, each having a rated electrical output of 860 MWe (net). OL1 was first connected to the national grid in September 1978 and OL2 in February 1980. In addition, a third plant unit, OL3 with a pressurised water reactor, is under construction and its rated electrical output is about 1,600 MW (net). It is scheduled to start commercial operations in 2011. At the end of 2007, a total of 6,750 assemblies of spent nuclear fuel were stored at the Olkiluoto power plant, corresponding to some 1,144 tons of uranium. Figure 1-3 presents the planned operating lives of the Olkiluoto nuclear power plant units.

Fortum's Loviisa nuclear power plant

Fortum's Loviisa nuclear power plant units, LO1 and LO2, are located on Hästholmen Island in Loviisa approximately 80 kilometres east of Helsinki. The Loviisa power plant has two pressurized water reactors, both having a rated electrical output of 488 MW (net). LO1 started its commercial operation in May 1977 and LO2 in January 1981. At the end of 2007, a total of 3,565 assemblies of spent nuclear fuel were stored at the Loviisa power plant, corresponding to approximately 428 tons of uranium. Figure 1-3 presents the planned operating lives of the Loviisa nuclear power plant units.

EIA procedures of TVO and Fortum

Both owners of Posiva, TVO and Fortum, carried out an environmental impact assessment procedure in 2007–2008 concerning the construction of a new nuclear power plant unit. TVO studied the expansion of the Olkiluoto nuclear power plant by a fourth plant unit and Fortum examined the expansion of the Loviisa nuclear power plant by a third plant unit. These nuclear power plant units would both produce an electrical output of 1,000–1,800 MW (net).

On 25 April 2008, TVO submitted an application to the Government for a decision-in-principle regarding the construction of a fourth nuclear power plant unit in Olkiluoto. Fortum is also in the process of preparing documents that would allow an application for a decision-in-principle regarding the LO3 plant unit.

1.8 Implementation option

The expansion of the repository in such a manner that the total amount of fuel to be disposed of will be 12,000 uranium tons, instead of the previously planned 9,000 uranium tons, is studied as the main option in the environmental impact assessment. The expansion will mainly be aimed at the need to increase the extent of the underground disposal facilities.

1.9 Zero option

The zero option to be studied is a situation where Posiva's repository will not be expanded and a maximum of 9,000 tons of uranium can be disposed of in the repository.

In the zero option, the spent nuclear fuel of six nuclear power plant units can be disposed of in the Olkiluoto repository. In this case, spent nuclear fuel from the seventh nuclear power plant unit will be stored in water pools in an interim storage for spent nuclear fuel until the processing of the fuel or its permanent disposal is decided upon.

The final disposal of spent nuclear fuel from six nuclear power plant units is estimated to terminate in 2120, after which the repository will be closed.

1.10 Current situation

Posiva's previous EIA report from 1999, the description of the current environmental status and assessments of the environmental impact caused by the final disposal of 9,000 uranium tons of spent nuclear fuel used as the reference point form the basis for inspecting the implementation option. Posiva's current and planned operations will be described on the basis of the research, development and design information over the recent years and the environmental impact assessment report updated in April 2008 and enclosed with Posiva's decision-in-principle application. The current environmental status and the estimated changes in it will be described on the basis of the available material illustrating the status of the environment.

1.11 Limits of environmental impact assessment

The environmental impacts have been assessed for the entire extent of the repository, taking into account the expansion of facilities. This means that the EIA report shows the environmental impacts of the final disposal facilities in a situation where 12,000 uranium tons of spent nuclear fuel is placed in the repository. In order to compare the alternatives, the environmental impacts have been shown in situations where either 6,500 or 9,000 uranium tons of spent nuclear fuel is placed in the repository.

The final disposal operations are scheduled to start in 2020 and end in 2120 when 12,000 uranium tons of spent nuclear fuel will be disposed of in the repository. The encapsulation and disposal of spent nuclear fuel from the new nuclear power plant unit to be disposed of in the expansion of the repository will begin in the 2070s at the earliest. The assessment has taken into account the long-term safety of the repository, i.e. the period following its closing. The inspection period for long-term safety extends to hundreds of thousands, even millions, of years. The behaviour of the disposal system has been described and analysed from the placement of the first canisters very far into the future (up to a million years).

The EIA procedure has primarily assessed the environmental impacts of operations taking place at the power plant site and transportation of spent nuclear fuel. In addition to the transportation of spent nuclear fuel, operations extending beyond the area include traffic during the expansion of the facility's underground section and during the repository's operations. The impact of these operations has also been assessed to the required extent.

The combined impact of the current and planned operations in Olkiluoto has been examined as part of environmental impact assessment. In connection with the EIA procedure, it has also been assessed whether the project will have impacts extending beyond Finnish territory.

In this context, observed area refers to the area defined for each type of impact within which the environmental impact in question is examined and assessed. The extent of the observed area depends on the environmental impact being examined. Affected area refers to the area within which the environmental impact is estimated to occur in accordance with the assessment.

1.12 Options excluded from the inspection

There are two principal alternatives for processing spent nuclear fuel: it is either stored until final disposal or transported for reprocessing. In reprocessing, uranium and plutonium are separated from the fuel.

The intention is to place the spent nuclear fuel originating from TVO's nuclear power plants in Olkiluoto and Fortum's plants in Loviisa in the spent nuclear fuel repository in a manner intended as permanent. Reprocessing options are excluded from this EIA procedure. Different forms of reprocessing are being studied but they are not currently realistic options in Finnish nuclear waste management. Chapters 1.12.1 and 1.12.2 present the current status of reprocessing and nuclide transmutation technologies and their future outlook. Chapter 1.12.3 estimates the volume of reprocessing waste, and Chapter 1.12.4 discusses the geological final disposal of high-level reprocessing waste. The costs of direct final disposal and advanced nuclear fuel cycles are compared in Chapter 1.12.5.

1.12.1 Reprocessing

Several significant or rising nuclear energy states, such as India, England, Japan, China, France, Germany and Soviet Union/Russia, continued to research and develop reprocessing technology even though the demand for reprocessing services reduced rapidly at the beginning of the 1980s. The states started to build plants to industrial scale, but some projects were abandoned before their completion. In France and England, plants intended to be commercial were, however, completed in the 1990s. The operation of the THORP plant located in Sellafield, England, has been troubled by a number of technical problems. The La Hague reprocessing plant owned by the French company Areva seems to be operating reliably. Furthermore, the amount and environmental emissions of nuclear waste produced by its processes have been reduced significantly. A unit based on the technical solutions used at the La Hague plant is at the testing stage in Japan. According to the information collected by the International Atomic Energy Agency, approximately 90,000 uranium-tons of spent nuclear fuel had been reprocessed by the end of 2003 *(IAEA 2005a)*.

The greatest problem of the reprocessing option continues to be high expenditure. The majority of foreign customers of the commercial reprocessing plants in France and England have decided not to continue their agreements after their commitments end. Several countries have decided to store spent nuclear fuel until the future of the nuclear energy industry becomes clearer. This is mainly influenced by the development possibilities of fourth generation reactors.

Reprocessing will hardly become a competitive option if the peaceful use of nuclear energy is limited to thermal reactors, which the majority of currently operating nuclear reactors are. Their benefits produced by reprocessing are rather limited. As a result, the efficiency of using uranium resources can be improved by a maximum of 20–25 percent *(Hanson 2007)*. The benefits obtained are divided evenly between separated plutonium and uranium. For reactor physics reasons, plutonium should only be recycled once in thermal reactors, and the reuse of separated uranium requires enrichment. However, the competitiveness of reprocessing is determined by the costs of different options and the price of uranium which increased manifold at the beginning of the 21st century.

Peaceful utilisation of nuclear energy has been supported more at the beginning of the 21st century, in the search for means to limit greenhouse gas emissions were

started to be studied. If several states decided to build more nuclear reactors quickly, the availability of uranium may constitute a problem. Its price could rise to such a level where reprocessing could be a profitable option even in a situation where thermal reactors produce the majority of nuclear energy. However, this requires long-term commitment to the utilisation of nuclear power, which requires slow transition to fast reactors that are able to utilise at least all uranium and plutonium efficiently. This comprises the starting point for national and international research and development programmes for fourth generation reactors *(GIF 2002)*. However, the commercial exploitation of fast reactors is not likely to commence until after 2050.

The question concerning the necessity of the reprocessing option and particularly its cost-effectiveness is still to be solved. Two reports have been conducted in the United States in this decade, ending in completely opposite results *(Bunn et. al. 2003, BCG 2006, Hanson 2007)*. It is, nevertheless, necessary to simplify and improve the efficiency of the reprocessing process and the manufacture of fuel from the separated material.

The economic competitiveness of reprocessing will require large units. A small country should not build reprocessing plants. Instead, they should prepare for the geological final disposal of high-level nuclear waste.

Spent nuclear fuel is not reprocessed in Finland and there is no reprocessing plant for spent nuclear fuel in Finland. According to the Nuclear Energy Act, spent nuclear fuel produced in Finland must be processed, stored and disposed of, in a manner intended to be permanent, in Finland. Currently, reprocessing is not at such a technical/financial level that it could be a realistic option for nuclear waste management. However, the expansion of the repository will be implemented in a long period of time and it is possible that reprocessing will be a financially and technically feasible option if the use of nuclear energy increases.

All future reprocessing options will create disposable nuclear waste. The high-level waste created using current reprocessing technology will, because of its heat production, require the same capacity of bedrock facilities as spent nuclear fuel that has not been reprocessed. It is difficult to predict in great detail the volume of other waste and the required disposal needs.

1.12.2 Partitioning and transmutation technology

Reprocessing can be developed so that other chemical elements or element groups are separated from spent nuclear fuel in addition to uranium and plutonium. The objective can be the partitioning of by-product actinides (neptunium, americium and curium) into separate product flows that are as pure as possible. In addition, it could be useful to divide fission products into groups. For example, caesium and strontium account for a significant part of the heat generation of spent nuclear fuel up to a hundred years. This evolved reprocessing procedure is called partitioning.

The power production of a nuclear reactor is based on a fission process where the heavy nucleus is split into two medium-mass nuclei. Furthermore, the composition of the fuel changes because of other neutron reactions. This process is called nuclide transmutation.

The partitioning and transmutation technology can, in theory, be used to easily alter the features of spent nuclear fuel in a way that reduces the problems related to nuclear waste management. Transmutation reactions can be performed so that long-lived radioactive nuclides are transformed into short-lived or even stable nuclides. In addition, a separate disposal solution, which is simpler and cheaper than the basic solution, can be developed for some of the partitioning process's product flows. Advanced partitioning technology can also be used to reduce environmental emissions by improving the efficiency of the recovery of highly volatile and gaseous chemical elements. Long-term resistance of the solidification matrix for high-level nuclear waste can be improved by removing any troublesome elements from the waste.

The technical implementation of partitioning and transmutation technology was assessed thoroughly for the first time at the end of the 1970s. The conclusion was negative at the time *(IAEA 1982)*. However, Japan started to identify the possibilities of the partitioning and transmutation technology in 1988 and France followed at the beginning of the 1990s. Research expanded quickly as several countries and international organisations launched their programmes.

In partitioning technology, the focus was placed on developing the standardised hydrometallurgical reprocessing method (PUREX) and studying the pyrochemical (electrochemical) processes. The transmutation technology also had two basic options: the regular fast reactor and the accelerator-driven sub-critical fast reactor (Accelerator-Driven System, ADS). In the latter option, the neutron flux is maintained at the required level by guiding the energetic protons produced using a particle accelerator into a target located in the reactor core *(NEA 2002)*.

The latest stage in partitioning and transmutation research has produced significant results, but they are mainly calculated or obtained in laboratory conditions, particularly with regard to fuel options but also partitioning methods. Experimental testing of the new solutions will take time. It will be carried out as part of the research

and development programme for the fourth generation reactors *(Pradel 2006, Minato et al. 2006)*. The objective is that new reactors are efficient actinide recycling and transmutation plants. If fast reactor demonstration plants are commissioned in 2020–2025 as Japan, France and the United States are now planning, they will, at first, use uranium and plutonium fuel which is separated and will be processed at reprocessing plants similar to the current plants.

Similar to regular reprocessing, the most efficient partitioning and transmutation technology will not remove the need for the final disposal of high-level nuclear waste. It may alleviate the technical requirements set for final disposal and reduce the need for disposal facilities *(NEA 2006)*, but some of the long-lived radionuclides will require geological final disposal.

1.12.3 Volume of reprocessing waste

An ordinary reprocessing plant produces three types of nuclear waste. The actual high-level nuclear waste consists of fission products, so-called by-product actinides (neptunium, americium and curium), as well as small amounts of non-extracted uranium and plutonium. It is solidified at the waste processing plant of La Hague, mixed with borosilicate glass, and put into standard-size vessels (diameter 43 cm, height 134 cm, effective volume about 0.18 m³). The volume of high-level waste currently generated is 0.13 m³ for each ton of uranium in the original fuel. Fuel rod claddings and other structural materials are also placed in similar vessels. They have managed to reduce the volume of this waste to 0.18 m³ per ton of uranium at La Hague. The operation of the plant also generates about 1.3 m³ of low and intermediate level waste with a short half-life per ton of uranium *(Hanson 2007)*.

According to Posiva's current plans, the spent nuclear fuel will be placed in canisters that have a volume in the range of 3–4.5 m³. The canisters will contain either 4 or 12 fuel assemblies with an original uranium mass of 1.4 to 2.2 tons *(Raiko 2005)*. These figures show that the volume of high-level nuclear waste to be disposed of will be in the range of 1.9 to 2.1 m³/tU. At best, reprocessing only produces one-fifth of the high-active waste requiring final disposal when compared to direct final disposal.

Reprocessing creates extracted uranium and plutonium, most of which is currently stored. Reprocessed uranium (RepU) can be handled like natural uranium, even though its activity is higher. It is usually stored in oxide form (UO_3 or U_3O_8) in 150–200-litre barrels *(IAEA 2007)*. The storage of reprocessed plutonium requires special measures, both because of the proliferation risk and for ensuring criticality safety. Attention must also be paid to radiation protection. Plutonium is stored in lots of few kilograms.

1.12.4 Geological final disposal of high-level waste

The requirements for geological final disposal facilities are usually determined on the basis of thermal analyses. During a cooling period extending to less than one hundred years, the fission products (mainly Sr-90 and Cs-137) generate most or the major part of the residual heat. That is why spent nuclear fuel and currently produced high-level reprocessing waste require roughly equal volumes.

In many safety analyses carried out for final disposal solutions, the highest dose rates are caused by fission products that readily migrate in the groundwater in the bedrock, such as I-129, Tc-99, Cs-135 and Se-79, for example. That is why the final disposal of spent nuclear fuel and that of high-level reprocessing waste do not significantly differ from each other from this point of view. Having said that, we must remember that, currently, most or part of iodine and technetium is still released into seawater in a controlled manner. However, the goal is to discontinue such practices in the near future. So far, there are grounds for including them in the safety analyses of final disposal facilities.

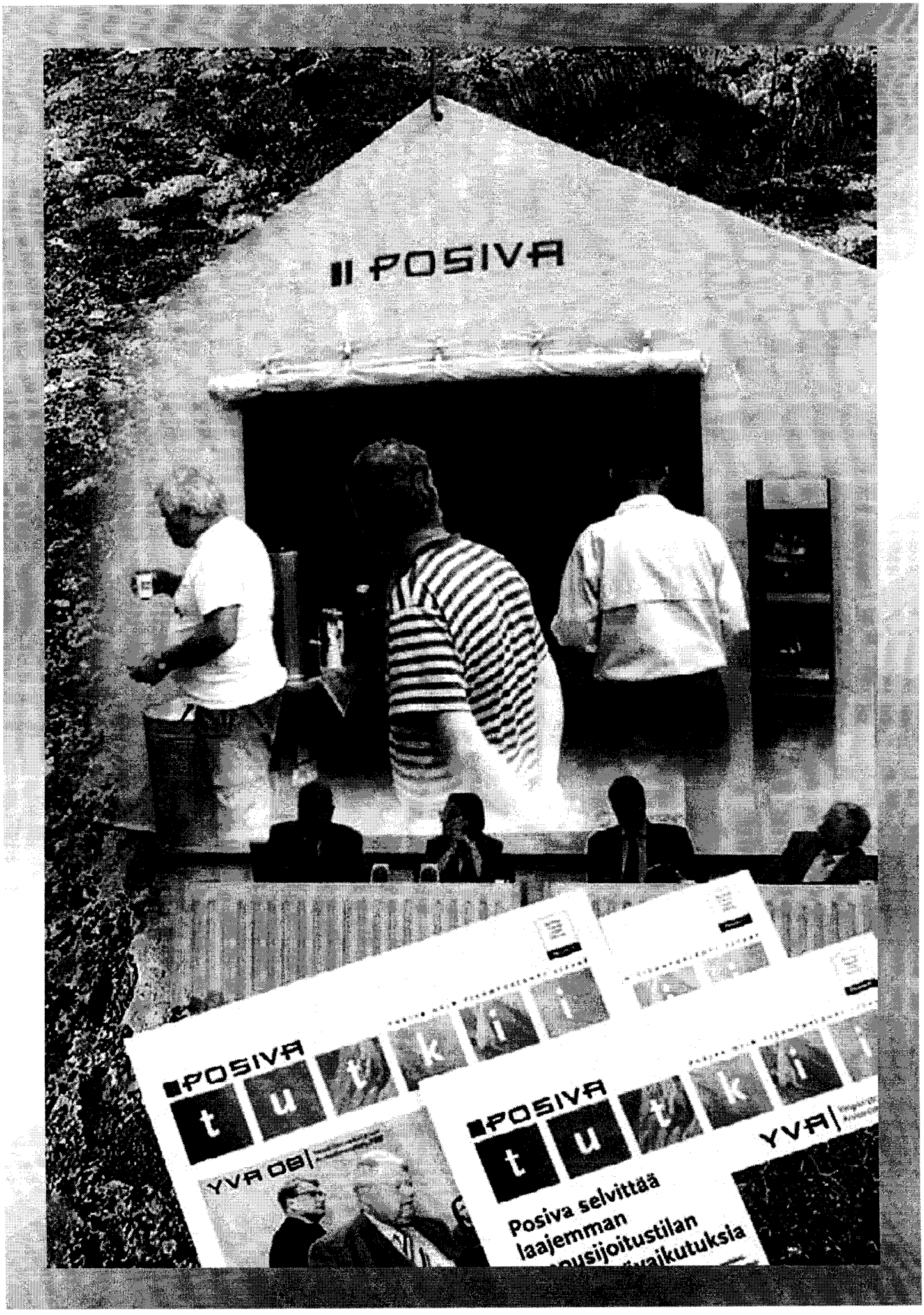
In advanced fuel cycles, the goal is to separate both heat-generating and readily mobile fission products from high-level nuclear waste. If that were to be accomplished, the need for geological disposal facilities could be significantly reduced while somewhat improving the safety of the final disposal. Achieving that goal still requires plenty of research and development. Adding new separation steps to the reprocessing process, and achieving the required separation efficiency in particular, may increase the volume of secondary waste *(INL 2007, NEA 2006, Westlen et al. 2007)*.

1.12.5 Cost comparison

The economic comparison of the costs of direct final disposal and advanced nuclear fuel cycles is hampered by the lack of reliable price information. Ordinary reprocessing is a commercial operation, and the companies prefer not to announce their costs in public. The development work for new technical solutions is still in progress. The normal practice in economic comparisons is that a probable basic price is chosen for each alternative and that is associated with a certain fluctuation range that is bigger the more distant from commercial applications the process in question is.

Studies on the price of nuclear electricity clearly indicate that the investment cost of the reactor is the biggest single factor affecting the price. The investment costs accounts for 60–70 percent of the price. When one further takes into account the operating and maintenance costs of the reactor, accounting for some 15–20 percent of the price of electricity, the significance of other costs in the fuel cycle can be deemed rather low. In the latest comparison of fuel cycles *(NEA 2006)* produced by the so-called development committee of OECD/NEA, the relative share of fuel procurement and production was shown to be slightly less than 10 percent in case of a direct fuel cycle. The cost of reprocessing was estimated to be of the same order. The relative share of nuclear waste management of the total price of nuclear electricity is always very small, at most a few percent. The basic result of this comparison was that although the fuel costs in some advanced fuel cycles could be double compared to those of an open cycle, the difference in the total price of electricity was only 20 percent at maximum.

The availability and price of raw uranium are the most important variables in the economic comparison of fuel cycles. If the price of uranium stabilises on a sufficiently high level, reprocessing will be competitive compared to direct final disposal *(NEA 2006, Hanson 2007)*.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2 EIA procedure, communications and participation

2.1 Need for and objectives of the EIA procedure

The Directive (85/337/EEC) issued by the Council of the European Community (EC) has been executed in Finland under the Act on the Environmental Impact Assessment Procedure (468/1994) and EIA Decree (713/2006). Facilities intended for the processing, storage and final disposal of nuclear waste created through the production of nuclear energy fall within the scope of the Act on the Environmental Impact Assessment Procedure and require an environmental impact assessment. According to the EIA Act, the Ministry of Employment and the Economy acts as the coordinating authority for EIA projects associated with nuclear facilities referred to in the Nuclear Energy Act.

The objective of the environmental impact assessment procedure (EIA procedure) is to promote the assessment and uniform observation of environmental impacts in planning and decision-making. Another objective of the procedure is to increase the opportunities for citizens to be informed, become involved in the planning of projects and express their opinions on the project.

Thus the EIA procedure does not make any decisions concerning the project or resolve any licensing issues; its objective is to produce information to serve as a basis for decision-making.

2.2 The main stages of the EIA procedure

The EIA procedure includes a programme stage and a report stage. The EIA programme completed in May 2008 presented the project's implementation options and the method to be used for assessing the impacts. Then, the citizens had the opportunity to present their opinions of the EIA programme and its comprehensiveness. The Ministry of Employment and the Economy requested statements on the EIA programme from different authorities and other parties, compiled the statements and opinions given and issued its own statement on 22 August 2008.

At the second stage, i.e. the EIA report stage, an environmental impact assessment report (this EIA report) was prepared on the basis of the EIA programme and the opinions and statements. The EIA report will present information about the project and a coherent assessment of its environmental impacts resulting from the assessment procedure. The EIA report presents the following:

- the options under assessment
- the present state of the environment
- the environmental impacts of the various options and the significance of these impacts
- a comparison of the assessed options (6,500 tU, 9,000 tU and 12,000 tU)
- measures to prevent and mitigate adverse impacts
- a proposal for an environmental impact assessment monitoring programme
- actions taken to facilitate interaction and involvement during the EIA procedure
- how the ministry's statement on the EIA programme has been taken into account in the assessment.

Once the EIA report is completed, citizens may present their opinions on it. Furthermore, official bodies will submit their statements on the EIA report to the Ministry of Employment and the Economy.

The EIA procedure is completed when the Ministry of Employment and the Economy provides its statement on the EIA report. The EIA report and the relevant statement by the coordinating authority are appended to the application for a decision-in-principle.

2.3 Communications and participation

An important part of the project's environmental impact assessment was the participation of different parties in the EIA procedure. The purpose of participation was to achieve interaction between those responsible for the disposal plans and the parties taking part in the EIA procedure. The parties involved in Posiva's EIA procedure are presented in Figure 2-1.

The purpose of interaction was to contribute to the recognition of the impacts to be assessed at the preparation stage for the EIA programme and in the later assessment process. Furthermore, the purpose was to introduce the knowledge of experts and the opinions of citizens on the

project and its assessed impacts to mutual discussion. Interaction was also used to reduce any misunderstandings and conflicts caused by the lack of information between the parties.

2.3.1 Audit group work

An audit group consisting of different interest groups was established, summoned by Posiva, to promote data flow and interaction in the EIA procedure. The parties to the audit group were selected so that the views of different parties would be presented. A month before the first meeting, an invitation was sent to the summoned parties, requesting the parties to appoint their representatives for the audit group. At the same time, the representatives were invited to the audit group's first meeting. The parties invited to the audit group were presented in the meeting. There were no proposals for changing the composition of the audit group.

The following parties appointed their representatives to the audit group:

- Municipality of Eurajoki
- Municipality of Kiukainen
- Municipality of Lappi
- Municipality of Luvia
- Municipality of Nakkila
- Ministry of Employment and the Economy
- Provincial State Office of Western Finland
- Southwest Finland Regional Environment Centre
- Satakunta Regional Council
- Satakunta Regional District of the Finnish Association for Nature Conservation
- TE Centre for Satakunta
- Rauman Seudun Kehitys Oy
- Fortum Power and Heat Oy
- Teollisuuden Voima Oyj (TVO).

In addition to the participants, other parties invited included the Town of Rauma, the municipality of Eura, the Radiation and Nuclear Safety Authority (STUK), the Western Finland Environmental Permit Authority, the Safety Technology Authority (TUKES) and the Rescue Department of Satakunta.

Audit group meeting of 8 April 2008

The audit group convened twice during the EIA procedure. The first meeting was held in the Vuojoki Mansion in Eurajoki on 8 April 2008. In addition to the representatives of Posiva and the EIA consultant, eight others participated in the meeting. The meeting presented the project, the EIA procedure and the draft for the EIA programme to the audit group representatives. The draft for the EIA programme was sent to the audit group members in advance.

At the audit group's meeting, the following issues gave rise to discussion: the definition of the zero option, the inspection area for the impact of traffic, the tightness and welding of the final disposal canisters, the need for land use in the repository and the impact assessment methods targeted at the bedrock and groundwater. In addition, the audit group provided additional information and correc-

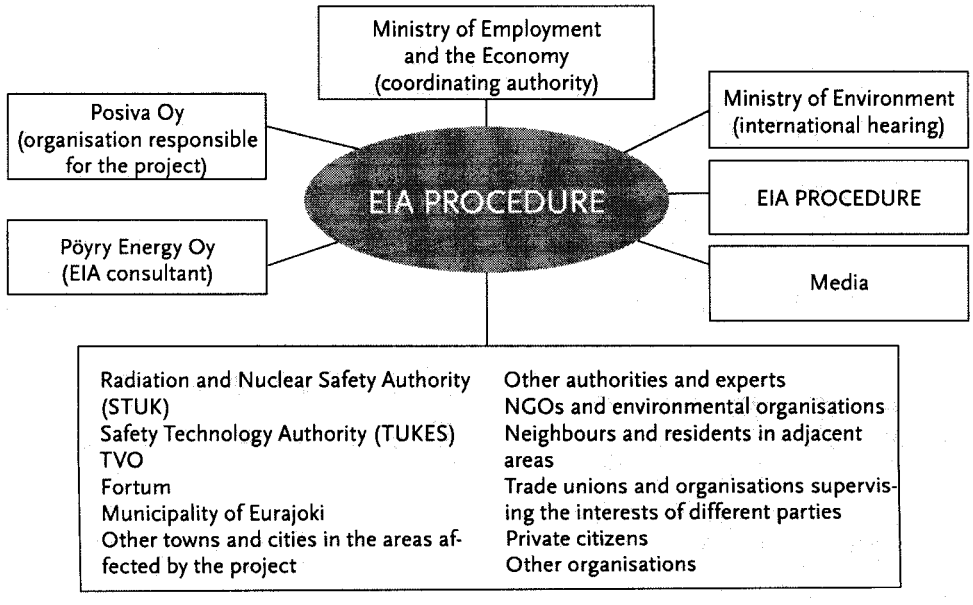


Figure 2-1 The parties who were involved in Posiva's EIA procedure.

tions concerning the present status of the environment. Minutes of the meeting were prepared and submitted to all of the audit group members. Comments and clarifications received during and after the meeting were taken into account in the preparation of the EIA programme to the largest possible extent as far as they concerned the EIA programme. Otherwise, any comments were taken into account in the implementation of the EIA procedure and in the EIA report. The most salient questions brought up in the audit group meeting were also repeated in the statements issued and opinions expressed regarding the EIA programme.

Audit group meeting of 27 August 2008

The second audit group meeting was held at the Vuojoki Mansion in Eurajoki on 27 August 2008. The meeting's topics included the coordinating authority's statement on the EIA programme and the draft for the EIA report. In addition to the representatives of Posiva and the EIA consultant, six other persons participated in the meeting. The audit group had the opportunity to present opinions on the preparation of reports and the consideration of the results in the EIA report. The draft for the EIA report was sent to the audit group members in advance. The following topics were discussed in the meeting:

- the safety of spent nuclear fuel transportation and ensuring it
- the amount of water seeping into the open rock cavities and the lowering of groundwater table level
- sealing of the final disposal tunnels (sealing techniques)
- situations where rock excavation work cannot be carried out (clarification of principles and criteria)
- location of rock fracture zones in relation to the final disposal facilities
- make-up of participation groups.

The following elements of the EIA report were further specified on the basis of comments obtained from the audit group:

- description of the methods for managing the impacts of transport of spent nuclear fuel
- description of the sealing of the final disposal facilities
- description of the assessment of the suitability of the location for building a final disposal facility (acceptance principles and criteria).

The report was also supplemented with an illustration of the locations of the underground disposal facilities and the main rock structures restricting the layout.

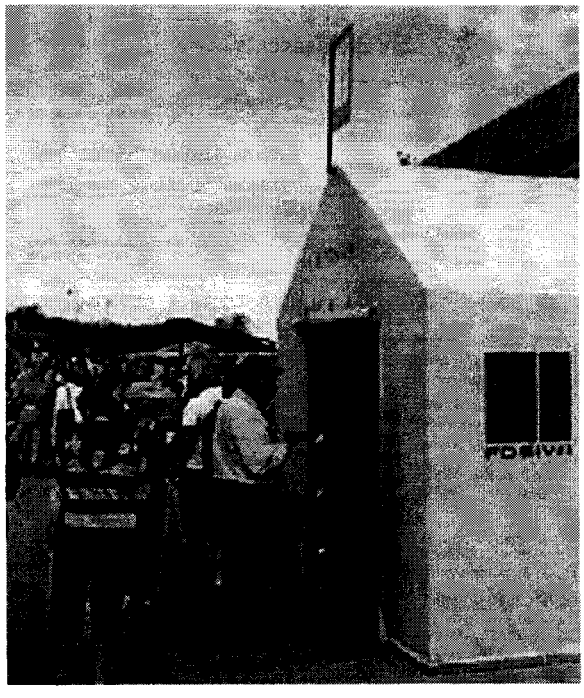
2.3.2 Briefing and discussion events

Residents' event organised for local and holiday residents

A public event for Olkiluoto residents and nearby and holiday residents of Olkiluoto was arranged in Vuojoki Mansion in Eurajoki on 19 March 2008. Some 30 persons participated. The project and the EIA procedure were presented in the event. The residents had an opportunity to ask questions and present comments relating to the project. The following themes were discussed in the meeting:

- new projects planned for Olkiluoto
- rock cavity volume required by the repository
- land usage in Olkiluoto and the location of the repository
- reprocessing of spent nuclear fuel.
- increase in bedrock temperature caused by final disposal operations
- radiation effects of the repository
- location of the encapsulation plant
- electricity consumption forecasts and generation methods
- the suitability of the bedrock for repository purposes.

One resident was concerned about how Posiva had examined the strength, crush structure and rock types of the bedrock. There was also concern about how young people in the area can be activated to handle issues that relate to them. All questions and opinions were recorded and discussed when preparing the EIA programme and report.

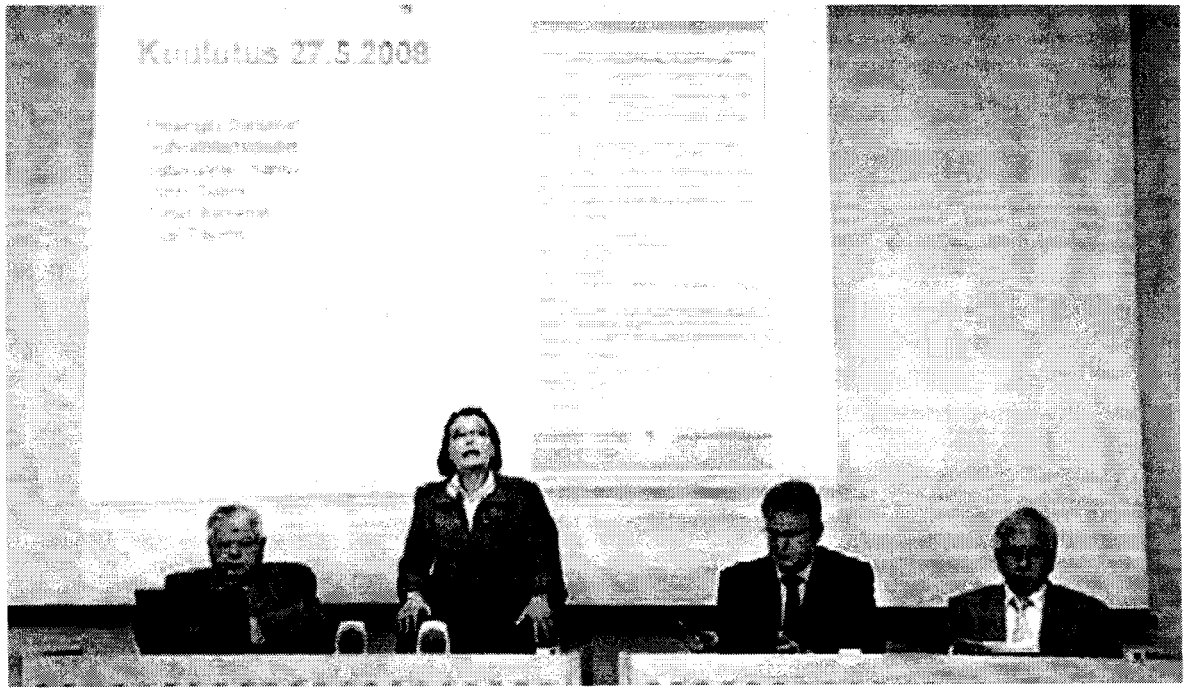


Events open to the public

A public event open for everyone concerning the project and its environmental impact assessment was organised in the Eurajoki Municipal Hall on 9 June 2008. Posiva's disposal project in Olkiluoto, the expansion of the repository, the environmental impact assessment procedure and related interaction and the possibilities of having an influence were presented in the public event. The public had the opportunity to ask questions and discuss the EIA procedure with representatives of the Ministry of Employment and the Economy, Posiva and the authors of the EIA programme. In addition to the representatives of Posiva, the EIA consultant and the authorities, ten other people participated in the event. The municipal manager of Eurajoki acted as the chairman. All statements presented in the event were recorded. The following is a summary of the issues and comments raised at the event, together with the answers to them.

1. It was asked in the public event why the expansion of the repository by 3,000 tons of uranium is already being handled in 2008, even though the final disposal of spent nuclear fuel will not be started before the 2070s.
   The process complies with the Nuclear Energy Act, which requires separate decisions-in-principle for each new nuclear power plant. The environmental impact assessment report is to be enclosed with the decision-in-principle. No decisions on whether the project is to be implemented or not are taken in the EIA procedure.
2. The participants enquired in the event about the location of the record number attached to written opinions and the display of issued opinions on the Ministry of Employment and the Economy's website.
   The record number can be found in the EIA programme's public announcement. All statements and opinions issued by the residents will be published on the ministry's website.
3. The tight schedule of the assessment report raised questions as it was considered to be alarming in terms of taking the residents' opinions truly into account.
   The EIA report prepared in 1999 and revised in spring 2008 is utilised when preparing the new EIA report. However, there will be more time if it is required for completing the report.
4. The international hearing also caused some astonishment. A resident wondered why statements must be requested from countries neighbouring Finland, even though the final disposal is not regarded as dangerous.
   The process follows an interpretation of the Espoo Convention, which prescribes an international hearing and according to which neighbouring States must be provided with the possibility to take part in the hearing, even though the project does not have any transboundary impacts.

In addition to the aforementioned points, it was proposed that more attention should be paid to the thermal impact of spent nuclear fuel, the disposal area should face away from residential areas, attention should be paid to the representation of citizens in public events, municipal authorities should be obligated to participate in the events and the



municipality's young people should be activated to discuss important matters. The questions and comments raised in the public event have been taken into account when preparing the assessment report.

Another open public event will be organised after the completion of the EIA report together with the Ministry of Employment and the Economy. The EIA project's results and the EIA report will be presented at the event.

2.3.3 Theme interviews

As part of the assessment of social impacts included in the EIA procedure, theme interviews were organised for nearby residents of Olkiluoto and the municipality's young adults, through which new information was obtained about the residents' attitudes towards the project. Through the theme interviews, the residents were able to present their opinions on matters and impacts important to them. Twenty-one persons were invited to take part in the theme interviews. The interviewees were selected so that all significant aspects concerning the project's impacts were identified. Eleven nearby/holiday residents and ten young adults living in the municipality were interviewed. The selection of young people as the target group was based on a comment presented at a public event in 2008, according to which the municipality's young people should be taken into account in the environmental impact assessment procedure. The second target group selected included those residents in the surrounding region that are mostly affected by the project. The interviews were carried out in Eurajoki in June 2008. The themes included knowledge of the disposal project, the future in Eurajoki, sense of security, communications and the availability of information. The results of the theme interviews are reported in Chapter 9.11.

2.3.4 Other communications and interaction

Posiva has given notification of the EIA procedure related to the expansion of the Olkiluoto repository in the Posiva Tutkii publication which is published five times a year. The publication has been a supplement of the Uusi Rauma and Satakunnan Viikko newspapers. The distribution of these papers covers the households in the municipalities of Rauma, Eurajoki, Lappi, Pyhäranta, Eura, Laitila, Pori, Ulvila, Luvia and Noormarkku. A postage-free feedback card for the EIA procedure was delivered to all households in Eurajoki in the Posiva Tutkii magazine issued in Febraury 2008. Thirteen feedback cards were sent to Posiva and the questions presented in them were handled in the Posiva Tutkii issue 2/2008.

The EIA procedure has been announced to a larger extent through media at the beginning of the programme stage and after the completion of the EIA programme report.

Material concerning the EIA procedure is available and on public display in the Olkiluoto Visiting Centre. Material presenting the EIA project will be displayed in the Eurajoki Municipal Hall throughout the EIA procedure.

During the EIA procedure, the final disposal project's expansion has been presented to Eurajoki residents in Posiva's exhibition section in Eurajoki marketplace on 14 June 2008 and at the fair on 16 August 2008. In addition, the project was presented at the national Environmental Technology 08 exhibition in Helsinki on 10–12 September 2008.

The EIA programme and report and their summaries are available for viewing on Posiva's website *(www.posiva.fi)* where everyone has had the possibility to send feedback on the EIA procedure. The EIA programme and report and related statements and opinions are available for viewing on the Ministry of Employment and the Economy's website *(www.tem.fi)*.

2.4 Public display of the EIA programme

The EIA procedure started as Posiva submitted the EIA programme, i.e. a plan for assessing environmental impact, to the Ministry of Employment and the Economy on 13 May 2008. The announcement concerning the start of the assessment procedure was published in the Helsingin Sanomat, Hufvudstadsbladet, Satakunnan Kansa, Turun Sanomat, Uusi Rauma and Länsi-Suomi newspapers on 27 May 2008. The announcement was also displayed on the Ministry's website.

The assessment programme was on public display in the municipal offices of Eurajoki, Eura, Kiukainen, Lappi, Luvia and Nakkila and the environmental office of Rauma on 27 May – 25 July 2008. In addition, the assessment programme was displayed on the websites of Posiva and the Ministry of Employment and the Economy. The Ministry, together with Posiva, organised a public event at the beginning of the assessment programme's display period on 9 June 2008.

2.5 The coordinating authority's statement on the EIA programme and its application

The Ministry of Employment and the Economy issued its statement on the project's EIA programme on 22 August 2008. The entire statement is appended to this report (Appendix 1). In its statement, the Ministry writes that, for the most part, Posiva's EIA programme covers the requirements of EIA legislation regarding content and that it has been processed in the manner prescribed in the EIA leg-

Table 2-1 The application of the coordinating authority statement on the assessment programme.

The coordinating authority's statement on the assessment programme	How the statement was taken into account in assessment work (references to sections of this EIA report)
The EIA report must be drawn up in such a manner that all the different points in the coordinating authority's statement set out in Chapter 4 (Appendix 1) are appropriately taken into account.	The different points in the coordinating authority's statement have been taken into account in the EIA report. This table shows how they were taken into account.
The statements and opinions include questions, comments and points of view that must be addressed appropriately and extensively enough in the EIA report while correcting any defects or incorrect information clearly pointed out.	The viewpoints and questions presented in the statements and opinions have been responded to as comprehensively as possible in the EIA report. Any defects and possible incorrect information pointed out in the EIA programme have been corrected in the respective sections of the EIA report.
The questions put in the international assessment must be answered both in the EIA report and in the summary of the international assessment to be drawn up on its basis. The material to be translated into the languages of the countries concerned must be sufficiently extensive and include the information prescribed in Appendix II to the Espoo Convention. The EIA report must be appended, as a separate section, with a description of the transboundary impacts. The material must indicate how the comments of the countries participating in the EIA procedure by virtue of the Espoo Convention have been taken into account.	The questions put in the international assessment and the related answers, as well as the issued comments and taking them into account are discussed in Chapters 2 and 13 as well as in the EIA report summary. Both the EIA report and its summary include a table indicating how the comments of the countries participating in the EIA process have been taken into account. The transboundary impacts are shown in Chapter 13 of the EIA report as a separate sub-chapter and in the EIA report summary that will be used as the document for the international hearing. The EIA report shows the information prescribed in Appendix II to the Espoo Convention.
Attention must be paid to the content and scope of the descriptions in the EIA report. The detail content of texts of a general nature should be reviewed, and, where required, the description must be more detailed than is set out in the EIA programme.	The organisation responsible for the project considers the content and scope of the descriptions to be sufficient. The texts have been enhanced by adding more detail when compared to the EIA programme (among others the descriptions of the repository and the disposal techniques).
Attention must be paid to the clarity and quality of drawings and map presentations.	The figures, drawings and maps selected for the report are the clearest ones available.
Project description and alternatives	
The project assessed through the EIA procedure is the construction of final disposal facilities in expanded size so that they are then capable of accommodating 12,000 tons of uranium.	The project assessed through the EIA procedure is the construction of final disposal facilities in expanded size so that they are then capable of accommodating 12,000 tons of uranium instead of the previously proposed 9,000 tons of uranium.
The EIA report is to describe final disposal facilities capable of accommodating 12,000 tons of uranium.	The repository facilities for the final disposal of 12,000 tU have been described in the EIA report. Among others, Figure 3-5 describes the location of the underground disposal facilities.
The EIA report must also present a description of facilities for accommodating 6,500 tU and facilities where 9,000 tU of spent nuclear fuel would possibly be placed.	Among others, Figure 3-5 shows the location of the underground disposal facilities. The disposal facilities for the current plants and plants under construction (6,500 tU), the expansion for a fuel volume of 9,000 tU and the expansion for a fuel volume of 12,000 tU have been indicated by markings in the figure.
The EIA report should describe intermediate storage as an activity preceding final disposal. The significance of intermediate storage from the point of final disposal should also be discussed.	Intermediate storage is described in more detail in Section 12.1 of the EIA report.
The Ministry deems it well justified that the assessment report should present a review of the current status of reprocessing and nuclide transmutation methods and their future outlook.	Section 1.12 presents the current status of reprocessing and nuclide transmutation technologies and their future outlook.
The EIA report must describe how the suitability of the location for building and expanding the repository is assessed.	Sections 11.4 and 15.10 describe how the suitability of the location for building and expanding the repository is assessed.
Impacts and establishing them	
The assessment must address the questions and comments presented in the statements and opinions to an extent that is sufficient from the point of the EIA procedure.	The viewpoints and questions presented in the statements and opinions have been responded to as comprehensively as possible in the EIA report.
The environmental impacts must be assessed for the entire extent of the repository, taking into account the expansion of the facilities. This means that the EIA report must show the environmental impacts of the final disposal facilities in a situation where 12,000 tU of spent nuclear fuel is placed in the repository. In order to compare the alternatives, the environmental impacts must be shown in situations where either 6,500 tU or 9,000 tU of spent nuclear fuel is placed in the repository.	The EIA procedure has assessed the expansion of the repository so that the total amount of spent nuclear fuel to be disposed of will be 12,000 instead of 9,000 tons of uranium. In order to compare the alternatives, the environmental impacts are shown for situations where either 6,500 tU, 9,000 tU or 12,000 tU of spent nuclear fuel is placed in the repository.
The environmental impacts must be shown in an illustrative manner so that the environmental impacts in different situations are clearly indicated.	Attention has been paid to showing the environmental impacts in an illustrative manner. In order to improve the ease of comparing the alternatives, a table showing a comparison between different fuel volumes to be disposed of has been added at the end of the report.
The assessment must pay attention to transboundary impacts. The impacts on the countries participating in the international hearing must be assessed.	The transboundary impacts are shown in Chapter 13 of the EIA report and in the EIA report summary that will be used as the document for the international hearing.

The geographical area limits that are to be used and have been used when assessing the impacts should be reviewed, and the reasons for omitting any areas from the assessment should also be stated in the EIA report.	The environmental impacts of the repository for spent nuclear fuel have been considered, in particular, in the immediate environment of the facility, where the impacts during the construction and the operation of the facility can be clearly identified. Therefore, the opinions, fears and expectations concerning the final disposal have been surveyed primarily among the people living in Olkiluoto island and the immediate environment. This delimitation is further supported by the results of the resident and employee survey in the Olkiluoto power plant area (Ramboll Finland Oy 2007), according to which the negative opinions concerning the safety of the final disposal are more prominent among the people living in the nearest vicinity of the power plant area, but become more moderate further away. Furthermore, due to resident feedback gained during the EIA programme stage, the survey has been extended to cover more young people and families with children who live in Eurajoki. Even if the environmental impacts caused by the final disposal project are relatively minor and geographically limited, the impacts on economy and employment extend over a wider area than the one considered above. Therefore, as regards the impacts on regional economy, the survey covers, besides Eurajoki, also the neighbouring municipalities (the region), the Satakunta area and the national level.
The impact assessment must also take into account the total impact and cumulative impacts that are caused by other projects in Olkiluoto. The combined effects of traffic, also taking into account the traffic related to the Olkiluoto power plant area, must be established, for example.	Among others, the traffic studies and noise model take into account the combined effects of the projects planned for Olkiluoto.
Certain information presented in the EIA programme must be made more specific, supplemented and possibly also corrected. These include: – further clarification of town planning issues – complementing the assessment of aquatic impacts (impacts on tap water, wells of private houses and their water quality, as well as on public bathing beaches) – habitat and abundance of the black Apollo butterfly – assessment of updating the birdlife survey – impacts on landscape – necessity of having roads in the conservation area.	The town planning issues are discussed in Sections 5.1, 8.1.2 and 9.2. The impacts on tap water, bore wells and public bathing beaches are discussed in Sections 9.3 and 9.5. Further details of the habitat of the black Apollo are presented in Section 8.6. A map showing the locations of spring corydalis populations in the island of Olkiluoto has been added to the section, for example. The project does not have any significant impacts on birdlife. There is no need to update the birdlife survey. However, the latest information on birdlife has been added to the EIA report. The impacts on landscape are described in Section 9.2. The new road connection to Olkiluoto is connected to the partial master plan for Olkiluoto and is not discussed in this EIA procedure for the expansion project of Posiva's repository. Posiva does not need a road on the conservation area.
Plan regarding the organisation of the assessment procedure and its associated participation	
The participation arrangements during the EIA procedure must be reviewed and supplemented.	The participation arrangements during the EIA procedure are described in Section 2.3.
The Ministry urges the organisation responsible for the project to ensure that sufficient time is reserved for preparing the EIA report.	The updated EIA report on the repository's environmental impacts, finalised in spring 2008, was utilised when preparing this EIA report. The necessary time was used for preparing the report.
The entire area of impact, irrespective of municipal boundaries and all population groups, must be sufficiently taken into account in communications and interaction.	The neighbouring municipalities to Eurajoki have been invited to join the project audit group. The public events have been open to all. The participation of young people was ensured by inviting them to theme interviews carried out during the EIA procedure.
The EIA report must clearly indicate how the statements issued and opinions expressed in conjunction with the hearing, as well as the comments received from the audit group, have been taken into account.	The viewpoints and questions presented in the statements and opinions have been responded to as comprehensively as possible (section 2.6). Section 2.3.1 shows how the comments received from the audit group were taken into account in the EIA report.
The EIA report must indicate the rationale behind the active and passive selection of the participants and the make-up of groups, as well as the possibilities for inviting expert authorities from the national level of the public sector to join in the assessment process.	Section 2.3 of the EIA report shows the rationale behind the active and passive selection of the participants and the make-up of the groups. Representatives from the Nuclear Safety Authority and the Safety Technology Authority were invited, among others, to join the audit group, but they declined. Posiva works in close co-operation with the experts of the Nuclear Safety Authority.
The Ministry would prefer the possible application for a decision-in-principle to be submitted to the Government only after the process of circulation for comments has been completed.	In its deliberations regarding the submission of the application for a decision-in-principle, Posiva will take into account the recommendation of the Ministry of Employment and the Economy.

islation. The Ministry states that the EIA report must be drawn up in such a manner that all the different points in the coordinating authority's statement are appropriately taken into account.

The issues presented in the Ministry's statement have been taken into account and included in the EIA report as applicable. Furthermore, the viewpoints and questions presented in other statements and opinions have been responded to as comprehensively as possible.

The statements and opinions presented on the assessment programme and the coordinating authority's statement are available for viewing on the website of the Ministry of Employment and the Economy. Table 2-1 presents the issues that, according to the statement, must be taken into consideration when carrying out studies and preparing the assessment report. In addition, the table presents how the Ministry's statement has been taken into account when organising the assessment procedure and preparing the assessment report.

2.6 Statements and opinions on the EIA programme and their significance for the EIA procedure

In addition to the announcement published in newspapers, the Ministry of Employment and the Economy requested written statements on the EIA programme from the Ministry of the Environment, the Ministry of the Interior, the Ministry of Social Affairs and Health, the Ministry of Defence, the Ministry of Finance, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, the State Provincial Office of Western Finland, the Western Finland Environmental Permit Authority, the Finnish Environment Institute, the Radiation and Nuclear Safety Authority, the TE Centre for Satakunta, the TE Centre for Southwestern Finland, Satakuntaliitto, the Occupational Safety and Health Inspectorate of Turku and Pori, the Southwest Finland Regional Environment Centre, the Uusimaa Regional Environment Centre, the Safety Technology Authority, AKAVA, the Confederation of Finnish Industries, Finnish Energy Industries, WWF, Greenpeace, the Finnish Association for Nature Conservation, Natur och Miljö rf, the Central Union of Agricultural Producers and Forest Owners (MTK), the Central Organisation of Finnish Trade Unions (SAK), the Federation of Finnish Enterprises, the Finnish Confederation of Salaried Employees (STTK), Fingrid Oyj, Fortum Power and Heat Oy, Teollisuuden Voima Oyj and the following towns and municipalities: Eurajoki, Eura, Kiukainen, Lappi, Luvia, Nakkila and Rauma.

A total of 25 statements were submitted to the Ministry of Employment and the Economy. The following organisations did not issue a statement: the Ministry of the Interior, the Ministry of Defence, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, the Western Finland Environmental Permit Authority, the Finnish Environment Institute, the TE Centre for Satakunta, the municipality of Kiukainen, the municipality of Nakkila, WWF, the Central Union of Agricultural Producers and Forest Owners (MTK), the Federation of Finnish Enterprises, the Finnish Confederation of Salaried Employees (STTK) and Fortum Power and Heat Oy.

A total of 21 opinions were submitted, of which 11 represented associations, organisations and networks, and 10 private individuals. The following associations presented their opinion: The Artists for a Clean Future network, the Edelleen Ei ydinvoimaa popular movement against nuclear energy, Fennovoima Oy, the Irish Doctors' Environmental Association, the Lappilaiset Uraanivoimaa Vastaan popular movement against uranium energy, the Loviisa movement, the Naiset Atomivoimaa ja Uraanilouhintaa Vastaan popular movement against nuclear energy and uranium mining, the Naiset Atomivoimaa Vastaan popular movement against nuclear energy, the Naiset Rauhan Puolesta popular movement for peace, Réseau Sortir du Nucléaire and the Women's network against uranium mining and nuclear power.

A summary of the statements and opinions received is included in the statement by the Ministry of Employment and the Economy (Appendix 1, Chapter 3). The opinions and statements received regarding the EIA programme are available for viewing on the website of the Ministry of Employment and the Economy *(www.tem.fi)*.

The questions, remarks and views put across in the statements were taken into account when preparing the EIA report. The most prominent ones are:

- In order to compare the alternatives, the environmental impacts are shown for situations where either 6,500 tU or 9,000 tU of spent nuclear fuel is placed in the repository.
- The report describes how the suitability of the location for building and expanding the repository is assessed.
- The descriptions of the repository and disposal techniques have been enhanced by adding more detail when compared to the EIA programme.
- The safety and environmental impacts of the transportation of spent nuclear fuel have been described in the EIA report.
- Attention has been paid to describing long-term safety. Long-term changes in natural conditions, such as climate change, were taken into account in the assessment.
- Malfunction and accident situations have been described in a detailed and comprehensible manner.

- Combined impacts together with other functions planned in Olkiluoto have been discussed. Among others, the traffic studies and noise model take into account the combined effects of the projects planned for Olkiluoto.
- The EIA report presents alternative methods for reprocessing spent fuel by presenting an overview of the current status of reprocessing and nuclide transmutation technologies and their future outlook.
- In order to improve the ease of comparing the alternatives, a table showing a comparison between the different fuel volumes to be disposed of has been added at the end of the report.
- The principles of communications and participation during the EIA procedure are explained in the report.
- Attention has been paid to the extent of the scope for inspecting functional and technical-economical impacts and impacts on people The impacts on the regional economy, for example, have been studied for a region extending beyond Eurajoki because the impacts will extend further. The studied area was chosen by the extent of impacts, and the areas vary depending on the impact being considered. The assessment of impacts on public image was limited to Eurajoki because it is the municipality where the repository is to be located.
- Several comments expressed concerns that the building of a repository will result in nuclear waste from other countries being imported to Finland. According to the Finnish Nuclear Energy Act, the import of nuclear waste is prohibited, and all nuclear waste generated in Finland must be finally disposed of in Finland. This fact is stated clearly in the EIA report.

2.7 International hearing

The assessment of transboundary environmental impact has been agreed upon in the Convention on Environmental Impact Assessment in a Transboundary Context. Finland ratified the Convention of the United Nations Economic Commission for Europe (67/1997) in 1995. The Convention entered into force in 1997.

The parties to the Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland if the project under assessment is likely to have significant transboundary environmental impacts. Correspondingly, Finland is entitled to take part in an environmental impact assessment procedure of a project located in the area of another state if the project's impact is likely to extend to Finland.

This transboundary assessment procedure is applied to the repository project of Posiva. In Finland, the Ministry of the Environment is responsible for the practical arrangements of the international hearing. The Ministry of the Environment notified the environmental authorities of Sweden, Norway, Estonia, Latvia, Lithuania, Germany, Denmark, Poland and Russia of the commencement of the EIA procedure concerning the expansion of Posiva's repository and inquired about the willingness of these countries to participate in the EIA procedure. The authorities of the countries were provided with the EIA programme in Swedish or English and a summary of the EIA programme translated in the language of each country. The summary acts as the international hearing document.

Sweden, Germany, Norway and Estonia announced that they would like to participate in the EIA procedure. Sweden also made comments and suggested supplementing changes to the EIA programme. Denmark, Lithuania and Poland responded to the Ministry of the Environment that they will not participate in the EIA procedure. The Ministry of the Environment has not received a response from Latvia or Russia. The statements given on the assessment programme are available on the Ministry of Employment and the Economy's website.

Several international statements discussed the same issues as other statements and opinions issued regarding the EIA programme. The issues highlighted included the impacts of malfunctions and accidents and long-term safety in particular. With regard to these questions, the statements paid particular attention to transboundary impacts. The major subjects covered by the questions and comments included in the international statements are discussed in Table 2-2.

Once the EIA report is completed, the authorities of the countries taking part in the EIA procedure will provided with the EIA report in Swedish or English and a summary of the EIA report translated in the language of each country. The summary acts as the international hearing document.

2.8 Public display of the EIA report

The Ministry of Employment and the Economy will announce the public display of the assessment report once Posiva has submitted the assessment report to the Ministry. The public display will be arranged similarly to that of the assessment programme. According to the EIA Act, the deadline for submitting opinions and statements to the coordinating authority shall be no less than 30 and no more than 60 days after the publication of the announcement.

Table 2-2 The central themes of the statements given on the EIA programme in the international hearing and their application to the environmental impact assessment.

Statements given in the international hearing	How the statement has been taken into account in the assessment (references to sections of the EIA report)?
Sweden	
The EIA procedure is to handle the repository approved in the project's decision-in-principle and present an alternative location if Olkiluoto is not suitable.	The EIA report describes facilities for disposing of 6,500 tU, 9,000 tU or 12,000 tU spent nuclear fuel. The repository's environmental impacts are also described in the aforementioned situations. The environmental impact assessment only applies to the disposal location in Olkiluoto. It was selected as the final disposal location among several alternatives on the basis of extensive research work consisting of a number of stages in 1999. In 2000 the Government prepared a decision-in-principle, according to which the construction of the repository in Olkiluoto in Eurajoki is in the overall best interest of society.
The environmental impact assessment is to present the methods by which the transfer of radioactive substances to the Baltic Sea is prevented.	The long-term safety concept of the final disposal solution is based on the multi-barrier principle designed to prevent radioactive substances accessing the living nature. Release barriers include a canister, bentonite barrier, disposal tunnel backfilling and intact bedrock around the disposal facilities. The multi-barrier principle is described in more detail in Section 3.3 and Chapter 11.
The EIA report is to present the current understanding of long-term safety.	Mechanically strong and corrosion-resistant canisters placed in steady bedrock and surrounded with bentonite clay will most likely contain all radionuclides for the minimum of several millions of years. However, the possibility of individual canisters breaking during this time cannot be completely excluded. In such cases, radioactive substances could be slowly released into the environment. However, only a few canister damages are supposed to happen even in violent rock movements. Some such incidents have been analysed, and the release of radioactivity in these events has only a minimal effect on people and other biosphere. The current understanding of long-term safety is presented in more detail in Section 11 of the EIA report.
The assessment is to cover the entire facility, including transportation and related risks of accidents, as well as the actions used to prevent accidents.	The environmental impact assessment covers the environmental impacts of the normal operation (Section 9 of the EIA report), transients (Section 10.4) and accidents (Section 10.6) occurring in the repository (Section 3). Actions to prevent accidents in the repository facility are discussed in Section 15.2. The assessment also covers the environmental impacts of transportation (Section 3.6.3.) and the related malfunctions and accidents (Section 9.1.2). The actions to prevent transport accidents are discussed in Section 15.5. Radiation impacts caused by accidents at the repository or during transport do not exceed the limits set by the authorities.
The assessment is to take into account the preventive and transboundary joint actions taken for nuclear facility questions and the communication systems that will be installed for warning measures in the event of a radiation leakage.	Cooperation with international nuclear organisations (IAEA and OECD/NEA) takes place. In the event of any accident, STUK will notify the neighbouring countries of the accident in accordance with international agreements. A convention on the early notification of a nuclear accident (1017/86, FTS 98/86) has been agreed upon.
Estonia	
The EIA report is to present a detailed assessment of the impact of unanticipated and accident situations, and the possibilities for preventing them.	The doses caused by postulated malfunction and accident situations will be below the limit value set by the requirements, even close to the incident (a distance of less than five kilometres). The impacts of malfunction and accident situations are presented in Section 10 of the EIA report. The prevention of malfunctions and accidents and the management of consequences are presented in Section 15.2 of the EIA report.
The EIA report is to describe the methods used to supervise final disposal.	The provisions on the general principles on the use of and the monitoring of the use of nuclear energy are laid down in the Nuclear Energy Act. According to this Act, a separate permit is required for the final disposal of spent nuclear fuel, including transport. The Government issues the decision-in-principle, the construction licence and the operational licence of a nuclear facility. Other licences are issued by the Radiation and Nuclear Safety Authority (STUK). Supervision of the safety of the use of nuclear energy is the responsibility of STUK. Furthermore, STUK's responsibilities include the control of physical protection and the emergency planning as well as the safeguards of nuclear material. STUK employs a construction-phase monitoring programme to verify that the construction of the nuclear facility takes place according to construction licence, approved plans and regulatory decisions. STUK employs also an operation-phase monitoring programme to verify that the facility is operated and maintained according to regulatory decisions, desing bases and the instructions of the licencee's quality management system. STUK also supervises the final closure of the repository. According to the Nuclear Power Act, the final disposal must in its entirety be implemented in such a manner that no monitoring will be required afterwards in order to ensure its safety.

Cumulative impacts are to be assessed.	The assessment covers the disposal of 12,000 tons of uranium and the resulting impacts. The increased amount of fuel will extend the operation phase of the repository and postpone the sealing-off phase to a later date. The nature of the operations will remain similar throughout the operating phase. In addition to the duration of the repository's operational and closing phases, the size of the underground disposal facilities as well as the length and number of tunnels to be built will change. The area with an impact on groundwater possibly widens, and the amount of rock material increases.
Norway	
The assessment is to cover the entire volume of spent nuclear fuel.	The assessment covers the disposal of 12,000 tons of uranium and the resulting impacts.
The impacts of accidents and irregular situations on Norway are to be assessed.	The impacts of malfunctions and accidents during the operating stage are presented in Chapter 10 of the EIA report. The doses caused by postulated malfunction and accident situations will be below the limit value set by the requirements, even close to the incident (at a distance of less than five kilometres). Long-term safety is assessed in Section 11 of the EIA report. Even the maximum dose rates in the vicinity of the repository will be relatively small. In practice, there will not be any radiation doses in Norway because the distance between Olkiluoto and Norway is approximately 500 kilometres.
Germany	
The period covered by long-term safety is to be identified.	The inspection period for long-term safety extends to hundreds of thousands, even millions, of years.
Has a scenario been prepared for the assessment, inspecting the decay of a copper canister caused by geological movement as a result of an ice age, which would release radioactive emissions from the repository?	The assessment has utilised the safety assessments prepared for the disposal concepts KBS-3V and KBS-3H (a preliminary Swedish safety assessment for the vertical disposal solution SR-Can (*www.skb.se*, SKB TR-06-09) and a preliminary safety assessment for the horizontal disposal solution (*www.posiva.fi*, Posiva 2007-06)). These assessments include scenarios where the copper canister breaches as a consequence of geological movement.
Long-term impacts on the atmosphere and water system are to be identified in the event of an accident, such as when an aircraft collides with the encapsulation plant or in the aforementioned event where a copper canister breaks due to geological movement.	Long-term impacts on the atmosphere and water system are discussed in Section 11 of the EIA report. The encapsulation plant is structurally designed against postulated external incidents (including a collision with a small plane). In the assessment of the importance of external hazards, it must be considered that only small amounts of fuel are processed in the encapsulation facility at any one time. During the process, the fuel is processed in underground facilities for a majority of time, making the facility's structure the best protective measure against external hazards. Fuel waiting to be encapsulated is stored in the encapsulation facility, in a transport cask designed to endure accidents during transportation. Furthermore, the encapsulation facility is rather small in size, which plays a part in diminishing the probability of an aircraft crash. The probability and consequences of a major earthquake damaging the repository are presented in Section 11.6. Only some canister damage is possible even in violent rock movements. Releases of radioactive isotopes caused by such damage would only have a minimal effect on people and other living environments.

2.9 Termination of the EIA procedure

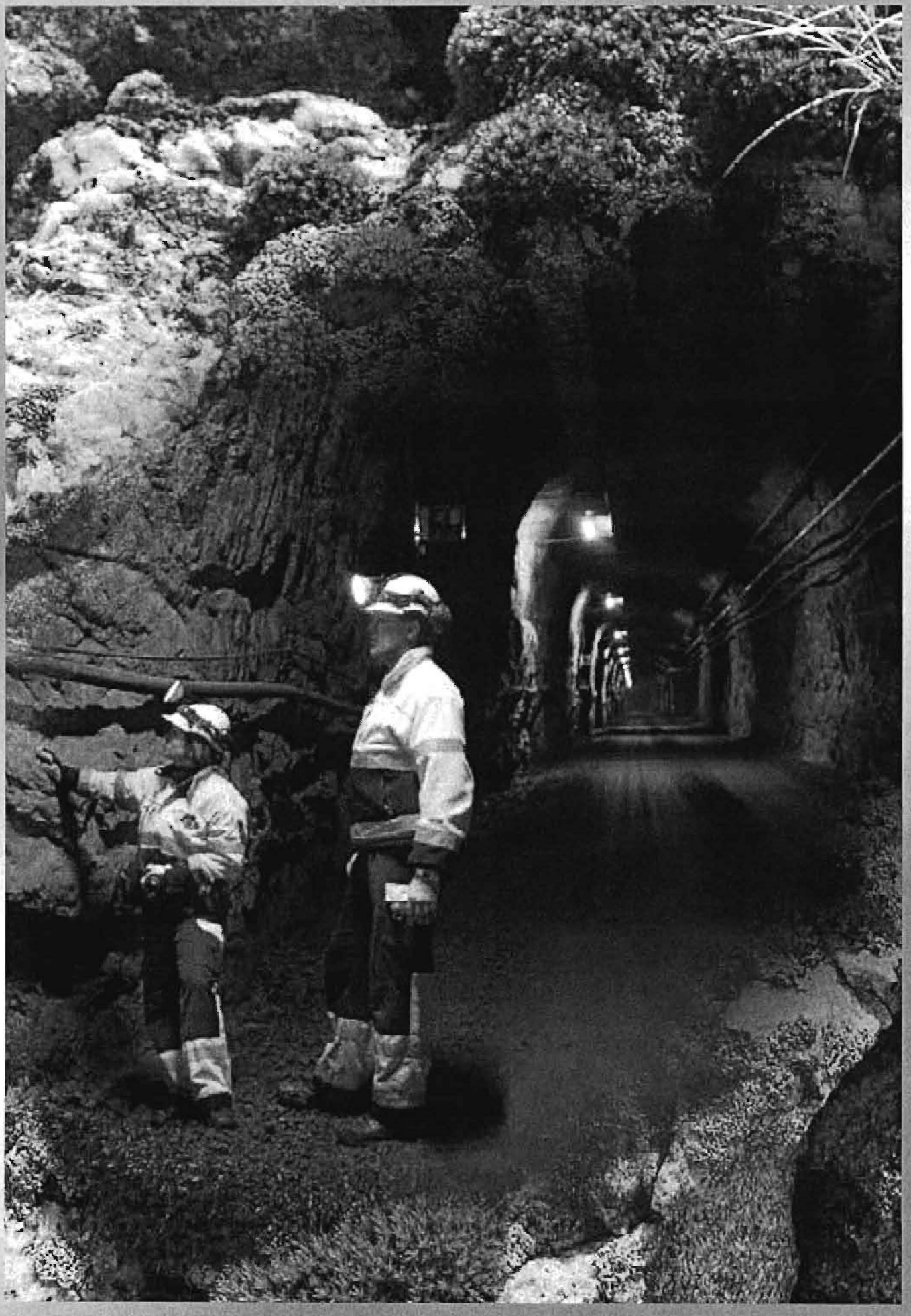
The EIA procedure is completed when the Ministry of Employment and the Economy provides its statement on the EIA report. This will take place within two months of the deadline set for submitting opinions and statements.

2.10 Interaction between planning/design and the EIA procedure

One of the objectives of the EIA procedure is to support the project planning process by producing information on the environmental impacts of the project. The purpose is to produce information as early as possible during the planning/design stage so that the environmental impacts are taken into account from the very beginning of the planning/design process.

The location of the expansion of the planned repository in Olkiluoto has been considered when preparing the EIA report.

The EIA report will be attached to any project-related licence applications and the licence authorities will use it as the basis for their decision-making process. The EIA report, any interaction occurring during the EIA procedure and the compiled materials comprise one of the starting points for design if the project proceeds to a detailed design stage.



3 Description of the repository

3.1 General description of the repository

Posiva's disposal solution is based on a principle solution entitled KBS-3 which is developed by Svensk Kärnbränslehantering AB (SKB), a company responsible for nuclear waste management in Sweden. The development of the solution was started in the 1970s and the KBS-3 solution was reported in 1983. KBS stands for KärnBränsleSäkerhet (nuclear fuel safety).

The purpose of the disposal of spent nuclear fuel is to:

- package (encapsulate) spent nuclear fuel assemblies in a form suitable for permanent disposal inside the bedrock
- dispose of the packaged spent nuclear fuel assemblies in a permanent manner inside the bedrock.

Correspondingly, the actual repository consists of two sections:

- the aboveground encapsulation plant where spent nuclear fuel is received, dried and packed into final disposal canisters, sealed and inspected
- the repository located deep inside the bedrock where the significant section consists of tunnels where the encapsulated spent nuclear fuel is disposed of in a permanent manner.

In addition to the encapsulation plant, the aboveground facilities consist of premises for auxiliary functions, such as the shaft building, office and laboratory facilities, storage and repair shop and the areas required by the HVAC systems. Separate areas will be reserved for storing quarried materials and crushed rock as well as the necessary

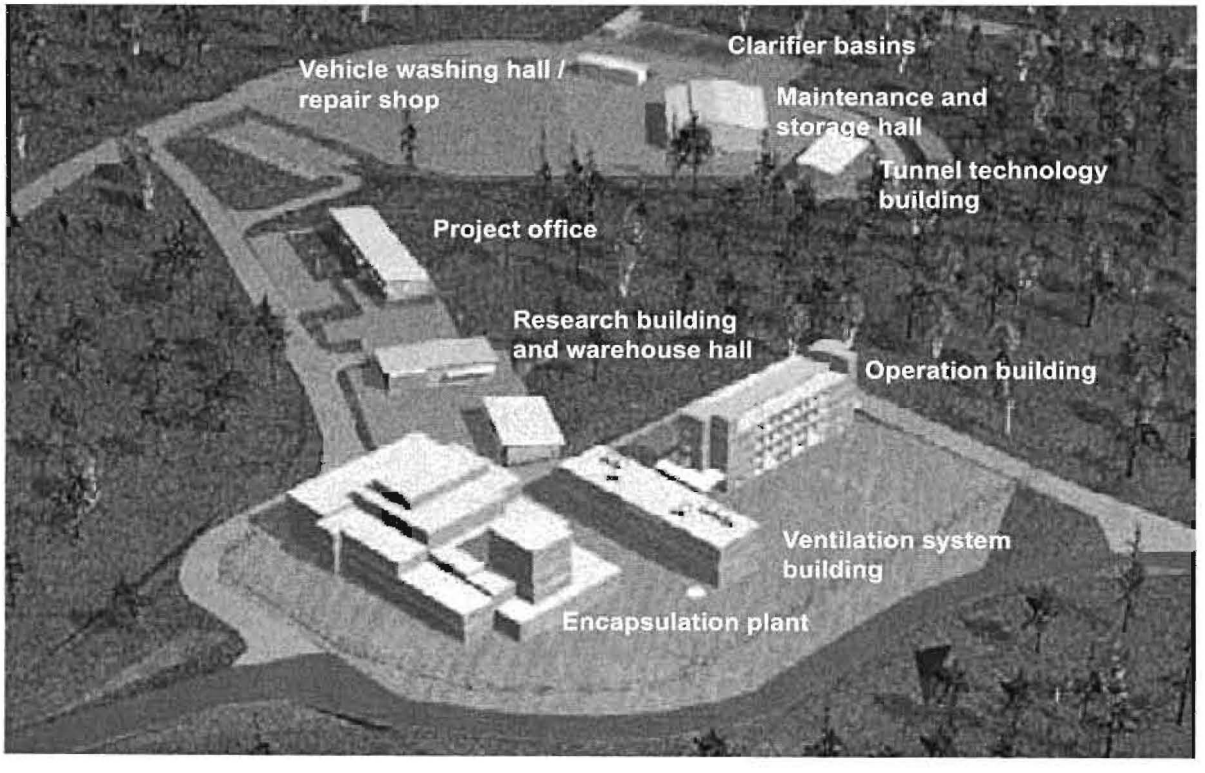


Figure 3-1 A conceptual image of the buildings at the repository site.

construction site activities. The aboveground construction area in the plant area (i.e. the area of buildings, roads, storages and fields) is about 20 hectares in all. The buildings to be built in the repository area are shown in Figure 3-1.

The surface and the repository are connected by an access tunnel and a sufficient number of vertical shafts for ventilation and personnel and canister transportation.

The underground tunnel system is divided into three parts at the disposal depth:

- final disposal tunnels where the canisters containing spent nuclear fuel will be placed
- central tunnels that connect the final disposal tunnels and shafts
- underground technical auxiliary facilities.

3.2 Design status

In Finland, the work for developing the final disposal solution began at the beginning of the 1980s soon after the introduction of nuclear power plants. The work has been progressed in stages according to the programme decided upon in 1983. Disposal site inspections were carried out in 1983–1999, and Olkiluoto in Eurajoki was selected as the final disposal location from among four options in 1999.

The period from 2000 to 2012 comprises research, development and planning operations aimed at Olkiluoto. The period is characterised by the construction of the underground research facility called ONKALO and underground research carried out in the facility. The underground research helps to obtain the knowledge required for applying for the construction licence in 2012. Aboveground research will be continued in addition to underground research work.

During 2013–2020, the detailed implementation plans required by the repository will be produced. If the Government grants the construction licence, the aboveground buildings required for the repository, the underground facilities significant for the operations and the first disposal facilities will be built. The operation licence application for the repository will be submitted to the Government by the end of 2018. Test use of the repository is to begin in 2019. Final disposal operations are to begin in 2020. The detailed plans concerning the expansion now under assessment will only be topical after decades, maybe only after a hundred years.

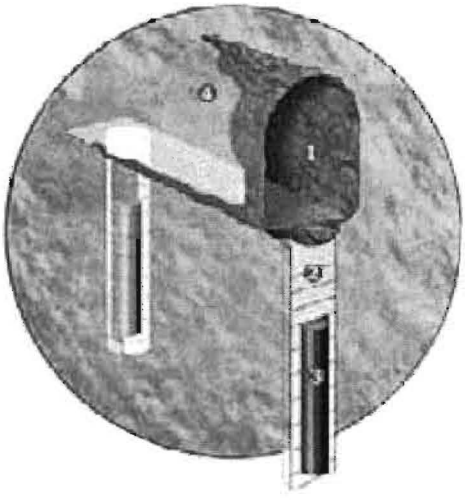


Figure 3-2 Multi-barrier principle for final disposal. Different barriers back-up each other.

3.3 Design criteria for final disposal

The long-term safety concept of the final disposal solution is based on the multi-barrier principle (i.e. several release barriers securing each other) so that the deficiency of one barrier will not compromise long-term safety. Release barriers include a canister, bentonite barrier, disposal tunnel backfilling and intact bedrock around the disposal facilities. The release of radionuclides is significantly slowed by the structure of the spent nuclear fuel; uranium dissolves very slowly in water in the conditions existing deep inside the bedrock. The multi-barrier principle for final disposal is shown in Figure 3-2.

The purpose of the gas- and water-tight canister is to isolate spent nuclear fuel inside the canister. Disposal canisters are massive metal casks. Their interior is made of nodular graphite cast iron, and the exterior is made of copper. Fuel assemblies are packed inside the canister. The interior of the canister is filled with inert gas (e.g. argon or helium) in order to slow down and minimise corrosion inside the canister caused by moisture and radiation. The cover of the copper canister is sealed shut. This will ensure isolation and prevent the access of radionuclides to groundwater and further to the bedrock and biosphere.

Single copper canisters are installed in the bedrock, inside vertical holes drilled into the base of disposal tunnels excavated to a depth of 400–700 metres or inside horizontal disposal tunnels. Hard-compressed bentonite clay is used as the barrier material. The use of bentonite in the disposal facilities is based on its low water permeability and the ability to expand when exposed to water. The disposal tunnels and the connecting central tunnels are backfilled after the installation of the canister and barrier

material. The backfilling process will continue throughout the operating life of the plant. The repository's technical facilities and surface connections, such as access tunnels and shafts, will be backfilled at the end of disposal operations.

The rock isolates fuel disposed of from the living environment. It protects the canisters against external impacts, creates mechanically and chemically stable conditions to the repository and limits the amount of groundwater coming into contact with the final disposal canisters. Research results indicate that hundreds of metres down in the bedrock, groundwater is virtually void of oxygen and flows only a little, because of which its corroding effect on the canisters and spent nuclear fuel is very small. If spent nuclear fuel would, due to unforeseen circumstances, come into contact with groundwater, the substances dissolved from it would mainly remain in the bentonite barrier and bedrock surrounding the canisters. The bedrock also effectively stops direct radiation emanating from the canisters because rock two metres thick alone is sufficient to attenuate the radiation to the level of natural background radiation.

3.4 Research work and reports prepared

Posiva has plenty of research information about Olkiluoto spanning a few decades. It covers research data on the area's bedrock, water areas in the environment, vegetation, animals and weather conditions. Information about the reports prepared is available on Posiva's website *(www.posiva.fi/tietopankki.html)*.

The technical design of the disposal solution is based crucially on information about the conditions prevailing deep inside the bedrock and any changes in them. The properties of the Finnish bedrock for final disposal have been studied since the beginning of the 1980s, at first at a general level and for developing research methods. Later, starting from 1986, the studies have been directly aimed at identifying the properties of bedrock suitable for the disposal of spent nuclear fuel at five research sites at first and later in four locations, from among which Olkiluoto in Eurajoki was selected as the final disposal site in 1999. The selection was confirmed through the Government's decision-in-principle ratified by Parliament in 2001.

Since the environmental impact assessment published in 1999 and the aforementioned decision-in-principle, the studies have been continued in Olkiluoto in Eurajoki and there are currently about 50 deep boreholes. The construction of the underground research facility, ONKALO, was also started in 2004. ONKALO provides possibilities for studying the bedrock at the disposal depth. A comprehensive summary of the information about the disposal site collected during 20 years is presented in the report entitled Olkiluoto Site Description 2005 *(Andersson et al. 2007)*.

The characteristics of the disposal site are disturbed because of ONKALO and the construction and operation of the disposal facilities. The understanding of these disturbances is of utmost importance in order to understand the development of the disposal site and system. The most recent materials and models related to the disposal site and impacts caused by construction have been utilised in a number of analyses *(Löfman & Mészáros 2005, Ahokas et al. 2006, Pastina & Hellä 2006)* and prediction-realisation assessments included significantly in the site description *(Andersson et al. 2007)*.

The disposal solution's technical properties and the impact of the bedrock on the materials and structures used have been studied along with bedrock research. Summaries of these studies have been published in 2003 and 2006 *(Posiva Oy 2003a and 2006)*. There has been plenty of research material available on the properties and behaviour of the disposal canisters and the surrounding bentonite produced by SKB which is a company responsible for nuclear waste management in Sweden *(SKB 2006)*.

Even though radionuclides are mainly isolated from nature using canisters in Posiva's safety concept, the bentonite barrier surrounding the canisters has a central significance for safety in vertical and horizontal disposal considering the durability of the canisters and any leakage. The action of bentonite is largely based on its expansion: as bentonite absorbs water from the bedrock, it condensates between the bedrock and canister so that substances can only flow through it through slow diffusion. As is typical for different types of clay, bentonite is also flexible and protects the canister mechanically. The properties of bentonite have been studied since the 1970s and there has been plenty of experimental and modelling information about its behaviour under the expected bedrock conditions. However, bentonite includes some features that have not been able to be satisfactorily identified (e.g. the effect of water with a rich salt content) and the suitability of certain previous test results for the disposal conditions is to be verified (e.g. gas permeability). Certain ice age scenarios have raised the question of erosion (due to water with poor ionic strength). The challenges and uncertainties raised comprise one of the points of emphasis for Posiva's current research.

The common objective of disposal-related research, development and technical planning is to achieve a solution which can be used to isolate waste so that there will be no health hazards in the future. However, a significant part of research has been aimed at identifying the causes and consequences of situations where isolation does not operate as expected. The studies in question have been

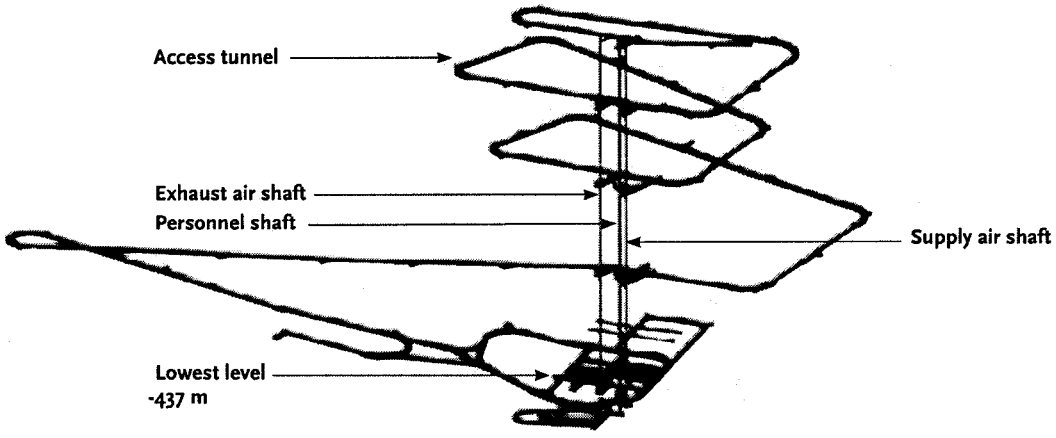


Figure 3-3 The underground research facility, i.e. ONKALO, consists of an access tunnel, connected ventilation and lift shafts and research and auxiliary facilities at the disposal depth.

aimed particularly at the solubility and migration properties of radioactive substances in the bentonite and bedrock environment and the caused radiation exposure. The significance of any emissions has been assessed using safety analyses, several of which have been conducted since 1982. The most recent comprehensive safety analysis has been performed for the horizontal disposal solution in 2007 *(Smith et al. 2007)*. A number of separate reports on the safety of final disposal have been published in recent years, but the next comprehensive summary of the safety of vertical disposal is to be completed as an attachment to the construction licence application by the end of 2012.

Social and economic impacts have also been studied. A number of monitoring studies have been carried out and reports have been prepared on the basis of the monitoring programme presented in the EIA report completed in 1999. These reports include a public image study *(Corporate Image Oy 2007)* and a financial impact study *(Laakso et al. 2007)*.

3.5 Accumulation of spent nuclear fuel

The existing Olkiluoto and Loviisa power plant units are estimated to produce a total of 4,000 uranium-tons (tU) of spent nuclear fuel. The OL3 plant unit under construction is estimated to produce a total of 2,500 tU of spent nuclear fuel. The planned sixth nuclear power plant unit will produce approximately 2,500 tU of spent nuclear fuel. The seventh power plant unit is estimated to produce spent nuclear fuel amounting to some 3,000 tons of uranium.

The accumulation of spent nuclear fuel depends on the following features of nuclear power plants:

- power levels of plant units
- duration of operating time
- capacity factor
- fuel properties.

3.6 Description of the repository and disposal technology

The description of the repository's structure and operations is based on the report entitled 'Facility description 2006' *(Tanskanen 2006)* and specifications added to the report subsequently. The report is a summary of the design material for the repository planned in Olkiluoto.

3.6.1 Verifying study stage

The study stage preceding the application for a construction license that is mainly intended for surveying the of bedrock at the repository site in order to verify its properties and to be used as the basis for detailed design and planning is called the verifying study stage. For this purpose, a research facility called ONKALO, reaching to the same depth as the actual repository facility, is being built in Olkiluoto (Figure 3-3).

ONKALO covers a spiral-shaped access tunnel, passenger and ventilation shafts, research, testing and demonstration facilities and technical facilities. ONKALO is designed and will be implemented so that it can later be used as part of the repository. Research at the disposal

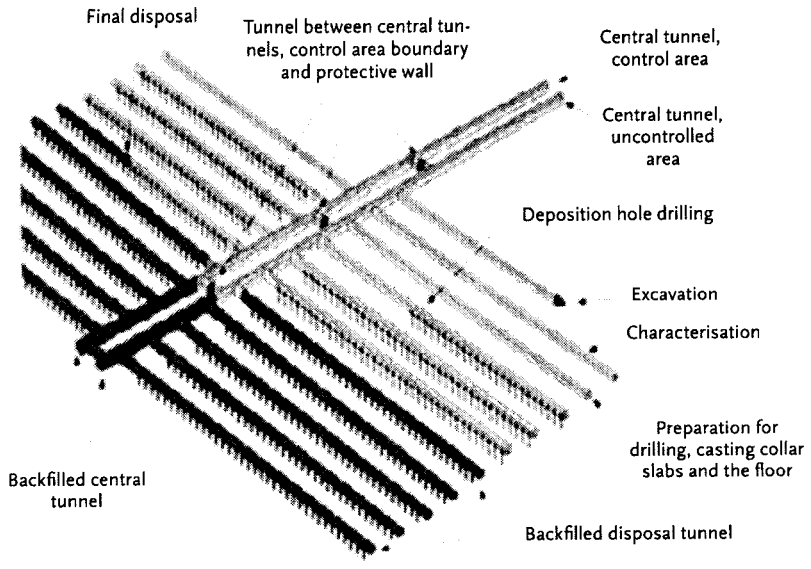


Figure 3-4 Principle illustration of constructing the disposal tunnels in stages.

depth will begin in 2010. Bedrock research will be carried out in connection with excavation work from the access tunnel. The results will be utilised immediately in excavation and construction work. By the beginning of October 2008, the excavation of ONKALO had progressed to an access tunnel length of about 3,150 metres and to a depth of about 297 metres. The designs will be specified according to information received from the bedrock and the design of the repository.

3.6.2 Construction stage

Some of the aboveground buildings have already been built during the ONKALO stage. These include the research building, storage hall, project office, tunnel engineering building, service and storage hall and the repair shop. The rest of the aboveground buildings are scheduled to be built before the start of the final disposal operations, i.e. before 2020.

The underground facility will consist of access routes leading deep inside the bedrock, tunnels and deposition holes inside the bedrock where the nuclear waste canisters will be disposed of, and of any underground facilities and access routes required. The surface and the repository are connected by an access tunnel and a sufficient number of vertical shafts for ventilation and personnel and canister transportation.

Some of the building work in the disposal facilities will already be performed at the ONKALO construction stage. ONKALO has been designed so that it can later function as an access route to the disposal facilities. The work methods and materials used in the construction of ONKALO have been selected so that they are also acceptable for the disposal facilities and operations.

The position of the disposal facilities in the underground repository is based on rock characterisation performed on the basis of research. Sections 11.4 and 15.10 describe how the suitability of the location for building and expanding the repository is assessed. The disposal tunnels and technical facilities in the repository will be connected by a central tunnel system. According to plans, only a small part of the disposal tunnels will be excavated ready before starting final disposal. After that, the tunnel system will be expanded in stages along with the disposal operations. The tunnel capacity open at any one time is to be minimised so that the impact caused by the open facility (e.g. water leakage, ventilation needs) are as small as possible. The underground facilities will be divided into separate sections using temporary walls so that the excavation of the disposal facilities, other construction work and final disposal can be performed separately and at a sufficient distance from one another. During the operating stage, approximately 10–20 disposal tunnels at a time will be excavated. When excavating the central and disposal tunnels, there must be sufficient protection distance between the excavation area and the available disposal tunnels. Some of the central tunnels will also be backfilled and sealed during the repository's operating stage. Figure 3–4 presents an example of the construction of the disposal tunnels in stages.

A cautious drilling-blasting technology has been planned to be used in the excavation of the disposal tun-

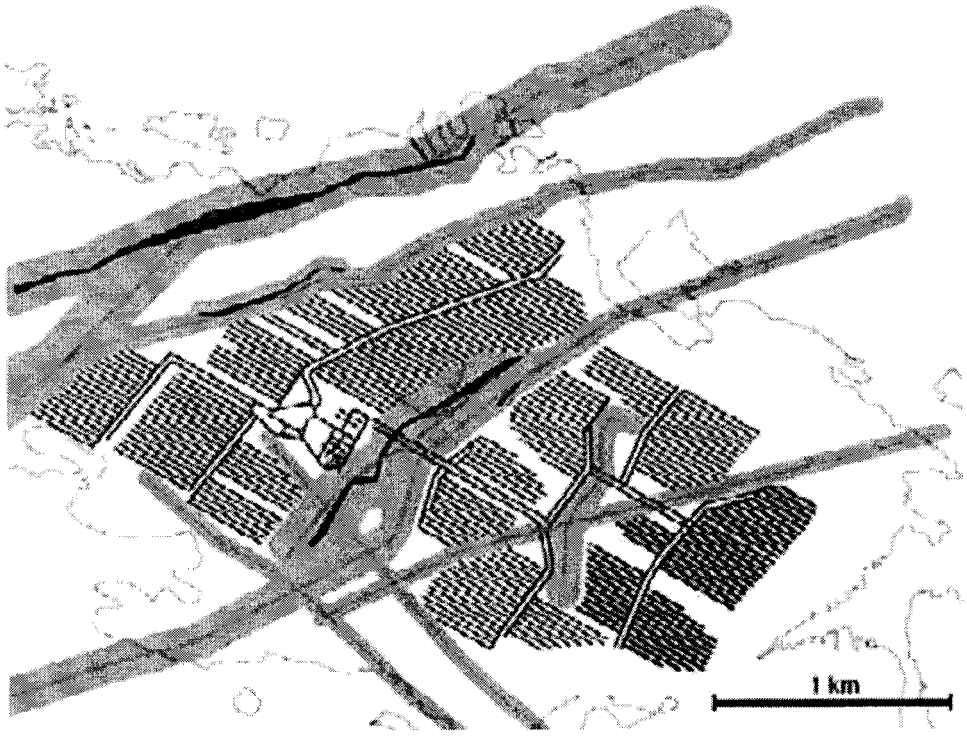


Figure 3-5 A conceptual image of the location principles of the disposal facilities in the Olkiluoto bedrock. Disposal facilities for the current plants and plants under construction are shown in green (6,500 tU). The underground expansion for a fuel volume of 9,000 tU is shown in blue and the expansion for a fuel volume of 12,000 tU in violet. The image presents the known bedrock fragmentation structures according to current research data that regulate the locations and their safety zones.

nels. This is to minimise any damage caused by excavation to the bedrock. Alternatively, tunnel-boring machine can be used in the construction of the tunnels. The technology will also be used when drilling the deposition holes. The rock material raised from the underground repository facility will be stored in a stack of quarried materials in Olkiluoto. If necessary, the quarried materials can be crushed and used as backfilling for the repository facilities or elsewhere.

There will be no need to excavate repository tunnels in the case of the horizontal disposal solution; instead, the tunnels will be drilled by utilising the tunnel boring principle. The crushed rock material generated will be transported to the surface and stacked in the same way as quarried materials. The materials will not require further crushing; instead, the materials may be used for other purposes as such.

Figure 3-5 presents a basic image of the disposal facilities following the current assessments for the disposal of 6,500, 9,000 and 12,000 uranium tons in Olkiluoto. The area required by the underground repository for 6,500 tons of uranium of fuel to be disposed of is about 150 hectares. When the disposable volume is 9,000 uranium tons, the area will be about 190 hectares. The expansion of the disposal facilities from 9,000 uranium tons to 12,000 uranium tons will increase the area required for final disposal by about 50 hectares.

3.6.3 Transportation and relocation of spent nuclear fuel

Spent nuclear fuel will be stored in interim storages of Fortum's Loviisa nuclear power plant and TVO's Olkiluoto nuclear power plant for an average of 40 years before final disposal. Spent nuclear fuel will be transported from the interim storages to Posiva's repository located in Olkiluoto in special containers.

The transportation of spent nuclear fuel is strictly regulated by national and international regulations and agreements. A licence for transporting spent nuclear fuel must be acquired in Finland from the Radiation and Nuclear Safety Authority (STUK). STUK will inspect the transportation plan, the structure of the container, the qualifications of transportation personnel, safety arrangements and the provisions made for accidents.

Figure 3-6 A transportation vehicle and container for spent nuclear fuel, with which fuel is transferred in the Olkiluoto power plant area.

Transportation of spent nuclear fuel at the Olkiluoto plants

The transportation of spent nuclear fuel in the plant area will be performed using a transport container specifically designed for this purpose. This container and the specifically designed transportation equipment are already being used in fuel transportation between the plant units' reactor buildings and the interim storage for spent nuclear fuel.

The current road connections in the Olkiluoto power plant area and partially new roads in the repository area will be used for fuel transportation from the interim storage to the encapsulation plant.

Transportation from Loviisa to Olkiluoto

The plan is that the fuel from Loviisa will be transported to Olkiluoto as road transport; however, railway and sea transport and their combinations have also been studied as alternative transport methods (Figure 3-7). The amount of fuel transportation depends on the fuel volume and type, burn-up, cooling time and size of the transport container. At maximum, there will be ten transports a year. The transportation of fuel to be disposed of in the expansion will be started in 2070 at the earliest.

The container for spent nuclear fuel will be loaded onto a lorry in the nuclear power plant's spent nuclear fuel storage using a crane. The container will be tilted in a horizontal position during transportation and collision guards will be installed at the ends of the container. During transportation, the container and transportation platform will be covered with a weather guard. Transportation will be carried out as supervised transportation, in which case it will be escorted by escort personnel, such as the police and STUK's supervisor *(Suolanen et al. 2004)*. The factors affecting road safety will be secured using convoys and surveillance.

The route for the train transportation option consists of a railroad section and road sections between Loviisa and Olkiluoto. Transportation from the power plant to the railroad and from the railroad to the repository requires the same equipment, escort and security measures as road transportation. Spent nuclear fuel transported via railroad will be loaded from a train to a road transportation vehicle about 20 km from Olkiluoto at the Vuojoki loading site located in the municipality of Eurajoki. It is likely that the railroad will not be extended to Olkiluoto. Deep-loading carriages will be used for the transportation of containers by railroad. *(Suolanen et al. 2004.)*

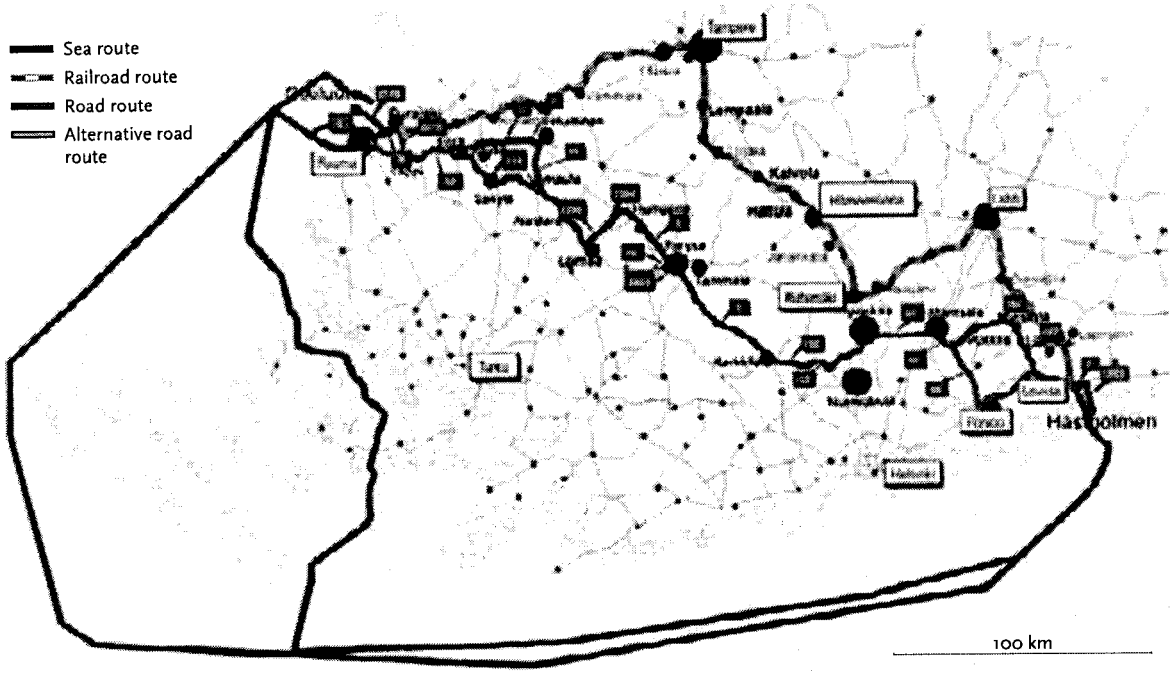


Figure 3-7 Alternative routes for road, rail and sea transportation from Loviisa to Olkiluoto inspected for the transportation of spent nuclear fuel.

Spent nuclear fuel can also be transported from Loviisa to Olkiluoto by sea. Two optional routes have been inspected on the Gulf of Finland. An option for the route through the Archipelago is a route around Åland Islands. The optional destination ports are Rauma or Olkiluoto. By combining these options, there will be several different ship routes to be inspected (Figure 3-7). The route for the sea transportation option also consists of a combination of different forms of transportation because of connecting traffic (road–sea–road).

Sea transportation can be implemented using a ship such as M/S Sigyn owned by SKB which is a company responsible for nuclear fuel and waste management in Sweden. M/S Sigyn has been built for nuclear waste transportation and has a transportation capacity of an effective load of 1,200 tons.

For the sea option, it will be possible to use the Valko port located in Loviisa about 25 kilometres from the interim storage for spent nuclear fuel. A possibility was reserved in the proposal for a partial master plan and the draft town plan for building a navigation channel and loading quay on the island of Hästholmen. In addition, the use of the Rauma and Olkiluoto ports has been inspected *(Suolanen et al. 2004)*. The containers will be transported between the interim storage and the ship using similar equipment as in the road option.

Spent nuclear fuel delivered by sea can be unloaded in the power plant's port (TVO's port) in Olkiluoto or the Olkiluoto port. In the sea transportation option, the use of the Olkiluoto port requires that it is repaired.

3.6.4 Operating stage

Processing of spent nuclear fuel at the encapsulation plant

The most important building of the aboveground facility will be the encapsulation plant. The main section of the encapsulation plant consists of the reception and cleaning facilities for transportation containers, the interim storage for containers and empty canisters, the canister transfer corridor, the fuel handling cell, the canister lid welding chamber, the weld inspection chamber and the canister buffer store for full canisters (Figure 3-8). The operations carried out at the encapsulation plant include reception of the transport containers, fixing the canister cover by welding and inspection of the welded seam.

The encapsulation plant will be designed so that it will be able to facilitate the processing of spent nuclear fuel from the current nuclear power plant units of Posiva's owners and those under planning and construction. Spent nuclear fuel is offloaded from the transport container that is docked in the same way as the final disposal canister in the processing chamber. The fuel assemblies are transferred from the transport container to the drying container. After drying, the fuel assemblies are transferred to the final disposal canisters one by one. The air inside the in-

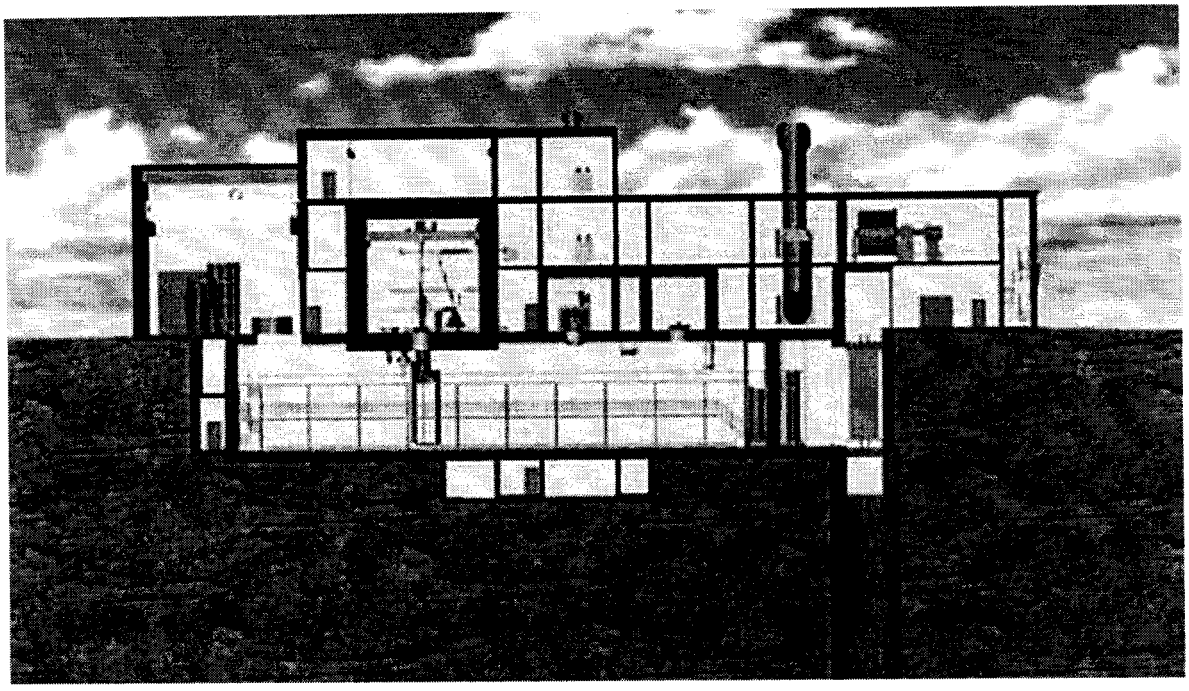


Figure 3-8 The encapsulation plant. Spent nuclear fuel transported to the plant will be packed into disposal canisters. The canisters will be sealed and transported to the repository using the lift shaft or access tunnel.

ner canister is replaced by inert gas in the gas exchange dome, the cover of the inner canister is screwed on and the tightness of the inner canister is checked. After the cover of the inner canister has been fixed, the separation cover of the processing chamber is replaced and the final disposal canister is removed from the docking position in the processing chamber. The copper cover is hoisted to the welding chamber and the final disposal canister is moved to the welding chamber. The canister is docked in the vacuum chamber of the welding chamber where the copper cover is inserted and welded in place using electron beam welding. The first checks on the welded surface are carried out visually during the welding process. If any defects are detected, repair welding is immediately carried out. The canister weld is machined and its quality inspected using ultrasonic, X-ray and eddy current equipment at the inspection station. After inspection, the canister is lowered to the transfer tunnel and washed with water to remove any debris. After cleaning, the canister can either be moved to a buffer store or directly to its final disposal position using the lift or the access tunnel.

Placement of canisters in the bedrock

According to the current designs, the repository will be located on one floor at a depth of about 420 metres from the surface.

Posiva's basic solution is based on the KBS-3 solution developed in Sweden in the early 1980s and, in its current form, is a result of more than 20 years of research and development. The designs of the disposal facilities are based on the vertical disposal solution of canisters (KBS-3V). The horizontal disposal solution (KBS-3H) where canisters are disposed of in horizontally drilled tunnels may also be used. The solutions are presented in Figure 3-9.

In the vertical disposal solution, vertical deposition holes are drilled in the floor of disposal tunnels where the tight and corrosion-proof canisters will be placed. Corresponding disposal tunnels do not need to be excavated in the horizontal disposal solution using the drilling-blasting method; instead they will be drilled using the tunnel boring method. In the horizontal disposal solution, several canisters will be placed one after another into 100–300-metre-long disposal tunnels that will be sealed immediately after installation using end plugs.

In both options, the space left between a canister and the bedrock will be filled with bentonite blocks. As a result, the canisters will be completely surrounded by bentonite blocks that will expand strongly when becoming wet. The disposal tunnels are backfilled after the final disposal (after installation of the canister and barrier material). The backfilling process will continue throughout the operating life of the plant. Similarly, the central tunnel is gradually backfilled as the connection to the final disposal tunnels is no longer required. The primary purpose of the backfilling is to return the repository's circumstances as close to natural as possible by, for example, preventing the tunnels

and shafts from becoming the groundwater's main flowing routes. The purpose of backfilling in the final disposal tunnels is to stop the flow of water, maintain the buffer material in place around the canister, and maintain the structural stability of the tunnels.

When expanding the repository, the disposal solution processed in the 1999 EIA procedure and approved in the 2001 decision-in-principle will remain unchanged with regard to its principles; only the fuel volume will increase. The additional fuel volume to be disposed of will lengthen the disposal time and increase the bedrock capacity to be excavated. The nature of the operations will remain similar.

3.6.5 Closing stage and retrievability of disposed nuclear fuel

The disposal tunnels will be sealed continuously during the disposal operations as canisters are disposed of. Once all spent nuclear fuel is disposed of and the disposal tunnels backfilled, radioactive waste accumulated during the operations of the encapsulation plant will be transferred to the repository. Waste will be packed into barrels or concrete boxes before transfer, after which any sections of the encapsulation plant containing radioactive substances will be dismantled. All dismantling waste will be transferred to a tunnel excavated for the purpose in the repository.

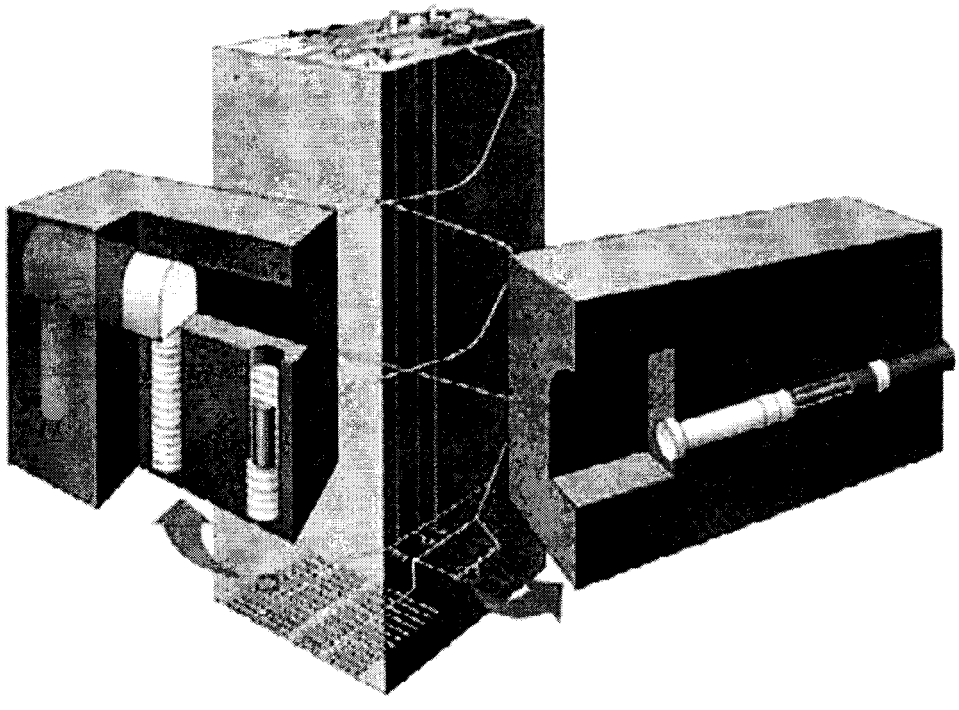
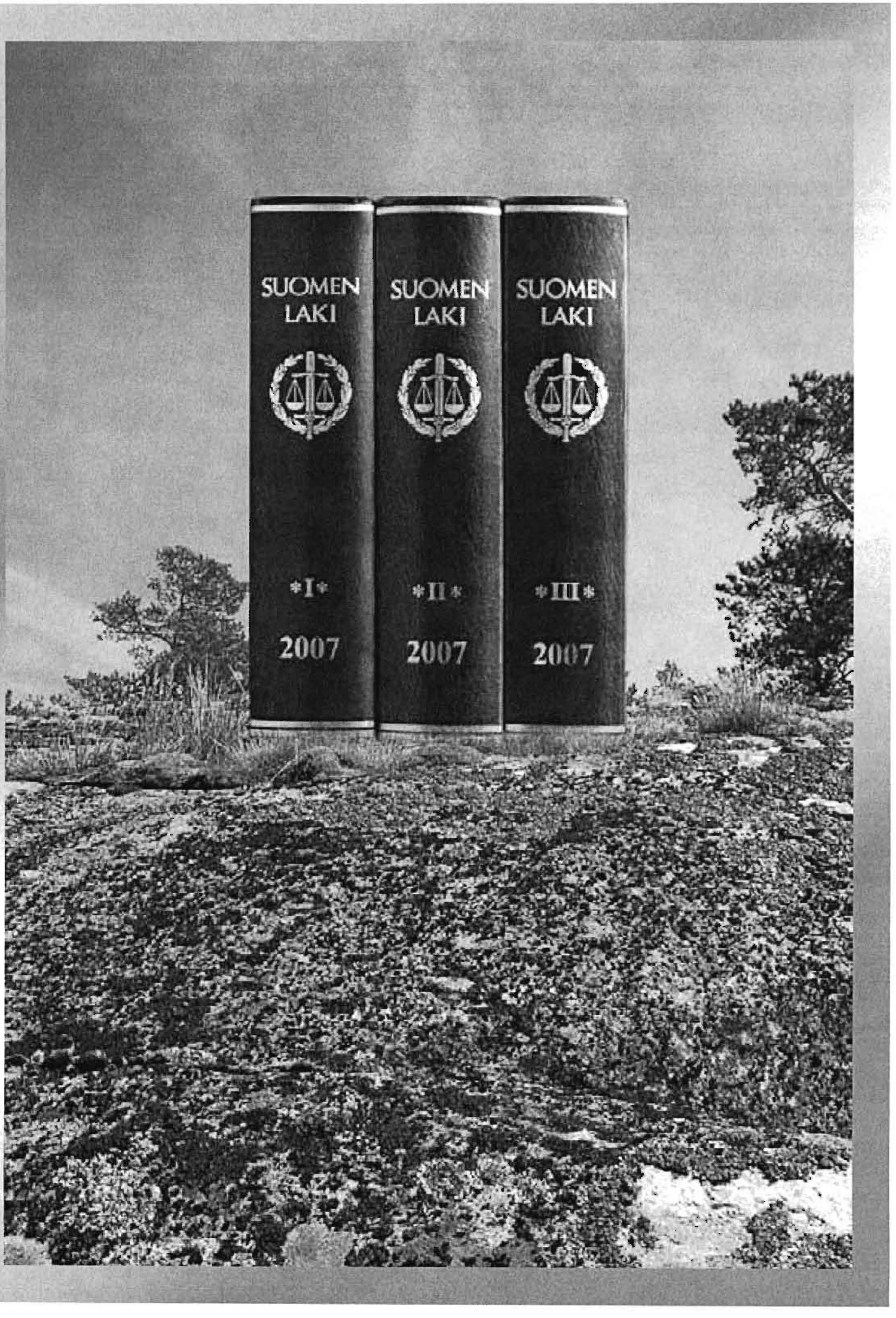


Figure 3-9 Drawing showing the principle of vertical disposal solution of spent nuclear fuel (KBS-3V) on the left and the horizontal disposal solution on the right (KBS-3H).

When all spent nuclear fuel has been finally disposed of and the encapsulation plant decommissioned, other tunnels and underground facilities will be backfilled in using backfilling material and all connections above ground will be sealed off. When the party responsible for nuclear waste management has sealed off the final repositories in an acceptable manner and paid the state the fee due for the future surveillance and monitoring of nuclear waste, the title of and responsibility for the waste materials will be transferred to the state. According to the Nuclear Power Act, the final disposal must in its entirety be implemented in such a manner that no monitoring will be required afterwards in order to ensure its safety.

However, the retrieval of nuclear fuel disposed of in the bedrock to the surface will be possible if sufficient technical and financial resources are available. Retrievability will provide future generations with the possibility of assessing the solution on the basis of their future knowledge. The retrieval will use the same regular work methods that were used in the excavation and construction of the repository. The retrieval of the canisters from the repository to the surface will be possible at all stages of the project, i.e. before sealing off the deposition hole, after sealing off the hole before the disposal tunnel is sealed off, after sealing off the disposal tunnel before sealing off all facilities, and after sealing off all facilities.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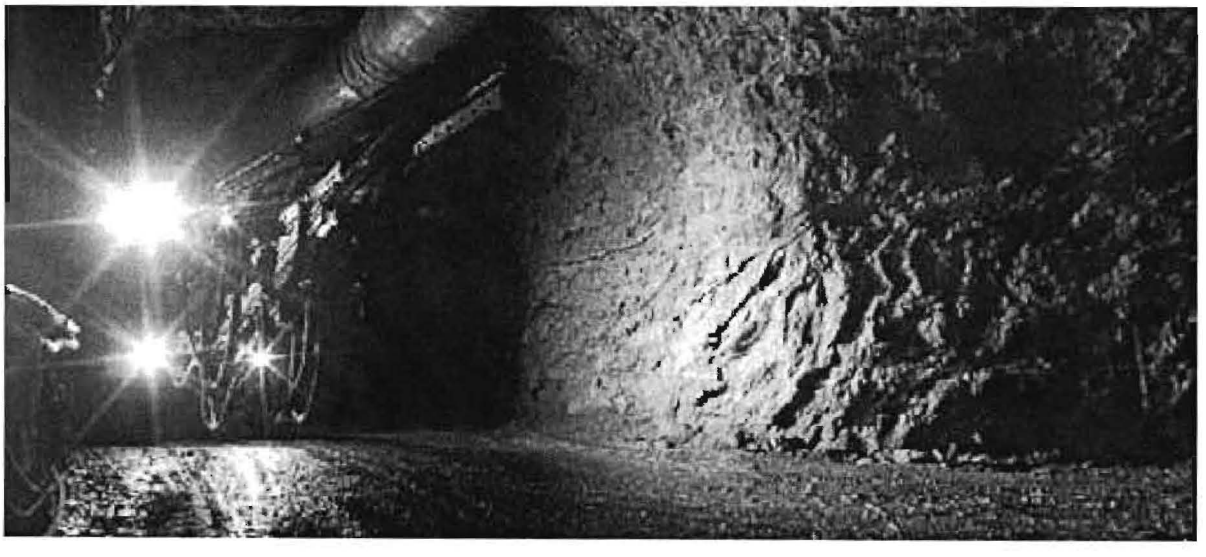
4 Legislation and guidelines regarding final disposal of nuclear fuel

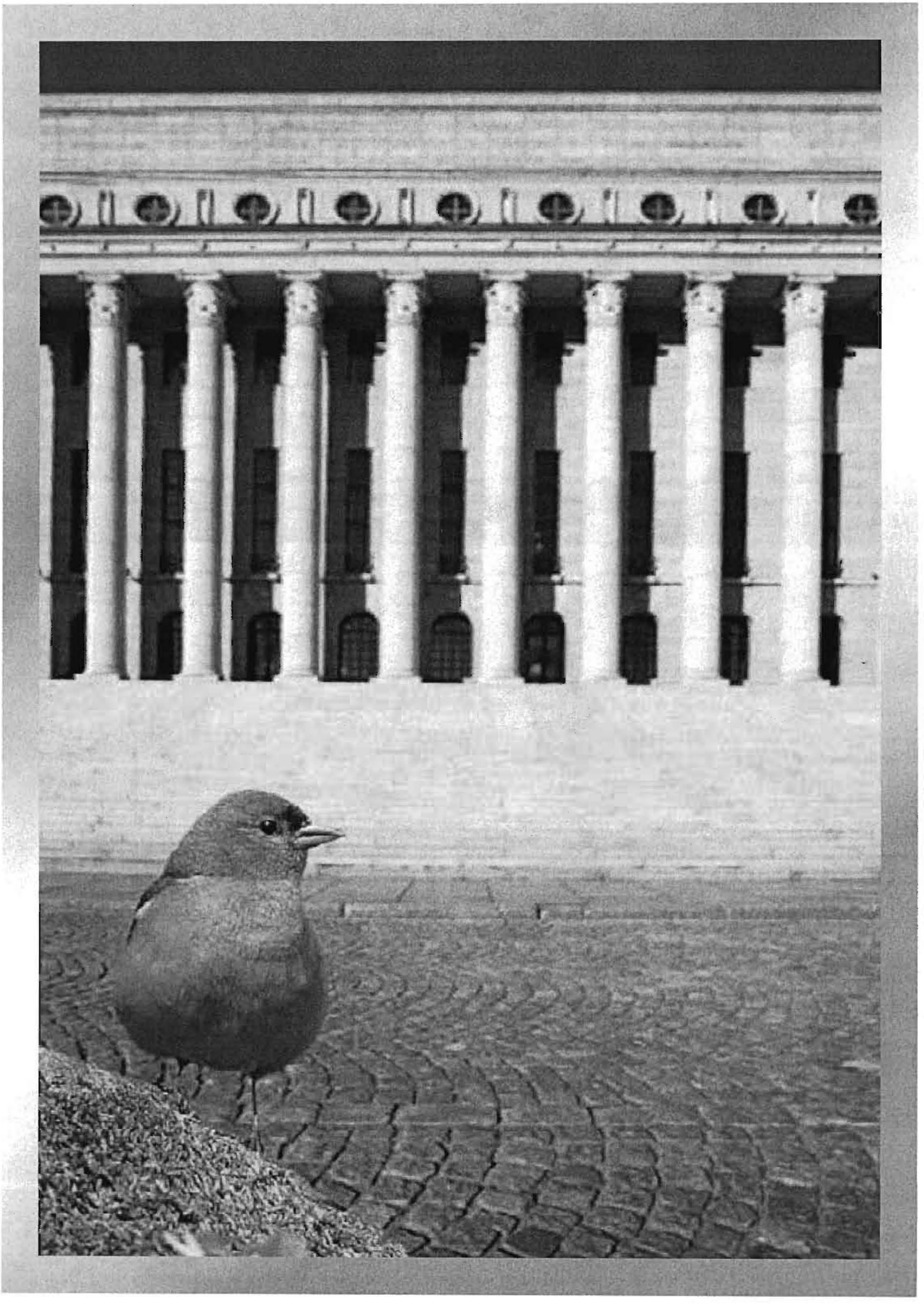
Nuclear waste management in Finland is regulated by the Nuclear Energy Act (990/1987) and the Nuclear Energy Decree (161/1988) that came into force in 1988. These define, for example, the liabilities of a nuclear energy producer, the implementation of nuclear waste management, the permit procedures and the supervision rights. The Nuclear Energy Act was amended in 1994 so that all nuclear waste created in Finland must be disposed of in Finland. The Nuclear Energy Act also forbids the import of nuclear waste to Finland.

The Government issues the general safety regulations concerning nuclear waste management. The safety regulations relating to the processing and storage of nuclear waste are included in the Government Decision on the Safety of Nuclear Power Plants (VNP 395/1991). The Government Decision (478/1999) regarding the safety of disposal of spent nuclear fuel particularly applies to the disposal facility. The radiation dose limits set forth in the decision for the disposal facilities are stricter than the corresponding limits set for nuclear power plants. The decision states, for example, that disposal shall not, in any assessment period, cause health or environmental effects that would exceed the maximum level considered acceptable during the implementation of disposal. *(The Finnish Government 1999.)*

STUK has also issued guidelines for the application of decision 478/1999 (Guide YVL 8.4) entitled 'Long-term safety of final disposal of spent nuclear fuel'. The guidelines refer to final disposal in crystalline bedrock in repositories constructed at a depth of several hundreds of metres, and deals with the long-term safety of final disposal. Furthermore, STUK has issued Guide YVL 8.5 entitled 'The use of a final disposal facility for spent nuclear fuel'. This guideline offers more detailed instructions on the design, construction and operation of a disposal facility.

The legislation concerning nuclear energy is currently being renewed. Parliament approved the Government's legislative proposal for amending the Nuclear Energy Act (Government Bill 117/2007) on 7 May 2005, and the renewed Act came into force on 1 June 2008. In addition, the work to renew the Government Decisions concerning nuclear safety (VNp 395-398/1991, 478/1999) is well on the way. Meanwhile, the Radiation and Nuclear Safety Authority has commenced preparatory work to renew the set of YVL Guides in the long term. The aim of this work is to bring the structure of the Guides up to date and re-edit the whole set in order to reduce the current number of individual Guides.





5 Licences, permits, plans, notifications and decisions required for the project

5.1 Land use planning

The construction area must have a valid local plan at the time of application for the construction licence for a final disposal facility from the Government. The Olkiluoto local plan is currently being revised to correspond to the content requirements set in the new Land Use and Building Act and to take into account the requirements for the building of disposal facilities for spent nuclear fuel in Olkiluoto. Areas for aboveground facilities will be reserved in the local plan. Expansion of the planned disposal facility will not require major area reservations to be made in the local plan.

5.2 Environmental impact assessment and international hearing

According to the Act on Environmental Impact Assessment Procedure (468/1994) and the Decree on Environmental Impact Assessment Procedure (713/2006), the construction of a facility for final disposal of nuclear fuel requires that an environmental impact assessment procedure be arranged. According to the Nuclear Energy Act, *the environmental impact assessment report shall be included in the application for a decision-in-principle concerning the construction of a nuclear power plant.*

The assessment of transboundary environmental impact has been agreed upon in the Convention on Environmental Impact Assessment in a Transboundary Context. Finland ratified the Convention of the United Nations Economic Commission for Europe in 1995. The Convention entered into force in 1997.

The parties to the Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland if the detrimental environmental impacts of the project being assessed are likely to affect the state in question. Correspondingly, Finland is entitled to take part in an environmental impact assessment procedure of a project located in the area of another state if the project's impact is likely to extend to Finland.

5.3 Decisions, licences and permits pursuant to the Nuclear Energy Act

5.3.1 Decision-in-principle

A disposal facility for nuclear fuel is a nuclear facility of considerable general significance referred to in the Nuclear Energy Act, the construction of which requires a decision-in-principle from the Government showing that the construction is in the overall good of society.

A decision-in-principle is applied for by submitting an application to the Government. The application for a decision-in-principle is not solely handled on the basis of the material submitted by the applicant; instead, the authorities will also obtain other reports, both those defined in the Nuclear Energy Decree and those otherwise considered necessary, in which the project is assessed from more general points of view. For handling the decision-in-principle application, the Ministry of Employment and the Economy requests statements from the municipal council of the municipality intended as the site of the facility and from its neighbouring municipalities, as well as from the Ministry of the Environment and other authorities stated in the Nuclear Energy Decree. In addition to the above, the Ministry must also obtain a preliminary safety assessment of the project from the Radiation and Nuclear Safety Authority.

Before the decision-in-principle is made, the applicant shall, according to instructions by the Ministry of Employment and the Economy, compile an overall description of the facility, the environmental effects it is expected to have and its safety, and, after a review by the Ministry, make it generally available to the public. The EIA report shall be enclosed with the decision-in-principle application.

The Ministry of Employment and the Economy shall provide residents and municipalities in the immediate vicinity of the nuclear facility, as well as the local authorities, with an opportunity to present their opinions on the project before the decision-in-principle is made. Furthermore, the Ministry shall arrange a public gathering in the municipality in which the planned site of the facility is located and during this gathering the public shall have the

opportunity to give their opinions. Those opinions shall be made known to the Government.

The granting of the decision-in-principle will be considered in accordance with Section 14 of the Nuclear Energy Act. A supporting statement from the municipality intended as the site of the planned nuclear facility is an essential prerequisite for a positive decision-in-principle. The Government will pay special attention to the following:

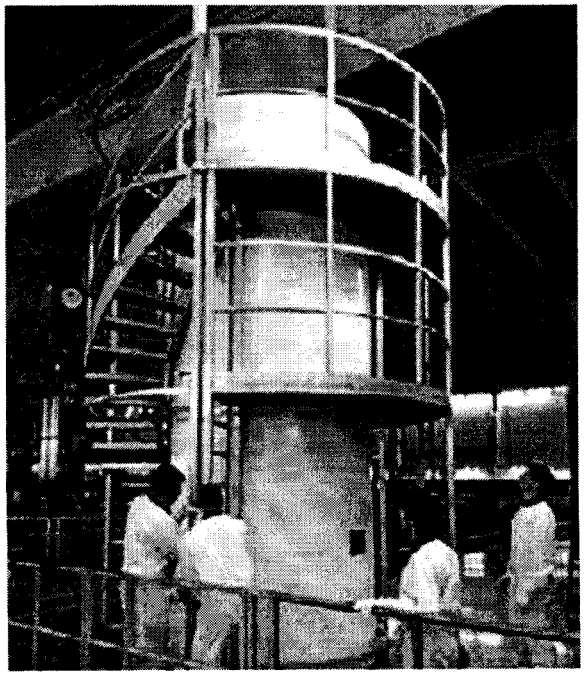
- the need for the nuclear facility project with regard to the country's energy supply
- the suitability of the intended site of the nuclear facility and the effects of the facility on the environment
- the arrangements for the nuclear fuel and waste management.

The Government decision-in-principle shall be forwarded to Parliament for perusal. Parliament may reverse the decision-in-principle as such or may decide that it remains in force as such, but Parliament is not allowed to revise its contents.

Prior to the entry into force of the decision-in-principle, the applicant shall not enter into any financially significant procurement agreements relating to the construction of the facility.

5.3.2 Construction licence

The decision-in-principle issued by the Government is followed by the actual licensing procedure. The Government grants the licences to construct and operate a nuclear facility. A licence to construct a nuclear facility may be granted if the decision-in-principle ratified by Parliament has deemed the construction of a nuclear facility to benefit society as a whole and the construction of the nuclear facility also meets the prerequisites for granting a construction licence for a nuclear facility as provided in Section 19 of the Nuclear Energy Act.



In accordance with the current schedules and the decision of the Ministry of Trade and Industry, Posiva will submit its construction licence for the repository to the Government by the end of the year 2012 *(Ministry of Trade and Industry 2003)*. The decision-in-principle states that a construction licence for the disposal facility shall be applied for in 2016 at the latest *(The Finnish Government 2000 and 2002)*.

Furthermore, the Ministry of Trade and Industry has stated that Posiva's readiness to apply for a construction licence will be assessed based on the documents to be submitted in 2009. In 2009, the Ministry of Employment and the Economy shall be presented with the reports required for the issuance of a construction licence described in Section 32 of the Nuclear Energy Decree. The reports shall show which parts of the documents required by the construction licence are incomplete and in which way and on what schedule the documents will be supplemented.

To accommodate the execution of the construction licence procedure for the disposal facility, Posiva shall provide the authorities with several reports showing the safety of the facility in accordance with the Nuclear Energy Act and the Nuclear Energy Decree. These include detailed technical designs of the facility, safety reports and up-to-date reports regarding the environmental impacts of all the waste types to be placed in the facility, and the design principles Posiva plans to follow in order to avoid environmental damage and to reduce the environmental load. *(The Finnish Government 2000.)*

5.3.3 Operating licence

The operation of a nuclear facility requires an operating licence issued by the Government. The licence to operate a nuclear facility may be issued as soon as a construction licence has been granted, providing the prerequisites listed in Section 20 of the Nuclear Energy Act are met. These preconditions include the following:

- the operation of the nuclear facility has been arranged so that industrial safety, the population's safety and environmental protection have been appropriately taken into account
- the methods available to the applicant for arranging nuclear waste management are sufficient and appropriate

- the applicant has sufficient expertise available and, in particular, the competence of the operating staff and the operating organisation of the nuclear facility are appropriate
- the applicant is considered to have the financial and other prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

Operation of the nuclear facility shall not be started on the basis of a licence granted until the Radiation and Nuclear Safety Authority has ascertained that the nuclear facility meets the prerequisites prescribed by law and the Ministry of Employment and the Economy has ascertained that provision for the cost of nuclear waste management has been arranged in a manner required by law.

In Finland, the operating licence for a nuclear facility is only granted for a fixed term. In considering the duration of the licence, special attention is paid to the safety precautions and the estimated duration of operations. The Radiation and Nuclear Safety Authority can interrupt the operation of a nuclear facility if it is necessary for ensuring safety.

5.4 Notifications pursuant to the Euratom Treaty

The European Atomic Energy Community (Euratom) Treaty requires that each Member State provides the Commission with plans relating to the disposal of radioactive waste (Article 37) in order to assess whether implementation of the plan will cause radioactive contamination of water, the soil or air in another member country. In accordance with Article 77, the Commission also controls nuclear safety in order to ensure that, for example, spent fuel is not transferred to any place other than that stated and that the licensee declares to the Commission the technical characteristics of the installation for its control (Article 78) and submits an investment report (Article 41).

5.5 Other permits

The construction and operation of a spent nuclear fuel disposal facility, and an encapsulation facility in particular, also require other permits. These include, for example, a building permit and an environmental permit, as well as the permits for changing the quality of groundwater and conducting water in accordance with the Water Act. These permits shall be applied for before the operations begin, in compliance with all valid national and municipal regulations. The authority responsible for the issuance of permits pursuant to the Water Act is the Western Finland Environmental Permit Authority.

Separate building permits for each building shall be obtained from the building inspection authority of the municipality. Currently, the plan is to apply for a building permit for at least a ventilation shaft building, an encapsulation facility, underground repositories and an operations building. In addition to these, a separate permit is required for crushing, for example. There is currently a valid permit for the storage of rock material.

Separate permits have been obtained for the underground research facility ONKALO. A building permit from the municipality of Eurajoki has been obtained for the ONKALO facility and the building aboveground serving the facility. The municipal building committee granted the permit on 12 August 2003. The building permit is valid for five years. Posiva applied for an extended permit in May 2008. The extended permit was granted on 11 June 2008 for three years.

Section 8 of the Nuclear Energy Act states that transportation of spent nuclear fuel requires a permit, and a permit pursuant to Sections 56–60 of the Nuclear Energy Decree shall be obtained for such transport. Transportation of spent nuclear fuel and the technology used in the transporting are regulated by the following:

- The Act on the Transport of Dangerous Goods (719/1994)
- The Government's Decree on the Transport of Dangerous Goods by Road (194/2002), the Ministry of Traffic and Communications' Decree on the Transport of Dangerous Goods by Road (277/2002)
- The Government's Decree on the Transport of Dangerous Goods by Rail (195/2002), the Ministry of Traffic and Communications' Decree on the Transport of Dangerous Goods by Rail (278/2002)
- The Decree on the Transport of Dangerous Goods in Packaged Form by Sea (666/1998)
- STUK's Guides YVL 6.4 "Transport packages and packagings for radioactive material" and YVL 6.5 "Transport of nuclear material and nuclear waste".

A separate permit is required for the transport of spent nuclear fuel during the operation of a disposal facility. The permits required for transportation of nuclear materials and nuclear waste in Finland are issued by STUK. Transportation may not begin until STUK has stated that the transportation equipment, the transportation arrangements and all safety and emergency arrangements meet the corresponding requirements, and that the nuclear liability in the event of nuclear damage has been properly covered (Nuclear Energy Decree, § 56, § 115). The first transportation licence will be applied for around the year 2020.

6 The project's connection to regulations, plans and programmes concerning environmental protection

6.1 The project's connection to valid environmental protection regulations

Table 6-1 presents the project's connections to valid environmental protection regulations that are central to the project. The table presents the content and legal validity of the regulation for the project. Land use and planning is described in Chapter 8.1.2.

6.2 The project's connection to plans and programmes

Table 6-2 presents the project's connections to plans and programmes that are central to the project. The table presents the content and legal validity of the plans and programmes.

6.3 The project's connection to conservation programmes

Nature conservation programmes help to reserve areas for nature conservation purposes in order to secure natural values of national importance. Nature Conservation Areas are areas protected under the Nature Conservation Act. Table 6-3 presents the project's connections to nature conservation programmes that are central to the project.

Table 6-1 The project's connection to valid environmental protection regulations.

Title	Content	Connection to the project
Environmental Protection Act (86/2000) and Decree (169/2000)	General regulations for preventing environmental pollution.	Obligation to apply for an environmental licence.
Guideline values for noise (Government decision on the guideline values for noise (993/1992)	The guideline values for noise in residential and recreational areas in urban areas or near urban areas are 55 dB(A) in the daytime (7:00 am–10:00 pm) and 50 dB(A) at night. The guideline value for noise in new areas at night is 45 dB(A). The guideline value in holiday home areas is 45 dB(A) in the daytime and 40 dB(A) at night. The guideline values for narrowband noise are tighter than those for normal noise. If noise is stated to be narrowband noise, 5 dB will be added to the measured noise level before comparing it to the guideline values.	The construction stages that cause noise will be planned so that the guideline values for noise in the surrounding areas of the repository will not be exceeded together with other operators. Noise abatement planning will prevent narrowband noise.
Waste Act (1072/1993) and Waste Decree (1390/1993)	The objective is to support sustainable development by promoting sensible use of natural resources, and preventing any damage to health and the environment caused by waste. The objective is primarily to be reached by reducing the amount of waste created and increasing the utilisation of waste. If utilisation is not possible technically or with reasonable added costs, waste must be placed so that any damage to health and the environment can be minimised.	Any waste produced at the disposal facility will be sorted and utilised so that the requirements set in the Waste Act are met. Waste unsuitable for utilisation will be disposed of in the manner required in the disposal facility's environmental permit.

Table 6-2 The project's connection to plans and programmes.

Title	Content	Connection to the project
Water protection objectives (Government's decision in-principle 23 November 2006 concerning water protection objectives up to 2015)	The decision presents acts to achieve a good status for water systems and preventing deterioration in the status. The programme applies to inland waters, coastal waters and groundwater. The guidelines support the preparation of regional water management plans. They also support the preparation and execution of the EU Marine Strategy Framework Directive and the Baltic countries' action plan for protecting the Baltic Sea. The objective is: – to reduce load which causes eutrophication – to reduce risks caused by detrimental substances – to reduce damage caused by water construction and water system regulation – to protect groundwater – to protect the multiplicity of marine wildlife – to maintain the water system.	The disposal facility and the water purification plant represent the best technology available. The disposal facility does not cause any significant emissions into the water system.

Table 6-3 The project's connection to nature conservation programmes.

Title	Content	Connection to the project
Natura 2000 network (Government's Natura decision 20 August 1998 which is based on the Habitats Directive (92/43/EEC and Birds Directive 79/409/EEC, amendment 91/244/EEC)	The Natura 2000 network is aimed at preserving biodiversity within the European Union region. Valuable habitat types and endangered animal and plant species have been selected for conservation.	The closest area belonging to the Natura 2000 network is the Rauma Archipelago (FI0200073). The old Liiklankari forest located on the southern coast of Olkiluoto is part of the Rauma Archipelago's Natura area. Aboveground plants will not be built in the Natura area.
Programme for the protection of old-growth forests	The objective is to preserve the natural values of old forests as sufficiently large entities. The selection criteria for the areas include biological variety and the structure of tree stand.	The Liiklankari conservation area located on the southern coast of the Olkiluoto island, in the immediate vicinity of the disposal area for spent nuclear fuel, is part of the programme for the protection of old-growth forests. Aboveground plants will not be built in the old forest protection area.
Herb-rich forest conservation programme	The objective is to preserve the variety and quality of Finnish herb-rich forests and vegetation.	The Reksaari coastal herb-rich forest area belonging to the herb-rich forest conservation programme and the Natura 2000 network is located about 5 km south of Olkiluoto. The Praminlehto and Mäentausta forests are located in the Sorkka village in Rauma.
Shore conservation programme	The basic objective is to preserve the areas included in the programme unbuilt and in their natural state in order to protect marine and lake habitats.	The outer archipelago north of Rauma, including the Susikari, Kalla and Bokreivi islands, belongs to the shore conservation programme. In addition, the western coast of Nurmes belongs to the shore conservation programme.
Valuable rock areas	This includes rock areas of national value for nature and landscape protection. The rock areas contain such biological, geological or landscape-related values that are nationally important or otherwise considerably important from the point of nature reservation as referred to in section 7 of the Extraction Act.	The Rannanvuori and Huikunvuori rock areas are located in Sorkka village in Rauma, about eight kilometres from the repository.
Nationally valuable landscape areas and the development of landscape management	The objective is to obligate different authorities to engage in extensive cooperation in organising landscape management and securing the valuable features of cultural landscapes. Areas assessed to be nationally valuable landscape areas represent the best preserved and most typical agricultural landscapes. State officials should act to promote the objectives of landscape management and ensure that other simultaneous projects do not endanger the preservation of cultural landscapes.	There are no valuable landscape areas near Olkiluoto.
National Strategy for the Conservation and Sustainable Use of Biodiversity 2006–2016 (an extension to the National Action Plan for Finnish Biodiversity 1997–2005)	The objective is to stop the deterioration of biodiversity by 2010, stabilise the favourable development of Finnish nature in 2010–2016, prepare for global environmental changes that threaten Finnish nature by 2016 (climate change in particular) and strengthen Finnish influence in the preservation of biodiversity globally through the means of international cooperation.	The Omenapuumaa nature conservation area and the Särkänhuivi cape have a regional conservation value. The luxuriant grove island of Omenapuumaa is located in the Rauma archipelago, approximately five kilometres south of Olkiluoto. The low, narrow, long and curved cape of Särkänhuivi is the outermost tip of the Irjanteenharju ridge that protrudes into the sea. The Kalattila Grove has local conservation value.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7 Environmental impact assessment and the methods used therein

7.1 General

The assessment of environmental impacts has focused on those impacts that are considered and felt to be significant. Information about issues deemed important by citizens and various interest groups has been obtained in connection with the notification and hearing procedures, among other things.

The significance of environmental impacts has been assessed on the basis of, for example, the settlement and natural environment of the observed area as well as by comparing the tolerance of the environment with regard to each environmental burden. In addition to the investigations carried out, the existing specifications have been employed when assessing the environmental tolerance.

The results of the environmental impact assessment are collected in this environmental impact assessment report. All relevant existing environmental data, as well as the results of the prepared environmental impact assessments, are presented in the EIA report. The EIA report also includes a plan for the mitigation of any detrimental environmental impact.

The delimitations of the environmental impact assessment in terms of each specific impact, the environmental impacts to be investigated, and the methods to be used are presented below. The delimitation of the observed and affected areas is given in connection with the description of each impact assessment.

7.2 Assessment of environmental impact during construction and operations

7.2.1 Assessment of environmental impacts from transport of spent nuclear fuel and other traffic

The most significant traffic impacts caused by the project will arise from the construction and operation of the expansion of the disposal facility and transport of spent nuclear fuel. Changes to the current traffic volumes arising from transports, as well as the means and routes of transport, have been presented. The noise impact caused by the traffic and its effects on comfort has been assessed based on the traffic changes in residential areas. The required changes to the traffic arrangements in these areas, as well as their impacts, have been assessed.

Spent fuel will be transported to the disposal facility from the nuclear power plants belonging to Posiva's owners. The plan is that the fuel from Loviisa will be transported to Olkiluoto as road transport; however, railway and ship transport and their combinations have also been studied as alternative transport methods. The EIA report presents an assessment of the safety of the transportation options for spent nuclear fuel and its impact on the environment. The assessment is based on studies made.

The radiation dose caused by transportation to individuals and the population has been assessed using Posiva's report entitled "Revision to the spent nuclear fuel transportation risk assessment" (*Suolanen et al. 2004*). The report specifies the health risks that are caused by transportation from the Loviisa nuclear power plant to the Olkiluoto disposal facility (normal transport) and exceptional events (incidents and accident situations). The studied routes include road, railroad or sea routes or combinations of these. In the transportation risk assessment, the radiation dose caused by normal transportation for the population was studied using the American RADTRAN model. Accident situations were studied in detail using the Technical Research Centre of Finland's (VTT) ARANO model. The expected values and health risks of radiation dose caused by transportation accidents were calculated using the RADTRAN model. By using the guideline values presented by the International Commission on Radiological Protection (ICRP), the radiation dose caused by transportation was converted into values that represent health risks.

The impact of transportation and road traffic has been studied for the roads affected by the project.

7.2.2 Assessment of impacts on land use, cultural heritage, buildings and structures

The project's impact on the present and planned land use, the landscape and the built environment has been assessed in terms of the area's land use planning and de-

velopment.

The landscape impact has been assessed on the basis of the plans prepared for the project, existing reports and visits to the terrain, as well as map and aerial photo studies. The landscape impacts arise from the building of aboveground parts of the disposal facility and related activities. The impact assessment includes descriptions of the features of the landscape surrounding the final disposal site as well as sites of value in the landscape and cultural environment. Furthermore, the impact assessment includes studies of possible changes in the landscape characteristics caused by the expansion of the repository area, possible significant changes in the view towards the final disposal site from different directions and the possibility of significant impacts on sites of value in the landscape and environment. Particular focus has been laid on impacts on residential and recreational areas located in the vicinity of the disposal facility.

7.2.3 Assessment of soil, bedrock and groundwater impacts

The project's impacts on the soil and bedrock in the facility area have been assessed based on the terrain, the quality of the soil and bedrock, and the area required for the facility and the associated structures as well as the dimensions of underground elements. The impact of the heat generated by spent fuel in the bedrock has also been assessed.

Extensive research work, such as quarrying, drilling, geophysical sounding, groundwater flow measurements and groundwater composition studies, has been and will be carried out in Olkiluoto as part of planning for the disposal of spent nuclear fuel. The research is aimed at identifying the characteristics of the bedrock and flow routes of groundwater. The bedrock information gathered by Posiva is mainly based on approximately 50 deep holes drilled in the bedrock from the surface and on measurements carried out between 1989 and 2008. Furthermore, information about the bedrock characteristics has been gathered since the beginning of the construction of the ONKALO facility by systematically surveying the walls of the tunnel.

In order to identify the impact on groundwater, the location of the expansion of the disposal area with respect to groundwater as well as the potential risks imposed on groundwater due to construction and operations, such as groundwater level reductions and changes in the chemical composition of groundwater, have been studied. The assessment is based on existing surveys, calculations and studies. The volume of groundwater leaking into the underground rock facilities has been assessed.

The impacts of the construction of the ONKALO facility are monitored by means of measuring and monitoring several hydrological, hydrogeochemical, environmental, rock mechanics and foreign agent parameters. The hydrological monitoring project includes monitoring groundwater level, groundwater pressure height, flow conditions in open holes, groundwater flow rate (cross flow in holes), water conductivity, groundwater salinity and electrical conductivity, precipitation (incl. snowfall), seawater level, runoff surface waters, infiltration, ground frost, leak water in tunnels, water balance of the tunnel system and water balance of the Korvensuo reservoir. Rainfall, frost and infiltration will be reported annually in the environmental monitoring report.

Hydrogeochemical monitoring will be focused on studying any chemical changes in groundwater. The rock mechanics monitoring programme includes the monitoring of micro-earthquakes and bedrock movement. Models will be updated on the basis of new information.

7.2.4 Assessment of air and air quality impacts

Civil engineering work, site traffic and separate functions (such as rock crushing and deposition of rock material) will cause local dust generation during construction. Vehicles and machinery will cause atmospheric emissions. These emissions and their impacts have been assessed by experts.

7.2.5 Assessment of water system impacts

The water procurement arrangements have been described and the impact of water procurement on the environment has been assessed on the basis of existing research data and expert assessments.

Treatment of wastewater generated during the operation of the planned disposal facility and the resulting loads have been presented. The increase in wastewater volumes due to the expansion of the repository has been assessed. The impact of wastewater on the quality of seawater has been assessed on the basis of existing research data and expert assessments. The assessment has utilised the results of environmental monitoring conducted by Posiva.

7.2.6 Assessment of the impacts of waste and by-products and their treatment

The EIA report describes the quantity, quality and treatment of ordinary, hazardous and radioactive waste generated in the disposal facility, and assesses the related environmental impact. The increase in waste volumes due to the expansion of the disposal facility has been assessed.

7.2.7 Assessment of the impacts of noise and vibration

The operations that will cause the most noise during the survey, building and operational phases of the disposal facility are quarrying, crushing and transportation. Noise impacts have been assessed on the basis of the results of noise measurements carried out in Olkiluoto, the design data, a noise model drawn up during TVO's EIA procedure *(Ramboll Analytics Oy 2007)*, and the data and standards concerning the level of environmental noise.

Ramboll Analytics Oy has identified the noise caused by the functions and planned operations in the Olkiluoto area through calculations in the autumn of 2007 *(Ramboll Analytics Oy 2007)*. The noise investigation was largely based on previous studies *(Insinööritoimisto Paavo Ristola Oy 2006 and 2006a)*. The noise calculations have been prepared using the SoundPlan calculation software (version 6.3) that takes the 3D terrain model into account and is based on a Nordic calculation model for road and industrial noise. Noise zones were calculated for the daytime (LAeq 7-22) and night time (LAeq 22-7). The terrain, the barrier and reflective impacts caused by buildings and the dampening effect created by the soil were taken into account in the model. The soil was assumed to dampen, and the buildings and water areas to reflect sound. Trees and other vegetation were not taken into consideration in the calculations. In addition to the existing buildings, Posiva's ONKALO construction site, rock material crushing, the OL3 nuclear plant unit currently under construction, the planned OL4 plant unit, the wind power plant, the port and Fingrid Oyj's gas turbine power plant were taken into account in the model.

Vibration has been assessed on the basis of the monitoring results obtained during the construction of the ONKALO facility.

7.2.8 Assessment of impacts on vegetation, animals and objects of protection

The impacts of the disposal facility on flora and fauna are primarily related to the land areas required for buildings and structures, as well as the construction work. These impacts have been assessed by experts. The assessment has utilised the results of environmental monitoring conducted by Posiva.

The project's direct and possible indirect impacts on flora and fauna have been assessed by experts. The impacts of diffferent project options on biodiversity and interactional relationships have been assessed on the basis of these results.

The assessment work has in part focused on studying whether the project, either individually or in combination with other projects and plans, is likely to have a significant adverse effect on the ecological values that serve as the conservation basis of the nearest Natura areas.

7.2.9 Assessment of impacts on utilisation of natural resources

The impacts on utilisation of natural resources refer to both the use of natural resources and prevention of the use of natural resources. The EIA report describes the use of natural resources and the resulting impacts. Relating to the utilisation of natural resources, the utilisation of quarried material generated and the consumption of natural resources required by the project (such as bentonite and copper) have been assessed.

7.2.10 Assessment of impacts on humans

In the environmental impact assessment, the impact of the expansion of the disposal facility on people's health, comfort and living standards in terms of, for example, land use changes, landscape impacts, increased radiation dose caused by radioactive emissions, traffic impacts, and noise have been studied. In addition to the above, the assessment report also discusses the impact of potential accidents. The focus areas of the assessment have been selected on the basis of the feedback received from the residents and commuters in the area. It must be noted that there are major uncertainties related to the assessment of social impact on actions taking place more than 60 years in the future. Interaction within the audit group and discussion events, as well as the information obtained from various interest groups and the media, have served as a tool for assessing the project's impact on people.

The impacts on people's health and comfort have been assessed using the "Human impact assessment guidelines" prepared by Stakes, the National Research and Development Centre for Welfare and Health *(www.stakes.fi)*. The guidebook on the application of the EIA Act in the assessment of health and social impacts, published by the Ministry of Social Affairs and Health *(Ministry of Social Affairs and Health, 1999)*, has also been utilised in the assessment.

Health impacts

The main focus in surveys pertaining to health impacts has been laid to potential health hazards caused by radioactive substances. The increase in radiation dose for residents in the surrounding areas caused by the transportation of spent nuclear fuel and radioactive emissions from the expansion of the disposal facility have been assessed.

The health impacts and risks have been assessed using calculations on the basis of radiation exposure.

In addition to radiation impacts, other possible health impacts potentially caused by the project have been assessed. Adverse impacts caused by traffic, noise and dust are being studied. This study is based on the presented assessments of emissions caused by the project and other concrete changes in the environment. Possible health impacts caused by the disposed materials have been studied separately.

The management of long-term safety (Chapter 11) ensures that the disposal facility will not cause any health impacts, even in the distant future.

Living conditions, comfort and recreation

Resident queries and other attitude studies conducted by Posiva have been utilised in the preparation of the report, where applicable. The attitudes of Finnish people towards nuclear waste were studied in the "Finnish Energy Attitudes 2007" survey as part of the "Finnish Energy Attitudes" monitoring research. The research series has studied the attitude of Finns towards energy policy issues for the past 25 years (1983–2007). The central results are presented in this EIA report.

The trust of Eurajoki residents in the safety of the disposal of spent nuclear fuel was studied through a qualitative interview and quantitative resident query conducted in autumn 2007 *(Aho 2008)*. The research results are presented in this EIA report.

The resident survey *(Ramboll Finland Oy 2007)* conducted in connection with the preparation of the Olkiluoto partial master plan (in 2006–2007) was aimed at identifying the residents' impressions of the current status of their living environment and obtaining information about the impact caused by the current operations in Olkiluoto on the immediately surrounding area. The central results are presented in this EIA report.

To support the social impact assessment, theme interviews *(Pöyry Environment Oy 2008)* have been organised in order to identify the opinions of those living close to the repository and young adults and parents of small children living in Eurajoki. The purpose of the theme interviews was to increase interaction by providing the person in charge of the project with information about the residents' attitudes towards the project and, conversely, by providing the residents with information about the project and its impacts on their living environment.

7.2.11 Impacts on community structure, local economy and the image of the municipality of Eurajoki

The assessment report includes an assessment of the number of direct and indirect jobs generated by the construction and operation of the disposal facility in the region. The project's impact on the development of the economic structure, planning of social activities and the outlook of local companies has also been studied. At its broadest, the study of the impacts on the regional structure and regional economy has covered the entire Satakunta area.

The regional and economic impacts have been assessed using Posiva's work report entitled "Regional economic, socioeconomic and municipal economic impacts of the repository for spent nuclear fuel" *(Laakso et al. 2007)*. The report includes an up-to-date assessment regarding the impacts of the construction of the disposal facility on employment, population development, construction, community structure and municipal economy in the municipality of Eurajoki and the broader affected area. The time span of the survey extends to the early 2020s, at which time the actual operation of the disposal facility will have been started. The inspection was conducted for Posiva's assignment by Kaupunkitutkimus TA Oy during the spring and summer of 2007.

The impacts of the project on the image of the municipality of Eurajoki have been assessed using the working report 'Municipal Image Survey 2006' by Posiva as an aid *(Corporate Image Oy 2007)*. The survey studied the image of Eurajoki amongst residents, Finnish consumers and representatives of companies. The survey was a follow-up study on a similar survey done in 1998. The survey was conducted by interviewing 500 consumers, 200 representatives of companies and 200 residents of Eurajoki over the phone from October to December 2006.

7.3 Assessment of the impact of incidents and accident situations

The EIA report has studied the impact of accidents on the health of people and the environment on the basis of safety analyses and requirements set for the disposal facility. The ramifications of irregular situations have been assessed on the basis of the extensive research data on the health and environmental impact of radiation. Radiation doses and affected areas in the event of an incident or an accident have been assessed.

7.4 Assessment of long-term safety

The safety design criteria for the planned expansion of the disposal facility, as regards the limitation of radioactive emissions and environmental impacts, are presented in the assessment report. Furthermore, an assessment of the possibilities for meeting the currently valid safety requirements are presented. The assessment is based on estimates of the final disposal of 9,000 tons of uranium (updated in 2008).

The long-term safety of the final disposal of the spent nuclear fuel is indicated using a safety case. The preliminary safety case material for the horizontal disposal solution was completed in 2008 *(Smith et al. 2007)*. The long-term safety study currently in progress is aimed at preparing a safety case for the construction licence application for the disposal facility.

The first plan concerning the safety case for the repository for spent nuclear fuel to be built in Olkiluoto was prepared in 2005 *(Vieno & Ikonen 2005)* and it has been reviewed and revised in 2008 *(Posiva Oy 2008)*. According to the plan, the safety case consists of a group of separate reports that present the starting points of safety assessment, the models and initial data used, the assessment methods, the assessment results and related uncertainties and conclusions of the safety inspections and their reliability.

The safety analyses included in the safety case identify the radiation dose extending over a period of thousands of years in development processes deemed likely and in unlikely events that would compromise long-term safety. For periods longer than that, the emission speeds of radioactive substances related to such events and processes into the living environment will be assessed.

The safety analyses present overestimatings for the radiation doses and release speeds of radionuclides. The purpose of the analyses is to study the consequences for people or the environment if one or several emission barriers failed and radioactive substances were released from the repository into the environment. The safety analyses also deal with the uncertainties associated with the assessment of the behaviour of the disposal system, various events and processes. When assessing risks, the probability of the events will be taken into account.

The radiation doses and emission speeds have been compared with the safety requirements that have been specified in legislation, Government decisions and YVL guides published by STUK.

7.5 Assessment of the impact caused by not implementing the project

The zero-option is the non-implementation of the project. This means that the condition of the environment and the impact of environmental loads correspond to a situation in which the amount of spent nuclear fuel to be disposed of is 9,000 tU. In the zero option, the spent nuclear fuel from six nuclear power plant units can be disposed of in the Olkiluoto disposal facility. In this case, spent fuel from the seventh nuclear power plant unit will be stored in water pools in the interim storage for spent fuel until a decision concerning the processing or permanent disposal of the fuel is made.

The information included in the EIA report drawn up in 1999 and the project's impact assessments have been updated to comply with the current design status. A summary of the information is presented in this EIA report. The possibilities for continuing interim storage of spent nuclear fuel at the Olkiluoto and Loviisa nuclear power plants and the impact caused by interim storage have been taken into account.

7.6 Comparing alternatives

The impact of the options has been compared using a qualitative comparison table in Chapter 14.2. The central environmental impacts of the options – positive, negative and neutral alike – have been recorded in an illustrative and uniform manner. The environmental feasibility of the options has also been assessed in this connection on the basis of the results of the environmental impact assessment.

8 Environment description

Since the environmental impacts of the Olkiluoto nuclear power plant and Posiva's disposal facility have been inspected widely, there are a number of reports available which describe the state of the environment in Olkiluoto and its surrounding areas. The state of the nuclear power plant's environment has been monitored for more than 30 years. The environmental impacts of Posiva's repository were last assessed comprehensively in connection with the EIA procedure in 1999, and in 2008 when an updated report of the environmental impacts of the repository was being drawn up. Posiva regularly monitors the state of the disposal facility's environment regularly.

A more specific description of the project's current state is a description of the time the final disposal requiring an expansion project will start, i.e. at the earliest around 2070. In practice, there are some uncertainties related to the description of the environmental conditions in 2070. For this reason, this document describes the current status in Olkiluoto and the possible changes caused by the activities connected to final disposal.

8.1 Land use and built environment

8.1.1 Operations located in the environment of Olkiluoto and land ownership

Hankkila, the village closest to Olkiluoto, is located approximately eight kilometres from the Posiva disposal facility area. Linnamaa, which is located approximately ten kilometres from the repository area, belongs to the Vuojoki cultural landscape that includes the Vuojoki Mansion area and the Liinmaa Castle ruins from the 1360s. The Kuivalahti village centre is located to the north of the Eurajoensalmi inlet approximately nine kilometres from the disposal facility area, and the Lapijoki village centre is located along highway 8 approximately 14 kilometres

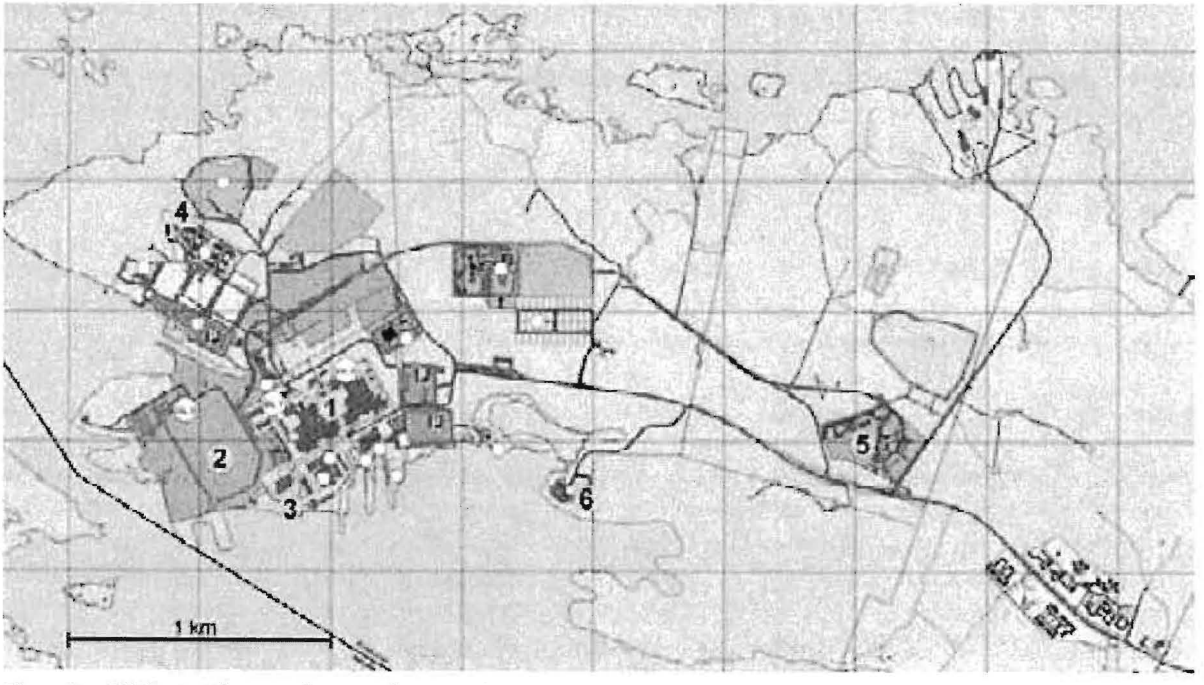


Figure 8-1 Olkiluoto. The map features, for example, OL1 and OL2 (1), the OL3 construction site (2), the KPA storage (3), the VLJ repository (4), the Posiva ONKALO construction site (5) and the visitor centre (6).

Figure 8-2 A conceptual image of the Olkiluoto area. TVO's nuclear power plant units OL1, OL2 and OL3 can be seen in the top left-hand corner. The buildings in the middle belong to Posiva's repository. Korvensuo reservoir and the blasted rock dumping site are located to the right of the buildings.

from the disposal facility area. The nearest village centre in Rauma is called Sorkka and is located approximately nine kilometres southeast of the disposal facility area.

TVO's 350-hectare nuclear power plant site is located on the west side of the Olkiluoto island. The site contains TVO's current power plant units OL1 and OL2. Furthermore, OL3 is under construction and is scheduled to start operation in 2011.

Posiva's disposal facility is located in Olkiluoto; currently, the disposal facility area is the ONKALO construction site. In addition to the nuclear power plant units and the ONKALO construction site, the area includes administrative buildings, a training centre, a visitor's centre, warehouses, repair shops, a backup heating plant, a reservoir, a raw water purification plant, a demineralizing plant, a purification plant for sanitary water, a landfill, an interim storage for spent nuclear fuel (KPA storage), interim storages for low- and intermediate-level operating waste (MAJ and KAJ storages), a repository for operating waste (VLJ repository), a contractor area and accommodation villages. Furthermore, Olkiluoto Island houses a Fingrid Oyj substation, a TVO wind power station and a Fingrid Oyj gas turbine power plant for backup power needs. The operations at Olkiluoto are shown in Figure 8-1.

Posiva has leased the site intended for the disposal facility for spent nuclear fuel from TVO until 2103. The site is located in the middle of the island and on the east side of the power plant site. The area of the leased site is about 36 hectares and it is limited in the south by the road leading through the island to the power plants and in the east by the road leading to the port and dockyard area. Immediately to the north of the site is located the Korvensuo reservoir, through which water taken from the Eurajoki river is fed for use in the nuclear power plant. To the west of the leased site, there is a dumping site where rock waste created by Posiva's underground excavation work and other construction work performed in the power plant area is transported.

Figure 8-2 presents the repository's planned location on the Olkiluoto island. The Olkiluoto nuclear power plant units are located at the top of the figure. The future dumping site for rock waste is on the right-hand side of the picture.

In addition to the entrance to the underground rock characterisation facility ONKALO, a project office, field laboratory, various storage and repair shop buildings, and lift and ventilation rooms required by the underground facilities have been built in the aboveground section in the area leased by Posiva by the year 2008. Furthermore, surveys to determine the rock and soil characteristics on the plant site and in its surroundings are underway. Because of this, connecting roads, protective buildings for research holes and other research-related structures have been built in the area and its surroundings.

To the east of the power plant site, the Olkiluoto island is mainly covered by forest. Olkiluoto's industrial port is located in the middle of the northern shore of the island. The eastern end of the Olkiluoto island features agricultural areas and holiday homes. A new accommodation village and caravan park providing temporary housing for nuclear power plant construction and maintenance personnel is also located in the area.

TVO owns most of Olkiluoto. On the eastern parts of the island there are holiday homes and vacant holiday home sites, as described by the master shore plan of the area, and a few privately-owned larger areas. The State owns the Liiklankari conservation area and the western part of the Kornamaa island. The Liiklankari area is governed by Metsähallitus.

TVO owns some of the waters around Olkiluoto directly and some through joint ownership. TVO owns approximately 70 percent of the water rights of Olkiluoto and Orjasaari, as well as approximately 40 percent of the Munakari communal area.

8.1.2 Land use planning

National land use objectives

The national land use objectives are part of the land use planning system pursuant to the Land Use and Building Act. The Government decided on national land use objectives in accordance with Section 22 of the Land Use and Building Act on 30 November 2000 and the decision gained legal validity on 26 November 2001.

Objectives aimed at securing the national energy supply have been of particular importance in the preparation of a partial master plan for Olkiluoto. Land use planning must ensure the protective zones required for nuclear power plants and prepare for the disposal of nuclear waste. As regards connection and energy networks, land use and land use planning must pay attention to land use in the surrounding areas and the nearby environment, particularly settlements, valuable natural and cultural sites and areas, as well as the special characteristics of the landscape.

The current regional plan

In the 5th Satakunta regional plan ratified by the Ministry of the Environment on 11 January 1999, almost the entire Olkiluoto area is designated a public utilities and infrastructure zone (ET-1). According to the special provisions concerning the zone, detailed planning and design must pay special attention to environmental protection, and the handling and storage of radioactive waste must be arranged in an absolutely safe manner. Furthermore, the regional plan also allows other energy production besides the nuclear power plants, as well as other industry based on the energy production in the region.

A port and a dockyard (LV) are located on the northern shore of Olkiluoto. Liiklankari Natura 2000 area and a protected old forest (SL) are located to the south of the site of the disposal facility for nuclear fuel. Kuusisenmaa (MY, area dominated by agriculture and forestry with recognised environmental value) is located to the southwest of Olkiluoto.

The Olkiluoto nuclear power plant site is surrounded by a hazard zone (va-1, remote protection zone) extending to a distance of approximately five to seven kilometres. In detailed planning and design, this zone may not be used for any large residential areas or facilities with a large number of employees or patients, or any facilities whose operations would be severely hampered by the potential effects of an accident. Furthermore, the zone must not be used for any facilities or equipment that could be a danger to the nuclear power plant, such as explosives factories, warehouses or airports.

Provincial plan of Satakunta in preparation

The Satakunta Regional Council is drawing up a provincial plan to replace the current regional plan. Drafting of the Satakunta provincial plan started in February 2003. The legally valid regional plan, dating back to the year 2001, will be revised and updated to comply with the requirements of the current Land Use and Building Act. The provincial plan will include a reservation for a general energy supply plant area (EN/la) and show the locations of high-voltage lines, regional road, boat and ship channels and conservation areas (Figure 8-3. An extract from the Satakunta provincial plan, draft version, 28 April 2008.). The EN/la marking indicates the nuclear power plant site reserved for plants, buildings and structures serving energy production or plants and buildings engaged in the disposal of spent nuclear fuel. Moving about in the area may be restricted for safety reasons. A building restriction pursuant to Section 33 of the Land Use and Building Act is in effect in the area.

The EN marking is used to propose a target area for developing energy production outside the nuclear power plant site. The design of the target area must take into account that the use of the areas will not endanger the development of energy maintenance and disposal operations and research. Special attention must also be paid to the actions required to preserve the solidity of the bedrock inside this target area.

The Satakunta provincial plan draft and the connected preparation documents were on public view from 12 May to 18 June 2008. A provincial plan proposal will be drafted based on the statements and opinions obtained, and the proposal will also be on public view when completed. Finally, the provincial plan proposal will be submitted to the Assembly of the Regional Council for approval and further to the Ministry of the Environment for ratification. The objective is for the Ministry of the Environment to ratify the Satakunta provincial plan by the end of the year 2009.

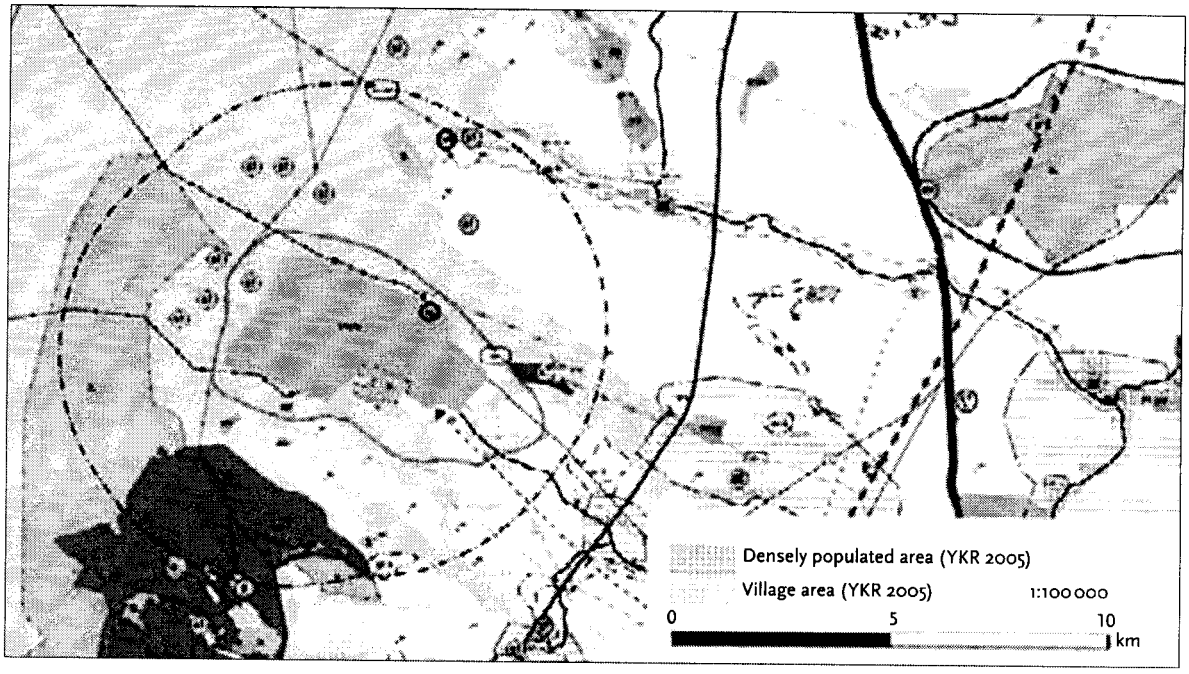


Figure 8-3 An extract from the Satakunta provincial plan, draft version, 28 April 2008.

Master shore plan

The Eurajoki master shore plan, ratified by the Southwest Finland Regional Environment Centre on 25 October 2000, is in force in the Olkiluoto area. The power plant site and the surrounding areas are designated a zone for industrial and warehouse buildings (T). Most of the area east of the power plant site is designated as a zone dominated by agriculture and forestry (M). The master shore plan also includes zones for holiday homes (RA), farmsteads (AM) and detached residential houses (AP). The Liiklankari area located along the southern shore of the Olkiluoto peninsula is designated a nature conservation area (SL).

The Eurajoki municipal council approved an amendment to the master shore plan on 12 December 2005, assigning an accommodation village and other functions serving energy production to the southeastern part of Olkiluoto.

The partial master plan for the northern shores of Rauma ratified on 23 December 1999 is valid in the northern coastal areas of Rauma.

Olkiluoto partial master plan

The Eurajoki Municipal Council approved the Olkiluoto partial master plan on 19 May 2008 (Figure 8-4). The town of Rauma is drawing up an amendment to the partial master plan for its northern coastal areas. The partial master plans in preparation are legally effective.

Within the municipality of Eurajoki, the partial master plan covers Olkiluoto, minor islands to its north and northwest side (Kornamaa, Mäntykari, Munakari and approximately 20 smaller islands), and the waters surrounding them.

For these areas, the partial master plan replaces the Eurajoki master shore plan, including the amendment made therein concerning the accommodation village with its surroundings.

An amendment to the partial master plan for the shores north of Rauma has been prepared simultaneously with the Olkiluoto partial master plan. Within the town of Rauma, the area covered by the plan includes the islands of Kuusisenmaa, Leppäkarta and Lippo off Olkiluoto, as well as the waters surrounding these islands. The partial master plan is an amendment to the partial master plan for the northern shores of Rauma ratified on 23 December 1999.

Several land use options were discussed during the preparation of the Olkiluoto partial master plan. The planning aims at a solution that realises the objectives set for a partial master plan in the best possible manner. The primary objective with regard to land use is to create the prerequisites for building the largest energy production site in Finland and a final disposal facility for spent nuclear fuel according to Finnish legislation and the requirements set for the safety of the operations.

The Eurajoki Municipal Council's decision to approve the Olkiluoto partial master plan has resulted in two complaints, which are currently being processed.

The partial master plan includes reservations for areas required for aboveground final disposal functions. The

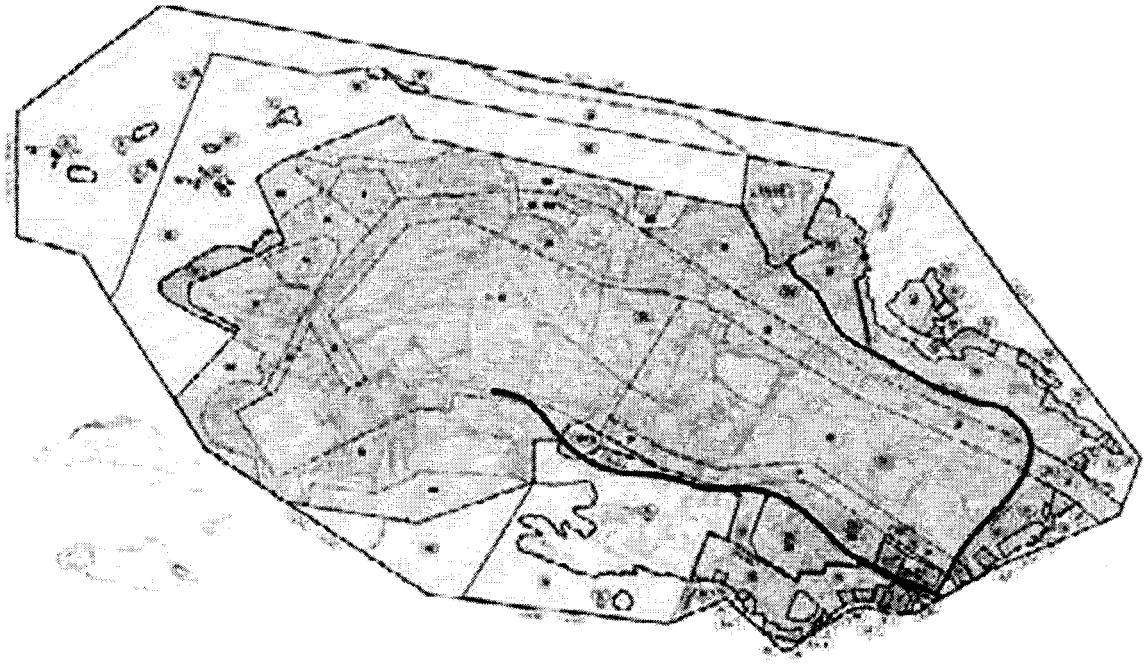


Figure 8-4 An extract from the proposed amendment to the Olkiluoto partial master plan, 28 April 2008. The indicative border for the final disposal facilities is shown in the plan.

regulations concerning the EN area include among other things:

- *the statement to the effect that nuclear waste facilities related to final disposal of low and intermediate level as well as high-level nuclear waste may be built on the area according to the construction licence granted under the Nuclear Energy Act. These include access buildings and structures providing access to underground repository facilities as well as encapsulation facilities and related auxiliary facilities.*

Furthermore, the partial master plan defines the area required for underground final disposal functions and its protective zone, which are stipulated as follows:

- *The indicative underground disposal facility area: The construction licence granted under the Nuclear Energy Act allows the building of a final disposal facility for high-level nuclear waste in the bedrock of the area. The extent of the area is determined on the basis of the occurrence of the bedrock type most favourable for final disposal at the final disposal level.*
- *The protective zone of the final disposal facility: The fact that the area belongs to the protective zone of the final disposal facility must be taken into account when excavation and drilling work is performed in the area. The party responsible for the final disposal operations must be consulted before excavation and drilling of the bedrock is commenced. Pursuant to section 63(1), paragraph 6 of the Nuclear Energy Act, the Radiation and Nuclear Safety Authority has the right to issue property preservation orders necessary for ensuring safety when the property contains a terminally sealed repository for spent nuclear fuel. According to section 85 of the Nuclear Energy Act, the Radiation and Nuclear Safety Authority must report the final disposal site of nuclear waste as well as the preservation order referred to above for entering it in the property register, land register or list of titles.*

The draft of the partial master plan for the northern shores of the town of Rauma was also on public display from 21 February to 22 March 2007. The plan proposal was completed on 31 October 2007 and the Planning Division officially put it on public display on 10 December 2007.

The aboveground parts of the repositories as defined in the draft proposal of the partial master plan for the northern shores of Rauma do not extend into the area of the town of Rauma.

Local plans and local shore plans

There are valid plans for the Olkiluoto area, ratified in 1974 and 1997. The repository area for spent nuclear fuel has been marked as an area reserved for industrial and warehouse buildings (T) into which nuclear power plants and other plants and equipment connected with power production, distribution and transfer as well as adjacent buildings, constructions and devices may be constructed, unless construction of such is otherwise limited (Figure

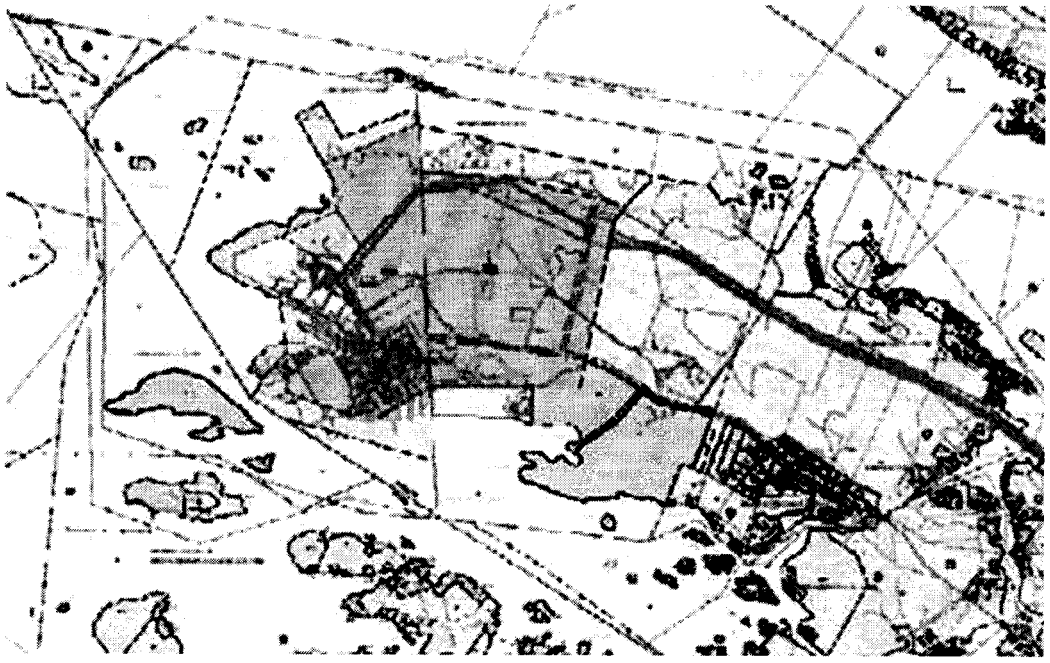


Figure 8-5 The status of local plans for the northern shores of Olkiluoto and Rauma in the planned area.

8-5. The status of local plans for the northern shores of Olkiluoto and Rauma in the planned area.). The Liiklankari area is designated as a park (P) and a special zone (EL). There are no areas specifically reserved for final disposal operations in the current local plans.

On 12 December 2005 the Eurajoki Municipal Council approved two local plans defining a zone for accommodation buildings serving energy production (AS_{EN}), a zone for office buildings (KTY), a zone for a caravan park serving energy production ($RV\text{-}1_{EN}$), a tower zone (EMT), a protective green zone (EV), an agricultural and forestry zone (M), and an agricultural and forestry zone with special environmental values (MY/s) in the south-eastern part of Olkiluoto.

There are three local shore plans for the eastern parts of the Olkiluoto island, ratified on 11 November 1975, 20 March 1981 and 8 December 1992 respectively. In these plans, holiday buildings are indicated for the shore area.

All information concerning the status of land use planning in Olkiluoto and its surroundings has been compiled in a combination map showing the valid local plans and local shore plans, as well as a general shore plan for these outside areas. This planning map combination covers one local plan in the Rauma area and the partial master plan for the northern shores of Rauma.

Amendment to the local plans

Local plan drafts are being prepared for the Olkiluoto and Rauma areas. The drafts are to be available for public viewing by the end of the year 2008.

According to the participation and assessment scheme, the aim of the local plan is to reserve the area for final disposal of spent nuclear fuel as set forth in the partial master plan.

8.2 Landscape and cultural environment

Landscape

Olkiluoto island is located in the municipality of Eurajoki on the coast of the Bothnian Sea. Typical characteristics of the Bothnian Sea coast include capes pointing to the northwest, shallow bays between them and small archipelago zones.

In the division of landscape regions, the Olkiluoto area belongs to coastal Satakunta. The region is characterised by low-lying terrain and the absence of strong profiles: in addition to rocky land, it features glacial deposits, small areas of clay soil and ridge formations. The coastal area features long sheltered bays dominated by reeds that are turning to land due to land uplift which occurs at a rate of approximately six millimetres per year.

Olkiluoto island is approximately 6 kilometres long and 2.5 kilometres wide. The Bothnian Sea opens to the west of the island. The southern part of the island borders on the Rauma archipelago. The Lapinjoki river discharges to the east of Olkiluoto island, into a narrow inlet between Olkiluoto and the Orjasaari island. The Eurajoki river discharges into the Eurajoensalmi inlet north of the island.

The waterways separating Olkiluoto island from the mainland are slowly closing up. The highest points of

Olkiluoto island are the Liiklankallio cliff, approximately 18 metres above sea level, and the Selkänummenharju ridge, approximately 15 metres above sea level. The Olkiluoto landscape can be roughly divided into the following zones:

- inland forest zone,
- partly rocky forest shorelines
- inhabited zones on the southern and eastern shores
- industrial zones at the western end of the area (the power plant site) and the northern shore (the port).

The forest zone is divided by a wide power line clearing and the Olkiluodontie road. Operations related to the operation of the final disposal facility and the power plant take place on the wooded inland zone. These are not visible in the overall landscape or from the roads. On the forest zone, the most visible element in the road landscape is the accommodation village located on both sides of the road.

Seen from the sea, Olkiluoto appears as a predominantly forested island with the elements indicating power plant operations – the power plant buildings and their stacks, the wind power plant and the power lines – rising above the forest; they can be also seen at a distance. The industrial port with its cranes stands out from the wooded northern shoreline. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007b.)*

Cultural history

In the 1960s, most parts of Olkiluoto still belonged to Vuojoki Manor, one of the buildings of major cultural and historical significance in the Satakunta region. At that time, the central and western parts of the island were uninhabited forest land, used as pasture for the Vuojoki Manor's horses. On the eastern side of the island there were small farms owned by fishermen. These farms had forest pastures and small fields, which have remained nearly the same in size and have been continuously cultivated. The first proper road leading to the island was not built until the 1960s. The construction work for the first Olkiluoto power plant commenced in the 1970s. There are small farms belonging to local fishermen on the nearby islands, some of which have been demolished and others extended and renovated into holiday homes. The oldest buildings on Olkiluoto were built in the first half of the 20th century. Most of the buildings date back to the reconstruction period after WWII or to later periods. Holiday homes have been built since the 1960s and 1970s.

There are no nationally or regionally valuable buildings or other objects of cultural history in the area *(National Board of Antiquities 2007)*. No relics of antiquity have been found in the Olkiluoto area *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007b)*.

8.3 Climate and air quality

Olkiluoto is located on the coast of the Bothnian Sea in a maritime climate. A maritime climate is characterised by the stability of temperature conditions. In the spring, the temperature close to the coast is clearly lower than further inland. In the autumn, the warm sea evens out the daily temperature differences and there is almost no night frost. The winter in the Satakunta region is mild because the Bothnian Sea remains open for almost the entire winter. The thickness of the snow cover does not usually exceed 20 centimetres. Soil frost generally reaches a depth of 10–70 centimetres. The average length of the growing season has in recent years been 180 days *(Ikonen, A.T.K. 2007)*. The prevailing direction of the wind is from the southwest. The annual precipitation at Olkiluoto varies between 400 and 700 millimetres.

Air emissions in Eurajoki are minor. The emissions from smaller industrial plants, i.e. point sources, and so-called local sources (detached houses, saunas, etc.) have not been assessed. There is no air quality monitoring system in Eurajoki. The closest monitoring point is in Rauma. The air quality is also monitored at the industrial areas in Harjavalta and Pori. The emissions from the Rauma region are low in comparison to those from Pori and Harjavalta.

8.4 Water system description

Olkiluoto is delimited by the Eurajoensalmi inlet of approximately 1.5 kilometres in width on the north side and the Olkiluodonvesi water area of approximately 3 kilometres in length and one kilometre in width on the south side. The Rauma archipelago begins to the south of Olkiluodonvesi. The area west of Olkiluoto is a shallow coastal area with a relatively high number of small islands and islets. The Bothnian Sea opens to the west of the islet zone.

The water quality, ecological condition and production in the sea around Olkiluoto are affected by the general condition of the coastal waters of the Bothnian Sea as well as the nutrients and other substances carried by rivers. Local impacts are caused by increased temperature and changes in flow conditions due to cooling water from the nuclear power plant units, as well as the nutrient load of waste water conducted with the cooling water. *(Kirkkala & Turkki 2005.)*

Physical, chemical and biological monitoring of the waters around Olkiluoto has been conducted since 1979. The purpose of the monitoring is to survey the impacts of

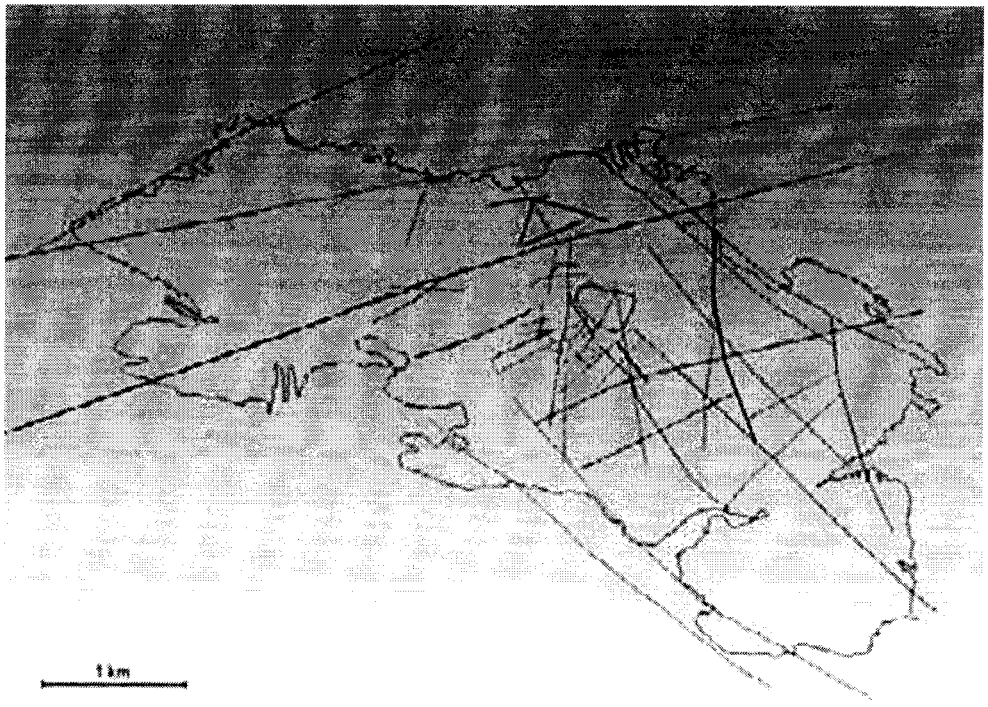


Figure 8-6 Bedrock breakage formations interpreted for Olkiluoto Island.

cooling water from the Olkiluoto power plants on the quality and usability of the water in the surrounding sea area, as well as biological production. *(Turkki 2007.)*

Surveys conducted in accordance with the environmental radiation monitoring programme have measured minor concentrations of radioactive substances originating from the nuclear power plant in algae, sedimenting matter and shellfish, and occasionally very minor concentrations in fish. The proportion of natural radioactivity in the samples was substantially higher than that of radioactivity originating from the power plant. *(Taivainen 2007.)*

There are no lakes, rivers or brooks in the Olkiluoto area. The only lake on the island has dried up due to ditch drainage. The lake currently visible in the present Olkiluoto map (the Korvensuo reservoir) was constructed as a raw water basin for the power plant in the 1970s.

8.5 Geology and seismology

8.5.1 Soil and bedrock

Extensive bedrock surveys with the help of methods such as quarrying, drilling and geophysical sounding have been and will be carried out at Olkiluoto for the purpose of planning of spent nuclear fuel disposal. The surveys aim to determine the properties of rock and the groundwater flow routes and provide confirmation for the rock models in the Olkiluoto research area.

The main rock type in Olkiluoto bedrock is migmatite, which is a compound of gneiss and granite. The bedrock in the area is approximately 1,800 to 1,900 million years old.

Posiva's bedrock information is mainly based on 50 deep boreholes drilled in the bedrock and related measurements carried out in 1989–2008. Furthermore, information about the properties of the bedrock has been gathered since the beginning of the construction of the ONKALO facility by systematically surveying the walls of the tunnel. On the basis of the surveys, the surface section of the bedrock is more fractured, up to the depth of about 120–140 metres, than the underlying bedrock. In addition, the fractures in the surface sections of the bedrock conduct water better than the deeper sections.

Olkiluoto island is quite flat, with no major differences in elevation. The ground is approximately five metres above sea level. The highest point of the island (the Liiklankallio cliff) is approximately 18 metres above sea level. The elevation of the surface level of the bedrock varies. However, moraine evens out the terrain. Slumps contain thick layers of moraine, whereas the bedrock higher up is bare or covered by a thin layer of soil. *(Lahdenperä et al. 2005)*. The uplift, which occurs at the rate of approximately 6 millimetres per year *(Eronen et al. 1995)*, combined with the low level of the ground have kept the island's nature in a state of change, and the changes will continue in vegetation and the soil. The sea areas near the island are mainly shallow; thus, the island's surface area is growing fairly rapidly and the island will eventually be connected to the

mainland. The base of the sea area surrounding Olkiluoto is mostly formed of rock, clay and moraine. *(Rantataro 2001.)*

Because Olkiluoto island has risen from the sea over the past 3,000 years, its soil is mainly young and in the early stages of its development. The young age and the vicinity of the sea can be seen in the characteristics of the soil and soil water. *(Haapanen et al. 2007)*. The prevailing soil type is fine moraine. However, there is a noticeable abundance of rocks. The organic layer in forest soil is typically raw humus or peat mould. *(Tamminen et al. 2007.)*

Olkiluoto's geological model

Posiva published a geological site model for Olkiluoto in early 2006. After the publication of the geological model, the hydrogeological flow model was updated. The hydrogeochemical and rock mechanical models were also updated in 2006. A summary report in English was drawn up for the said models *(Andersson et al. 2007)* and published at the beginning of the year 2007. A summary of the surface environment studies was also drawn up *(Haapanen et al. 2007)*. The groundwater level modelling assessments included in Section 9.3.4 are based on a hydrogeological model updated in 2008.

The first version of the geological model for the eastern part of Olkiluoto island has been completed, and a report on it will be issued in connection with the Olkiluoto Site Descriptive Model 2008. The model is based on geophysical measurements taken at ground level, a lineament survey for the entire island and two boreholes in the eastern part of the island (OL-KR40 and OL-KR45). The term 'lineament survey' refers to an interpretation of the permanent geological characteristics, such as bedrock variability formations, rock type units or rock type contacts, made based on the bedrock topography and geophysical earth surface data. As the middle part of the island have been studied, it has been observed that the lineament in the Olkiluoto area always has to be ensured either by means of drilling or by means of a soil survey before its formation can be reliably interpreted.

The middle part of Olkiluoto island has been studied for almost 20 years, and about 50 deep boreholes have been made in this area. The information obtained from these boreholes also applies to some of the eastern parts of the island. For example, based on 3D seismology survey results *(Cosma et al. 2008)*, extensive formations draining water from the middle part of the island to the east, at an angle of approximately 20 degrees going to south-south-east, have been observed (generally known as R19, R20 and R21). The lineament interpretation states that there are several long vertical lineaments in the eastern part of the island. In the model, these have been interpreted as vertical formations. More boreholes will have to be drilled in the future in order to determine their characteristics.

Figure 8-6 shows the ground cross-section of all the new formations interpreted for Olkiluoto island. The best-known formations, which have been determined with the help the boreholes, excavations or revealed bedrock and by several geophysical surveys, for example, have been used in designing the repository areas in the eastern part of the island (Figure 3-5). The existence and characteristics of other formations will be ensured during the eastern area drilling project, and the model will be updated based on new data by the year 2010.

Hydrological model

The hydrological model of Olkiluoto, the preparation of which started in 2007, refers to both non-saturated and

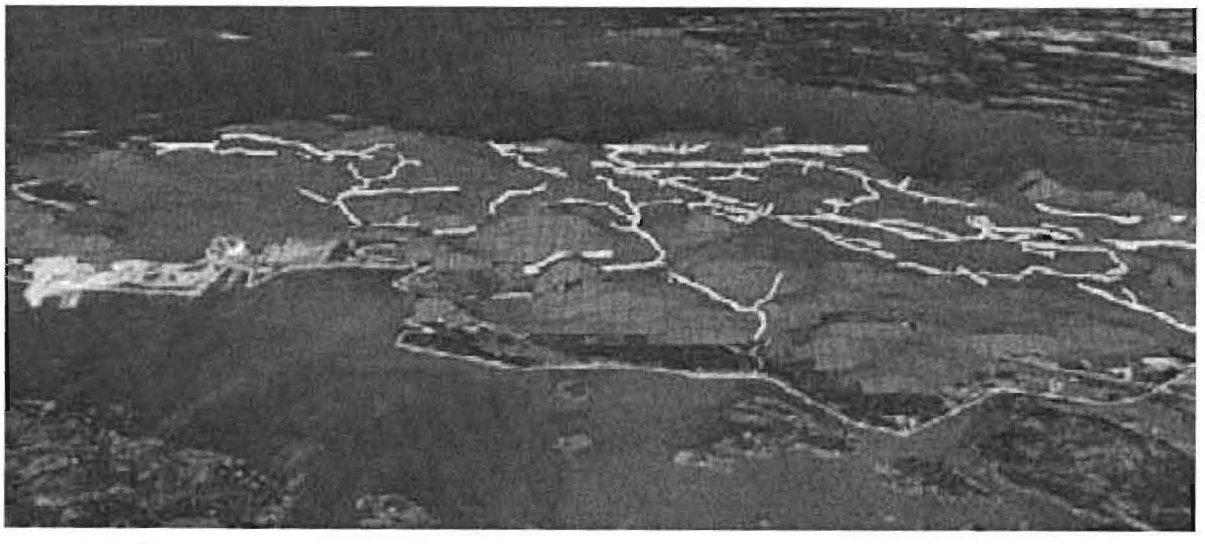


Figure 8-7 Uplift (exaggerated) and ditch network of Olkiluoto Island.

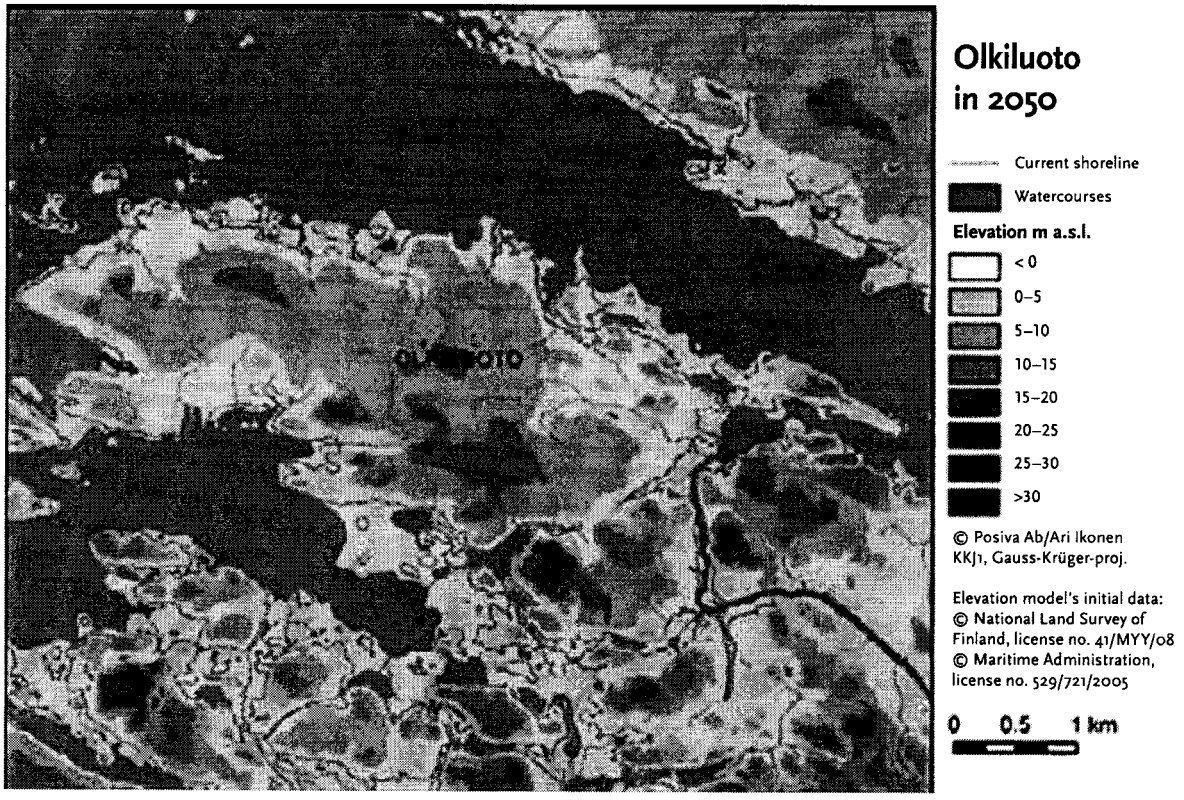


Figure 8-8 Topography of Olkiluoto island in the 2050s.

saturated water flow in the ground, connecting surface flow with bedrock groundwater flow. The initial data used in the modelling includes, for example, the Olkiluoto island ditch network (Figure 8-7), land use and vegetation data, data from hydrological measurements of the soil and characteristics related to bedrock groundwater flow. Essential information pertaining to the hydrological characteristics of the soil includes the soil's water retention properties and the water conductivity of non-saturated soil.

All ditches on Olkiluoto island are man-made forest, roadside and agricultural drying ditches that take water from the drainage area and empty into the sea surrounding the island. Fifteen drainage areas from which water flows to the sea were recognised on the island (Figure 8-7).

According to the modelling results, the annual runoff surface waters amount to approximately 32 percent and the total transpiration 56 percent of the precipitation *(Karvonen 2008)*. The model also assessed the amount of water seeping into the bedrock groundwater. The results state that approximately 10 millimetres of water seeps into the groundwater each year; this is approximately 1.7 percent of the long-term annual precipitation. The modelling has been continued in 2008, also taking into account the possible impacts of the Korvensuo reservoir to the flow conditions.

Land uplift

No major impacts resulting from uplift are expected to occur in the Olkiluoto area in the next hundred years. The Munakari islet will become a part of Olkiluoto island, and there will be a lake or a wetland where there is currently a strait separating the islet from the island (Figure 8-8). Olkiluoto island will be connected to the mainland when the narrow strait currently separating them dries up.

8.5.2 Seismology

The Finnish bedrock belongs to the Precambrian Fennoscandian shield that is one of the most seismically stable areas in the world. However, there are tensions that may discharge and cause minor earthquakes. These are generally focused on the weakness zones existing in the bedrock. About 10 to 20 earthquakes are registered in Finland each year. These earthquakes are relatively small, with a magnitude of 1–4 (on the Richter scale). The most powerful earthquake registered since 1965 took place in Alajärvi on 17 February 1979. Its magnitude was determined to be about 3.8. The most powerful earthquake observed in Finland measured 4.9 on the Richter scale *(statistics starting from the 1880s; Marcos et al. 2007)*. Between 1977 and 2001, nearly half of all earthquakes observed in Finland took place in the Kuusamo region. Observations of earth-

quakes in Finland have been recorded for almost 400 years. Occurrences of earthquakes in Finland from 1965 to 2006 are shown in Figure 8-9 *(University of Helsinki 2007)*. Figure 11-2 presents the earthquakes that have occurred in northern Europe since 1375.

In Finland, earthquakes are usually caused by tension arising from the widening of the mid-oceanic ridge in the North Atlantic. The Eurasian and North American plates diverge from each other at the rate of approximately two centimetres per year, which causes compression stress across the entire Fennoscandia. At some point, the gradually accumulating stress exceeds the strength of the rock material and is suddenly discharged as an earthquake. At that time, the parts of the bedrock surrounding the origin of the earthquake move in relation to each other. This movement usually occurs along existing faults in the crust. Other local reasons include uplift, which causes earthquakes mainly in the Gulf of Bothnia region. *(University of Helsinki 2007.)*

The bedrock of Olkiluoto has been studied in particular detail during recent years. Geological surveys have already shown that the bedrock is stable and that earthquakes affecting plant operation are non-existent. *(La Pointe & Hermanson 2002, Enescu et al. 2003, Saari 2006, Saari 2008).*

Seismic measurements performed with the help of Posiva's local seismic station network in Olkiluoto commenced in February 2002. At first, the station network consisted of six seismic stations. In June 2004 the station network was expanded with two new stations to cover the measuring needs of the underground research facility ONKALO, the construction of which was started at that time. At the beginning of 2006 the station network was expanded with four stations, one of which is located underground inside the VLJ repository and three farther away outside the Olkiluoto island.

Microseismic measurements serve to provide more information about the structure, movement and stability of the Olkiluoto bedrock. Surveys have been carried out regarding tectonic microseismic incidents and those induced by excavation work. The measurements also form a part of ONKALO's nuclear non-proliferation control.

A total of 2,041 microseismic incidents were observed in the Olkiluoto area over the reported period in 2006. The magnitudes of the observed incidents varied from ML=-1.1 to ML=3.1. Nearly all observations were cases of rock blasting. Two incidents were classified as microseismic earthquakes caused by blasting work. *(Saari & Lakio 2007.)*

8.5.3 Groundwater

The level of groundwater loosely follows the topography of the ground; in areas covered by moraine, the groundwater is at a depth of one to two metres, and at the shoreline the groundwater level joins the sea water level. There are no classified groundwater areas in Olkiluoto, and the area is not significant for the procurement of water for communities. The island includes eleven bored wells belonging to private owners, five of which are in continuous or recreational use. The nearest classified groundwater area is located in Kuivalahti to the north of Eurajoensalmi, approximately 6 km northeast of the repository.

Groundwater in the bedrock is fresh for the first few tens of metres, after which there is brackish water (1–10 g/l of salt). At the final disposal depth (about 400 metres) the water is saline water (11–21 g/l). Below this level the salinity increases as the depth increases. The greatest salinity value (84 g/l) has been measured at a depth of 860 metres *(Andersson et al. 2007)*.

The construction of ONKALO affects the water flow routes and rates inside the Olkiluoto bedrock and, as a result, the hydrochemical characteristics of water. These changes are studied as part of the monitoring programme for the construction of ONKALO, described in 2003 *(Posiva Oy 2003b)*. The impacts of the construction of the ONKALO facility are monitored by means of measurement and

Earthquakes in Finland from 1965 to 2006

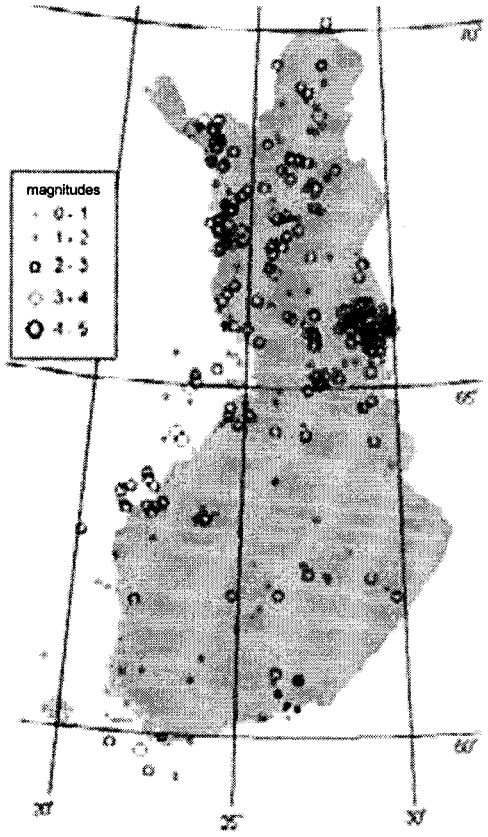
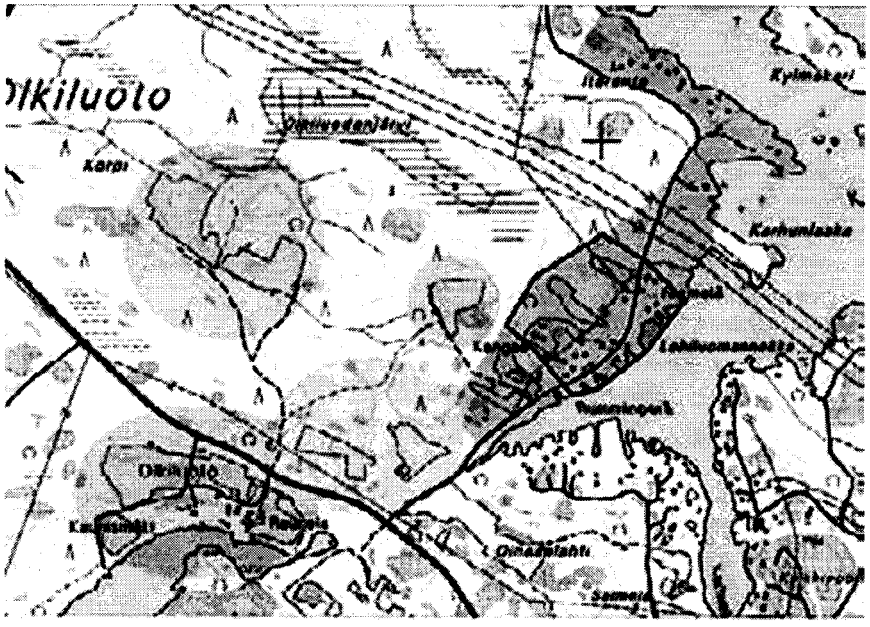


Figure 8-9 Earthquakes in Finland from 1965 to 2006 (University of Helsinki 2007).



Inventory taken, no observations of the species made
Spring corydalis growths of varying sizes
Fields cleared and taken into other use
The area where spring corydalis leaves that have been consumed (ground) by black Apollo larvae have been observed – the most suitable habitat for the black Apollo in the area covered by the partial master plan.

Figure 8-10 The growths of spring corydalis.

monitoring of several hydrological, geochemical, environmental, rock mechanics and foreign material parameters. The hydrological monitoring project includes monitoring of groundwater level, groundwater pressure height, flow conditions in open holes, groundwater flow rate (cross flow in holes), water conductivity, groundwater salinity and electrical conductivity, precipitation (incl. snowfall), seawater level, runoff surface waters, infiltration, ground frost, leak water in tunnels, water balance of the tunnel system and water balance of the Korvensuo reservoir.

8.6 Flora and fauna

Olkiluoto belongs to the Gulf of Bothnia coast, where land uplift is rapid, approximately 6 millimetres a year *(Eronen et al. 1995)*. The low-lying terrain and rapid land uplift cause a change in the island's flora as the habitat changes. The meadowy shores of land uplift areas are becoming swampy and are bordered by a bush zone consisting mainly of willow, buckthorn and myrtle. There is an alder zone between the bush and the forest, consisting almost exclusively of black alder in the Olkiluoto area.

In the geobotanic division of the regions, Olkiluoto belongs to the southern boreal zone and further to the anemone zone characterised by demanding forest plants such as hepatica and wood anemone. The coastal flora in the area is characterised by zonality that is constantly changing due to rapid land uplift. The zonality of flora is evident on the coast in that coastal forests are moister and more luxuriant than inland forests; going inland, the forests become drier and more infertile due to the change in the depth of groundwater. However, this zonality is not clear in Olkiluoto because differences in altitude within the island are minor and luxuriant habitats can be found both on the shores and inland. However, the most infertile habitats are clearly located at the highest points of the island.

Apart from the Liiklankari conservation area, the Olkiluoto area represents a typical south-western Finland coastal area in terms of the natural conditions, in which the species of flora and fauna and the soil are very similar to the surrounding areas. Undeveloped shores, particularly on the northern side, represent shore biotopes in a natural and often luxuriant state. Olkiluoto is quite abundant in species but few rare or endangered species have been observed. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007a.)*

There are approximately 570 hectares of forests owned by TVO on Olkiluoto island; the majority of the forests (90 percent) are heaths of the bilberry type (MT), wood sorrel and bilberry type (OMT) or lingonberry type (VT). There are 22 hectares of swamps, 19 hectares of which are in productive forest use. The main tree species in the young cultivated forests is pine, and in more mature forests it is

spruce. Deciduous trees (grey and black alder, silver and white birch, rowan and willows) grow mainly in a zone surrounding the island at the sea shore, and as undergrowth. The inland forests are dominated by pine; spruce copses are mainly located on the shores inside the black alder zone. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007a.)*

Forests ready for felling represent 18 percent of the total area. The small amount of private land, as well as forests administered by the Metsähallitus State Enterprise outside the Liiklankari Natura area, are in intensive forestry use and the area no longer has any mixed forests in a natural or near-natural state. The soil to the south of the island is clearly moister than to the north, which can be seen from mild swamp formation and a higher number of vascular plants that tolerate or favour dampness. There are not many bushes in the forest, and most of the bush layer constitutes seedlings of the local tree species and juniper. The forests in productive use in the area are primarily free of rotten wood as well. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007a.)*

The rocky forests are characterised by their natural state. All rocky forests have open rock areas where lichen and low twigs grow. There are also peat-covered rocks, but their area is very small. Black alder grows as narrow strips on the shore, and, together with meadowsweet growing in the field layer, forms a zone surrounding the entire island. On the shores, common reed forms an almost unbroken belt around the island. Low meadows are rare on the island. This is because of the eutrophication of the Baltic Sea, spreading of human settlement and ditch drainage. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007a.)*

In 1997 the land and aquatic birds of Olkiluoto were counted using the linear count and point count methods respectively. According to the birdlife survey, the most common aquatic bird species is the eider, and the rarest species observed at Olkiluoto is the greater scaup. Common shelduck, which is rare in Finland, and velvet scoter also nest in the Olkiluoto area. These observations have been described as valuable but not extraordinary. The most valuable part of Olkiluoto island in terms of aquatic birdlife is the northern shore. *(Yrjölä 1997.)* The island borders on the Eurajoki river delta FINIBA area (Finnish Important Bird Areas 120075) at its northeastern corner.

Olkiluoto does not differ from its surrounding areas with regard to ground birdlife; there are a lot of species but not many rarities. Like in the rest of the country, the most common species in the area are chaffinch and willow warbler. In addition to the observations referred to in the above, a grey-headed woodpecker (Picus canus, NT, a species listed in Annex I to the bird directive) was seen eating in an aspen tree in 2006 in connection with other surveys; however, the area is not suitable as a nesting biotope for the species as there are very few aspen trees of a small diameter in the Olkiluoto area and trees suitable for hole nesting are almost non-existent. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007a.)*

An inventory of birdlife on the islets of Olkiluoto was taken in the summer of 2007. The birdlife in the area consisted of islet birds and seabirds typical of the Eurajoki sea area. The most valuable species found in the inventory were black-headed gull (VU), velvet scoter and Arctic skua. Furthermore, among the species listed in Annex I to the bird directive, common tern and Arctic tern were found nesting in the area. *(Loikkanen 2007.)*

Data concerning the occurrence of mammals in the Olkiluoto area is based on active observation of animal tracks in winter, information received from hunting clubs and airborne survey data. The elk stock in Olkiluoto is estimated at 10–15 animals before the hunting season and ten animals after the season. The white-tailed deer stock is estimated at 10–25 animals, and the roe deer stock at 5–20 animals. The stocks vary year by year but still remain stable. Other mammals common in the area include raccoon dog, fox, mink, ermine, polecat, badger, hare, brown hare and rodents. The areas of the island most important for animals are the shores and the northern parts of the island. *(Insinööritoimisto Paavo Ristola Oy & Ramboll Oy 2007a.)*

Inventories of the endangered (VU, vulnerable species) black Apollo butterfly, which is protected by law, were taken in the spring and summer of 2007 *(Ramboll Oy 2007)*. The inventory was related to the partial master plan of Olkiluoto. The black Apollo (Parnassius mnemosyne) is completely dependent on the spring corydalis (Corydalis solida), which is the only food plant for its larvae. On the basis of the inventory data acquired in 2007, observations in previous years and eating marks of larvae, it can be noted that the eastern/north-eastern part of Olkiluoto island is most probably a black Apollo habitat and that the area belongs to a larger metapopulation with subareas on Olkiluoto island and its immediate vicinity (Figure 8-10). For the black Apollo, the most important growths of spring corydalis are found in the sunny fieldsides and courtyards in the norteastern part of the island; the growths found in the courtyards of the northern shore are too damp and shadowy to form a suitable habitat for the black Apollo. *(Ramboll Oy 2007.)* The Liiklankari nature conservation area does not, and will never, form a suitable habitat for the black Apollo because the species favours warm areas found on forested edges of open fields.

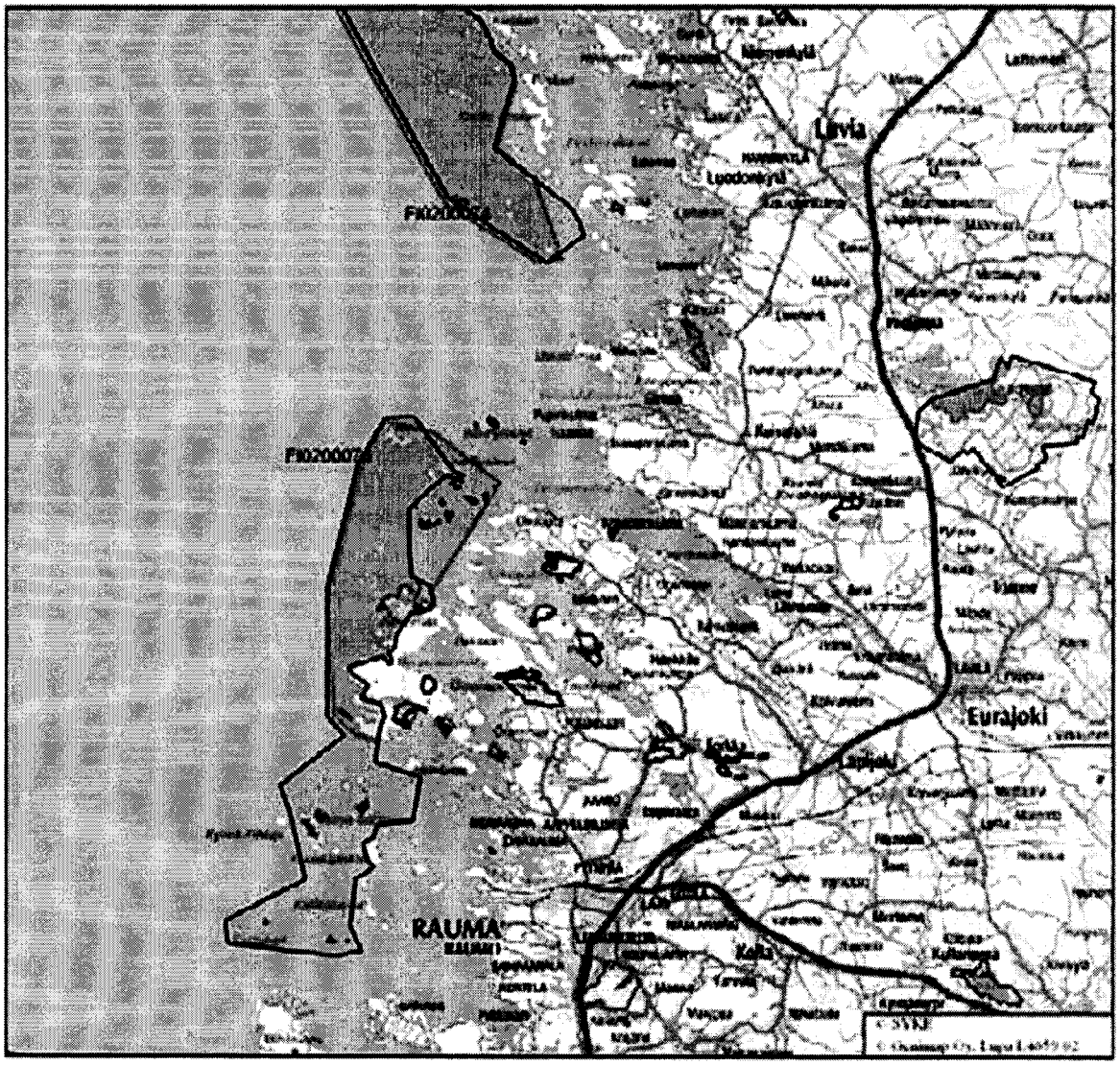


Figure 8-11 Conservation sites and areas around Olkiluoto.

8.7 Conservation sites

The Liiklankari nature conservation area is located on the southern shore of Olkiluoto island in the immediate vicinity of the final disposal site for spent nuclear fuel.

The Liiklankari forest is included in the old-growth forest conservation programme, and it has been established as a national nature conservation area. It also belongs to the Rauma archipelago area included in the Natura 2000 network.

The Metsähallitus State Enterprise conducted a biotope inventory of the Liiklankari area in accordance with the Nature Directive in the summer of 2006. With regard to biotopes listed in Annex I to the Nature Directive, boreal natural forests are found in the Liiklankari Natura area. The biotope belongs to the priority biotopes, the conservation of which is of primary importance. A survey of the Liiklankari area identified flood plains and swamps with trees as new biotopes in the area.

According to present information, no species listed in Annexes II and IV to the Nature Directive is found in the Liiklankari conservation area. Grey seal is the only species listed in Annex II of the Nature Directive that is found in the Rauma archipelago Natura area. Neither does the Rauma archipelago Natura area have any other species requiring strict protection listed in Annex IV of the Nature Directive.

Surveys / preliminary reviews of certain groups of species were carried out in the Liiklankari area in the autumn of 2006. The groups of species studied were bryophytes, shelf fungi, beetles and macrofungi. No species listed in Annex II to the Nature Directive, nationally or regionally endangered species, or species to be observed were observed in the area. Among the indicator species for boreal forest, two occurrences of goblin's gold were found. One observation of Phellinus ferrogineofuscus was made; it is a species to be observed (NT). Other notable shelf fungi included Asterodon ferroginosus, Leptoporus mollis, Phellinus chrysoloma, Phellinus nigrolimitatus, Phellinus viticola and Postia leucomallella. A noteworthy species of macrofungus observed in the area was Lactarius scrobiculatus. Ganoderma lucidum has also been observed in the area. *(Insinööritoimisto Paavo Ristola Oy 2006b.)*

The area belonging to the Rauma archipelago (FI0200073) Natura 2000 network is located in the sea area off Olkiluoto island. The site is included in the Natura 2000 network as an SCI area (Sites of Community Importance, included in the Natura 2000 network by virtue of the Nature Directive). The area extends to 5,350 hectares and comprises 15 different biotopes in total.

The outer archipelago north of Rauma, including the Susikari, Kalla and Bokreivi islands, belongs to a shore conservation programme. These areas also belong to the Natura 2000 area of the Rauma archipelago. The area contains sparsely located small isolated rocks and two larger, almost treeless, islands close to the open sea. The area is a representative archipelago and landscape entity. It is significant as a breeding ground for animals and a resting stop for migratory birds. The conservation sites and areas in the immediate vicinity of Olkiluoto are shown in Figure 8-11.

The Omenapuumaa nature conservation area in the inner archipelago and the Särkänhuivi cape have regional conservation value. Omenapuumaa also belongs to the Natura 2000 network. The luxuriant grove island of Omenapuumaa is located in the Rauma archipelago, approximately five kilometres south of Olkiluoto. The extremely variable natural environment of Omenapuumaa features a labyrinth of broken landscape patterns. The central parts of the area consist of relatively infertile coniferous forest, but on the edges, particularly along the southern shore, there are luxuriant shore groves. The central part also features remnants of grove meadows as a consequence of grazing in the past. The noble broad-leaved trees once planted in the area have grown very large. The vegetation close to the shore consists of black alder, and farther up it becomes a grove of the hepatica and wood-sorrel type that is being taken over by spruce and is abundant with Solomon's seal. A rarity growing in the area is cowslip, possibly in its northernmost habitat. The low, narrow, long and curved cape of Särkänhuivi is the outermost tip of the Irjanteenharju Ridge that protrudes into the sea. The ridge of the cape has a road along its entire length, and – with the exception of the end – there are holiday homes in the area.

The Luvia archipelago area (FI0200074), which belongs to the Natura 2000 network, is located approximately nine kilometres north of Olkiluoto. The site is included in the Natura 2000 network as an SCI area (Sites of Community Importance, included in the Natura 2000 network by virtue of the Nature Directive) and an SPA area (included in the Natura 2000 network by virtue of the Nature Directive). The Luvia outer archipelago represents the island nature of Satakunta at its most diverse. The area has more than 60 islands and islets of at least one hectare, as well as several small islets and rocks.

Other valuable natural sites near Olkiluoto include the Pyrekari islets and Kaunissaari island; they have national conservation value. The Pyrekari islets are located to the north of Olkiluoto, approximately four kilometres from the disposal facility site. The Pyrekari Islets are small rocky outer islets with endangered plant species. They also serve as an educational site. Kaunissaari island to the east of Olkiluoto island is a significant site of cultural history.

The Kalattila Grove has local conservation value. The

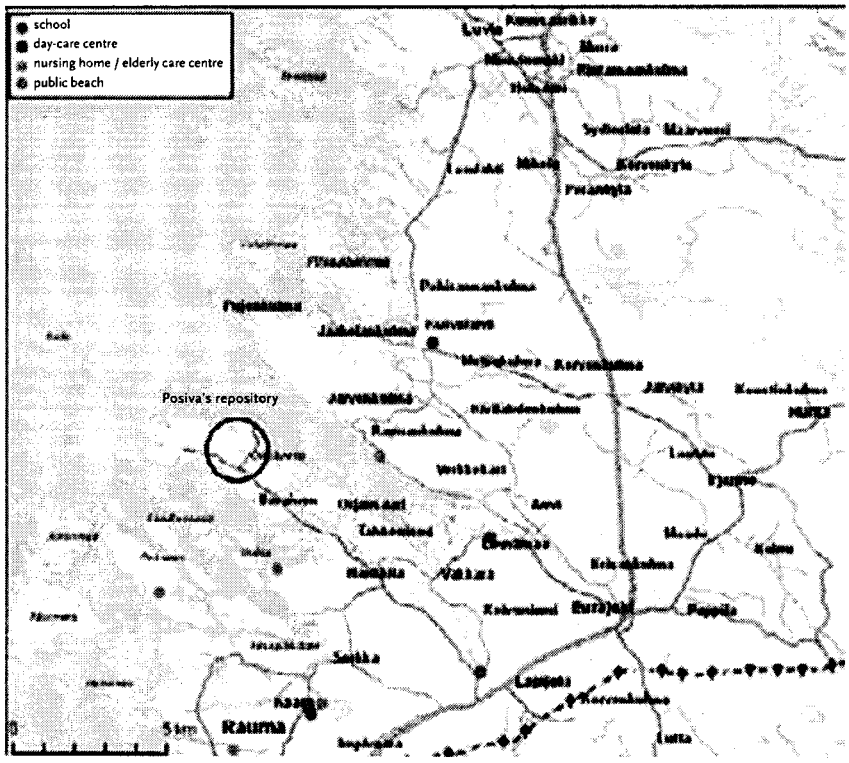


Figure 8-12 Schools, day-care centres, nursing homes or elderly care centres and public beaches within a range of approximately 10 kilometres of the disposal facility.

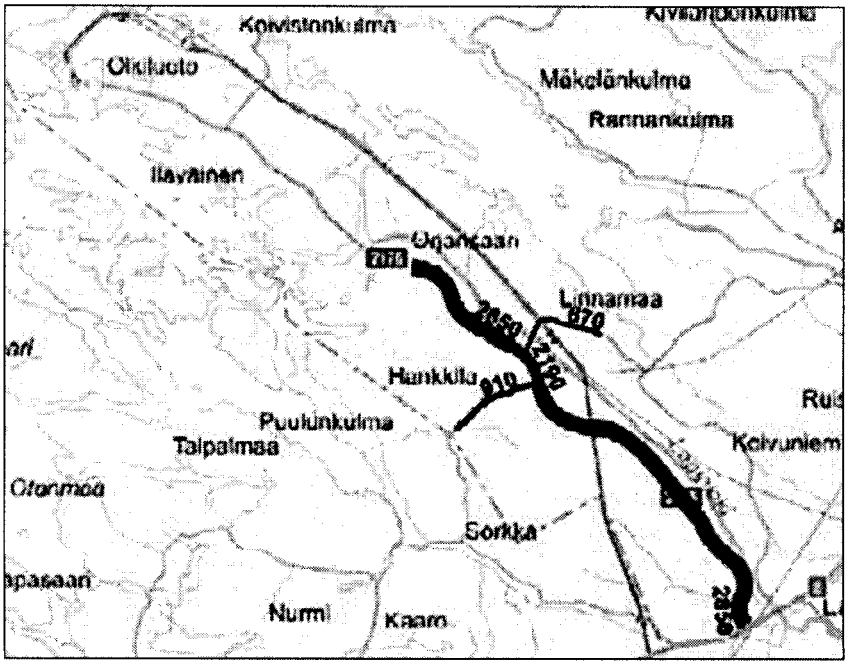


Figure 8-13 Roads to Olkiluoto and the traffic volumes (vehicles per day) in August-September 2007 (Ramboll Finland Oy 2008).

Kalattila Grove features peculiar luxuriant grove vegetation typical of the northern Rauma archipelago *(Satakunta Regional Council 1996)*.

8.8 People and communities in the vicinity of Olkiluoto

The population of Olkiluoto island is very low. The nearest house is located approximately one kilometre from the power plant site on the Kornamaa island. Apart from the village of Ilavainen, there are three permanent residences on Olkiluoto island. Ilavainen village comprises the easternmost part of the island, and there are several permanent residences in the village.

There is a large number of holiday homes on the island and the nearby coastal areas and islands. There are approximately thirty holiday homes on Olkiluoto island. These are located in the eastern part of the island. Approximately 550 holiday homes are located within five kilometres of the disposal facility site, mostly on the nearby islands and the villages of Ilavainen and Orjasaari. The closest holiday homes are located on the northern coast of Olkiluoto, on Munakari island. The closest holiday homes in the south-southwest sector are located on Leppäkarta island.

In 2006 there were a little over 5,800 residents in the municipality of Eurajoki. From 1960 to 2006, the population has varied between 5,200 and 6,200 *(Ollikainen & Rimpiläinen 1997; Statistics Finland 2007)*. In 2004, more than half of the labour force in the municipality was employed in the service industry, less than 40 percent in processing and less than 10 percent in production. TVO is the largest employer in the municipality.

There are four schools within a ten-kilometre range of the disposal facility. These are primary schools. All schools, day-care centres, nursing homes, elderly care centres and public beaches in the immediate vicinity of the final disposal area are shown in Figure 8-12.

8.9 Traffic

Eurajoki parish village is located along main road 8 between Rauma and Pori. The Olkiluodontie road (connecting road number 2176, between Lapijoki and Olkiluoto) leading to Olkiluoto separates from main road 8 at Lapijoki. The crossing is located approximately seven kilometres from Rauma and approximately 40 km from Pori. There is also a road connection from Rauma to Olkiluoto via Sorkka. A road goes from Eurajoki via Linnamaa to Olkiluoto. The roads to Olkiluoto and the average traffic volumes (vehicles per day) estimated in 2007 are shown in Figure 8-13.

The traffic volumes in Olkiluoto vary greatly as a result of major construction projects and maintenance carried out during annual plant outages. Traffic has been busier than normal in 2007 due to traffic attributable to the OL3 and ONKALO construction sites. The busiest section of the Olkiluodontie road is the one-kilometre stretch immediately after the junction of main road 8 towards Olkiluoto. The average daily number of vehicles measured on the Olkiluodontie road during a two-week period in late August to early September 2007 was 2,850 vehicles per day *(Ramboll Finland Oy 2008)*. Most of the traffic results from commuting.

The amount of traffic measured on the road (no. 12766) leading from Sorkka to Hankkila in August–September 2007 was 910 vehicles per day on average, while that of the road (no. 12771) from Linnamaa to Hankkila and further to the Olkiluodontie road was 670 vehicles per day on average *(Ramboll Finland Oy 2008)*. In 2007, an average of 10,440 vehicles per day used main road 8 between Rauma and Eurajoki. Approximately 5,790 vehicles per day travelled between Eurajoki and Luvia. *(Finnish Road Administration 2007.)*

8.10 Noise

Posiva's ONKALO construction site, TVO's current power plant units OL1 and OL2, the OL3 construction site, the TVO wind power plant, the port and Fingrid Oyj's gas turbine power plant influence the noise level in the Olkiluoto area. Noise in the Olkiluoto area has been studied by measuring and computations in 2005, 2006 and 2007.

The noise levels measured in the island close to Olkiluoto varied between LAeq 42 to LAeq 46 dB. The measurements were taken during the daytime while the OL3 construction site was in operation. Calculated noise levels at the nearest holiday homes under various circumstances varied between 36–38 dB at night in 2005 and 45–47 dB by day during construction. According to the results, the OL3 construction site may lead to the daytime directive value for noise in holiday home areas (LAeq 45 dB) being exceeded at the closest holiday homes. However, the night-time directive was not exceeded in the situation prevailing in 2005. *(Insinööritoimisto Paavo Ristola Oy 2005.)*

According to a noise survey updated in 2006, the noise level in the closest disturbed site, a holiday home on Leppäkarta island, will not exceed the daytime or night-time directive value after the OL3 construction project is completed. The noise level under normal operational conditions at the closest holiday home on Leppäkarta island will be 38–39 dB, which is lower than the night-time directive value for holiday homes (LAeq 40 dB) *(Insinööritoimisto Paavo Ristola Oy 2006a)*.

9 Environmental impacts of construction and operation

9.1 Impacts of transportation and traffic

The current Olkiluoto power plant area already has the infrastructure required by nuclear power production. The external infrastructure required by the repository consists of traffic connections. Most of this infrastructure has already been built in connection with the ONKALO construction project. There are functional traffic connections, including a port, roads and parking areas, in the Olkiluoto area.

9.1.1 Traffic volumes

The traffic volumes in Olkiluoto vary a great deal as a result of major construction projects and maintenance work at the nuclear power plant area. Most of the traffic is the result of people commuting to and from work. Heavy traffic in connection with the construction of the repository consists, for example, of maintenance traffic and transportation of construction materials, devices, quarried materials, bentonite, fuels and canisters.

A traffic estimation for the Olkiluoto partial master plan *(Ramboll Finland Oy 2008)* studied the current situation when OL1 and OL2 are in operation and OL3 and the underground research facility of Posiva, ONKALO, are under construction. As regarding the future, traffic in 2015, when the repository will be under construction, was studied. Furthermore, a traffic estimation for 2020 was made. At that time, the repository and the four TVO nuclear power plant units will be in operation. The traffic volumes given in connection with the traffic estimation for the current situation, in 2007, and the estimated years 2015 and 2020 are given in Figure 9-1.

The repository has been estimated to employ approximately 100 people per year in the operation phase. In the Olkiluoto area, public transport accounts for approximately 50 percent, i.e. the total share of personnel will be about 100 vehicles/day (50 in and 50 out). Other transportation is random, hence, outside the annual maintenance outage of TVO's nuclear power plant, Posiva's share of the traffic estimated for 2020 is approximately 5 percent (a total

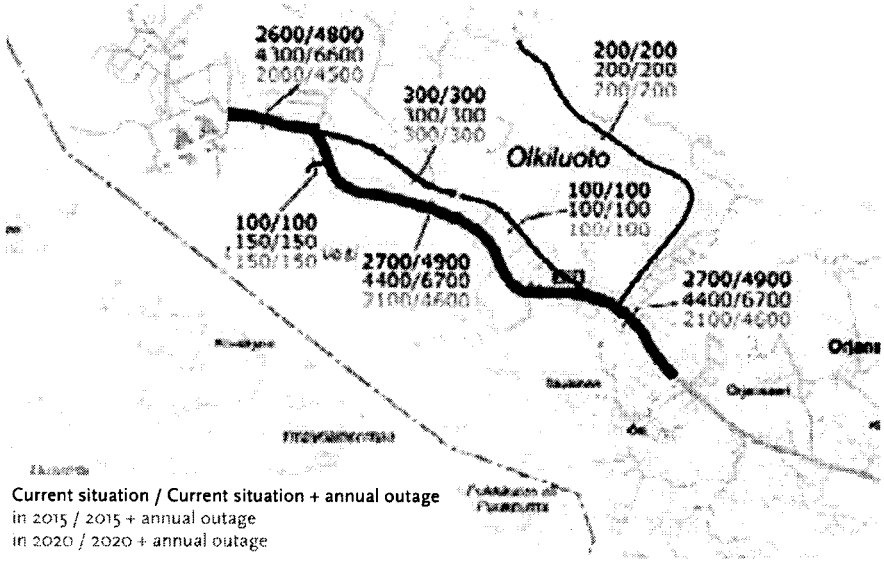


Figure 9-1 Traffic estimation for Olkiluoto. The figure shows the traffic volumes in 2007 and for the estimated years 2015 and 2020. (Ramboll Finland Oy 2008.)

of 2,000 vehicles/day). If the final disposing operations do not cause any extra traffic during the annual outage, Posiva accounts for 2–3 percent of the traffic estimated for 2020 during the nuclear power plant's annual outage (a total of 4,500 vehicles/day).

The traffic impact will concentrate on the road stretches between Olkiluoto and Highway 8 as well as in downtown Rauma. The traffic pertaining to the Posiva repository will be low (approximately 5 percent of the total traffic volume), and it will not have a major impact on the total traffic volume and traffic impact. Expansion of the repository facilities will not have any impact on the daily traffic volume.

9.1.2 Impacts from transport of spent nuclear fuel and transportation-related risks

Spent nuclear fuel will be transported to the repository from the Olkiluoto nuclear power plant and also from the Loviisa nuclear power plant. The plan is that the fuel from Loviisa will be transported to Olkiluoto as road transport; however, railway and ship transport and their combinations have also been studied as alternative transport methods. The number of fuel transports depends of the volume and type of fuel, burn-up, cooling time and the size of the transport container. The number of transports is at most ten per year.

For transport, expansion of the repository means that the operation will continue as before but there will be transportation for a longer period of time. In all different transportation options, the environmental impact caused by exhaust emissions is insignificant because of the small number of transports.

A transport risk assessment has been made for the different transport alternatives *(Suolanen et al. 2004)*. In this assessment, health risks due to transport from the Loviisa nuclear power plant to the Olkiluoto repository were studied (both impacts from normal transport and impacts in case of disturbances and accidents). The studied transport routes were road transport, railroad transport or sea transport routes, or combinations of these.

Normal transport

In the survey, the actual radiation dose level within one metre from the outer surface of a container, 0.03 mSv/hour, has been used. The measurements were taken using spent fuel that has been allowed to cool for 3–4 years, and thus the dose rate and the doses calculated based on the dose rate are conservative for long cooled spent fuel.

In the case of normal transport, the radiation impact area extends in practice to a maximum of 300 metres from the transport route. The environmental radiation dose rate emitted by spent fuel through the walls of a container will reach the radiation level that normally occurs in the environment at approximately 30 metres from the container.

The radiation dose which the most severely afflicted person in the general population will receive in the course of a year is 0.0009 mSv, assuming that the person remains within a ten-metre range of a container for a total of two hours.

The highest radiation dose from normal transport in the studied routes (30 tU/year) was 0.00027 manSv/year for the general population, 0.00089 manSv/year for transport personnel, and 0.0028 manSv/year for persons handling containers. Generally speaking, one can state that the road transport routes caused the highest and the sea transport routes the lowest radiation dose for the general public. Employees were subject to a higher radiation dose from transport than the general population because the transport personnel and the persons handling the containers remain closer to the containers during transport.

Transport transients and accidents

A studied transport transient is a case in which a fuel delivery has to be stopped during transport for a period that is longer than normal. At that time, people may gather around the site where the transport stopped, and they may therefore be subject to radiation from the container.

In case of a transient where the transport has to be stopped for a period that is longer than normal, a group of fifty persons around the container would be subject to a radiation dose of approximately 0.0002 manSv during a period of eight hours. During transport, detachment of radioactive materials (activity 10,000 Bq) that have gathered on the outer surface of a container during intermediate storage would cause a radiation dose amounting to approximately 10 percent of the normal annual dose caused by background radiation to the person subject to the highest radiation dose, even if all the radionuclides outside the container were to end up in the air the person breathes.

A transport container may become improperly sealed in case of an accident if the fuel assemblies inside the container are damaged. In such a case, part of the radioactive materials inside the container could be released into the air. The transport containers have been designed and manufactured in such a manner that the probability of such a lack of sealing is very low. Possible accidents include a collision with a fixed barrier, a fire (such as a collision with a vehicle transporting flammable liquids or a fire on a ship), intentional damaging acts, etc.

An individual accident causing emissions would cause a maximum annual dose of 0.02 µSv to a single individual within one kilometre from the accident site in case of neu-

tral weather. In case of an accident causing a fire, the initial emissions would be higher and the highest dose would be obtained approximately one kilometre from the container. If there is no fire, the radiation exposure is highest in the immediate vicinity of the container.

Even for imaginable serious cask damages, the radioactive release would not cause immediate health effects for the population in any normal weather conditions. Accidents at sea would also cause no danger to the population, as the exposure distance would be great. Accidental emissions to the sea would cause very minor activity concentrations only, and thus humans or fauna will not be exposed to radiation due to fuel transport.

The expected radiation doses from accidents were $7 \cdot 10^{-14}$ manSv/year for the ship and railway routes, and $4 \cdot 10^{-13}$ manSv/year for the road transport routes. The lower expected dose for the railway transport routes is due to, for example, the lower number of passengers and other members of the general public along the transport route during transport.

A summary of the transport impacts

For the studied routes, the risk of severe cancer cases was lower than 0.00007/year and the expected value for accidents even lower. This means that no fatal transport-related cancer cases are to be expected. The health risk due to radiation for transport personnel and persons handling the containers was approximately ten times higher than the risk for the general public. The risk related to radiation from transport of spent fuel was approximately ten times lower than the risks due to regular accidents.

9.2 Impact on land use, cultural heritage, landscape, buildings and structures

Impact on land use

The Olkiluoto area has been used as a nuclear power plant site for almost thirty years, and it has proven to be a well-suited location. The aboveground part of the repository is located in the middle of Olkiluoto Island. The land use at the repository site complies with the land use in the rest of Olkiluoto Island, and the repository will be well supported by the already existing infrastructure in Olkiluoto. The repository will be able to utilise the activities supporting the current power plant units as well as the facilities and structures built for the power plant units. The external infrastructure required by the repository consists of traffic connections. Most of this infrastructure has already been built in connection with the ONKALO construction project.

Areas for the repository's aboveground operations will be reserved in the partial master plan. Nuclear waste treatment plants for the final disposing of low and intermediate level waste as well as high-level nuclear waste may be built in the area in accordance with the construction licence granted on the basis of the Nuclear Energy Act. They comprise entrance buildings and constructions leading to the underground repository facilities as well as encapsulation plants and their auxiliary facilities.

In the partial master plan, the area designated for the underground operations of the repository is also defined and its protective zone formed. According to the construction licence granted on the basis of the Nuclear Energy Act, a repository for high-level nuclear waste can be implemented in the bedrock in the area. The size of the area is determined on the basis of the existence of bedrock that is most suitable for final disposing at the disposal depth.

It must be noted when excavating and drilling the bedrock that the area is the repository's protective zone. Before excavating and drilling, the party carrying out the final disposing must be heard.

In the valid local plan, the plant area has been designated as an area of buildings, equipment and plants connected with power production, distribution and transfer as well as adjacent buildings, structures and devices that may be constructed, unless construction of such is otherwise limited.

The normal operation of the repository, anticipated operational malfunctions or accidents do not pose any limitations on the land use outside the aboveground repository area. However, preparations in case of a severe accident will be made in the surroundings of the Olkiluoto nuclear power plant by drafting plans regarding the use of the surrounding areas and protection of the general public. These arrangements will be used as the starting point for the safety and emergency arrangements pertaining to the repository.

Land use restrictions to be entered in appropriate registers (Nuclear Energy Act 990/1987) can be prescribed when granting a closing licence for the repository. Such limitations may apply to, for example, excavation or drilling activities in the area. At the same time, a decision has to be made on which limitations a requirement on the ability to open the repository will pose on land use, as regards marking the repository facility, for example.

Impact on buildings, structures and landscape

In addition to the aboveground encapsulation plant, there are facilities for auxiliary and additional activities, such as the shaft buildings, office and laboratory facilities, warehouses, repair shop facilities and facilities required by the HVAC and electricity systems. Separate areas are reserved for storing blasted stone and for the necessary site operations. The surface and the repository are connected by an access tunnel and a sufficient number of vertical shafts for ventilation and personnel and canister transportation. The total building area of the facility, including the area of buildings, roads, storage and fields, is approximately 20 hectares.

A paved storage field for bentonite containers will be constructed along the road from the Olkiluoto port. The storage site will house a hundred containers. District heating pipelines and the pipeline network for household water travel in ditches in the repository area mainly along the road lines. Other pipeline networks include basic plumbing system pipes and rainwater drainpipes. Separate ditches will be made for cables.

The buildings constructed and designed in the area are shown in Figure 3-1. The most important building is the six-storey planned encapsulation plant. Three of the stories will be above ground level, and the building will be approximately 15 metres tall. The encapsulation plant will be separated from the rest of the area with a fence.

Figure 9-2 shows the Olkiluoto repository's planned location on Olkiluoto Island as seen from the sea to the north of the island. The view from this direction is dominated by the rock dumping site. A rock crushing station and a crushed stone storage are next to the rock dumping site. There is a filler manufacturing plant next to the crushed rock storage. The bentonite container storage field is located left of the rock dumping site. The north shore

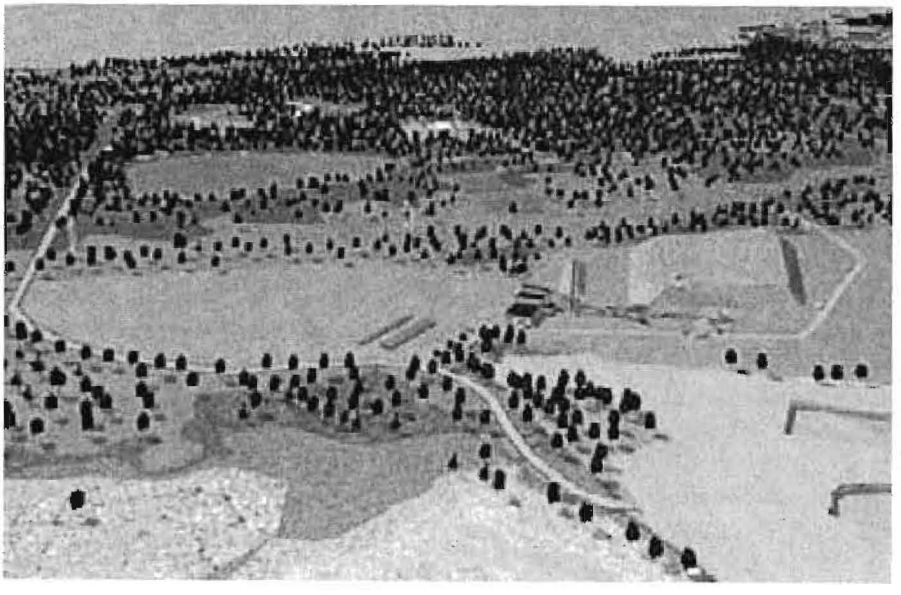


Figure 9-2 Computer image of the Olkiluoto repository area and its environments.

port and dockyard area will probably remain, and these have a major impact on the landscape. The landscape in the western part of the Olkiluoto Island is dominated by the current power plants.

The final disposal facility will have a minimal impact on the landscape. The impacts can be further reduced by leaving a sufficiently dense forest stand around the repository and the shaft buildings.

Impact on cultural heritage

There are no nationally or regionally valuable buildings or other objects of cultural history in the repository area. No relics of antiquity have been found in the Olkiluoto area.

9.3 Impact on the soil, bedrock and groundwater

9.3.1 Aboveground structures

During construction, rock will be excavated above ground for a couple of months. The surface excavation will be necessary when constructing buildings, roads and yard areas. Most of these have already been done for the ONKALO facility. Later, the material from the excavation of the bottom of the encapsulation plant will also be placed in the dumping site.

The expansion of the repository facilities may require construction of new vertical shafts outside the current plant area for the ventilation system and as exit routes. A building of approximately 20 m² would be built at a vertical shaft, and the building would be separated from the rest of the area with a fence. The shafts will be made by using raise boring technology, and thus they will not require much construction above the ground level.

Other aboveground buildings will already be built before starting the final disposal operations.

9.3.2 Impact of the underground repository on the bedrock

The area required by the underground repository for 6,500 uranium-tons (tU) of fuel to be disposed of is about 150 hectares. When the amount of disposable fuel is 9,000 tU, the area required is about 190 hectares. The expansion of the repository from 9,000 tU to 12,000 tU will increase the area required by final disposal by about 50 hectares. The length of underground tunnels will increase from 82,000 to 104,000 metres.

The plan is to carry out the excavation required for the repository by drilling and blasting, except for the deposition holes and the shafts. When planning excavation, especial attention will be paid to the excavation marks and the impacts of the excavation on the bedrock surrounding the tunnels. The overbreak tolerance will be kept low in order to avoid unnecessary increases in the volume to be filled in later on. When excavating tunnels, the bottom parts may be separately excavated in order to reduce the impacts on the bedrock forming the floor and the bottom parts of the walls.

The drilling and blasting method to be used during excavation includes several intermediate stages. First, the excavation holes required to detach one round will be drilled. Then explosives will be placed in the holes, the round will be blasted and the tunnel will be ventilated.

Blasted quarried materials will be loaded onto vehicles and taken through a tunnel to the surface. When the excavation face has been emptied, drilling of new holes for the next round will begin. Grouting and reinforcing will take place in between these stages whenever necessary. The excavation works may also be interrupted by various kinds of surveys and studies.

The deposition holes to be made onto the floor of the repository tunnels will be drilled by utilising a method applicable for this purpose. The materials generated during drilling will be removed from the bottom of the hole by means of underpressurised air. The system allows for drilling holes with a large diameter from above in the low repository tunnel.

Most of the structural engineering works for the repository facilities will already be done during construction of the ONKALO facility. This refers to, for example, the structural engineering works required by the vehicle tunnel, the supply and exhaust air shaft and the technical facilities in the non-controlled area. Structural engineering works to be implemented before the final disposal stage include, for example, construction of the controlled area, the canister shaft, a second exhaust air shaft, the first disposal tunnels and the central tunnels. In the operating stage, construction works will take place in the central tunnels and disposal tunnels in connection with excavation works every 5–10 years.

Impact of canister heat generation on the bedrock

The heat generation of each canister will increase the temperature in the surrounding area. Each batch of fuel disposed from a reactor must be cooled so that the temperature of the bentonite surrounding the canisters will not exceed 100°C during final disposal.

If the temperature around the canisters rises too high, chemical changes in the bentonite buffer could occur, and these changes could deteriorate the bentonite's capacity to protect the canister. The total heat generation of the final disposal facilities is roughly comparable to the number of canisters in the facilities. The temperature in the area immediately around the canisters is not considered especially responsive to the total number of canisters stored in the repository, since the canisters will in any case be placed separate from each other in order to avoid overly high temperatures.

The heat generated by the spent fuel will cause the bedrock to expand. When calculated by utilising the element method and when calculated analytically, the ground is expected to rise at the middle of the repository facility by a maximum of seven centimetres in a little over a thousand years. *(Ikonen K. 2007.)*

9.3.3 Amount of quarried materials and other rock materials generated

An increase in the amount of fuel to be disposed from 9,000 to 12,000 uranium tons will increase the amount of quarried materials to approximately 410,000 m³ and the total quarried material generation from approximately 1,670,000 m³ to approximately 2,080,000 m³. The amount of quarried materials is approximately 1,450,000 m³ if the amount of fuel is 6,500 uranium-tons. An average of 20,000 m³ of rock waste will be created annually.

The rock material raised from the underground repository facility will be stored in a stack of quarried materials in Olkiluoto. If necessary, the quarried materials can be crushed and used as backfiller for the repository facilities. The entire amount of quarried materials will not be required as backfiller for the underground facilities; instead, they may be used for other purposes. One alternative is selling the quarried materials, either as such or crushed, to be used as filler and construction material elsewhere.

If a horizontal disposal alternative is to be used, less quarried materials will be generated, since the horizontal disposal alternative requires less open rock space than a vertical disposal solution. There will be no need to excavate repository tunnels in the case of a horizontal disposal solution; instead, the tunnels will be drilled by utilising the tunnel boring principle. The crushed rock material generated will be transported to the surface and stacked in the same way as quarried materials. The materials will not require further crushing; instead they may be used as such for other purposes either in Olkiluoto or elsewhere.

Solids generated in Olkiluoto during construction, such as unnecessary soil, will be stacked in the landfill of the current TVO nuclear power plant. Waters from the stacking area will be drained into a regulating, clarification and observation basin, and then drained via a measuring and observation well into a drain ditch. The waters will not cause any major environmental impacts.

9.3.4 Impact on groundwater

The construction of ONKALO and the repository will affect the water flow routes and rates inside the Olkiluoto bedrock and, as a result, the chemical characteristics of groundwater. These changes are illustrated within the monitoring programme for the construction of ONKALO drafted in 2003. Figure 9-3 shows the locations of shallow groundwater observation points on Olkiluoto Island.

When constructing the tunnels and operating the final disposal facilities, groundwater will leak into the open tunnels. The water will be pumped to the ground surface level. This will reduce the groundwater pressure height around

the tunnel system and may also cause the groundwater level in the Olkiluoto Island area to decrease. The volume of leakage water and the extent of impacts will be reduced during construction work by sealing the bedrock around the tunnel.

The amount of groundwater that will flow into the repository's expansion part and the impacts of the expansion part on the groundwater level have been assessed by means of numeric flow modelling. The modelling has referred to the entire Olkiluoto Island area. The numeric flow model of 2006 (for example, *Andersson et al. 2007*) has been updated to comply with the observation data gathered at the end of 2007. Observations regarding the amount of groundwater that has leaked into the tunnel and the groundwater pressure level fluctuations caused by the already constructed tunnel part in the deep boreholes in Olkiluoto have been made, for example. Based on the observations, the assessments regarding the amount of water that will leak into the tunnel have been reduced when compared to the previous model by more successfully modelling the sealing of the bedrock.

The current assessments have been calculated with both successful and satisfactory sealing of the repository tunnels. It has been estimated that if the tunnels are successfully sealed, the transmissivity or water conducting capacity of the fissure or fissure zone going through the tunnel, which will carry water, will be 10^{-9} m²/s. The effect of successful sealing has been estimated to reduce the transmissivity to 10^{-8} m²/s.

The numerical model predicts that the amount of water leaking into the expansion part, depending on the success of the sealing, will be on average 0.11–0.14 l/min for each 100-metre tunnel section. 25–30 l/min of water will leak into the entire expansion part, depending on the success of the sealing. This will increase the amount of water flowing into the entire tunnel system by approximately 20 percent when assuming that both ONKALO and the entire repository area will be open at the same time. practice, the tunnel system will be built in stages and only a part of the tunnel system will be open at the same time, which will reduce the true impact from the estimate.

The increase of leak water will cause an average groundwater surface level reduction of 2–4 metres in the studied area, depending on the success of the sealing. Locally, the decrease will be greater in areas where bedrock capacities that convey water better than average are located near the surface. Figure 9-4 presents the extent of the decrease estimated by the numerical model in different parts of the

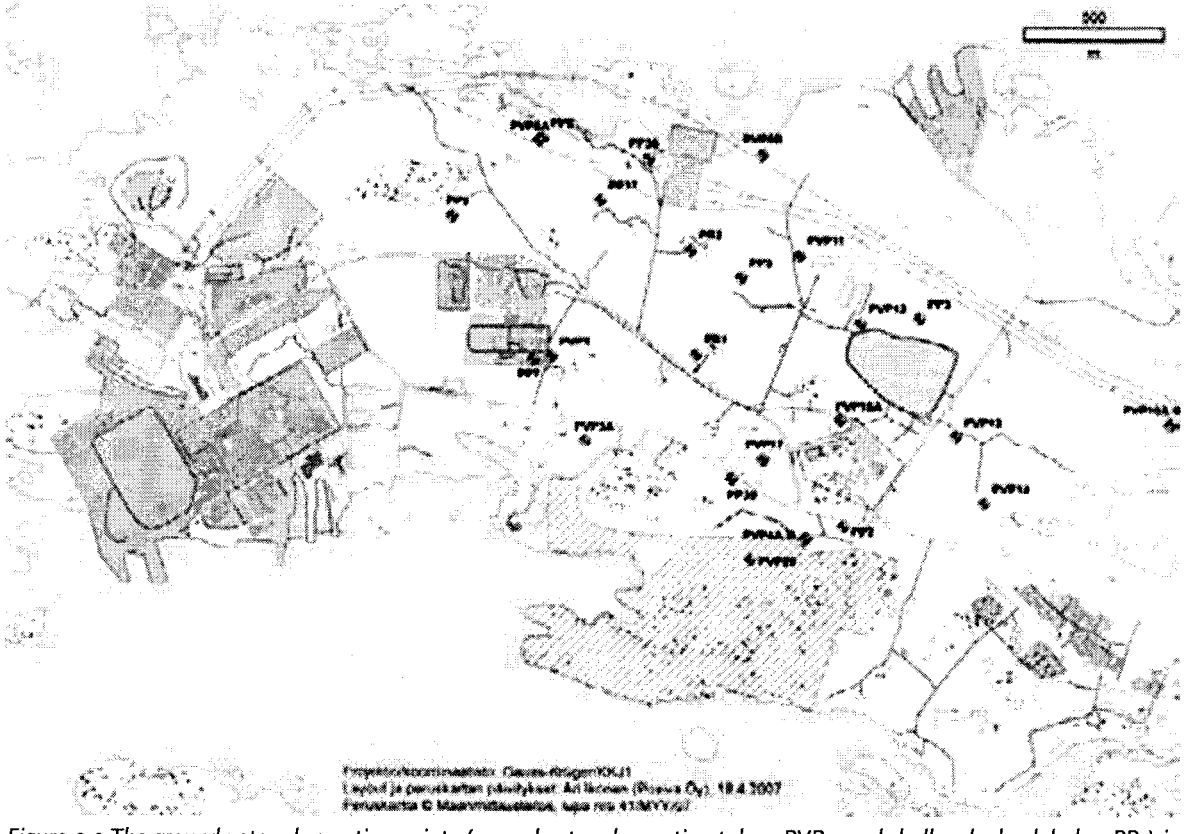


Figure 9-3 The groundwater observation points (groundwater observation tubes, PVP1, and shallow bedrock holes, PP1) in Olkiluoto in 2007.

island, using two different models for the sealing process.

Both short-term and long-term groundwater pressure level changes have been observed. The short-term changes have been due to a variety of research activities both in the research area and in ONKALO as well as temporary leaks when holes made in ONKALO have penetrated zones or fissures which drain water. The pressure level has recovered once the leaks have been sealed, however. The long-term changes (drawdown in pressure level) in holes close to ONKALO up until the end of the year 2006 amount to approximately one metre. *(Klockars et al. 2007.)*

Changes in flow conditions in open holes have revealed some hydraulic connections between certain hole sections and ONKALO. Both increase and decrease of electrical conductivity values have been observed deep in the bedrock. The cement used when grouting has decreased the water conductivity also in fractures which drain water poorly in the holes close to ONKALO. *(Klockars et al. 2007.)*

The most clearly visible changes in the shallow groundwater principal ions occurred in the autumn of 2002, 2004 and 2005. Some of these changes may be caused by seasonal fluctuation but also the construction activity in the area has locally influenced the quality of shallow groundwater. Changes in shallow groundwater due to the construction of ONKALO have not been observed. *(Pitkänen et al. 2007.)*

The gas composition and chemical composition of deep groundwater is still close to the so-called basis sta-

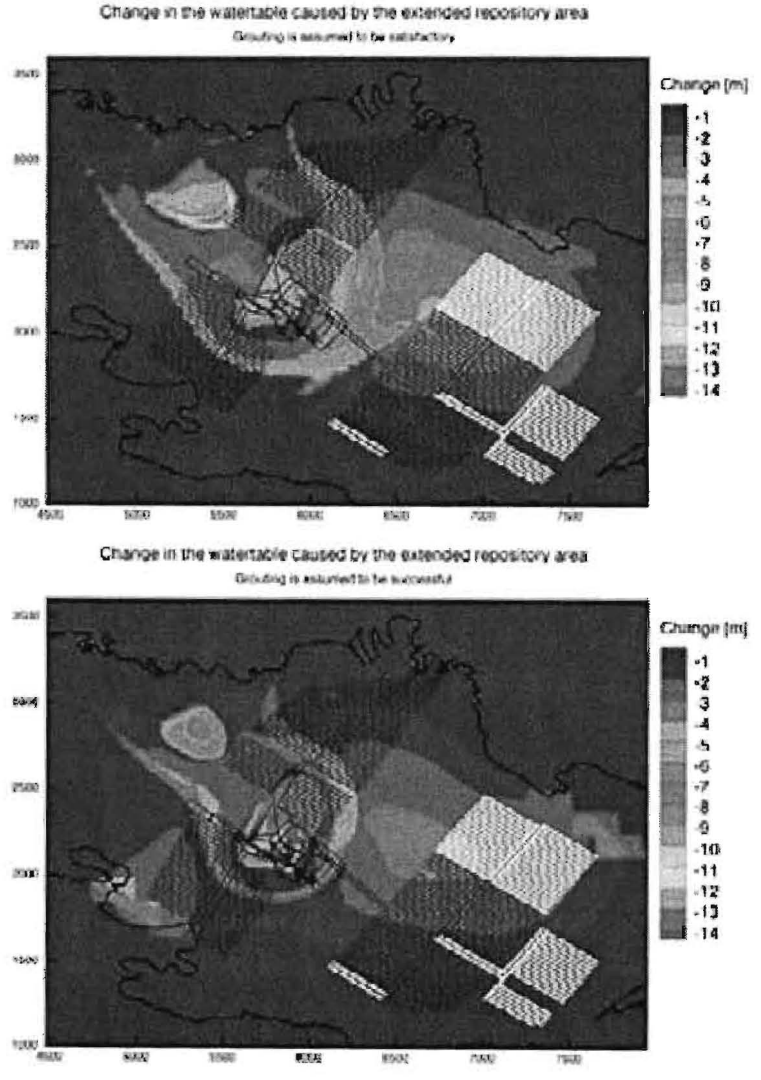


Figure 9-4 The estimated change in the level of groundwater caused by the expansion facilities when the sealing of the repository is assumed to be satisfactory (figure on the left) and good (figure on the right). The figures present ONKALO's tunnels, disposal facilities and the outline of Olkiluoto Island. The planned expansion area for the repository is marked with white lines. There will be no changes in the level of groundwater outside the illustrated area or the island's outlines. The figures on the scales are distances as metres.

tus that prevailed in Olkiluoto Island before the construction of ONKALO started; no major changes have occurred. Changes in salinity have been observed during the monitoring period in one of the hydrogeological zones (HZ20). These have probably been caused by surface water being able to mix with the salty groundwater via open boreholes. The hydrogeological monitoring period has been short, however, and the hydrogeochemical changes due to the construction of ONKALO deep within the bedrock may appear only after several years. *(Pitkänen et al. 2007.)*

Changes in groundwater samples taken in ONKALO have also been minor. The only clear changes were observed in holes bored for the purpose of monitoring ONKALO's injecting cement; it has been observed that the injecting cement clearly influences the groundwater composition in the boreholes. *(Pitkänen et al. 2007.)*

9.4 Impacts on air and air quality

9.4.1 Impacts of excavation, crushing and rock deposition on the air quality

Dust from surface blasting can be observed at a distance of a couple of hundred metres downwind *(LT-Konsultit Oy 1998)*. When taking into account the duration and timing of excavation and the size of the afflicted area, there are no major environmental impacts. The dust from underground blasting will not have any impact above the ground.

At the operation and shutdown stage, quarried rock will be crushed for a period of approximately four weeks biannually. Excavation and crushing will not take place at night.

The dust impacts of a transportable crushing plant have been assessed based on the guideline values issued by the Government and guidelines of the Road Administration. Crushing will take place when it is warm and spreading of dust will be limited by means of irrigation. Dust sources will be protected with tarpaulins or enclosures in the wintertime. The protective distance must be 300 metres. If dusting is to be limited only when necessary, the protective distance must be 500 metres. The protection offered by vegetation has not been taken into account in the protective distances *(LT-Konsultit Oy 1998; Tolppanen 1998)*.

The environmental impacts of crushing and rock deposition are not significant due to their short duration and small affected zones.

9.4.2 Vehicular emissions

Posiva's environmental impact assessment report of 1999 stated that the project will increase the total emissions of road traffic in the area by a maximum of a couple of percent. The traffic caused by the repository does not have any significance in the local air quality. For example, the nitrogen oxide contents will clearly remain below the guideline values. Expansion of the repository will not have any impact on the daily traffic volume. The facility will be simply used for longer if more fuel is to be disposed. Therefore, the traffic caused by the repository will not have any major impacts on the air quality.

9.5 Impact on waters

9.5.1 Water supply

A potable water, drilling water and fire fighting water system will already be built during the construction of the ONKALO facility. Most water will be used during construction (150 m^3 / day). Water consumption will be approximately 55 m^3 / day during operation. The potable water is regular tap water that comes from the Olkiluoto water pipeline network. The current capacity is sufficient for future water needs. Drilling and fire fighting water will come from the Korvensuo reservoir after humus has been filtered. Expansion of the repository will not have any impact on the daily water consumption. The facility will be simply used for longer if more fuel is to be disposed.

9.5.2 Household wastewater

Water leaking from the bedrock and washing water will be drained with a drainage system to a clarification basin and further pumped through a drain in the personnel shaft to the ground level. Sanitary wastewater will be gathered into a closed container and taken to the surface level to be processed.

The repository will generate approximately 30 m^3 of household wastewater per day. The wastewater will be drained to the wastewater purification plant on the island. The household wastewater will not cause any major environmental impacts. Expansion of the repository will not have any impact on the daily household wastewater volume. The facility will be simply used for longer if more fuel is to be disposed.

9.5.3 Wastewater from the encapsulation plant

All water used in the controlled encapsulation plant area will be treated with a cleaning compound. Used cleaning compound will be disposed of and cleaned water will be drained into the sea after monitoring measurements have been taken. The washing water from the controlled area will not cause any major environmental impacts.

9.5.4 Impacts of civil engineering work on waters

The impacts of civil engineering work on surface waters have been assessed by means of terrain surveys and maps *(LT-Konsultit Oy, 1998)*. The Olkiluoto terrain assessments have been supplemented by further calculations on the Olkiluoto surface hydrology model *(Karvonen 2008)*. The surface water network of Olkiluoto consists almost solely of excavated forest ditches and road ditches made when constructing roads.

The construction of the facility will change the surface water absorption conditions when the water coming from roofs and paved yard areas (a total of three hectares) is drained into the water system. The drain directions of the drainage areas may be retained by installing drum pipes even if the drainage areas are changed. Regardless of the scope of operations or their placement, the facility will not have a major impact on the surface water flows.

Drainage of surface water caused by heavy rain into the ditches has been calculated with a surface hydrology model, and the calculations show that the changes of the water level in the ditches from the current levels will be short-term and will have no detrimental impacts. *(Karvonen 2008.)*

In addition to an assessment pertaining to the flow changes, an assessment on the impacts of the civil engineering work and paving connected with the repository on the nutrient and solid loads of the surface water routes and the adjacent sea area has been made. The impact of the civil engineering work and paving in the discharged nutrient and solid loads was calculated by multiplying the water volumes calculated with the Olkiluoto surface hydrology model by contents assessed based on studies made by the Hydrology Laboratory of the Helsinki University of Technology *(Kotola & Nurminen 2003)*.

Most of the surface water drain routes in Olkiluoto are forest or road ditches where the load from the repository area will not cause any major environmental hazards. The general state of the Bothnian Sea coast waters and the nutrients and solids coming from the Eurajoki River (watershed 1,336 km²) and the Lapinjoki River (watershed 462 km²) influence the water quality and biological production of the Olkiluoto sea area. The cooling water of the nuclear power plant on the island also has a clear impact. When compared to the above-mentioned load sources, the additional load caused by the repository in the sea area surrounding Olkiluoto Island is very low.

9.5.5 Impacts of excavation, crushing and rock deposition on the waters

Residual amounts of explosives, such as nitrogenous compounds (nitrite and nitrate), will remain in the quarried rock and in the bedrock due to the blasting. Any residual in the bedrock will dissolve into the tunnel leak water, and this water will be drained into the clarification basins of the repository. The clarified water will be pumped up and drained to the waters close by. The chemical properties of the drilling water used in ONKALO have been studied, both in the water going to ONKALO and the water pumped out of ONKALO. The waters will not cause any major environmental impacts. The residual amounts can be reduced by using explosive cartridges and irrigating rock heaps before loading.

Water coming from the heaps of rock and quarried materials will be clarified and then drained into the water close by. The excavation, crushing and rock deposition will not have any impact on the surface water quality.

9.5.6 Impact of the repository on household water and bored wells

The groundwater of Olkiluoto Island is continuously monitored with the help of a dense network of observation points. As part of this observation, certain household water wells on Olkiluoto Island are regularly monitored. This monitoring helps to get a good understanding of the impacts of the repository on groundwater of Olkiluoto Island. Furthermore, Posiva's groundwater experts have stated, on the basis of the acquired knowledge, that the impact of ONKALO on decreasing the groundwater level is restricted to the construction site and its immediate vicinity, and it is very low also there. No development trends that could have been caused by Posiva's activities have been observed when surveying the household water taken from the monitored wells.

Environmental risks of the canisters and their contents have been assessed *(Raiko & Nordman, 1999)*. Concentrations of chemical elements of environmental significance in the well water assuming, for example, that the canisters become fully unsealed in 10,000 years have been conservatively assessed. The calculations show that the concentrations will clearly remain below the concentration limits set forth for household water.

9.5.7 Impact of the repository on public beaches

Public beaches located close to the repository are presented in Figure 8-12. The waters of the repository area

will not have any impact on the quality of water of public beaches.

9.6 Impacts of waste and by-products

9.6.1 Construction waste and other waste management

The waste management of construction sites is controlled in Finland by the Waste Act (1072/1993), the Waste Decree (1390/1993) and the Government Decision on Construction Waste (295/1997). Furthermore, waste collection is controlled by the general waste management regulations of the municipality of Eurajoki. In accordance with the Government Decision, at least the following waste fractions must be sorted at construction sites: excess soil, stone-based materials, wood-based materials and metals.

Small amounts of waste and hazardous waste normal for industrial activities will be generated during construction and operation of the facility, such as waste oils, solvents, batteries, fluorescent tubes, recyclable paper and household waste. Their consistency and properties will not deviate from similar waste from other industrial plants. Hazardous waste will be temporarily stored at the repository in proper facilities and then delivered to either a municipal hazardous waste collection point or a hazardous waste treatment facility. All waste fractions suitable for recycling will be sorted from the household waste: paper, wood, glass, any leftover food, recyclable plastic and metal scraps. These waste fractions will be delivered to be recycled. The remaining materials of no recycling value will be taken to a landfill meeting all regulations. Expansion of the repository will not have any impact on the daily waste volume. The facility will be simply used for longer if more fuel is to be disposed.

9.6.2 Nuclear waste management at the encapsulation plant

The encapsulation plant will not generate any active waste, except in the fuel handling cell and when removing the surface contamination of a fuel transport container.

High-level nuclear waste will be disposed of together with the fuel assemblies. Active deposit and any fuel fractions will be collected by vacuuming in the handling cell. The waste will be drained from the vacuum tank into the base of the final disposal canisters before placing the fuel assemblies in the canisters.

Liquid waste will mainly be generated when washing the outside of transport containers. The washing water will be deactivated and recycled. Filter materials will be solidified and taken into the repository.

All radioactive materials will be cleaned from devices taken out from the handling cell before repairing them. Cleaning solvents' filter materials will be solidified. If the devices cannot be repaired, they will be packaged and taken into the repository.

Filters from the ventilation system of the controlled area, the handling cell and the vacuuming system will be packaged and taken into the repository.

Most waste will be generated when the encapsulation plant is shut down. When the encapsulation plant is shut down, any radioactive materials in the systems and devices due to contamination must be properly cleaned. All devices from inside the handling cell will be packaged and taken into the repository. The steel lining of the handling cell and the active repair shop will be washed but not dismantled. Washing water will be solidified into concrete. The repository will generate approximately 5,000 m^3 of waste, including the waste generated during decommissioning *(Kukkola 2006)*. If the amount of fuel to be disposed of increases, the decommissioning of the encapsulation plant will be postponed. The expansion will slightly increase the amount of waste generated during encapsulation due to the increased amount of fuel being encapsulated.

9.7 Impacts of noise and vibration

Noise and vibration will be caused by the excavation, rock blasting, handling and crushing of quarry rock, as well as by the operation of vehicles and machines. For excavation operations, the main sources of noise are quarrying, crushing and rock drilling.

The disposal facility will be constructed in stages as spent fuel is disposed of. The crushing of rock waste will cause noise in the daytime, during construction. The crushing of rock waste will end when all the fuel to be placed in the Olkiluoto bedrock has been disposed of.

The noise from an explosion during surface blasting can be heard approximately a kilometre, on the sea even up to two kilometres, from the blasting site, depending on the wind conditions *(LT-Konsultit Oy 1998)*. When taking into account the duration and timing of excavation and the size of the afflicted area, there are no major environmental impacts. As far as is currently known, the expansion of the repository will not require any surface excavation.

The area in which the noise from an underground explosion can be heard has been assessed based on information obtained from mines at the same depth as the repository. In mines, more explosives are used in a more open space and thus the sound is louder. The noise from the excavation of the repository facilities will not be heard outside the repository area *(Tolppanen & Kokko 1998)*.

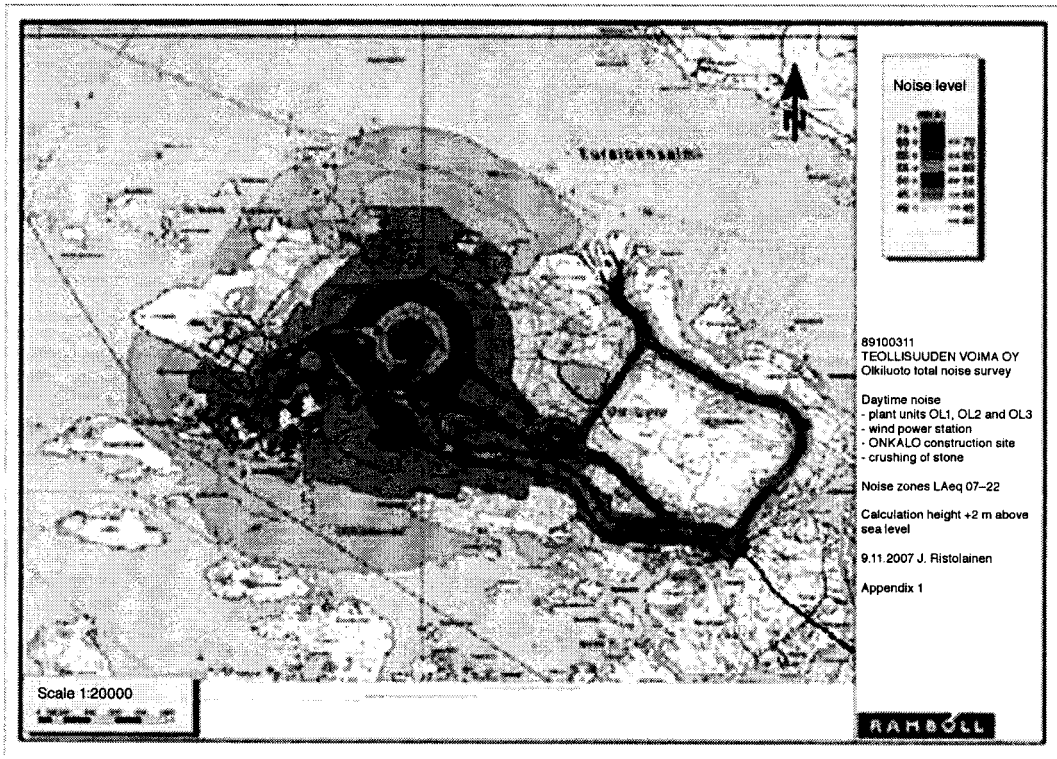


Figure 9-5 Daytime noise when power plant units OL1, OL2 and OL3 are in operation, the repository is under construction and quarried materials are being crushed.

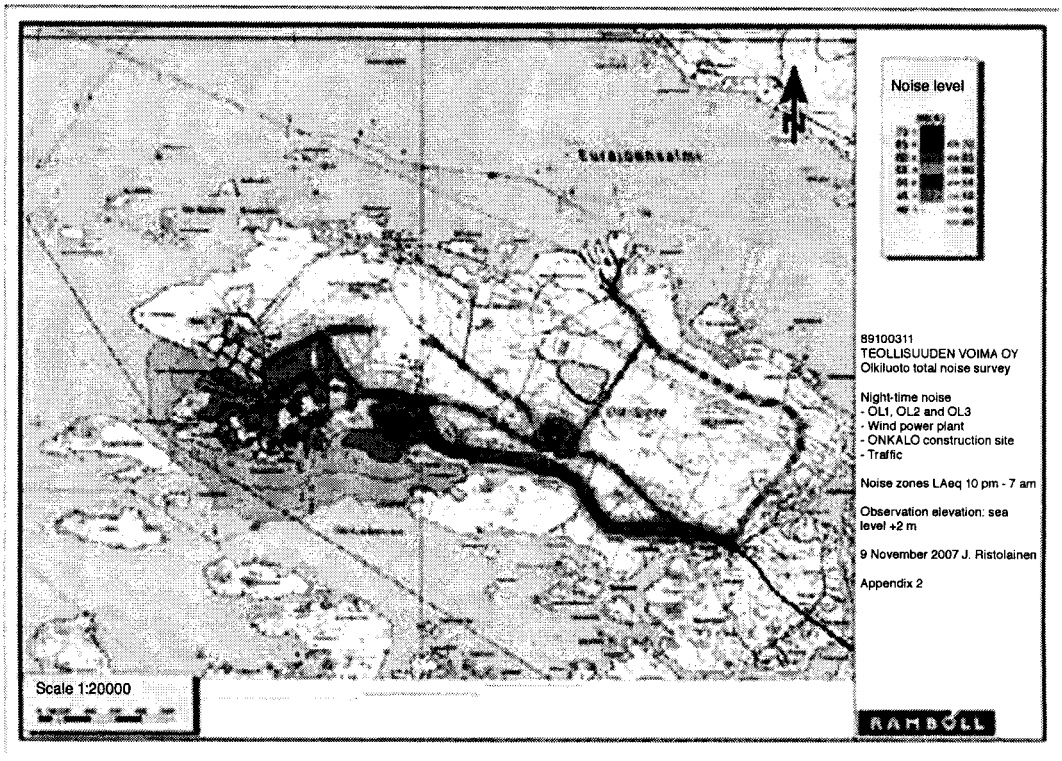


Figure 9-6 Night-time noise when power plant units OL1, OL2 and OL3 are in operation, the repository is under construction and quarried materials are not being crushed.

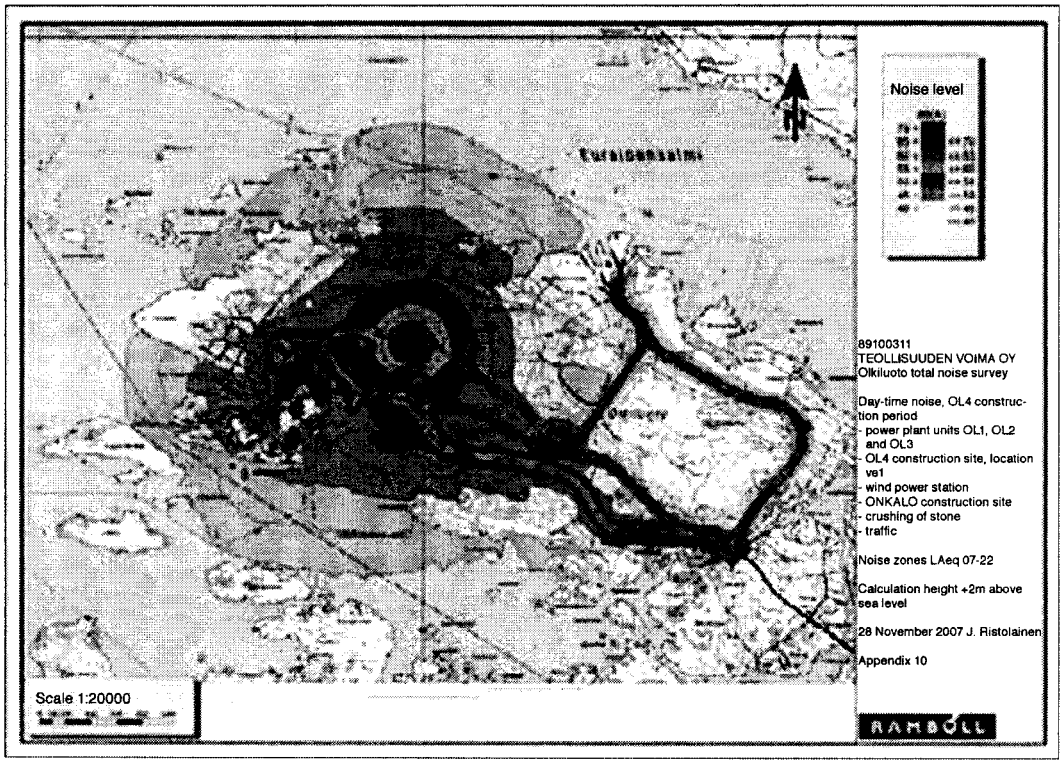


Figure 9-7 Daytime noise when power plant units OL1, OL2 and OL3 are in operation, OL4 and the repository are under construction and quarried materials are being crushed.

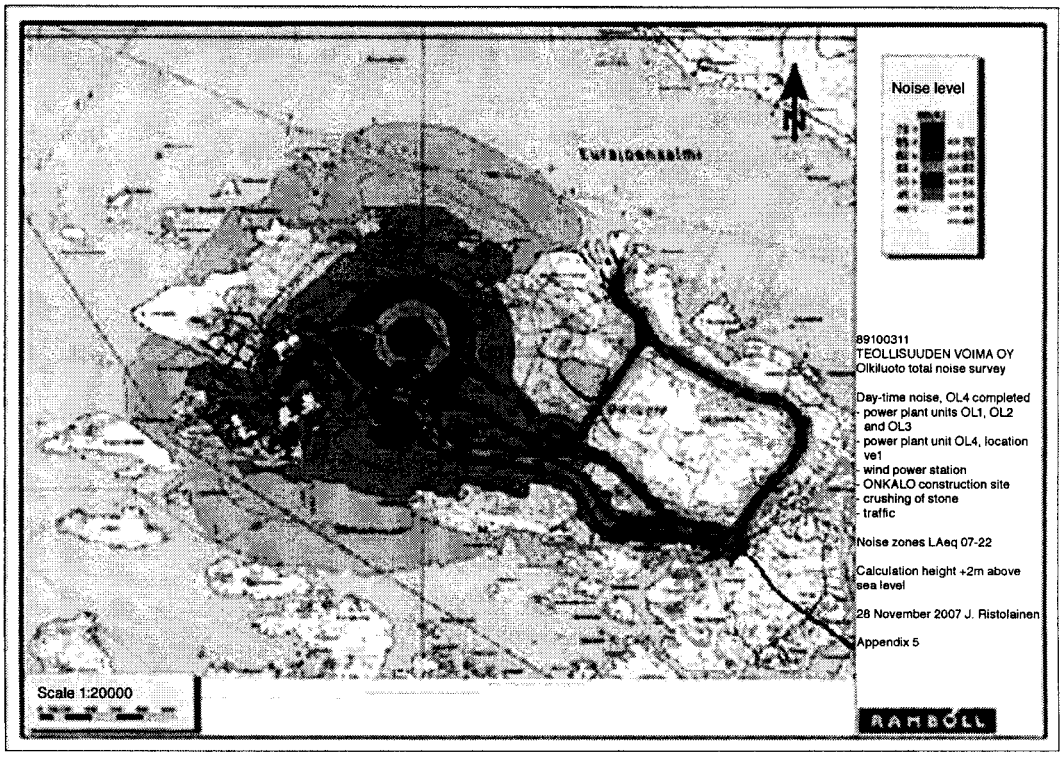


Figure 9-8 Daytime noise when power plant units OL1, OL2 ,OL3 and OL4 are in operation and the repository is under construction and quarried materials are being crushed.

The noise from the crushing plant has been assessed in accordance with the guidelines of the Road Administration. The daytime guideline value in residential areas given in the Noise Prevention Act is 55 dB(A). A correction of 5 dB(A) must be made in case of impact noise measurements. The Finnish Road Administration *(1993)* has defined the protective distances for crushing plants based on 50 dB(A). The sound level of normal conversation is 50–60 dB(A) and the sound level in a quiet residential area at night is 40 dB(A). The noise level will remain below 50 dB(A) at a distance of less than 500 metres, and the noise level will remain below 40 dB(A) at a distance of less than 1,200 metres. The impacts of structures and the terrain have not been taken into account in these distances *(Finnish Road Administration 1993)*.

If the quarried materials are to be placed within 50 metres of the crushing plant, the noise level will remain below 50 dB(A) at a distance of less than 200 metres, and the noise level will remain below 40 dB(A) at a distance of a little over 500 metres *(Finnish Road Administration, 1993)*. When taking into account the total impact from the quarried materials and the terrain, the noise level will probably remain below 40 dB(A) at a distance of 500 metres from the crushing plant. The shortest distances from the crushing plant to the shore or a summer residence in Olkiluoto is approximately 500 metres *(LT-Konsultit Oy 1998)*.

Expansion of the repository will have practically nonexistent impacts on the noise zones. If the amount of fuel to be disposed of increases, the repository will simply remain in operation for longer. Some noise may be caused by the excavation and drilling of any new shafts required. These impacts will be short-term due to the fact that the raise boring method will be used, and the excavation and drilling will not take long.

The traffic caused by the facility will increase, to a certain extent, the area affected by noise.

As shown below, the noise impacts of crushing and rock deposition are not significant due to their short duration and small affected zones.

Olkiluoto noise assessment results

The daytime and night-time noise zones (LAeq 7-22 ja LAeq 22-7) caused by the activities at Olkiluoto are given in Figures 9-5–9-8. Figures 9-5 and 9-6 show daytime and night-time noise zones in a situation where TVO's nuclear power plant units OL1, OL2 and OL3 are in operation and the repository is under construction. Figure 9-7 shows daytime noise zones in a situation where TVO's nuclear power plant units OL1, OL2 and OL3 are in operation, and OL4 and the repository are under construction. Figure 9-8 shows daytime noise zones in a situation where TVO's nuclear power plant units OL1, OL2, OL3 and OL4 are in operation, and the repository is under construction. In all the calculated situations, the noise levels remain below the target values at the nearest permanent residences and holiday homes during the day and at night alike.

When the third nuclear power plant of TVO is completed, the noise level for regular operation during the day, LAeq 7-22, at the closest holiday home on Leppäkarta Island, will be 41 dB. The similar night-time noise level, LAeq 22-7, will be 38 dB. The difference between the noise level during the day and at night at the closest holiday homes on the islands close by will be approximately 3 dB. The difference is mainly due to the fact that quarried materials will not be crushed at night, and there is also less traffic at night. The crushing of quarried materials is the largest single noise source in the Olkiluoto area. The fact that the crushing plant is located in the middle of the island will reduce the noise impacts outside the island, however. In the eastern parts of Olkiluoto Island, traffic will cause more noise than the power plants and the crushing plant. *(Ramboll Analytics Oy 2007.)*

The completion of TVO's nuclear power plant unit OL4 at location option 1 will increase the night-time noise level at the closest holiday home on Leppäkarta Island by about 1 dB *(Ramboll Analytics Oy 2007)*.

Vibration

The impacts on the bedrock caused by the underground research facility ONKALO construction site have been examined with Olkiluoto's seismic system. So far no significant changes have been detected. The status at Olkiluoto is being continuously monitored by measuring devices, and the system is able to show in real time the impacts of the repository excavation site. The blasting at the ONKALO construction site has caused impacts of a maximum of magnitude 0.7.

9.8 Impact on flora and fauna and protected areas

The impacts of the project on flora and fauna are primarily related to the land areas required for buildings and structures, as well as the construction work. There are no significant impacts during the operation and closing of the repository.

The environmental impacts of the rock material deposition and crushing activities, also including the quarried materials from the plant unit OL3, have recently been studied by collecting wet depositions and analysing pine and spruce needles gathered from the adjacent environment *(Haapanen et al. 2007)*. Stone dust and some road dust has accumulated in the canopy; this can be seen in the fact that unwashed needles contain more aluminium

and iron than washed ones. However, based on information obtained when washing the needles with chloroform in order to slightly mar their surface, one can state that the higher contents are unable to penetrate into the cellular tissue, and thus the trees do not experience any physiological harm.

The majority of plants take the water required from the soil water above the bedrock. As a result, the decrease in the groundwater level caused by the underground facilities will not have an impact on flora. As stated above in Section 9.3.4, no major drawdown of the groundwater table level in the soil layers is to be expected.

The noise caused by surface excavation will disturb nesting birds in the forests up to a distance of approximately 100–300 metres. The best bird nesting areas are not located close to the potential construction sites, however. Mammals are usually not disturbed even by powerful noise. The impacts of the noise on the fauna will be hardly noticeable.

According to a study, the impacts of the vibration from excavation on the fish stock will be insubstantial due to the fact that the local vibration will last only for a short time *(Kala- ja vesitutkimus Oy et al. 1996)*.

There are no nationally endangered animal or plant species in the area. No ecological connections between areas will be disrupted. Utilisation of the natural resources, such as picking mushrooms and berries, hunting, fishing and forestry, can be continued as before outside the area reserved for the repository.

The construction site has no natural objects of national or regional importance, or any Natura 2000 sites. The closest area included in the Natura 2000 network is the old forest of Liiklankari, a part of the Rauma archipelago Natura 2000 area. According to calculations made with the Olkiluoto surface hydrology model *(Karvonen 2008)*, the water volumes discharging into the rock tunnels have at their worst a very minor impact on the growth of plants in the Liiklankari conservation area. In other areas, any natural sites which the groundwater could influence are so far away from the potential construction site that no impacts are likely to occur. When the facilities are closed down, the groundwater surface level will be restored in a couple of years.

Inventories completed in 2006 studied the nature types of the Liiklankari Natura area. Species surveys (beetles, shelf fungi, bryophytes and macrofungi) were made in the area in the autumn of 2006. The final conclusion of the Natura assessment made in 2006 was that the projects (including the repository) possible in Olkiluoto based on the land use plans will not have any major impact on any of those values based on which the Liiklankari area was included in the Natura 2000 conservation programme. The activities will not have a major impact on retaining a favourable protection level in the old forest system of southern Finland. *(Insinööritoimisto Paavo Ristola Oy 2006b.)*

9.9 Impacts on utilisation of natural resources

Utilisation of copper

The amount of copper required at the operational stage per year is less than 1 percent of the Luvata Pori Oy's and less than 0.01 percent of the global annual production. Oxygen-free copper required by Posiva is sufficiently well available. Copper is a globally generally utilised material, and one can assume that the availability will remain good. Copper products can also be acquired in storage in order to secure continuity of the activities, if necessary.

Utilisation of bentonite

Bentonite is a form of clay consisting of greatly expanding clay minerals. These are not found to any large extent in Finland. The amount of bentonite required during operation and shutdown of the facility amounts to less than 0.1 percent of the global annual production. Availability of bentonite is good. Bentonite is a material generally utilised for various purposes, and one can assume that the availability will remain good.

Utilisation of rock material

The rock material raised from the underground repository facility will be stored in a stack of quarried materials in Olkiluoto. If necessary, the quarried materials can be crushed and used as filler for the repository facilities or elsewhere. The crushed rock material generated using tunnel boring technique will be transported to the surface and stacked in the same way as quarried materials. The materials will not require further crushing; instead, the materials may be used for other purposes as such.

An amount of 20–25 percent of the quarried rock material will be sold. The share to be sold will conserve the gravel ridges in the region. Increasing the fuel to be deposited and construction of a vehicle tunnel will increase the amount of rock material to be sold.

9.10 Impacts on human health

In this report, the term 'health impacts' refers to changes in the health of humans, the health-related conditions in their living environment or a threat of such changes (health risks), as described in the guide by the Ministry of Social Affairs and Health *(Ministry of Social Affairs and Health 1999)*. According to the guide, the changes may be direct or indirect, accumulated, short-term or long-term,

positive or negative, permanent or temporary, severe or mild. In this report, key attention has been paid to studying possible health hazards.

A health hazard is:

- a disease observed in a human being
- other disturbance in health
- a factor or condition which may reduce the healthiness of the general public's living environment or the living environment of an individual.

The main attention in surveys pertaining to health impacts has been paid to potential health hazards caused by radioactive substances. At first, how the radiation emitted by radioactive substances may influence the health of humans is studied at a general level. Subsequently the kinds of opportunities humans have to become exposed to the radiation from radioactive substances in connection with the transport of spent nuclear fuel, at the encapsulation and final disposal stage and once the facilities have been closed down are assessed. The review refers to both normal conditions (operations according to plans) and a variety of operational transients and accidents. The long-term safety assessment (Chapter 11) refers to processes deemed probable and unlikely events deteriorating long-term safety, and the assessment of their probability and uncertainties connected with them. In each case, the impact on people is assessed. The assessing methods used are reported in connection with the assessments.

9.10.1 Health impacts caused by impurities, noise and vibration

The non-radioactive emissions from the repository's research, construction and operational stage to the air and water as well as the noise and vibration caused by the activities have been studied above. The emissions and other physical changes in the environment due to the activity are deemed minor. Below is a summary of these assessments from the viewpoint of human health and health-related conditions:

- Conventional health impacts caused by the project are minor. The increase in traffic volume due to the project will not influence the local air quality. Traffic noise will not experience any major increase due to the project.
- In practice, the most major health hazard and factor deteriorating comfort is the noise caused by the excavation, crushing and blasting. The excavation will not cause any major health impacts to the general public. The crushing station has been placed in such a location that there are no buildings inside the protective zone.
- The health risks caused by the dust from excavation and crushing can be minimised by means of technical measures.

9.10.2 Health impacts due to radiation

Health impacts of ionising radiation

When studying the health hazards from radiation, especial attention is paid to the ionising radiation generated by the radioactive decay. The health impacts and risks of ionising radiation depend on, for example, the properties and amount of radiation, and the organ or tissue subjected to radiation. *(Paile 2002; STUK 2005.)*

In addition to a physical variable, the absorbed dose, the amount of radiation from the viewpoint of health hazards, is studied by using the variable equivalent dose with the unit of measure Sievert (Sv). The equivalent dose is calculated from the absorbed dose by multiplying it by a number dependent on the radiation type. The number is 1 for beta, gamma and X-ray radiation, 5–20 for neutron radiation, depending on the energy level, and 20 for alpha radiation.

When taking into account the different impacts of the radiation types on the health of organs and tissue and their susceptibility to radiation with weighting factors, the concept of the effective radiation dose (weighted equivalent dose) is employed, described by using the same unit (Sv) as for the equivalent dose. The Sievert is a large unit of measure; often, a thousandth (mSv) or a millionth (μSv) of it is used.

When studying the radiation exposure of the entire population or a population group, the variable collective dose is used (usually the collective effective dose), and the unit used here is mansievert (manSv). The term 'collective dose' refers to the total radiation doses received by several persons.

The health impacts of radiation can be divided into two main groups: direct and coincidental impacts. Direct impacts are caused by extensive cellular destruction due to a high dose of radiation. For example, if a person receives a high dose of radiation in his or her body during a short period of time, he/she may die within weeks from so-called radiation sickness. Early impacts have been observed mainly after the nuclear bombings of Hiroshima and Nagasaki, some accidents and radiation treatment.

Coincidental impacts are impacts whose occurrence in different persons randomly varies due to individual differences of the afflicted persons, for example. The likelihood of a coincidental impact, such as cancer, increases as the radiation dose increases; the severity of the impact is not dependent on the dose, however. A direct impact, such as cataract or skin damage, will only occur when the radiation

dose exceeds a certain threshold value, and the severity of the impacts increases when the dose increases.

The impacts of low radiation doses have not been observed even in statistical studies including a large number of people because the possible impacts, which have been claimed to be positive when the doses are low, are minor and several cases of cancer, for example, also occur due to other reasons besides radiation.

Certain views state that radiation below a certain threshold value does not have any detrimental impacts. In accordance with the principle of caution, the assumption in case of radiation safety is, however, that the likelihood of cancer and other disadvantages is directly proportional to the radiation dose without any threshold value. The International Commission on Radiological Protection, ICRP, uses 0.005 percent / mSv for small doses and dose rates as the cancer risk factor. This is to assume that in a group of people of approximately 18,000, of whom all have been subjected to a dose of 1 mSv, one case of cancer would be radiation-related *(ICRP 2007; Paile 2002; UNSCEAR 2000)*.

Radiation is suspected to have hereditary impacts. Even though it has been proved in animal tests that radiation causes hereditary impacts, none have been observed in humans. The risk factor of the ICRP for severe hereditary impacts is 0.0002 percent / mSv. Thus, the ICRP uses a total risk factor of 0.0057 percent/mSv for severe health hazards *(ICRP 2007)*.

Reference data on radiation sources and radiation doses in Finland

Below is a summary of the radiation doses in Finland for comparison purposes.

The average annual radiation dose of a Finn is approximately 3.7 mSv. Finns are exposed to radiation mainly from natural sources and medical use. Approximately half of the radiation dose of a Finn, i.e. approximately 2 mSv, comes from radon in indoor air. The average annual dose caused by external radiation to one Finn from the ground and construction materials amounts to 0.5 mSv per year. People all over the world are exposed to radiation originating in space, those travelling by aeroplane more so than those on the ground. Finns are subjected to approximately 0.3 mSv of space radiation per year. Furthermore, people eat, drink and inhale natural radioactive substances. Natural radioactive substances in the human body cause an average annual radiation dose of approximately 0.4 mSv per year for Finns. It has been estimated that the radioactive fallout of Chernobyl amounts to a radiation dose of approximately 0.02 per year for Finns *(STUK 2008a and 2008b)*.

The radiation dose caused by natural background radiation varies from one area to the next. The indoor air radon content varies a great deal from one area to the next. Finns are exposed to most radiation due to radon in indoor air. There are approximately 70,000 residences where the radon content exceeds the maximum value of 400 Bq/m³ in Finland. Living in a residence with the maximum value of 400 Bq/m³ causes an annual dose of approximately 7 mSv. The radiation dose caused by external radiation from the soil and buildings varies from between 0.2 and 1 mSv/year in different locations within Finland. Aircraft personnel receive an extra radiation dose of approximately 2 mSv per year from space radiation *(STUK 2008b, 2008c, 2008d, 2008e and 2008f)*.

The radiation dose caused by the current nuclear power plants in Finland to the most exposed group in the immediate vicinity of the plants is less than a thousandth of the average annual radiation dose of Finns *(STUK 2008a, 2008b and 2008g)*.

In Finland, the radiation dose due to utilisation of radiation almost solely comes from radiation used for medical purposes. Approximately 4.2 million x-ray examinations, approximately 1.3 million regular dental examinations and almost 200,000 dental panorama imaging examinations are conducted in Finland each year. When the radiation doses caused by various x-ray examinations are divided among all Finns, the average dose is approximately 0.5 mSv per year. The average dose per examination for all forms of x-ray imaging is approximately 0.6 mSv *(STUK 2008a and 2008h)*.

Health impacts due to the repository

When spent fuel is normally handled in a repository, small amounts of radioactive substances may be released. Gaseous radon may be released into the air of the repository facility from the bedrock and the groundwater leaking into the facilities. There are more detailed descriptions of the generation of regular emissions in a publication by Posiva *(Rossi et al. 1999)*. Under normal circumstances, the radioactive materials are at all times strictly isolated from nature and people. The main attention is thus paid to the consequences of a variety of operational transients and accidents (Chapter 10) and assessment regarding the long-term safety of the repository (Chapter 11).

The maximum radioactive emissions of the repository under normal conditions are shown in Table 10-1. The normal annual radioactive emissions are insignificant.

The dose for a person of the population caused by normal one-year emissions over a period of 50 years will very likely be less than 0.01 mSv in the immediate vicinity of the plant area. This is assuming that the person permanently lives near the facility, practices agricultural

activities and mainly consumes their own produce. The most important radionuclide from the viewpoint of health impacts is cesium-137.

Most of the dose accumulates in the ground as fallout radionuclides transfer to agricultural produce, such as milk, and thus become internal radiation sources after consumption. Direct external radiation from the fallout and inhaling of airborne radioactive substances cause the second highest dose. Direct radiation from the emission cloud causes a dose clearly smaller than this. The dose will be clearly smaller at a distance of five kilometres than in the repository's immediate vicinity. The dose farther away is even smaller. As a result, dose caused by normal emissions will be insignificantly small compared to natural radiation (about 3 mSv/year). The doses caused by natural radon and its breakdown products are not significant.

As the amount of fuel to be disposed of increases, the duration of the operational stage will also increase. The increase in the amount of fuel to be disposed of or a longer period of operation does not have a significant impact on the radiation doses a person of the population receives as a result of the plant's normal operation, anticipated operational transients or postulated accidents. Instead, the total dose the population receives as a result of the operation of the repository and the probability that during the entire operating stage there will be operational transients or accidents increases roughly in direct proportion to the increase of the amount of fuel. Hence, a greater fuel volume does not increase health risks at the individual level. When health risks concerning the entire population are assessed, they increase approximately in direct proportion to the increase of fuel volume.

The increase of the natural radon gas due to the excavation of the bedrock facilities has been assessed based on measurements taken by the Radiation and Nuclear Safety Authority and boring results of Posiva *(Vesterbacka & Arvela 1998)*. Spreading was assessed by using a Gaussian spreading model of a spot source, and the doses obtained were higher than the actual doses. Even these doses remain so low in the immediate vicinity of the facility that it is practically impossible to discern them from the outside air radon content. Thus, no major environmental impacts occur.

The radiation doses to the employees of the encapsulation plant are assessed as lower than the doses to the employees of nuclear power plants. Small amounts of radioactive substances are handled at a time in the encapsulation plant when compared to those handled at nuclear power plants. The encapsulation plant will not release any detrimental amount of radiating materials even in case of a disturbance at the fuel handling stage.

The applicability of the final disposal system and the repository site and the meeting of safety requirements will be proven by means of safety assessments. The assessments will study both probable processes and unlikely events deteriorating the long-term safety, and assess the consequences to people and the environment in each case (Chapter 11).

9.11 Attitude towards final disposal of spent nuclear fuel

9.11.1 Attitude of Finns towards final disposal of spent nuclear fuel

The attitudes of Finns towards radioactive waste has been studied as part of a monitoring study called 'Finnish attitudes towards energy'. The research series has studied the attitude of Finns towards energy policy issues for the past 25 years (1983–2007). The research results of 2007 are based on answers by a total of 1,278 persons. 979 of the respondents represent the population of entire Finland and the rest (299 persons) the population of the special study sites Loviisa and Eurajoki. The total number of respondents for the entire research series is 33,114.

The data has been gathered by means of a questionnaire in writing in November and December 2007. It represents the population between the ages of 18 and 70, and the most important demographical, economic and social and regional groups. The study was done in two languages, that is, the respondents were able to answer a questionnaire in Finnish or in Swedish, depending on their native language. The study was conducted by Yhdyskuntatutkimus Oy and ÅF-Consult Oy based on an assignment given by Fortum Oyj and Teollisuuden Voima Oyj. Communication pertaining to the research results is taken care of by Finnish Energy Industries.

In the previous studies, visible suspicion towards nuclear waste has been observed. In the study carried out in 2007, a third (32 percent) of the respondents deemed disposal of spent nuclear fuel in the Finnish bedrock safe. Nearly half of the population (46 percent) had doubts about nuclear waste. Attitudes towards final disposal are more confident than in the study a year earlier but almost the same as the study two years previously, and the results are close to the average level for the past ten years. The permanency of attitudes shows that the attitude towards spent nuclear fuel is not directly connected to the support of nuclear power as an energy form. During the first ten years of surveying (1983–1993), there was slightly less trust than now, however.

The reserved attitude can be partly explained by a view shared by two-thirds of the respondents (68 percent): ra-

dioactive waste poses a continuous threat to the life of future generations. Only approximately one in seven disagreed with this statement (15 percent). In the light of this indicator, the concern with radioactive waste is almost exactly the same as two years ago and thus slightly below the regular level. Attitudes covering the survey period have not changed in a more neutral direction during the 25 years of research.

The idea that radioactive waste should be kept in their current intermediate storage facilities and wait for new solutions rather than permanently place the waste into the bedrock was approved by a little over two fifths of the respondents (45 percent) in the 2007 study. Approximately one in five disagreed with this statement (21 percent). Even though the support for a 'time for thinking' has not changed much from the last survey, the level of support has clearly declined over the entire research period. Such a total change from the beginning of the 1990's (in 1991, 62 percent of respondents were in favour of intermediate storage) is major. One should take into account the fact that an export prohibition for radioactive waste came into force in 1994, however, and the prohibition limited the possible final disposal alternatives.

The attitude towards radioactive waste in the power plant municipalities is less negative than in the entire country on average, as has been the case in previous studies. More people trust in the safety of a final disposal facility in these municipalities than elsewhere in Finland. The results obtained during the previous studies should also be kept in mind here. The previous studies have repeatedly shown that the residents of Eurajoki and Loviisa are in principle ready to receive spent nuclear fuel, i.e. place it in their own municipality. There is a slight change in the attitude of the residents of these municipalities in the survey this time, however. The attitude of the residents of Eurajoki towards radioactive waste is roughly the same as in the two previous years. The attitude of the residents of Loviisa shows signs of a gradual increase in reserve, however. The difference between the power plant municipalities and the average for the entire country has decreased rather than increased in the past few years. *(Finnish attitudes towards energy 2007.)*

9.11.2 Trust of the residents of Eurajoki in final disposal of spent nuclear fuel

In a study done in winter 2007–2008 *(Aho 2008)*, the trust of the residents of Eurajoki in safe final disposal of spent nuclear fuel was studied. The most important issues in the survey were the generation of trust and the division of trust into trust types.

The research method included both qualitative interviews and a quantitative questionnaire. The questionnaire was mailed in the autumn of 2007 to 400 randomly selected residents of the municipality of Eurajoki. 49 percent of the recipients responded. The questionnaire was used to obtain general results on the attitude of the residents on final disposal of spent nuclear fuel, on Posiva and on the personnel of Posiva. The views of eighteen residents of Eurajoki were studied by means of themed interviews in January 2008.

The survey aimed at finding answers to the following questions:

- What kind of trust do the residents of the municipality of Eurajoki have in the safety of disposal of spent nuclear fuel and the expertise of Posiva?
- What are the issues influencing the generation of such trust?
- What kind of trust do the residents have in final disposal and expertise of Posiva when this is divided into different types of trust?
- What are the issues with which the residents are concerned when it comes to final disposal and how serious do they deem these concerns?
- Which issues generate mistrust towards the safety of final disposal and the expertise of Posiva?
- What kind of information do the residents need regarding their questions about final disposal, how and where do they obtain information, and have they obtained sufficient information?
- What kind of impacts do the residents' positive vs. negative attitudes and images have on the generation of trust or mistrust?

At first, the interviews focused on the respondents' attitudes towards nuclear power. The attitude of most respondents was positive, which was also proven by the results of the questionnaire survey (59 percent). Many interviewees said that in their opinion, nuclear power is the best method of energy production at present. They did not deem alternative energy production methods as viable answers to the growing needs. None of the interviewees was willing to compromise their standard of living either.

Some of the interviewees saw great threats arising from nuclear power, however. The threats connected with nuclear power included globally increased terrorism, military conflicts and nuclear accidents of all types. In the interviewees' opinion, the nuclear power plant operations reduce their safety and the safety of all of Finland.

The attitude towards final disposal was fairly positive. Based on the results of the questionnaire survey, the attitude of approximately 40 percent of the residents of Eura-

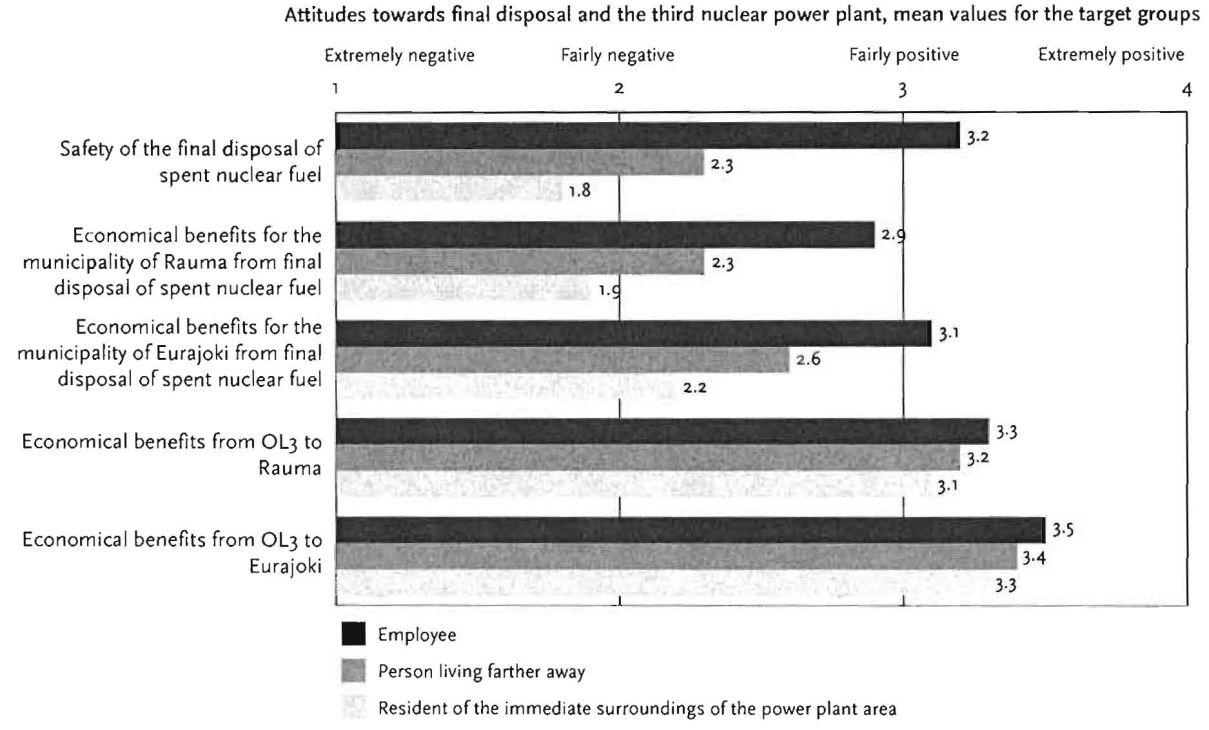


Figure 9-9 Attitudes of the different target groups towards final disposal and the third nuclear power plant. All 'unsure' replies have been left out. (Ramboll Finland Oy 2007.)

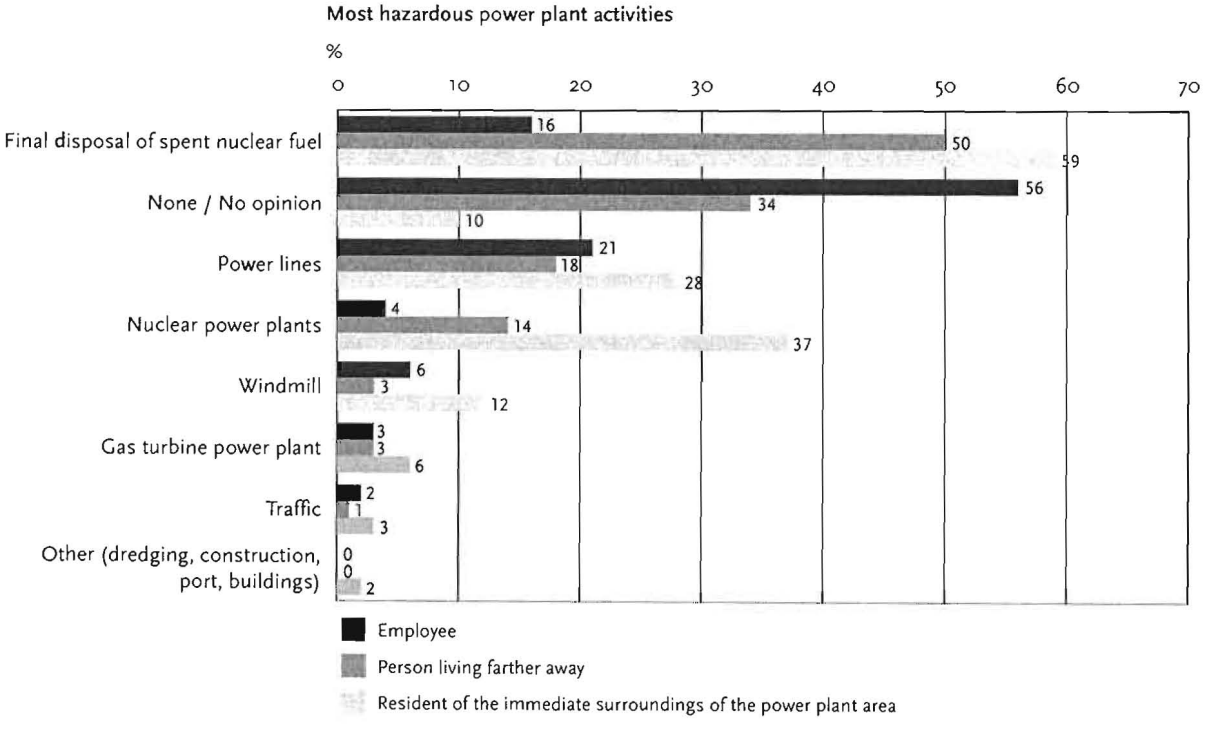


Figure 9-10 Most hazardous power plant activities (Ramboll Finland Oy 2007).

joki towards final disposal of spent nuclear fuel is positive and that of 12 percent neutral. A special risk mentioned was fuel transport, and this is why Eurajoki was deemed a suitable final disposal site. However, based on the survey results approximately 45 percent of the residents were worried about the fact that spent nuclear fuel might be placed in their hometown. On the basis of the interviews, the greatest concern related to final disposal is the import of spent nuclear fuel from abroad to be disposed of in Finland and Eurajoki.

In a study done in 1998 *(Viinikainen 1998)*, the social impacts of the final disposal of spent nuclear fuel among the residents of the municipality were studied. At that time, the survey results did not show that the residents of Eurajoki were afraid of the import of spent nuclear fuel from another country to be disposed of at Olkiluoto. The major worries at that time included, for example, nuclear fuel transport in Finland, long-term safety of final disposal and the risks inherent in the encapsulating stage. Now, the above-mentioned concern regarding the import of spent nuclear fuel from abroad to be disposed of in Olkiluoto was mentioned several times. It was deemed one of the most major threats in the final disposal of spent nuclear fuel.

The interviewees' attitude towards final disposal had remained relatively stable. None of the interviewees mentioned any radical changes in their attitude. The residents deemed the economic benefits from nuclear power and the final disposal of nuclear fuel important. Several of the interviewees deemed economical benefits one of the most important factors shaping their attitudes. Many of the interviewees deemed the services offered by the municipality of Eurajoki exceptionally good. They stated that the service level shows the wealth of the municipality, and they supposed that the wealth is attributable to Olkiluoto. *(Aho 2008.)*

Attitude towards Posiva

The interviewees considered Posiva's operations to be stable and unsurprising. Except for some single incidents, nothing unexpected has occurred in the activities of Posiva over the years in their opinion. This was mainly deemed a positive issue, and the good and stable excavation work of the underground research facility ONKALO was praised, for example. According to the interviewees, Posiva does not put safety at risk and cares for the residents of Eurajoki and every Finnish citizen by prioritising safety factors. The trust towards final disposal was mainly described and justified based on images.

The interviewees deemed Posiva and its personnel competent, honest and able to safely take care of the final disposal of spent nuclear fuel. Most of the respondents did not base their trust on the safety of final disposal on the final disposal method and its durability but their images of the expert and capable company and its personnel. Several interviewees stated that visits to Olkiluoto had generated trust or increased their trust. The trust towards final disposal is mostly automatic trust slowly generated over a long period of time.

Mistrust towards final disposal has also been generated based on images. In the interviewees' opinion, an issue especially influencing the rate of mistrust is a lack of criticism towards the information offered about final disposal of spent nuclear fuel. They said that the entire issue is too good to be true. Those with mistrust towards the issue deemed the lack of criticism and the fact that only positive issues are emphasised an attempt to smooth out or cover up something.

The interviewees' level of knowledge on final disposal of nuclear fuel was defective. The best known issues were the final disposal site, the final disposal canister and the final disposal depth.

None of the interviewees described an especial need to find out more about issues connected with the final disposal. More than half of the respondents (approximately 56 percent) felt that they had received a sufficient amount of information about issues connected with final disposal. They said that information on the issue is mailed free of charge at home so often that there is no time to wish for more information. Most of the respondents deemed the information available clear and comprehensive. Most of the interviewees said that they trust the communications of Posiva.

As many as 69 percent of the respondents are of the opinion that Posiva has good expertise in final disposal of nuclear fuel. Posiva was deemed a reliable expert organisation: 69 percent of the respondents agreed with this statement. 68 percent of the respondents relied on the expertise of the Posiva personnel. According to the survey results, 75 percent of the residents of the municipality are interested in issues connected with final disposal. *(Aho 2008.)*

9.11.3 Resident and employee survey in the Olkiluoto power plant area

A resident survey, 'Resident and employee survey in the Olkiluoto power plant area', was conducted in 2006–2007 *(Ramboll Finland Oy 2007)*. A total of 1,500 questionnaires were mailed to residents close to Olkiluoto, persons living in Eurajoki or Rauma and TVO's employees. A total of 774 replies were received, and thus the response rate was 52 percent. The survey was conducted in order to study the residents' views on the current state of their environment

and receive information on the impacts of the current Olkiluoto power plant activities in the surrounding area. In addition to studying the current status, the survey investigated the residents' attitude towards the plans of TVO, the fears and expectations connected with the plans, and the most important issues pertaining to the immediate surroundings to which attention should be paid when planning the project. The survey was also used to support the social assessment required by the partial master plans.

An issue which all the respondent groups deemed important in the partial master plan of Olkiluoto was the safety of the nuclear power plants. The residents living close to the power plant area stressed the importance of retaining the current holiday homes in the area. Furthermore, they deemed important the fishing and recreational opportunities in the Olkiluoto sea area and development of a boat harbour. The employees considered the opportunities to expand nuclear power production and traffic connections important. Those living farther away from the power plant area especially stressed the importance of limiting the underground final disposal site and adding more wind power plants in the sea and on land.

The attitudes of women were statistically clearly more negative than those of men, and the attitudes of persons over the age of 65 clearly more negative than those of younger persons. The attitude of the residents who responded to the questionnaire towards the safety of final disposal of spent nuclear fuel and its financial benefits to municipalities was negative but their attitude towards the financial benefits from the third power plant in Olkiluoto was positive (Figure 9-9). The people working at Olkiluoto had a positive attitude towards final disposal and the OL3 plant unit.

Half of the respondents deemed the disposal of spent nuclear fuel as the most hazardous activity of the power plant area (Figure 9-10). Those living farther away deemed power lines more hazardous than nuclear power plants; the attitude among those living close to the power plant area was just the opposite.

Based on the open replies given, the respondents require most information about safety and construction problems. Those living close to the power plant area are especially interested in the hazardous impacts of nuclear power plants and final disposal. The residents would also like to obtain more information on issues connected with the nuclear power plant and its impacts on holiday homes. *(Ramboll Finland Oy 2007.)*

9.11.4 Results of themed interviews

The opinions, attitudes and possible concerns of the residents of Eurajoki were studied by means of a themed interview survey *(Pöyry Environment Oy 2008)* in June 2008. A total of 21 people were interviewed in person (11 women and 10 men). Group I, 11 persons, were selected among those living in Olkiluoto or its immediate vicinity. Group II, 10 persons, represented the younger generation in Eurajoki: half of the interviewees were 18 and 19-year-old upper secondary school students and half parents under the age of thirty with small children. A Posiva representative first enquired as to whether the persons were willing to participate in the survey, and then an interviewer from Pöyry agreed on the more specific date and time. The interviews were conducted in order to study the interviewees' opinions on the impacts of the expansion of the repository on safety and the future of the municipality of Eurajoki.

The interviewees did not consider the impacts of the expansion of the repository to be significant compared to the situation that the repository will be, nonetheless, built in the municipality. The majority of the interviewees had neutral or rather positive attitudes towards the repository. The location inside the bedrock was considered to be the best of all disposal options. However, there were also safety risks, mainly in the long term. None of the interviewees had any actual fears regarding the final disposal. They did have some concerns, however. The impact of the repository on employment and tax income was considered to be positive for the municipality.

These results were fairly consistent with the survey done by Aho *(2008)*. The most major concerns voiced during the interviews were transport, possible import of nuclear waste from abroad and long-term safety; unlike in the Aho survey, many of the interviewees were concerned about the risks in case of an earthquake when considering the long-term safety.

'I'm confident that they will stay there'

A clear majority of the interviewees deemed final disposal in bedrock a fairly safe alternative and stated that there is no better alternative available. Treatment in Finland was deemed safer than export abroad, and it was also deemed a moral obligation for Finns. Some of the interviewees strongly criticised the repository. The most important reasons behind the criticism were doubts pertaining to the long-term safety and a view that it is wrong to leave nuclear waste behind for future generations to worry about. On the other hand, even the critical interviewees deemed bedrock the best among the current disposal alternatives.

Many of the interviewees stated that they do not properly understand the issue and only trust that everything is fine. Some of them supposed that a permit for disposal would not be given if there were risks. Almost all of them felt that they had received sufficient information about final disposal. Some of them said that they do not like

to think too closely about the issue; instead, they trust those who are supposed to take care of it. All interviewees deemed Posiva to be at least fairly reliable.

The attitude of most of the interviewees towards building a repository in Eurajoki of all places was neutral or positive. In their opinion, it is natural to place the repository close to a nuclear power plant and it is also rational in order to minimise transport. Some of the interviewees stated, however, that the waste from each power plant should be placed close to the plant. Some of the interviewees said that if a good and safe place has been found, it should be used. Others were of the opinion that if an accident occurs, it does not matter much whether the power plant is right next door or farther away. Some interviewees would rather have the plant somewhere else.

Concerns regarding final disposal were also voiced. Many of the interviewees were dubious about the extremely long time span of final disposal even if they do not have any concrete worries or concerns. Something unexpected could occur over such a long time. Doubts as to whether or not the canisters can remain eternally intact were voiced, for example. Some of the interviewees also noted that no-one can estimate how the world will change over the course of thousands of years. Almost half of the interviewees wondered whether or not one can be sure that there will be no powerful earthquakes in Finland in the future even though there are none at present. The concern about earthquakes is so common probably partially because news about a major earthquake in China had just been announced before the interviews. Some of the interviewees voiced their concern about the potential unanticipated impacts of climate change and the increase of the sea level. Others wondered whether or not research results negative for the project would be published if such occurred.

The concerns related to the final disposal are mainly issues one wonders about from time to time. None of the interviewees said that they experience actual fear due to the repository project or that concerns regarding the project show in their everyday life or cause stress. Only one of the interviewees believed that final disposal could cause danger to personal safety.

The interviewees felt that their lives are safe as a whole. The feeling of security arises from one's health and work situation, and decreased for some by the nuclear power plants among other issues. Especially the younger interviewees felt that they have gotten used to the nuclear power plants. Even some of the residents living close to the power plant area said that they have gotten used to nuclear power; however, some of these residents reminisced about Olkiluoto before the power plants and said that the area is no longer the same.

The most concrete concerns regarding final disposal were connected with nuclear waste transport; many of the interviewees deemed this the most critical stage of the process. The interviewees had their concerns about both road and sea transport. Half of the interviewees voiced a concern regarding import of nuclear waste to Eurajoki from abroad. Except for one person, all those who mentioned this issue were strongly opposed to import. The interviewees were aware of the fact that the legislation currently prohibits import of nuclear waste; they stated that laws can be changed, however. As grounds for this, the interviewees mentioned foreign ownership of Finnish energy companies and possible greed of the owners of the repository. The interviewees deemed the idea of Finland becoming Europe's 'nuclear waste dumping site' extremely negative and stated that each country should take care of their waste in their country.

However, the expansion of the repository compared to the fact that a smaller plant will be built in any case was a neutral or positive factor regarding safety according to nearly all interviewees. Most of those deeming it neutral stated that a large amount of nuclear waste will come to the facility in any case. If something happens, it does not matter if there is more. There were several arguments in favour of the expansion. If a good place has been found, it should be used, and the activity should be centralised in one place. Expansion during operation was deemed dangerous. The general opinion voiced was 'let's make a facility that is sufficiently large, once we start building'. The expansion mainly aroused concern because many believed it to include plans to import nuclear waste from abroad.

The future of the municipality seems quite bright'

All interviewees said that they feel at home in Eurajoki. Specifying why was difficult, but some of the issues mentioned were the fact that the municipality is small and quiet, the fact that the nature and the sea are close by and the fact that the municipal services are good for a municipality of this size. Some of the interviewees deemed the small size an issue lessening comfort, however. A couple of persons deemed the nuclear power plants an issue making the municipality a less desirable place to live.

Most of the interviewees plan to stay in Eurajoki also in the future. The future plans of most are connected with their current residence rather than Eurajoki as a municipality. Many of the interviewees were quite adamant about planning to stay in their current home for as long as possible.

Six of the interviewees plan to move away from Eurajoki. Most of them were the youngest of the interviewees who plan to study elsewhere. They had not planned their future

after graduation much. Two of them hoped to be able to eventually return to Eurajoki and two deemed this unlikely. Eurajoki was deemed a good place to live as regarding a future family and children. All of the interviewees who are parents of small children deemed Eurajoki a good place to live and plan to stay there. Three interviewees stated that moving away due to work, for example, is also an option. Their plans to move away were connected with their life situation; only one person is planning to move away partially because of the repository.

Most of the interviewees see the future of the municipality of Eurajoki in a positive light. The municipality was estimated as financially sound, and the interviewees are confident that there will be employment and life in Eurajoki also in the future. TVO and the income from TVO were considered important; a couple of the interviewees also mentioned Posiva in this connection. Several of the interviewees pondered the possible consolidation of municipalities; they did not hope for it to become reality. Other questions raised included the ability of the decision-makers to do what is right for the municipality and their responsibility for retaining the nature and the seashores.

When discussing the impacts of the repository on the future of Eurajoki and the residents, most interviewees described positive impacts. The factors deemed most important included the positive impacts on employment and the economy; only a few of the interviewees expect there to be major impacts, however. Some of the interviewees thought that the residents of the municipality will benefit from the new jobs, whereas others assumed that most of the workforce will come from outside the municipality. Some of the interviewees thought that the repository might slightly improve their opportunities to obtain employment in their hometown. Some of the interviewees thought that a more extensive final disposal unit would bring more income and jobs while others did not think an expansion would have such an impact.

The interviewees had two kinds of opinions regarding the impacts of the repository on population growth and the willingness to move: on one hand, the jobs may bring more people to the municipality and on the other, as some of the interviewees thought, some families will not want to move to a municipality housing a nuclear power plant. Some even thought that some people already living in Eurajoki might move out because of the plant. The interviewees did not, however, think that the size of the repository would have any impact on either alternative. Some of the interviewees also voiced their concerns regarding potential safety risks related to final disposal when the future of the municipality was discussed.

Differences between the groups of respondents

Differences between the views of women and men and also between the different groups of respondents were fairly minor. Half of the women were at least somewhat negative towards the project, while the attitude of most of the men was neutral. The women voiced somewhat more concerns than the men; on the other hand, more women than men stated that they believe the project will be properly handled. The men deemed the impacts to the municipality to be slightly more positive than women.

Almost all of the interviewees who had a negative attitude towards the project were those living close to the power plant area. They also had more concerns than the younger interviewees. The residents of the nearby areas were more often concerned about, for example, waste imported from abroad, transport and earthquakes than the young. Those living close to the power plant area were also clearly more attached to their current home than the young. Many of the residents of the nearby areas were

concerned about the expansion of the power plant area and possible compulsory purchases in Olkiluoto. Many of them also voiced concrete local concerns, such as the concern for the water of their bore wells, traffic safety on the Olkiluodontie road and the actual durability of the bedrock. *(Pöyry Environment Oy 2008.)*

9.12 Impact on social structure, regional economy and the image of the municipality of Eurajoki

The purpose with a survey done in 2007, 'Regional economic, socioeconomic and municipal economic impacts of a disposal facility for spent nuclear fuel' *(Laakso et al. 2007)*, was to draft an up-to-date assessment regarding the impacts of the construction of the repository on employment, population development, construction, community structure and municipal economy in the municipality of Eurajoki and the broader affected area. In the survey, the broader affected area has been defined as three regional zones: the municipality of Eurajoki, the region (Eurajoki, Kiukainen, Lappi, Rauma, Kodisjoki, Nakkila and Luvia) and Satakunta. The time span of the survey extends to the early 2020's, at which time the actual operation of the repository will have been started.

The study is based on information on implementation and costs of the facility based on Posiva's latest plans, information on Posiva's personnel and information on other issues pertinent for the survey. The civil servants of the municipality of Eurajoki, Rauma and Pori have also been interviewed when drafting the survey. They have offered their views on the current impacts and the future impacts of the repository on employment and population structure of the area and the financial status of the municipalities, land use and services.

The decision on where to place the repository, the fact that Posiva transferred to Eurajoki, the major renovation of the Vuojoki Manor, the reformation of the activities, the research stage of the repository and the fact that construction of ONKALO has started have had a positive impact on the socioeconomic, regional economy and municipal economy development in Eurajoki and the entire region during the first years of the new millennium. The facility project in itself does not explain the changes occurred, however: the impacts of the Olkiluoto 3 nuclear power plant are more major, for example. Furthermore, there are several other factors which have positively influenced the development in Eurajoki and the Satakunta region as a whole, such as the general business trends during the first years of the millennium, EU's structural fund programmes and the Regional Programme *(Laakso et al. 2007)*.

9.12.1 Impacts on employment

The total employment impacts of the repository design, research and construction stages in 2001-2020 will be approximately 6,800 man-years, of which direct impacts account for 4,200 man-years and indirect impacts 2,600 man-years. The direct impacts of the entire project on employment at an annual level are a maximum of 325 man-years. During the operational stage, the direct employment impact has been estimated at approximately 130 man-years. The indirect employment impacts of the project have been estimated at approximately two thirds of the direct impacts. At most, the project's annual impact on total employment rate is approximately 550 man-years.

At its most, approximately 45 man-years/year of the total employment impacts (direct and indirect impacts) will be directed to the municipality of Eurajoki. During the operational stage, the Eurajoki share has been estimated at approximately 30 man-years / year. For the entire region, the employment effect of the repository will be significant, i.e. about 220 man-years/year at maximum. Most of the employees of Posiva and the Vuojoki Manor will probably live close by. Furthermore, major employment impacts due to construction and indirect impacts are to be expected in the region. During the operational stage of the facility, the annual employment impact in the region is estimated to be, approximately, 90 man-years. The project is expected to provide 300 man-years of employment per annum for the whole of Satakunta as a maximum, and 125 man-years per annum during the operating phase.

A major part of the project's indirect impacts will be directed to outside the province, especially during the construction stage. Even though the national employment impacts are fairly large when compared to the local ones during the peak periods, their significance for the employment of the entire country will remain marginal. This is why the impacts on the municipality of Eurajoki and the region as a whole are especially interesting: these impacts will have a major positive influence on the employment rate of the municipality and the region. The project is estimated to increase the annual employment rate in the municipality of Eurajoki almost by 2 percent, and in the region almost 1 percent. *(Laakso et al. 2007.)*

9.12.2 Impacts on the population

The repository will bring more jobs into the location municipality and the surrounding affected area. This will increase the population in the region and change the population structure. It has been assessed that the cumulative population increase in Eurajoki due to the facility project by the year 2020 will be 80 residents; 1.4 percent

of the municipality's current population. The population increase due to the facility in the entire region by the year 2020 will be approximately 415 persons, i.e. 0.7 percent of the current population of the region. The population impacts due to the project will make the age structure of the municipality of Eurajoki younger but these impacts will be so minor that the positive impacts will not reverse the ageing trend of the municipality.

The impacts of the facility on the population will be further reflected in the demand for housing and thus also construction and the social structure. It has been estimated that the project will cause increase in the demand for housing by approximately 40 dwellings in Eurajoki by the year 2020, i.e. an average of two dwellings per year. *(Laakso et al. 2007.)*

9.12.3 Impacts on municipal economy

The construction and operation of the repository will influence the municipal economy. The clearest major impacts here will be seen in real estate taxation and its impacts on inter-municipal tax income balancing. It has been estimated that a maximum of EUR 3.5 million in real estate tax will be paid for the repository facilities. The increased real estate tax income will have an impact on the tax income balancing of the municipality of Eurajoki, but only partially. Even though the highest real estate tax income levels will change the balance negative for the municipality, the total impacts will be minor because the net real estate tax paid by Posiva to the municipality after balancing will be approximately EUR 3 million, i.e. a municipal taxation income of more than 4 percent.

The real estate tax paid by the repository will slowly increase the taxation base of the municipality as the real estate tax rate is raised up until the year 2020. This will offer the municipality a higher annual margin and exceptional latitude for the municipality; the municipality can use the profits for several purposes. The municipality can invest in basic infrastructure or new services, or improve the already existing services, which would improve the wellbeing of the residents and also make the municipality a more attractive place to live for persons working in the municipality but living elsewhere and potential new residents living in other municipalities. Another alternative is to use the increased real estate tax income to reduce the municipal tax rate. Either policy would lead to increased attraction of the municipality for potential new residents when compared to the other municipalities in the region.

As stated above, the municipal economic impact of the repository will mainly be realised through real estate tax. The real estate tax is paid in its entirety to the municipality where the plant is located, i.e., to Eurajoki. The majority of the plant's impact on employment and population will be channelled to a wider area outside Eurajoki, and, similarly, the resulting increase of municipal tax income. It has been assessed that Posiva's employees living in Rauma account for approximately 0.5 percent of the city's tax income, and the share will further increase as the number of employees increases. In proportion to the size of the region, these impacts remain rather minor, and they are distributed over a long time span. On the whole, the impact of the repository on the municipal economy in Rauma and other municipalities in the region outside Eurajoki is likely to remain small. *(Laakso et al. 2007.)*

9.12.4 Posiva's role in Eurajoki and the adjacent area

According to a survey on the regional economic impacts *(Laakso et al. 2007)*, the municipalities of the region are pleased with the project's positive impacts on the regional economy. It is considered to be particularly positive that the construction and operations of the plant constitute long-term activities where the impacts can be relatively well foreseen and extend over a long period of time. Co-operation between Posiva and the municipalities has been deemed mostly successful. The municipalities value Posiva's activities and investments in the restoration of the Vuojoki Manor and its reformation. *(Laakso et al. 2007.)*

The potential negative outsourcing impacts associated with the repository have not been realised. On the basis of the information available, the plant project has not disturbed the residents or companies, and the visibility and image of the municipality of Eurajoki have become stronger. *(Laakso et al. 2007.)*

9.12.5 Impacts of the repository on the image of the municipality of Eurajoki

The impacts of the project on the image of the municipality of Eurajoki have been assessed by using working report 'Municipal Image Survey 2006' by Posiva as an aid *(Corporate Image Oy 2007)*. The survey studied the image of Eurajoki amongst residents, Finnish consumers and representatives of companies. The municipal image of Eurajoki was compared to other potential final disposal sites considered in 1998 (Äänekoski, Loviisa and Kuhmo). The survey was a follow-up study for a similar survey done in 1998. Naantali was also included as a reference location, since Naantali has obtained fairly good grades in municipal image surveys, and the type and location of Naantali is close to the potential final disposal municipalities. The survey was conducted by interviewing 500 consumers, 200 company representatives and 200 Eurajoki residents over the phone from October to December 2006.

Of the respondent groups, the representatives of companies were clearly more positive towards the final disposal of spent nuclear fuel than the other groups. One should note that the attitude of the residents of Eurajoki towards final disposal was clearly more positive than the attitude of consumers in Finland in general. On the other hand, consumers in southern and western Finland were more positive towards final disposal than eight years ago.

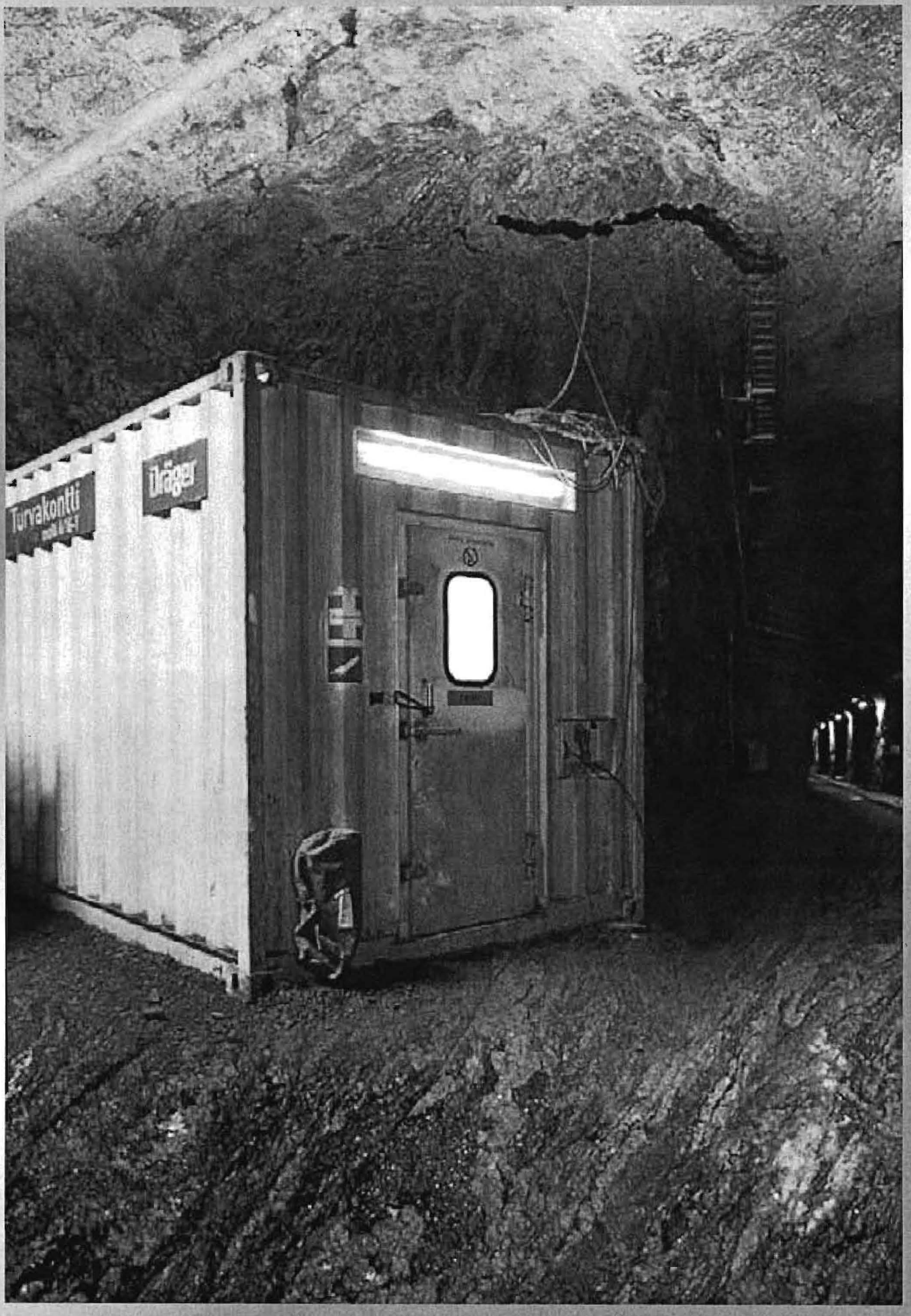
All the respondent groups (residents, consumers, companies) deemed the impacts of final disposal on the municipal image of Eurajoki more positive than before the decision on final disposal was made in 1998. The assessments of the residents of Eurajoki on the impacts of final disposal on their home were clearly more positive than the assessments of the other consumers. The impacts of the final disposal on the attraction of Eurajoki as a place to live, as a tourist attraction and as a location for companies were all sectors in which the associated positive assessments clearly dominated over the negative ones.

All interviewed residents of Eurajoki were aware of the Olkiluoto nuclear power plant, and except for a few respondents they were also aware of the fact that the municipality had been selected as the location of a nuclear fuel disposal facility.

The attributes associated by the residents to Eurajoki included, above all, a good place to live, a developing municipality and an area dominated by forestry and agriculture. When the results are compared with the ones obtained in 1998, one can see that the residents of Eurajoki deemed their municipality clearly more attractive, more quickly developing and a more interesting tourist attraction. 66 percent of the residents of Eurajoki associated the attribute 'a safe place to live' to their municipality; this is a clearly higher percentage than they gave to the other municipalities included in the survey.

Half of the consumers responding knew that Eurajoki had been selected as the final disposal site. Most of the consumers still believed that final disposal would make Eurajoki a less attractive tourist attraction and place to live, although the assessments were more positive than before. A third of the consumers believed that final disposal would have a positive impact on the municipality's attraction as a place to run a business.

Two out of three of the company representatives knew that Eurajoki was a final disposal site. The company representatives were fairly critical when assessing the impact of the final disposal on the attractiveness of Eurajoki as a place to live and as a tourist attraction, although the assessments of this group were also more positive than in the previous survey. *(Corporate Image Oy 2007.)*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10 Safety and the effects of accidents and operational transients

10.1 Safety criteria

The design concepts of the final disposal facility are mainly based on proven technology already in use. There is long experience with the design, construction and operation of both nuclear plants and rock facilities in Finland and in other parts of the world. There is also nearly 30 years of experience with handling spent nuclear fuel in Finnish nuclear power plants.

Components are designed based on technology developed for the purpose. It can be assumed that technical development will offer new alternatives for technical details in the future. Since the facility has a long planning stage, there is time for testing new technical solutions as well as solutions currently under development, and they can be carefully proven functional before implementation. Posiva and the corresponding Swedish organisation, the SKB, have jointly performed tests aiming at the validation of the manufacturing, sealing and inspection technology for the final disposal canister. Full-scale development and testing of the entire final disposal technology is in progress in the Swedish Äspö laboratory, built in a rock cavern, and also partly in Finland.

The methods used for the technical design and safety assessment are similar to the methods applied in the design work and safety analyses of modern nuclear power plants. The validity of the experimentation and calculations used will be confirmed with independent comparisons.

Finnish nuclear power plants, which are a central factor behind Posiva operations, have an advanced safety culture. The concept refers to the organisation's prevailing attitudes, the way of thinking, the operational methods and the working atmosphere that emphasises the priority given to the safe operation of the plant and to issues important to safety at all operational stages. It also refers to safety consciousness, high professional skills, careful working methods and vigilance and initiative to detect and remove factors compromising safety. A similar safety culture is also observed in Posiva operations. The principle of open publicity applied to nuclear waste research in Finland promotes the maintenance and development of the safety culture.

Development and maintenance of the Posiva organisation and operational system ensure that the design, construction and operation of the final disposal facility remain compliant to requirements. Constant monitoring and evaluation of operating experience and the improvements based on these are an essential part of developing operations. As the operational life of the final disposal facility will be of a considerable length (approximately 100 years) due to the extension of the lifecycle of existing nuclear power plants and the commissioning of new plant units, renovation and modernisation will also be required during the facility's operational life.

10.2 Radiation safety

Section 5 of the Government Decision 478/1999 requires that 'in any assessment period, disposal shall not cause health or environmental effects that would exceed the maximum level considered acceptable during the implementation of disposal'. The design of the final disposal facility is naturally based on the principle of keeping the radiation exposure to the population and the environment as low as reasonably achievable.

Although protection of living nature and people is the primary safety objective, the Government Decision requires that the final disposal solution will also effectively prevent the release of radioactive substances into the bedrock for the minimum of thousands of years. At all times, safety must be ensured by multiple barriers so that significant environmental and health effects can be avoided even if individual barriers would not for some reason function as expected.

Safety requirements have been defined using the limits concerning the highest allowed annual individual dose and the average activity release. According to Section 4 of the Government Decision 478/1999, the disposal facility and its operation shall be designed so that:

- when the plant is running faultlessly, the amount of radioactive emissions to the environment remains negligible

- the effective annual dose to people who are not part of the staff and who would be the most exposed due to anticipated operational transient remains under 1 millisieverts (mSv); and
- the effective annual dose to people who are not part of the staff and who would be the most exposed due to a postulated accident remains under 1 millisieverts (mSv).

The releases of radioactive substances resulting from the undisturbed operation of the final disposal unit can be considered insignificantly low when the average annual effective dose to the most exposed people is no higher than 0.01 mSv. Effective annual dose means an effective dose that arises from external radiation and intake of radioactive substances during a period of one year. An effective dose is the weighted sum of the equivalent doses of tissues and organs subjected to radiation, where the equivalent dose denotes the product of the mean energy absorbed per unit mass in the tissue or organ and of the radiation weighting factor.

An operational transient stands for an incident that has an impact on safety and is estimated to take place less frequently than once a year on average, but that has a notable possibility of taking place at least once during the plant's operating period. As a result of an operational transient, spent nuclear fuel may be damaged, dose rates and radioactive substance concentrations may increase within the final disposal facility, and radioactive substances may be released into the environment of the facility.

A postulated accident refers to an incident that is used as a design criterion for the repository's safety functions and has only a minor probability of taking place during the plant's operating period. As a result of a postulated accident, spent nuclear fuel may be damaged and large amounts of radioactive substances may be released to the plant premises or to the environment.

Estimated with ICRP's nominal risk coefficient, the probability of health effects to an individual from the dose of 1 mSv is 0.0057 percent during the first year and smaller during subsequent years.

Taking into account the small probability of accidents, the probability of the health impacts caused by accidents is smaller than the radiation dose, accumulated as a consequence of the accident, represents. Neither is the health risk to the entire population significant when compared with, for example, the risk caused by natural radiation, as the dose caused by the accident to individuals would be the smaller the further from the facility the individual lives.

The same annual doses are applied to the operating personnel as to the operating personnel of a nuclear power plant. The dose limits are stipulated by the Radiation Decree.

10.3 Operational transients

Operational transients can be divided into two categories according to the immediate effects: transients that may cause immediate radiation doses and which therefore

Table 10-1 Normal annual maximum releases of radioactive substances into the atmosphere from the final disposal facility during the operation of the facility, and the maximum releases of radioactive substances into the atmosphere from the final disposal facility during operational transients and accidents occurring during the operation of the facility. The amounts are presented as percentage of the maximum quantities contained in the transport cask (CASTOR-TVO transport cask).

Radionuclide	Release (% of maximum cask content)		
	Normal operation	Transient	Accident
Tritium (Hydrogen 3)	$2.3 \cdot 10^{-1}$	$3.8 \cdot 10^{-2}$	$4.4 \cdot 10^{-1}$
Krypton-85	$5.2 \cdot 10^{-2}$	$8.7 \cdot 10^{-3}$	$8.7 \cdot 10^{0}$
Strontium-90	$4.0 \cdot 10^{-9}$	$6.6 \cdot 10^{-10}$	$7.8 \cdot 10^{-7}$
Ruthenium-106	$3.8 \cdot 10^{-9}$	$6.4 \cdot 10^{-10}$	$8.5 \cdot 10^{-7}$
Iodine-129	$2.2 \cdot 10^{-2}$	$3.7 \cdot 10^{-3}$	$3.5 \cdot 10^{0}$
Caesium-134	$2.2 \cdot 10^{-8}$	$3.6 \cdot 10^{-9}$	$2.9 \cdot 10^{-6}$
Caesium-137	$2.1 \cdot 10^{-8}$	$3.4 \cdot 10^{-9}$	$3.1 \cdot 10^{-6}$
Plutonium-238	$4.7 \cdot 10^{-9}$	$7.8 \cdot 10^{-10}$	$6.1 \cdot 10^{-7}$
Plutonium-239	$3.8 \cdot 10^{-9}$	$6.3 \cdot 10^{-10}$	$8.6 \cdot 10^{-7}$
Plutonium-241	$3.7 \cdot 10^{-9}$	$6.1 \cdot 10^{-10}$	$8.8 \cdot 10^{7}$
Americium-241	$3.6 \cdot 10^{-9}$	$6.1 \cdot 10^{-10}$	$8.7 \cdot 10^{-7}$
Curium-244	$5.1 \cdot 10^{-9}$	$8.6 \cdot 10^{-10}$	$4.9 \cdot 10^{-7}$

require immediate measures and predefined instructions, and other transients, which will not cause immediate radiation doses, and for which the reparative measures can be considered and decided upon with no hurry. However, reparations may also cause radiation exposure in the latter case at a later stage.

Operational transients causing immediate exposure are caused either by incorrect actions or various device failures. Actions are incorrect when predefined instructions or directions are not complied with when fuel is received, encapsulated or finally disposed of. Device failures usually stop the process. The system may begin to leak gas, liquid or both. Failures in the spent fuel processing devices usually interrupt the processing of fuel. A device failure may also damage the fuel.

Other operational transients include disturbances in the encapsulation and disposal process, encapsulation of fuel damaged during processing, loss of power for a limited time, fires, floods and water leakages. These may be caused by various device failures, incorrect actions or events outside the system.

Descriptions of design basis transients are described in a 1999 report *(Kukkola 1999)*. The corresponding description of normal operation, operational transients and accident situations has been updated in 2003 *(Kukkola 2003)*, and is currently being updated for the new operational safety analysis; however, no major changes are expected.

10.4 Impacts of operational transients

10.4.1 Emissions in operational transients

Of the operational transients of the final disposal facility, the following were considered the most significant:

- A fuel rod has lost its tightness during transportation, and the radioactive substances released into the fuel cask during the emptying of the cask cannot be properly recovered.
- As a result of a faulty operation or device failure, fuel assemblies are damaged in the encapsulation facility, and fuel rods are damaged.
- In connection with possible drying of fuel assemblies, a device failure causes the temperature to rise; as a result, a fuel rod loses its leak tightness, or it has already lost it previously.

As to the releases of radioactive substances, the relevant situation in operational transients is one where several fuel rods lose their leak tightness at the same time, or where the higher temperature increases the release from an originally leaking rod.

In operational transients, radioactive substances may be released into the encapsulation facility or to the equipment located in these facilities. Exhaust air filtration is assumed to function normally. Table 10-1 presents the highest estimated radioactive releases into the atmosphere caused by a single incident, when 100 percent of the gaseous substances and 0.3 percent of other substances released into the final depository facility are assumed to enter the environment.

10.4.2 Radiation doses and the impact areas in operational transients

Natural radon and its decay products mainly cause radiation doses when taken in through respiration. Vesterbacka and Arvela *(1998)* have estimated the radiation doses caused by these. Radiation doses resulting from normal operation and operational transients have been estimated using the ARANO computer software *(Rossi et al. 1999)*.

Probabilities of operational transients are estimated in connection with detailed design. Operations are designed to ensure low probability of transients.

The dose caused by a single operational transient, accumulated over the period of 50 years, will very likely be less than 0.001 mSv for a person of the local population. Thus the doses caused by operational transients will be clearly smaller than the required limit value of 0.1 mSv a year. The doses in neighbouring countries would be smaller by several orders of magnitude; the distance from Olkiluoto to mainland Sweden is more than 200 kilometres.

Radiation doses and health risks also depend on factors related to the environment of the final disposal facility, such as the number and location of the population, the population's manner of living and the climate.

Very low concentrations of radioactive substances from releases could be measured in the immediate environment of the facility and, as a result of operational transients, further away. Detection of concentrations would be made difficult by natural radioactive substances and artificial radioactive substances originating from other sources. No changes in the environmental radiation would be detected by measuring the total dose rate.

10.5 Accident conditions

The structure of the final disposal facility will be such that any accidents concerning the fuel in its various stages of processing and leading to significant damaging of the fuel will not cause immediate health risks to the personnel or the residents in the surrounding area. Fuel assemblies are only handled in such parts of the facility that have walls designed to dampen the direct radiation from the

fuel to a harmless level. In accident conditions, ventilation of the controlled area of the facility can be stopped or transferred to pass through filtering to retrieve nearly all radioactive substances released from the damaged fuel. Any solid and liquid radioactive substances released to the fuel handling area in accident conditions are collected with cleaning equipment to be further processed. However, minor quantities of radioactive gases, mainly krypton (noble gas) possibly released from damaged fuel in accident conditions, are difficult to retrieve.

Accidents may result from serious device failures or exceptional external events. The equipment is designed and operations planned to prevent accidents caused by processing errors. In some situations, a faulty plan may cause an accident.

The encapsulation plant located on the ground surface will be structurally measured against any assumed external incidents, such as the collision of a small aircraft with the building, earthquakes and floods.

A criticality accident, that is, an uncontrolled neutron-induced chain reaction of fissions in the fuel, could occur if fuel assemblies formed a large enough accumulation of optimal density, and the empty space between the assemblies was filled with water. Such an accident will be prevented by designing the fuel handling and storage facilities and handling equipment so that the situation becomes practically impossible.

Adequate security measures will be taken to prepare for any malicious damage. The fuel will be well protected in the encapsulation facility and in the repository.

Serious (hypothetical) accidents are even rarer than postulated accidents. Serious accidents and their impacts are limited by the following generally prevailing characteristics of the final disposal facility, among others:

- No large quantities of spent fuel are stored in a single place within the final disposal facility.
- The probability of a criticality accident is non-existent.
- Due to small fire loads, the probability of serious fire in the area containing spent nuclear fuel is non-existent.
- Even if a large quantity of fuel was damaged at once in the final disposal facility, there is no mechanism to immediately spread the radioactive substances contained in the fuel to the environment in any great quantities. Gaseous radioactive substances within the fuel rods would be likely to be released into the atmosphere, but their quantity is small in fuel cooled for the minimum of 20 years, and they cannot cause extensive danger. In the current system, fuel is stored for an average of 40 years before final disposal.

In connection with the application for an operating licence, guidelines are created for the personnel to minimise the consequences of any accident. In addition, plans for safety and emergency preparedness will be prepared for emergencies; the necessary measurement, communications and alarm systems will also be allocated for this purpose.

10.6 Impacts of accident conditions

When the final disposal facility meets the safety requirements, radioactive substances cause no significant health risks to the residents of the area even during postulated accidents either during operation or at the closure of the facility. The annual dose limit concerning postulated accidents, 1 mSv, is only a third of the average annual dose of about 3 mSv caused to the Finnish population by natural radiation, including radon in indoor air.

In the case of nuclear power plants, postulated accidents refer to situations used as a design basis for safety systems. The same definition is also assumed here for the final disposal facility. Accidents more severe than the design basis accidents can be imagined, but their probability is estimated smaller than that of design basis accidents. Thus the total probability of health effects caused to an individual by such accidents can be estimated as so low as to be insignificant, even when the annual dose to the most exposed people were higher than 1 mSv/year in the case of the accident.

10.6.1 Releases in accident conditions

At least the following postulated accidents will be considered in the design of the final disposal facility:

- A fuel cask is dropped; all fuel rods are damaged and lose their tightness; the cask remains leak-tight; fuel is removed from the cask in a controlled way.
- A canister is dropped; all fuel rods are damaged and lose their tightness; the canister remains leak-tight; fuel is removed from the canister in a controlled way.
- The lid of the fuel cask is dropped into an open cask; 1/10 fuel rods are damaged and lose their tightness.
- A fuel rod is dropped on top of other assemblies; all rods of two assemblies are damaged and lose their tightness.
- A canister elevator drops into the silo filled with LECA gravel, functioning as a shock absorber at the bottom of the shaft; the canister and all rods in the fuel assembly are damaged and lose their tightness.

In these accident conditions, particles of various sizes may be released from the fuel rods in addition to gaseous and other emissions easily released into the atmosphere. With a speed depending on their size, the particles settle on surfaces of the room; smaller particles remain in the air for a long period. If a canister is broken in a pool filled with water, mainly gaseous substances are released into the atmosphere. In these situations, no significant heating of the fuel will occur. In the postulated accidents, radioactive substances are first released in the encapsulation facility or the elevator shaft. It is assumed that the filtering of the exhaust air from these areas is working normally.

Table 10-1 presents the highest estimated radioactive releases into the atmosphere caused by a postulated accident, when 100 percent of the gaseous substances and 0.3 percent of other substances released into the final disposal facility are assumed to enter the environment.

It is assumed that in accident conditions during the operation or closing of the final disposal facility, radioactive substances will primarily access the environment through the atmosphere and only to a minor extent through water discharges. For this reason, only emissions that leak into the atmosphere are examined more closely in this connection.

10.6.2 Radiation doses and the impact areas in accident conditions

Radiation doses caused by accident conditions were estimated similarly to the radiation doses of operational transients *(Rossi et al. 1999)*. Probabilities of accident conditions are estimated in connection with detailed design. Operations will be so planned that the probability of accidents during operation and closing of the facility is very small.

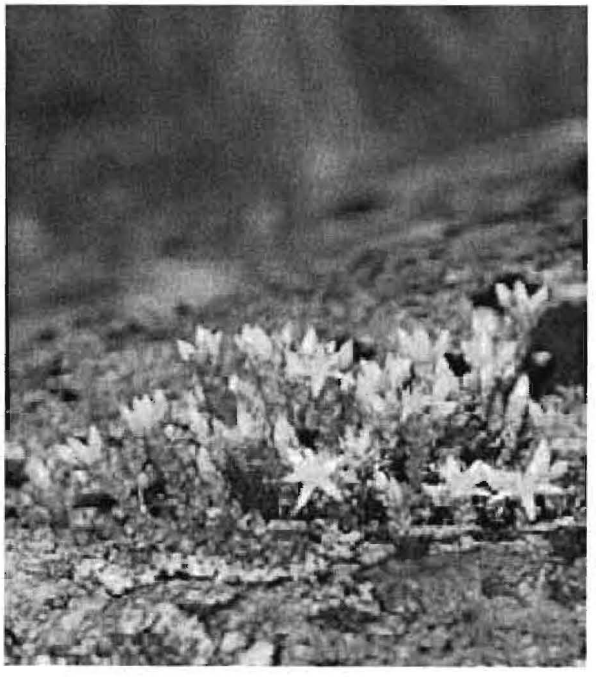
With a high probability, the dose caused by a postulated accident for a person of the general public will be less than 0.5 mSv during the first year and less than 0.8 mSv in 50 years. Doses caused by postulated accidents thus remain smaller than the required annual limit (1 mSv/year). The largest dose will be generated immediately next to the plant area, provided that there are permanent residents, agricultural operations and self-produced products which are mainly used for nutrition. The majority of the dose will be generated by radionuclides that have settled on the ground through food chains similarly as in malfunctions.

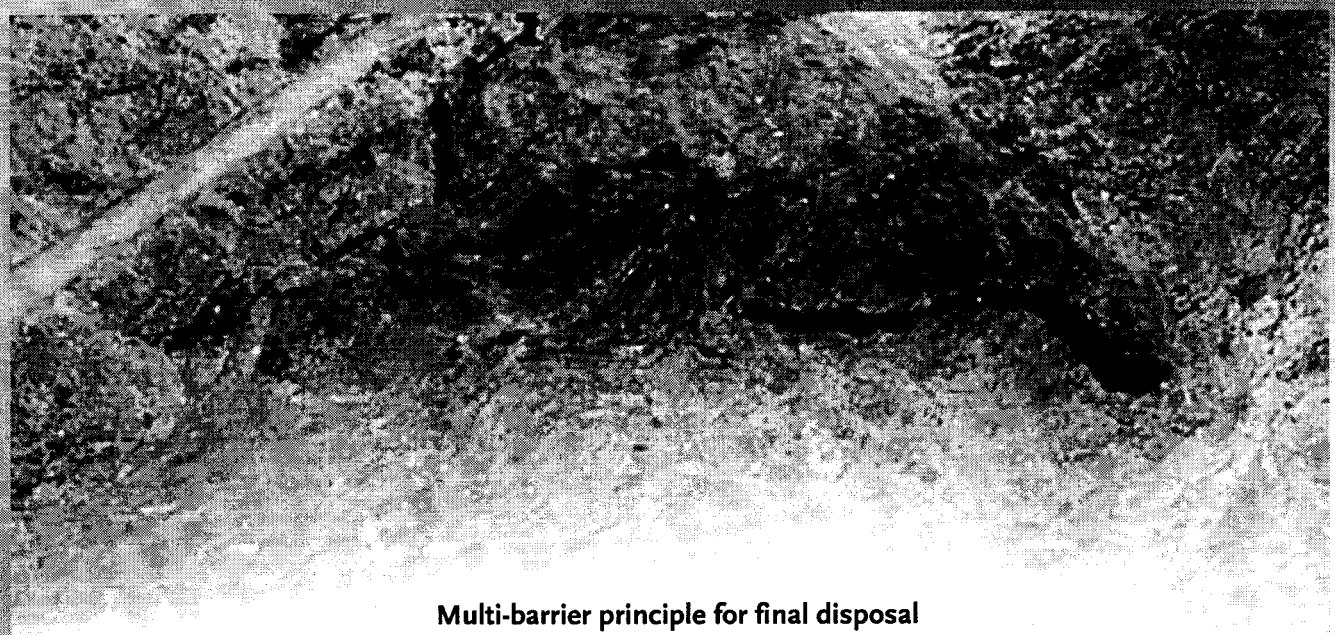
The dose will be clearly smaller at a distance of five kilometres from the plant, and even smaller farther away. The doses in neighbouring countries would be smaller by several orders of magnitude; the distance from Olkiluoto to mainland Sweden is more than 200 kilometres.

Radioactive substances released in accidents and their radiation could be observed in the environment using measurements. The size and shape of the affected zone would depend on the extent of emissions and the prevailing weather conditions.

Detection of concentrations would be made difficult by natural radioactive substances and artificial radioactive substances originating from other sources. The affected zone of a postulated accident would, in the spreading direction, extend to a distance of about five kilometres, if the annual dose of 0.1 mSv is considered to be the limit value (an average of 3 mSv/year for natural radiation).

As the amount of fuel to be disposed of increases, the duration of the operational stage will also increase. The increase in the amount of fuel to be disposed of or a longer period of operation does not have a significant impact on radiation doses a person of the population receives as a result of the plant's normal operation, anticipated operational transients or accidents. Instead, the total dose the population receives as a result of the operation of the repository and the probability that during the entire operational stage there will be operational transients or accidents increases roughly in direct proportion to the increase of the amount of fuel. Hence, a greater fuel volume does not increase health risks at the individual level. When health risks concerning the entire population are assessed, they increase approximately in direct proportion to the increase of fuel volume.

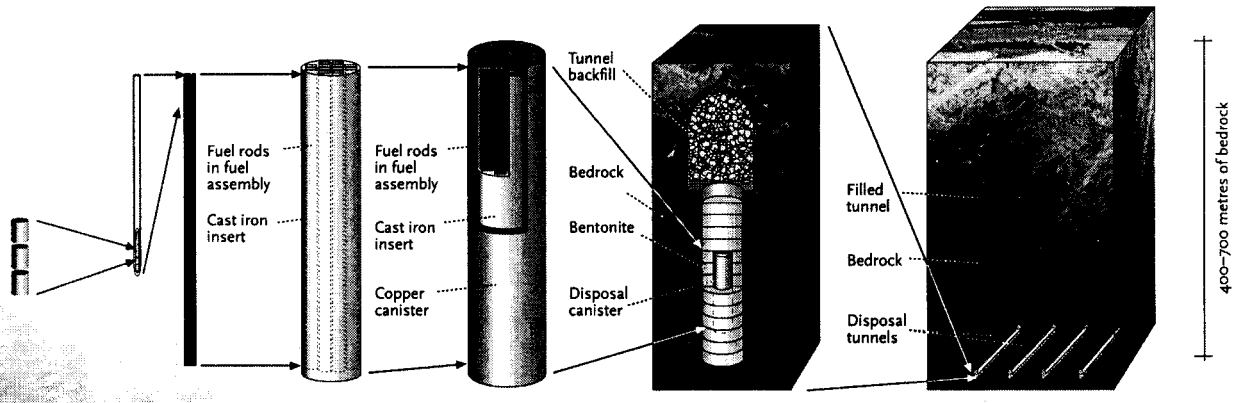




Multi-barrier principle for final disposal

- several release barriers ensure long-term safety

Fuel pellet ▶ Fuel rod and fuel assembly ▶ Cast iron insert ▶ Copper canister ▶ Bentonite barrier and disposal tunnel backfill ▶ 400–700 metres of bedrock



11 Long-term safety

11.1 The basis of long-term safety

Posiva's final disposal plans are based on the KBS-3 concept, developed by SKB, the company responsible for nuclear waste management in Sweden. In the basic final disposal solution, spent fuel will be packed into strong water-tight canisters. The canisters will be placed into the bedrock at a depth of 400–700 metres, where they are isolated from the population and where they will require no maintenance to remain leak-tight for as long as their content could in any way harm living nature.

The walls of the canister and a couple of metres of bedrock are enough to completely obstruct the radiation emitting from the fuel. The purpose of the strong and completely leak-tight canister is to prevent the access of radioactive substances into the groundwater. The canister is protected by the bentonite clay surrounding it, preventing the flow of water on the surface of the canister and dampening any effect of rock movements on the canister. The main purpose of the bedrock is to create favourable conditions for the canister and the bentonite buffer to remain functional as long as possible. If the canister started to leak for some reason, the bentonite clay and the bedrock would slow down and reduce the access of radioactive substances to living nature.

Thus the basis of long-term safety is the multiple barrier principle described in section 3.3 and above. Radioactive substances are contained in several barriers supporting each other, but as independent from each other as possible so that the failure of one barrier will not endanger the functioning of the isolation.

The risks of spent nuclear fuel quickly diminish during the first decades after the fuel has been removed from the reactor. During the first 40 years, activity is reduced to approximately one tenth of what it is one year after the fuel is removed from the reactor. The lowering trend then continues so that within a thousand years, activity is reduced to approximately a thousandth part of the first year's level. At the same time, the radiation level on the surface of the canister is reduced to approximately a one-hundredth part of the level prevailing at the time of final disposal.

A small part of the radioactive substances contained in the canister have a very long lifespan and require a long-term isolation from living nature. For this reason, the final disposal canisters are designed to remain leak-tight for as long as possible in their final disposal location. Bedrock is the natural place for the canisters in Finland, as it is the place where the canisters would most probably be least subjected to quick changes in conditions. The Finnish bedrock has achieved most of its current form already more than a thousand million years ago. Since then, changes in the bedrock have been slow and very small during the millions of years. Placed deep into the rock, the canisters are protected from changes occurring above ground, such as future ice ages, and, at the same time, far away from the natural environment of people. As the selected location is in ordinary bedrock, the likelihood of anyone penetrating into the bedrock near the repository is small even if knowledge of the location of the repository is lost. Figure 11-1 presents the main features of a safety concept of a repository for spent nuclear fuel, located in crystalline bedrock and based on the KBS-3 concept.

11.2 Safety requirements

According to the general safety stipulations *(The Government 1999):*

"In any assessment period, disposal shall not cause health or environmental effects that would exceed the maximum level considered acceptable during the implementation of disposal."

A detailed presentation of safety regulations is included in Guide YVL 8.4, Long-term safety of disposal of spent nuclear fuel. In the safety regulations, requirements are listed separately for the predictable period of time of the next thousands of years and the longer period of time, including major climate changes. For the predictable period of time, 0.1 mSv has been set as the limit of annual radiation dose caused to people by final disposal. Since it is more difficult to estimate the doses caused to individuals in the far future, the assessment of long-term impact to people and the environment is based, instead of radiation doses, on the quantity of radioactive substances released

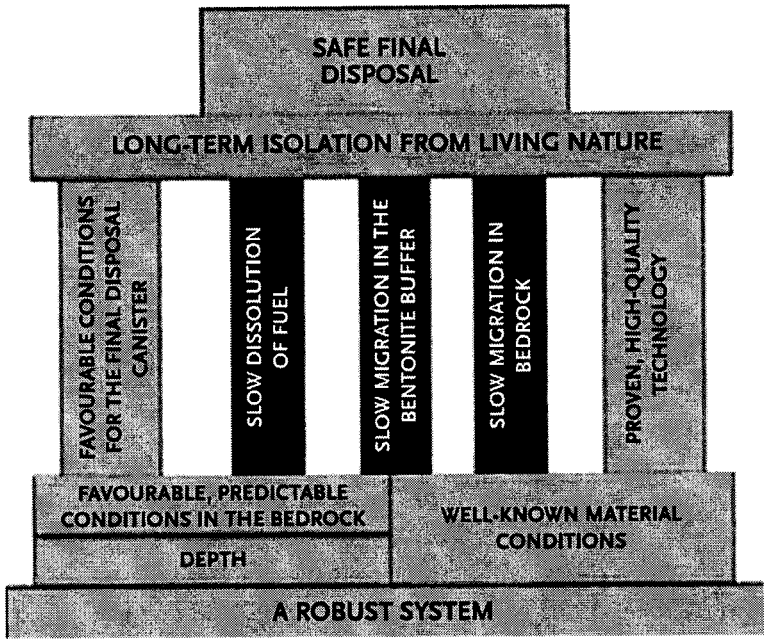


Figure 11-1 Main features of the safety concept for a KBS-3 type final disposal facility for spent nuclear fuel in crystalline bedrock. The yellow bars represent the primary safety functions of the safety concept, intended to preserve the operational condition of the barriers, above all, the canister. Green bars represent secondary safety features that may become significant in case radionuclides are released from the canister.

from the repository to the living nature, presented as activities (expressed as Bq per annum).

In Guide YVL 8.4, STUK requires that a scenario analysis shall cover both the expected evolutions of the disposal system and unlikely disruptive events affecting long-term safety. Scenarios must be created systematically using the phenomena, events and processes with possible significance for long-term safety. As unlikely events, at least the following must be considered:

- The making of a deep drilled well at the final disposal location
- Rock sample drilling hitting a final disposal canister
- A significant movement of the bedrock near the repository.

The consequences of such scenarios will be described later in the section discussing the conveyance of radionuclides.

11.3 Safety case

Long-term safety surveys have been concentrated on Olkiluoto since 2001, when the Parliament issued a decision-in-principle on the construction of a KBS-3 type final disposal facility for spent nuclear fuel in Olkiluoto. Earlier, the long-term safety of Olkiluoto and other potential final disposal locations was assessed in the TILA-99 safety analysis *(Vieno & Nordman 1999)*. The analysis was based on the same principles as the TVO-92 and TILA-96 safety analyses published in 1992 and 1996 *(Vieno et al. 1992, Vieno & Nordman 1996)*.

Parallel to the vertical deposition solution (KBS-3V) used as a reference, the placing of the canisters in horizontal holes (KBS-3H) has been developed since 2002 in cooperation with SKB. In 2003–2007, a complete safety analysis report *(Smith et al. 2007)* was prepared for the horizontal deposition solution. The results of the analysis are mostly also valid for the vertical deposition solution. The safety case work concerning the vertical deposition solution currently in progress has resulted in several reports according to the Safety Case plan published in 2005 *(Vieno & Ikonen 2005)*. The most recent of these is the radionuclide transport report reviewing the release of radioactive isotopes from the repository and the migration of these isotopes into the living environment *(Nykyri et al. 2008)*.

The Swedish SKB has published their own safety report, the SR-Can, in 2006 *(SKB 2006)*. The report concentrates on the KBS-3V final disposal solution and two different location options. The main part of the safety report is also largely applicable to the Olkiluoto repository, as the technical solution and the main characteristics of the final disposal location are similar.

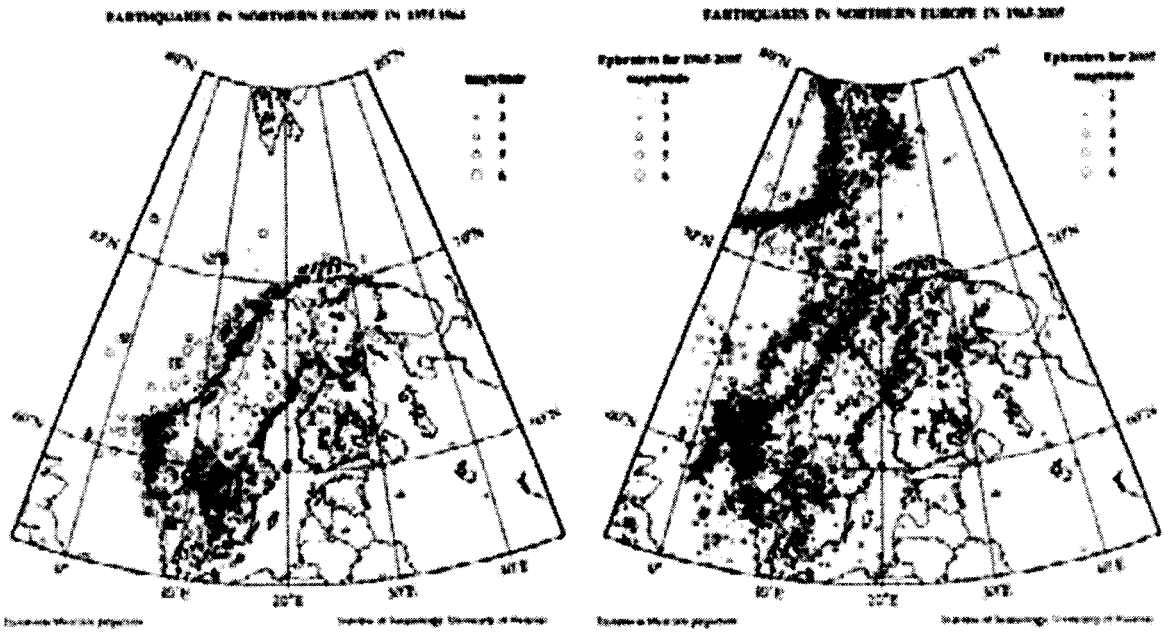


Figure 11-2 Earthquakes in northern Europe in 1375-1964 (on the left) and in 1965–2005 (on the right). Note that the frequency and intensity of the earthquakes is lower in Finland than elsewhere in northern Europe. (Source: The University of Helsinki.)

11.4 Proof of the canisters' ability to contain radionuclides for the minimum of one million years

How do the characteristics of the location and the plan improve the long-term durability of the canister?

The copper canisters containing spent nuclear fuel are mechanically durable and corrosion-resistant. They are also protected by the surrounding bentonite clay and the geologically stable bedrock. The final disposal location has no characteristics, such as valuable ores, that would induce deep drilling, disturbing the repository.

Olkiluoto is located in western Finland, on a shield area 1,800–1,900 millions of years old. As generally in Finland, seismic activity is very low. Figure 11-2 presents the earthquakes that have occurred in northern Europe since 1375. The Figure shows that the frequency and intensity of earthquakes is smaller in Finland than in many other North European areas. The largest earthquake observed in central Sweden, approximately 500 kilometres from Olkiluoto, has measured 5.1 on the Richter scale *(Ahjos & Uski 1992)*. The largest earthquake observed in Finland measured 4.9 on the Richter scale *(statistics starting from the 1880's; Marcos et al. 2007)*. Current seismic activity in Olkiluoto is low as well *(see e.g. La Pointe & Hermanson 2002, Enescu et al. 2003, Saari 2006, Saari 2008)*.

The bentonite buffer is plastic and protects the canister from small movements of the bedrock that may result from the construction of the repository or, in the long term, from post-ice age seismic activity. Microbes that could change the chemical conditions of the immediate area and, for example, increase the corrosion of the canister, are nearly passive in the buffer. The buffer also provides a physical barrier that effectively prevents the access of chemical substances (particularly sulphides) from the bedrock to the surface of the canister.

The disposal tunnels are constructed and canisters are placed in bedrock where the probability of rock movements in the long term is very low and where groundwater flow, groundwater chemical conditions and rock mechanical properties are favorable in regard to the long-term functionality of technical release barriers and, on the other hand, also promote the absorption of possibly released radionuclides. Rock characterisation is used in order to recognise a bedrock suitable for a disposal facility. Rock characterisation is performed in phases. The first phase is to recognise wider rock areas where disposal tunnels can be constructed, and after this, on the basis of more specified research data, the suitability of single disposal tunnels and canister holes for final disposing is determined.

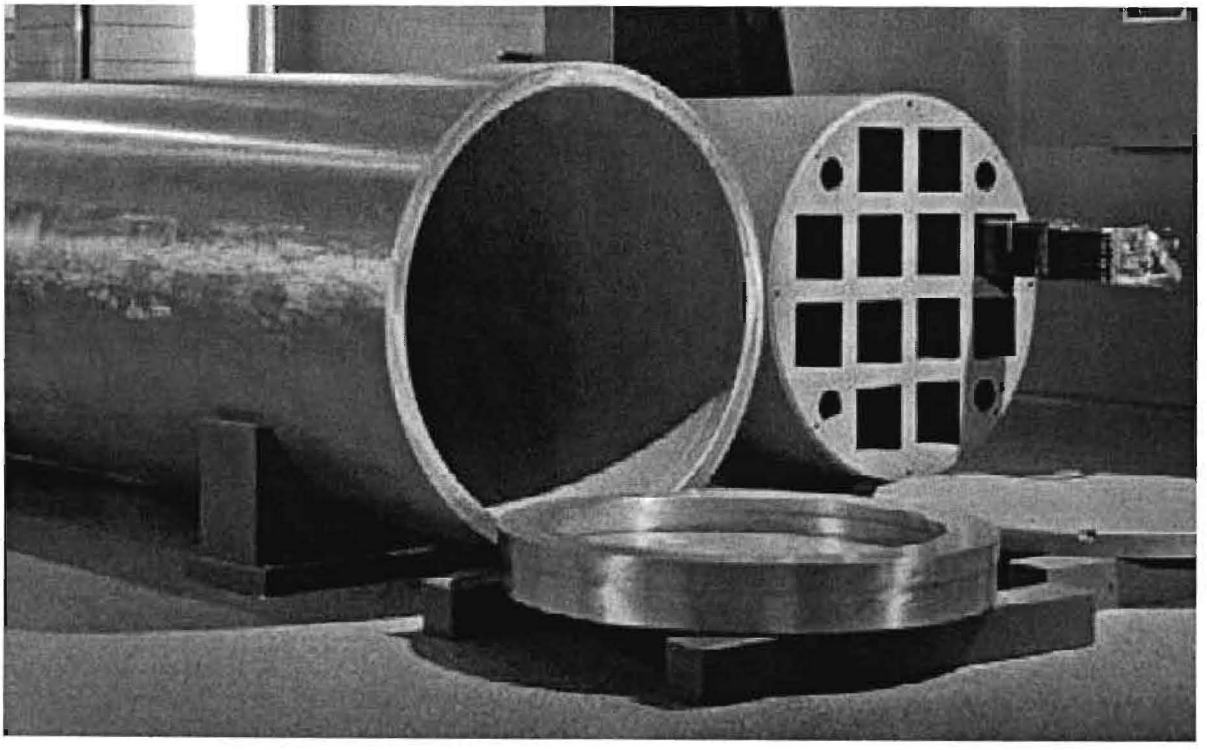
How do conditions around and in the canister develop with time?

Conditions around the canister and on its surface vary greatly during the first few hundreds of years after the closure of the repository, but the changes are not expected to have a significant effect on the canister integrity. For example, the bentonite that is originally only partly saturated with water, gradually absorbs water from the bedrock and expands to fill the installation gaps between the bedrock and the canisters. The expansion of the bentonite brings pressure to the canister walls, but the canisters are designed to endure such pressure with a large safety margin. Oxygen contained in the air remains in the repository after closure, but this causes only minor corrosion of the canister surface. In addition, the oxygen-induced corrosion decreases as the corrosion and other chemical reactions spend the oxygen.

With time, the conditions around the canister are balanced. Groundwater contains small quantities of sulphides that cause corrosion to the canisters, but the speed of corrosion is very slow. It has been calculated that it will take at least a million years for the corrosion to make a hole in the canister, even if local above-average corrosion is assumed. The bentonite buffer also works in favour of corrosion resistance, hindering the conveyance of sulphides from the bedrock to the canister surface.

Helium is generated in the canister as a result of radioactive decay, which increases the pressure. However, it takes millions of years for the pressure to become so high that it would be able to break the canister.

Formation of permafrost and ice sheets in the colder climate of the future may affect underground conditions. The effects will be considerably smaller in the depth of the repository than in the parts of bedrock closer to the surface. Ice ages have been regular in the past, and they are expected to occur in the future as well, even though the effects of human activity, such as greenhouse gas emissions into the atmosphere, may change the time when they occur. Numerical simulations suggest that in Olkiluoto, the formation of permafrost and ice and the back and forth movement of the ice sheet have only a minor effect on the temperature at the repository level. In contrast, these factors do have an effect on the groundwater flow within the bedrock and the chemical composition of the water. These effects are, however, only temporary. Seismic activity, currently very low in Olkiluoto, will diminish further under future ice sheets *(e.g. La Pointe & Hermanson 2002, Enescu et al. 2003, Saari 2006)*. Major earthquakes may, however, occur when the ice sheet is receding. The placing and design of the repository are prepared to prevent any significant effect of such events on the canister durability. The breaking of canisters for example as a result of post-ice age earthquakes is considered within the safety case (described in Section 11.6).



Can additional proof be found in the nature to support the long lifespan of the canisters?

Natural copper formations have already lasted millions of years in various parts of the world, which can be considered as evidence of the long-term durability of copper canisters in final disposal conditions *(e.g. Marcos 1989)*. For example in Hyrkkölä and Askola, Finland, copper is found in its original form within granite stones, even though the copper has been exposed to sulphate-rich groundwater under oxidising conditions. Further proof has been gained from archaeological discoveries. Evidence includes a bronze cannon found in Sweden, buried in the bottom sediment of the sea since 1676. This can be compared to copper canisters in the bentonite clay. Only very small corrosion was observed on the cannon, even though the conditions at the bottom of the sea are considerably worse than in the repository (including a higher concentration of oxygen and salt).

11.5 Consequences of possible canister manufacturing defects

Why is it unlikely that defective canisters will get to the repository?

Canisters have a central role in the long-term safety of final disposal. It is particularly important to recognise any manufacturing defects that penetrate the copper cladding protecting the canister from corrosion. If such a defect occurred, water could come into contact with the cast-iron insert of the canister. Water would gradually corrode the iron, producing solid corrosion products and hydrogen gas. Water coming from the bedrock and seeping through the bentonite clay would in time get inside the canister, creating a release route for the radioactive substances and enabling them to be conveyed towards the ground surface. As described in more detail below, the processes related to the release and conveyance of radioactive substances are very slow, and only very small quantities of radioactive substances would ever reach the ground surface. Therefore, environmental effects would remain very small.

The use of a defective canister in the repository is prevented by using a well-researched manufacturing technique and adopting a suitable quality assurance procedure. The possible defect could in principle occur at any place on the canister, but it would be most likely to occur at a welding seam, particularly at the point where the canister cover is attached. In Sweden, the SKB has prepared a first assessment of the reliability of the adopted welding method (friction stir welding) and included a preliminary statement on their SR-Can safety report to the effect that it is impossible that a canister with a defect penetrating the copper shell would be used for final disposal. Posiva plans to close the canister lids with electron beam welding, considering friction stir welding an alternative method. A non-destructive examination method for inspecting the manufacturing of the canister components and sealing of the canister will be selected by the end of 2008. The quality assurance programme related to the examination method and the examination itself is currently under development. Therefore, it is not yet possible to define the likelihood of not detecting a defective welding in the examination.

As the possibility of a defective canister being used for final disposal cannot be completely excluded, the possibility has been considered in the final disposal safety assessments. Thus the release of radioactive substances and their conveyance from a defective canister are included in the final disposal safety analysis. (Similar calculations were performed within the SR-Can safety analysis, even though the probability of such a defect was essentially considered zero.)

What would be the consequences of a defective canister being used in the repository?

If water should access the canister, small quantities of radioactive substances not tied to the structure of the fuel matrix or the surrounding cladding would dissolve in the water relatively quickly. The main part of radioactive substances are, however, only released gradually when water starts to react with the fuel assembly components. Even spent nuclear fuel is very stable in the oxygen-free conditions expected to prevail within the final disposal canister. Dissolution or chemical transformation of fuel, resulting in the release of the main part of radioactive substances, is not likely to occur within the next millions of years. In addition, many of these radioactive substances are only soluble to a very small extent in the conditions prevailing within the canister, and their concentrations in the water will therefore remain low.

Radioactive substances dissolving in water gradually diffuse through the hole penetrating the canister into the buffer surrounding the canister, and then mix with the water flowing in the fractures within the bedrock.

In the vertical deposition solution, radioactive substances may be diffused from the buffer into the tunnel filling before they are mixed with the water flowing in the fractures within the bedrock. Canisters will be placed in locations where there are minimal fractures and very little water flow. In spite of all this, the slowly flowing water will convey the released radioactive substances towards the surface environment. Due to radioactive decay, part of the slowly conveyed substances will become inactive, losing their radioactivity. There are also processes that slow down this passage. Such processes include the slow proceeding of the conveyed substances in the microscopic pore net-

work within rock, in which water does not move and into which the conveyed substances are diffused, thus proceeding slowly compared to the water flowing in the fractures. In addition, many substances react physicochemically with the minerals on the fracture surfaces and in the pore network of the rock matrix. Chemical reactions with the corroding canister internals and the bentonite minerals also slow down the emissions from the canister and the bentonite buffer and decrease emissions into the bedrock.

Within a very long time, a small quantity of radioactive substances may access the ground surface, where they may bond with particles in the ground and mix with waters (brooks, rivers and lakes). Part of the substances may enter the cycles of the living nature. Computer models have been used to estimate the quantity of radioactive substances possibly reaching the surface environment in the case of a defective canister and other possible chains of events leading to damage. These cases will be discussed below. Detailed and simplified computer models have been created to describe the effect of the radioactive substances on people and other living nature in the surface environment. The so called well dose is a simple way of expressing the effects of radioactive releases. Well dose is expressed using the Sievert (Sv), and it describes the biological effects of the dose received by drinking water for one year from a well contaminated by radioactive substances. The Sievert is a large unit, and practical applications generally utilise the smaller unit of milliSievert (mSv). Detailed modelling has also been used to examine the behaviour of radioactive substances in the surface environment. Based on the results, similar conclusions can be made as when estimating the well doses. To simplify the examination, only the well dose is used in the following.

As an example of well doses calculated for the final disposal concepts KBS-3V and KBS-3H, Figure 11-3 presents a case in which a small hole, with the diameter of 1 mm, is assumed to reach through the copper shell of one canister. This scenario roughly corresponds to the largest defect that could be left undetected with current non-destructive testing and quality control methods. The size of the hole is so small that it will significantly limit the release of radioactive substances from the canister. However, with time, the corrosion of the canister wall may increase the size of the hole. In the calculated cases presented in Figure 11-3, the strong increase in the dose at 10,000 years is due to the assumption that the canister will at that time quickly and wholly lose the ability to restrict the release of the radioactive substances contained in it. The purpose of such a very pessimistic assumption is to describe the behaviour of the emission barrier system in one extreme situation.

The highest well dose of 0.00001–0.00003 means that any biological effects of the releases are extremely small. As a point of comparison, the average annual dose of all ionising radiation in Finland is approximately 3.7 mSv, consisting of both natural radiation and radiation generated as a result of human activity, such as medical radiography and the radiation from the Chernobyl fallout. The Finnish radiation protection regulation concerning the final disposal of spent nuclear fuel set the annual dose limit at 0.1 mSv for the members of the most exposed group in the period of several thousands of years after the closure of the repository.

11.6 The probability and consequences of a major earthquake damaging the repository

Why is the probability of canister damages caused by an earthquake low?

According to regulatory guidelines issued by the Radiation and Nuclear Safety Authority (STUK), the significance of a major bedrock movement must be assessed, and the consequences and effects of such an event must be reviewed when assessing the safety of final disposal. A major earthquake is the only imaginable cause of a major bedrock movement. Even though current seismic activity in the Olkiluoto area is low, higher activity in the future cannot be excluded. In the past, the highest seismic activity in the area has occurred after the receding of the ice sheet covering the ground in the ice age. In the future, major earthquakes are most likely to occur at the final stages of ice ages.

Geological characterisation and modelling of the Olkiluoto area, partly completed and partly still in progress, will yield information on the geological structures that could be affected by major earthquakes in the future. When designing the repository and planning its layout, any significant zones with a potential for rock movement endangering the repository or the long-term safety of the facilities, or with other disadvantageous properties, will be avoided. Layout has been discussed in section 3.6.2.

A major earthquake may, however, trigger secondary rock movements in smaller fractures which cannot be totally avoided when building the final disposal tunnels and holes. These small movements could cause transformations in the bentonite buffer and additional stress to the canister. Excessive stress could lead to mechanical damaging of the canister.

Secondary rock movements damaging canisters are most likely to occur in large fractures. La Pointe and Hermanson *(2002)* have estimated the probability of rock movements and canister damage caused by earthquakes at the Olkiluoto final disposal facilities. Based on their results, the risk of damages is very low. The risk of damages can be further diminisged by selecting the location of the

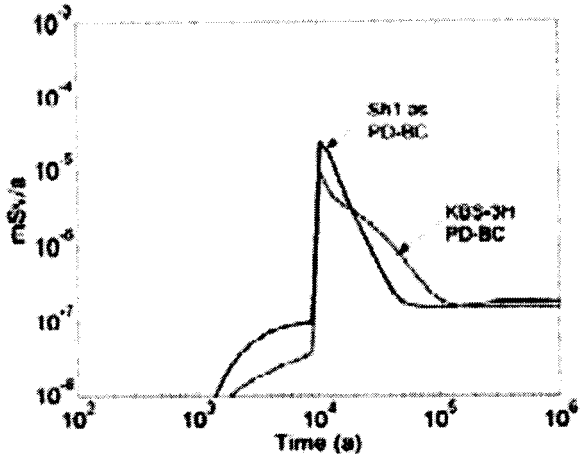


Figure 11-3 Calculated well dose in case of a defect penetrating the canister's copper shell. The blue curve Sh1 as PD-BD is taken from the radionuclide transport study RNT-2008 concerning the KBS-3V alternative (Nykyri et al. 2008). The green curve KBS-3H PD-BC is from the KBS-3H safety assessment (Smith et al. 2007).

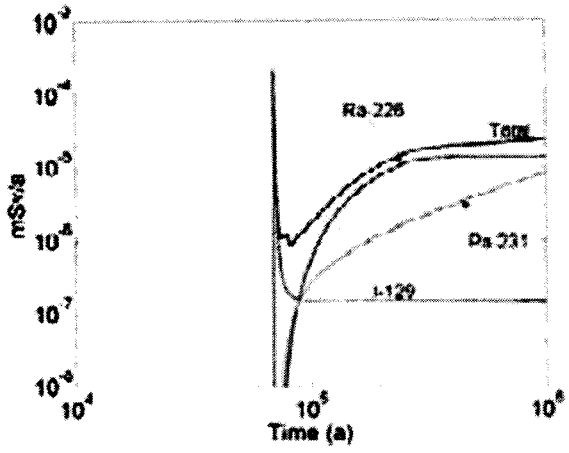


Figure 11-4 The calculated well dose rates (annual doses) as a function of time when the canister is damaged 70,000 years from now (Nykyri et al. 2008). The figure presents a total dose for all radioactive substances and separate doses of three most important nuclides for the KBS-3V alternative.

deposition hole in the tunnel so that no such fractures intersect the deposition hole. The difficulty is that the dimensions of the fractures can rarely, if ever, be measured reliably. However, a fair idea of the dimensions of the fractures can be achieved by observing the intersections of the fracture and the underground facilities, such as the tunnels and deposition holes. For example Hagros et al. *(2005)* have proposed that the observed length of the fracture mark was taken into account when assessing the suitability of a hole for final disposal.

In the Swedish preliminary safety assessment, the SR-Can, a criterion was developed for rejecting the considered deposition hole location if the intersection imprint on the tunnel walls indicates that the fracture will also intersect the considered deposition hole. The deposition hole or its location will also be rejected if a fracture imprint can be detected in several subsequent locations (SR-Can: five locations). If a hole was already drilled in the location, it would be filled up and no canister would be placed in it. This criterion presented in the SR-Can is called the Expanded Full Perimeter Intersection Criterion (EFPC).

Fractures with the potential for rock movement damaging the canister may still be left undetected. Based on an analysis using models, SR-Can states that when the EFPC criterion is applied for Swedish candidate locations, the probability of deposition hole locations in which a damaging rock movement could occur in connection with a major earthquake is very small (0.00008 in the Forsmark area and 0.0004 in the Laxemark area). In the case of SKB, the most likely situation for the quantity of 6,000 canisters would thus be that the maximum of one or two canisters would be unintentionally placed in a location susceptible to damage. If no selection criteria was used for the deposition holes, the probability of holes susceptible to damages would be 0.019 for Forsmark, that is, 114 holes of the total of six thousand *(Hedin 2005)*. The example proves that the selection of the location of deposition holes can significantly reduce the damage caused by rock movement.

The frequency and dimensions of fractures are similar in Olkiluoto to the extent that the same general conclusion can be assumed. The completed KBS-3H safety assessment estimates that 16 canisters out of three thousand would be susceptible to a rock movement in case of a major earthquake *(Smith et al. 2007)*. The corresponding estimate of the number of canisters susceptible to damages in the case of KBS-3V is 20 *(Pastina and Hellä 2006)*. This is a much higher percentage than that estimated in the SR-Can, as a criterion such as the EFPC was not used to reject hole locations based on large fractures. Even though a location approval criterion for deposition holes will only be developed in the future, it can be assumed that the estimated number of 20 canisters located in a place susceptible to damage can be significantly reduced with an appropriate location approval criterion.

What would happen if a major earthquake occurred at the repository?

Since canister damage cannot be completely excluded if a major earthquake occurred near the repository, even if large fractures were avoided when selecting locations of deposition holes, the radioactive releases caused by such damage have been estimated in the SR-Can and the Olkiluoto safety assessments for both alternatives, KBS-3V and KBS-3H.

As stated above, the strongest earthquakes are expected to occur when the heavy ice sheet recedes from the area at the end of an ice age. The points in time when the permafrost and ice sheet are created and when the ice recedes are uncertain, particularly due to the uncertainties of the effects of greenhouse gas releases into the atmosphere. If it is assumed that the stages of the previous ice age will be repeated, it can be expected that the receding stage of the next ice age and thus the time when the melting waters will enter the final disposal depth will occur in approximately 70,000 years.

In the receding stage of an ice age, the melting waters may reach the disposal level. The impact of the penetration of melting waters is discussed in section 11.9.

Figure 11-4 presents an example of well doses calculated for some of the most significant radionuclides in the case of such natural disasters, first presented in a radionuclide release and transport analysis published in 2008 *(Nykyri et al. 2008)*. Doses have been calculated for substances released from one damaged canister in the KBS-3V alternative. The canister damage is assumed to be caused by rock movement occurring 70,000 years from the closure of the repository. It is pessimistically assumed that the rock movement not only damages the canister but also diminishes the ability of the bentonite clay and the bedrock to reduce the release of radioactive substances and to delay their access to the ground surface.

The annual well dose maximum of 0.0002 mSv calculated for the damaging of one canister will be reached very soon after the canister has been damaged. Subsequently, the dose quickly diminishes and then starts to grow again, continuing to grow until the end of the reference period of one million years. In a very pessimistic case that ignores the possibility of avoiding large fractures with the use of the EFPC criterion, or another similar criterion in the case of the KBS 3H alternative, 16 canisters of the total of three thousand could be damaged by rock movement. Even in this case, the worst possible annual well dose would only be 0.003 mSv (and somewhat lower if the canisters were not simultaneously damaged, but the damages were distributed over a long period of time, such as a million years). Thus the estimated dose remains well below the regulatory limit for the most exposed people concerning the final disposal of spent nuclear fuel (0.1 mSv per year). The estimated dose is about a one thousandth part of the average total annual dose received in Finland from all radiation sources. It should also be noted that according to the regulatory Guide YVL 8.4, the small probability of unlikely events, such as a substantial rock movement occurring in the environments of the repository, can be taken into account when comparing doses to the limits set by the authorities.

11.7 Entering the repository and the consequences of the entry

Why is it unlikely that anyone would enter the Olkiluoto repository?

Being near the final disposal canisters within a hundred years from the final disposal without appropriate protection would cause a serious health risk. Immediate health effects would be possible if the person entering the facility were near uncovered canisters for several hours. From the point of view of the environment and particularly the people living in the area, significant health effects would only be expected if canisters were brought to the surface and the contents of the opened canisters were spread into the environment.

The information on the repository and the spent nuclear fuel placed there is planned to be kept for future generations, to give them full information on the repository and its risks. Accidental or unintentional disturbances of the repository caused by human activity are unlikely at least as long as this information is preserved.

As it is difficult to predict long-term social development, it cannot be guaranteed that the information is available forever. However, no such natural resources exist in Olkiluoto that would tempt for example such deep rock drilling that could disturb or damage the repository. The area has no potential for profitable oil and gas exploration or production. (Even though considerable concentrations of methane and some higher hydrocarbons exist in the deep groundwater, the concentrations are too low for financially profitable production.) Due to the low geothermal gradient, i.e., the rate of increase in temperature with the increase of depth in the crust, the utilisation of geothermal heat is unlikely. Neither does the area have any indication of metallic minerals or deposits of industrial minerals that could have economical significance in the future.

On the other hand, the considerable amount of spent fuel and the high-quality copper in the repository could be considered such a valuable raw material in the future that the facility is intentionally accessed. The currently valid decisions require that the possibility to open the repository is shown. *(The Government 2000.)* In these cases, the knowledge of the spent fuel and copper also indicates that the people entering the facility are likely to be aware of the dangers and difficulties of utilising the materials. The people entering the facilities thus also carry the responsibility of any consequences *(Grimwood and Thegerström 1990)*.

What would be the consequences of entering the repository?

Finnish regulations require assessment of long-term safety in case a deep drilled well is made in the final disposal location and in case a sample drill hits a waste canister. The consequences of the drilled well scenario have been estimated with computer modelling as a part of the radionuclide transport assessment published in 2008 *(Nykyri et al. 2008)*. The sample drilling scenario is assessed later in connection with the biosphere analysis.

Canister damage due to future drilling has been discussed in the Swedish SR-Can safety assessment. The SR-Can assessment assumes that the drilling occurs 300 years after the closure of the facilities. It was conservatively assumed that fuel elements are brought to the surface, they are left unprotected and people remain near them. Only a situation this serious was shown to have significant health effects. Using a drill hole that has hit a waste canister for household water supply has less significance. Average annual doses calculated for this case were 0.1–1 mSv. This dose is somewhat lower than the dose received from natural background radiation in Finland (some 3 mSv per year).

11.8 Uncertainties pertaining to the quantity and type of the fuel to be disposed of

What are the consequences of finally disposing a larger quantity of fuel than currently planned for the area?

TVO and Fortum have given the following estimates on the quantity of spent nuclear fuel generated in their reactors:

- Loviisa 1 and 2: 698 canisters, containing 1,018 tU of spent nuclear fuel
- Olkiluoto 1 and 2: 1,210 canisters, containing 2,533 tU of spent nuclear fuel
- Olkiluoto 3: 932 canisters, containing 1,980 tU of spent nuclear fuel
- total: 2,840 canisters, containing 5,531 tU of spent nuclear fuel.

These estimates have been used as starting points for the safety assessments for the KBS-3V and KBS-3H. Uncertainties are inherent in these estimates, and the presented figures must be increased for example when extending the service life of the reactors. In addition, TVO has applied for a decision-in-principle for Olkiluoto 4. Posiva is also preparing to take into account that Fortum may submit an application for a decision-in-principle regarding Loviisa 3 plant unit. The previous Posiva EIA report from 1999 discussed the environmental impact caused by the disposal of 9,000 tons of uranium. The current report concerns the effects of increasing the amount of fuel from 9,000 tons of uranium to 12,000 tons of uranium.

Increasing the quantity of the spent fuel to be finally disposed of requires extending the area of the repository, unless the repository is planned to be built on two levels. In the preliminary repository layout plans, 3,000 spent fuel canisters would cover 80–95 percent of the currently well known and available Olkiluoto bedrock. A significant addition to the quantity of fuel to be disposed of therefore requires an extension of the area in which the rock foundation is investigated. The extension of the investigation area would most likely be located to the east from the current area, as presented in section 3 (Figure 3-5).

The heat production of each canister raises the temperature of the surrounding area. If the temperature near the canisters increased too much, chemical changes could occur in the bentonite clay that would weaken its ability to protect the canister. The total heat production of the repository is roughly in direct proportion to the number of waste canisters in the repository. However, the temperature near the canisters is not expected to be very sensitive to the total number of canisters located in the repository, as the canisters will in any case be separated from each other so that excessive temperature rises are avoided.

The probability of a single damaged canister passing the post-closure inspection is considered to be independent of the number of canisters. Similarly, the probability that a bedrock fracture intersects with a deposition hole, enabling rock movement in connection with an earthquake and resulting in damage to a canister, is considered to be independent of the number of waste canisters. The probabilities mentioned above are kept low by efficient quality assurance procedures. The number of canisters possibly damaged in the repository and the quantity of radioactive substances thus released into the bedrock is therefore roughly in proportion with the total number of canisters.

The radionuclide retaining ability of the bedrock is ensured by the above average integrity of the rock surrounding the deposition holes. Most of the possibly damaged canisters are likely to be located in very solid bedrock, in which the migration of radionuclides is slow, while other canisters may be located in less favourable places, where migration to the ground surface may be faster. Canisters damaged by rock movements would be most probably located at the fastest flow routes of the area, but on the other hand, the probability of rock movements strong enough to damage canisters occurring before the next ice age is considered very low. All in all, the total quantity of radioactive substances reaching the ground surface would still be roughly proportional to the total number of damaged canisters.

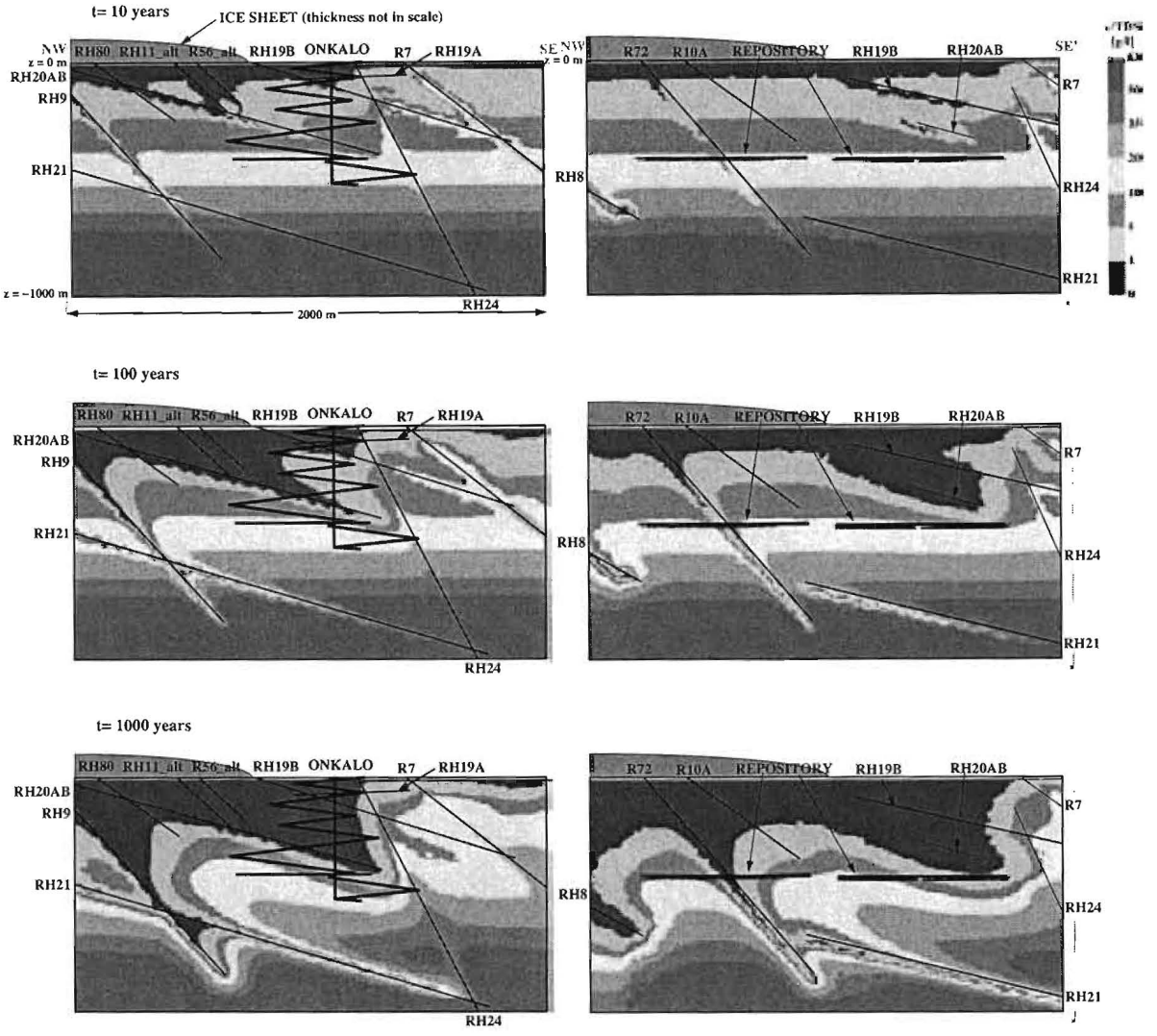


Figure 11-5 Penetration of diluted surface waters (dark blue) deeper into the bedrock in various periods of time, estimated with computer modeling. The ice sheet, from which the melting water originates, is shown in grey. The salt content of the groundwater (g/l) is expressed as total dissolved solids (TDS). (Pastina and Hellä 2006.)

When the canister damage is caused by a fault penetrating the canister, undetected in inspections, the calculated quantities of released radioactive substances described above remain so small that even if all finally disposed canisters were assumed defective to some extent, and even if all released radioactive substances were assumed to be conveyed to the same household water supply well, the estimated radiation doses during the next thousands of years would still remain under the set individual dose limits. In practice, it can be estimated that a few defective canisters at most will pass the inspection. Therefore, even if the probable number of faulty canisters increased as the total number of canisters increases, the increased emissions have no significant effect on people or other living environment. In addition, it should be noted that if the surface area of the repository increased, the probability of the releases from several damaged canisters migrating to one single household water supply well would become even smaller.

In case of an earthquake, the estimated releases to the ground surface could be higher than in the case of canisters with a manufacturing defect. This is due to the assumption that an earthquake would also weaken the bentonite clay's and the surrounding bedrock's ability to delay radionuclides. In this case, however, several dozens of canisters should be damaged before the releases would exceed the limits set in regulation. When care is taken that the canisters are placed in such locations within the bed-

rock that have a small probability of significant rock movements, the probability of many canisters breaking at once is small, regardless of the total number of canisters.

What would be the consequences of finally disposing of spent nuclear fuel with a significantly higher discharge burn-up in the area?

The discharge burn-up of spent nuclear fuel refers to the quantity of energy produced with the fuel per mass unit. The higher the discharge burn-up of the fuel, the less fuel is required to produce the same amount of energy, making the quantity of spent fuel smaller as well. However, the discharge burn-up of spent nuclear fuel affects the fuel's radionuclide composition and heat production. In the case of a damaged canister, it also has significance for the radionuclide release rate.

The safety assessments of final disposal solutions based on the KBS-3V and KBS-3H concepts discuss three types of fuel: the VVER-440 fuel from the LO1 and LO2 reactors, the BWR fuel from the OL1 and OL2 reactors and the EPR fuel from the OL3 reactor. In most of the calculations of the safety analyses, the damaged canister was assumed to have contained BWR fuel from the OL1 or OL2 reactor. Differences in emissions to the ground surface, due to the fuel type, were small. Calculations assume 40 MWd/kgU as the discharge burn-up of the spent fuel, and 4.2 percent as the degree of enrichment, which is quite high.

Higher burn-up will increase the intensity of the fuel's ionising radiation. If water gains access to a damaged canister, the ionising radiation may sever the chemical bonds of water molecules. This phenomenon is called radiolysis, and it can potentially speed up the release of radioactive substances from solid fuel. However, the corrosion of the cast iron internals and the hydrogen generated in the corrosion is expected to dominate the chemical conditions in the canister. Therefore, radiolysis is not expected to have a significant impact on the release rate of radionuclides from the fuel even with the highest burn-up *(Cui et al. 2008)*.

A high burn-up has a significant effect on the free space within a fuel rod and the free spaces within the fuel pellets, as well as the quantity of radioactive substances accumulating in pores. When water enters the canister, these substances will be released relatively quickly compared, for example, to the radionuclides within the fuel matrix. The quantity of these quickly released radionuclides is important for long-term safety. The immediately released part of the I-129 isotope is a major part of the radiation dose resulting from using a defective canister for final disposal. This share tends to increase as burn-up increases. Models describing the immediately released substances for PWR and BWR fuels have been developed within the Spent Fuel Stability Project of the EU *(Nagra 2005)* for burn-ups of 37–75 MWd/kgU. The results of the project indicate that the immediately released share of the BWR fuel's I-129 isotope could triple when burn-up increases from 41 to 48 MWd/kgU, and become sevenfold when the burn-up of PWR fuel increases from 41 to 75 MWd/kgU. The results received from using the model have not been compared with experimental results, but the model is believed to overestimate the share of immediately released isotopes. The increase in the quantity of released iodine would still not lead to exceeding the dose limits in the case of canisters with a manufacturing defect.

11.9 Other uncertainties

Are there other potential scenarios leading to the breaking of a canister, and what are their consequences?

Possible scenarios that could lead to damages to a canister within a million years have been examined in several Finnish and Swedish safety analyses published in recent years. Scenarios of damaged canisters, extensive earthquakes and people entering the repository have been discussed in the above. The effect of the melting waters of future ice ages on the repository have been brought to attention in recent safety assessments as a new issue with possible importance to safety.

Melting waters from the ice sheet could transport oxygen with them, accelerating corrosion when coming into contact with the canister surface. However, according to the current knowledge, neither the chemical composition of the Olkiluoto groundwater nor the geological history of the area indicate that oxygen would have been transported to the repository level in the past; therefore, they also do not support the assumption that oxygen would penetrate the level in the future. Oxygen transported by the melting water is assumed to react with fracture minerals already in the upper parts of the bedrock. Even if the oxygen from surface water reached the near vicinity of the canisters, the required long period of exposure would make it unlikely that the canisters would be corroded as far as to start to leak. The SR-Can safety analysis estimated that on the whole, oxygen would not reach the level of the repository in the examined Swedish areas.

The ice age melting waters could possibly have an impact on the properties of the bentonite clay. The melting waters will probably have a low ion content (low overall salt content) compared to the present Olkiluoto groundwater. When transported to the depth of the repository, such melting water could create bentonite colloids and cause the bentonite to drift out of the deposition hole. The weakened bentonite buffer could, in its turn, facilitate the access of sulphides to the canister surfaces, accelerating

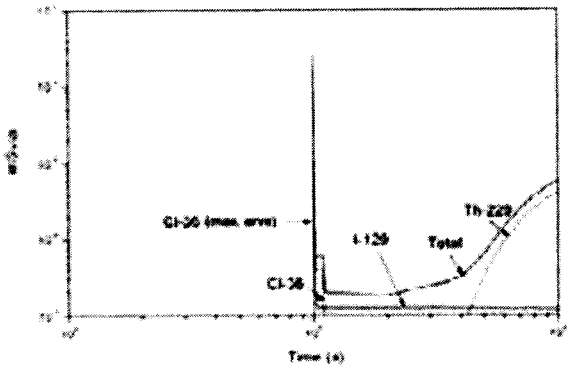


Figure 11-6 Calculated well dose rates in relation to time as a canister breaks as a result of corrosion 100,000 years from final disposal (Smith et al. 2007). The figure presents the doses from the most significant radioactive isotopes.

the corrosion of the canister. The phenomenon is currently being studied in practical examination and theoretical research.

The exhaustion of the oxygen contained in the melting water before the water reaches the final disposal depth does not exclude the possibility that the water might have an effect on the salt content of the repository and the groundwater in the near area (Figure 11-5). Current site investigations study whether such variations in the salt content have occurred in the past.

The consequences of the canister being corroded through in 100,000 years from the final disposal have been analysed in recent safety analyses. This assumption of the canister's breaking time is based on the assumption that ice sheet melting waters will penetrate into the repository and a significant erosion of the bentonite buffer will occur in 70,000 years from the final disposal and that, as a result of these, the canister will be corroded through due to the effect of sulphides transported by the groundwater. The assumption of 70,000 years is based on the assumption of the previous ice age cycle being repeated. Figure 11 6 presents an example of safety analysis results, taken from the safety assessment of the KBS-3H concept. Corresponding calculations, with similar results, have also been made for the KBS-3V concept in the radionuclide transportation report published in 2008. *(Nykyri et al. 2008.)*

The maximum annual dose immediately after the canister damage remains below 0.001 mSv. This is less than 1 percent of the dose limit for the most exposed individual. The dose is thousands of times smaller than the average annual natural radiation dose in Finland.

The effect of chemical erosion on the buffer and the canister vary depending on the location of the canisters, as the quantity of water in the repository, particularly the quantity of melting water, varies by location. The SR-Can safety assessment estimated, based on a preliminary chemical erosion model, that a maximum of a few dozen canisters located unfavourably in relation to water flows could be damaged due to chemical erosion at Forsmark. However, it was stated that the estimate was so far very uncertain.

Better quantitative understanding of chemical erosion is expected to be achieved with further research. Based on the better understanding, more reliable estimates could be given on the number of canisters possibly damaged. Technical measures are also being studied to help limit the effects of the phenomenon.

What are the central uncertainties when estimating the consequences of a broken canister, and what effects do these uncertainties have?

In the above, it was explained why the possibility of one or more canisters breaking and, as a result, radioactive substances slowly entering the environment within a million years from the final disposal cannot be completely excluded. At the same time, it was stated that in spite of canister leaks, the effects of the radiation on people and other living nature would remain so small as to be insignificant. However, there are always uncertainties in the estimated effects. Our understanding of the connected phenomena can never be perfect, as the releases will occur during a very long time period. Uncertainties are not only related to the understanding of the conditions leading to the canisters breaking, but also to our knowledge of the behaviour and migration of radioactive substances in nature. The precise quantity of groundwater released in surface waters, such as lakes, and possibly carrying radioactive substances, is not known; it also varies periodically.

Figure 11-7, presented in the 2008 radionuclide transportation analysis *(Nykyri et al. 2008)*, shows the release routes of radioactive substances from the rock facilities to the ground surface released from broken canisters located in central parts of the repository. The groundwater flows of the calculation are expected to prevail in 10,000 years. It must be noted that possible release points to the surface are spread in an extensive area, which reflects both the uncertainties related to the estimate and variation in the properties of the fracture network creating the groundwater flow route. This kind of spreading does not lead to diminished safety. The routes calculated for the thousand year time point are very similar to those shown in the figure.

Studies carried out for the KBS-3V and KBS-3H final disposal concepts have systematically surveyed the uncertainties such as those described above and estimated the effects that these uncertainties could have as people and other living nature are exposed to radioactivity originating from the repository. In the safety analysis, some uncertainties have been discussed using the worst case scenario. An example of such a conservative assumption would be to leave the reaction of the broken canister's cast iron inserts with the radioactive substances out of consideration. In this case, the transportation of radionuclides to the ground surface would be slowed down or completely prevented, but due to uncertainties related to the details of the reactions, this phenomenon that clearly increases safety has not been considered in the safety assessment. The significance of uncertainties is often studied by analysing the effect of alternative assumptions on the safety of final disposal.

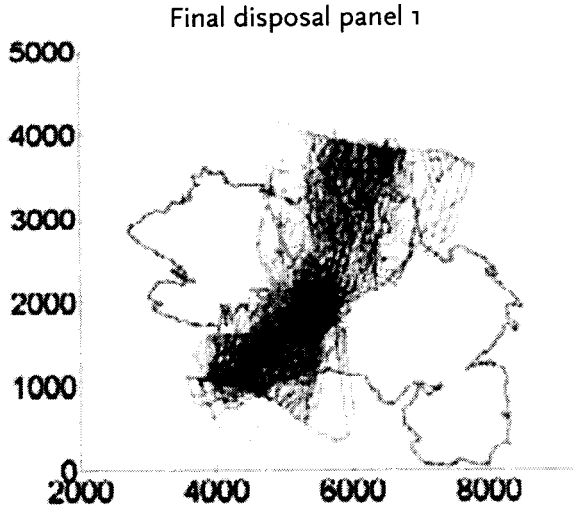


Figure 11-7 Release routes of radionuclides from the part of the repository that will be among the first to be used. The starting points of the route lines are located in the repository, in the central part of the island. The lines end, both in the south and in the north, in points where the routes reach the ground surface. The analysis is based on the groundwater flows estimated to prevail in 10,000 years. The figure shows the current shoreline, which, due to land uplift, will be receding further to the sea, making the Olkiluoto Island bigger. Routes marked with different colours have been calculated using different initial data, in order to assess how the uncertainties of the data entered to the model affect the result. The figures on the scales are distances as metres. (Nykyri et al. 2008.)

11.10 The development of the repository after a million years

Even though the breaking of one or more canisters within the first million years cannot be completely excluded, it is most likely that no significant amounts of radioactive substances will ever be released from the repository. Most likely, the canister's copper cladding will break in the distant future due to corrosion or another mechanism, leading to the canister contents slowly dissolving and spreading into the environment of the repository. Before this, the radioactivity of the disposed fuel has decreased to a level harmless to the environment.

Plenty of information on the development of Olkiluoto's bedrock during the past millions of years is available. All observations indicate steady conditions deep in the bedrock, and nothing indicates the possibility of the current status being disrupted within a few millions of years for example as a result of continental displacements. It is, however, possible that slow geological processes would cause land uplift and erosion within millions of years, eventually bringing the disposed matter to the surface. Until such a

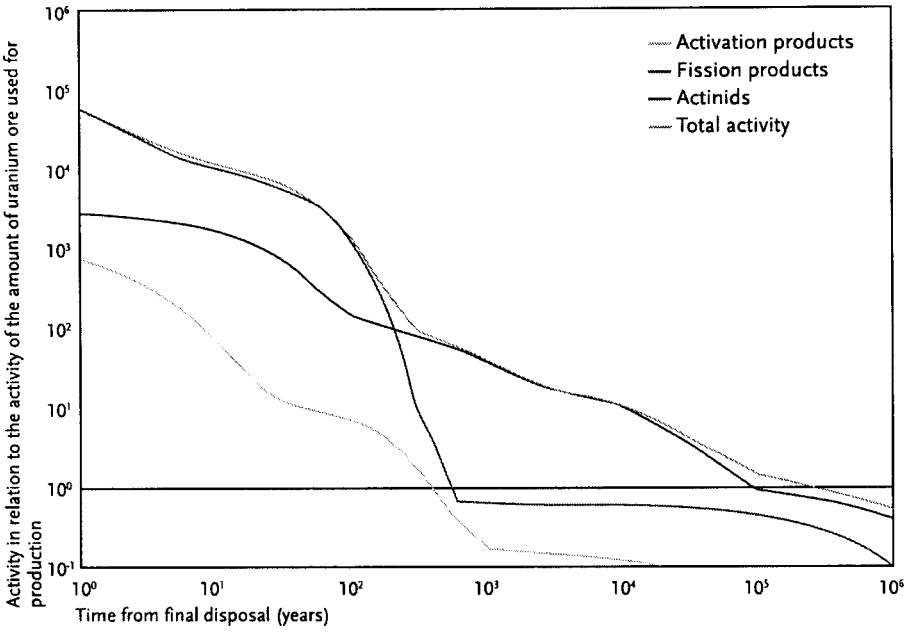


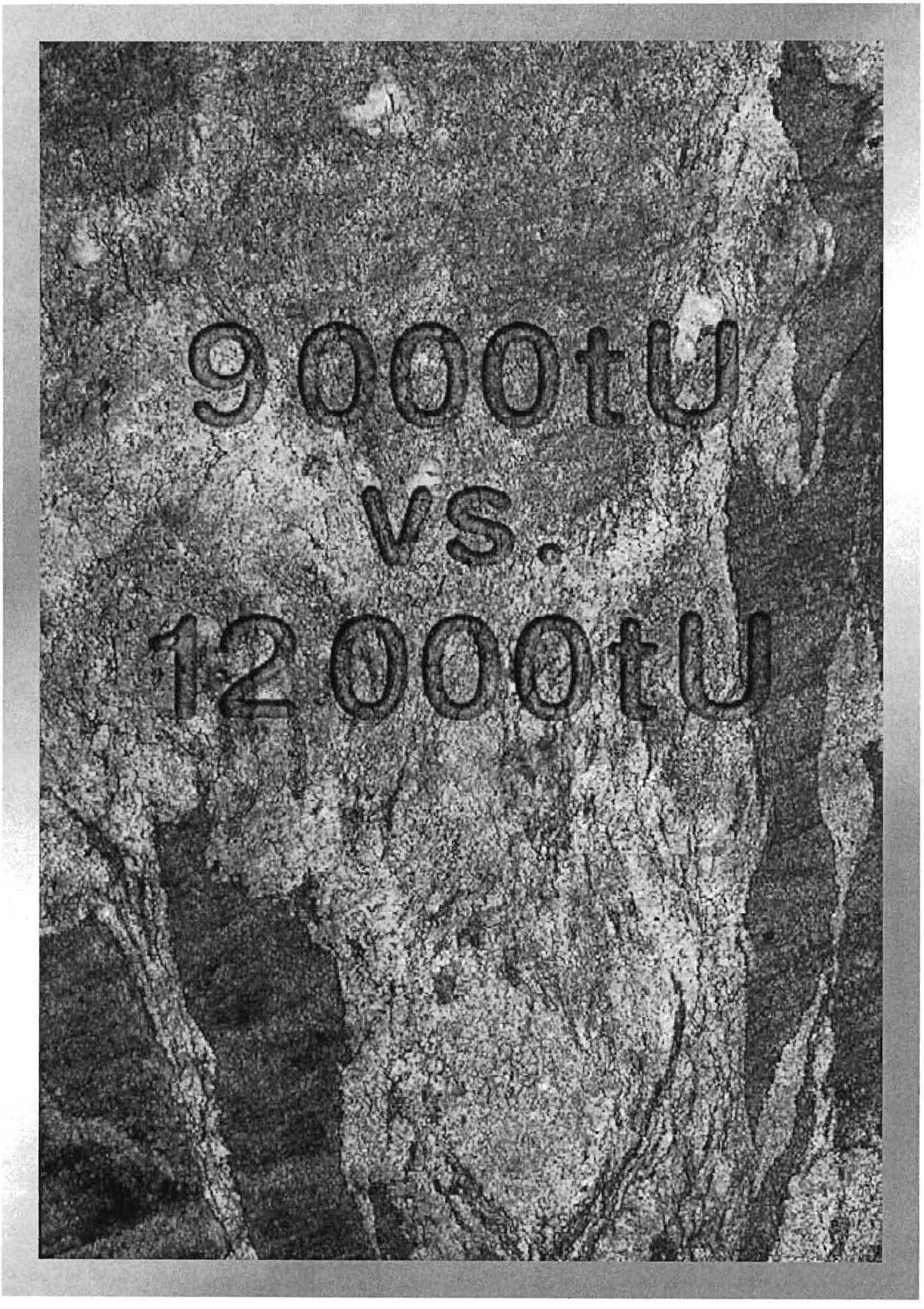
Figure 11-8 Overall activity of Finnish BWR type spent nuclear fuel at various points of time from the final disposal onwards, compared to the activity of the amount of uranium ore needed to produce the fuel. Discharge burn-up of the fuel is assumed at 40 MWd/kgU. (Neall et al. 2007.)

situation is realised, it is very unlikely that any extensive spreading of the disposed spent nuclear fuel into the environment should occur. It is more likely that spent nuclear fuel will remain in place, and the repository will in many respects resemble a small uranium deposit (Figure 11-8). The effects of final disposal above ground would then be comparable to the effects of uranium deposits.

Long-term safety conclusions

Mechanically strong and corrosion-resistant canisters placed in steady bedrock and surrounded with bentonite clay will most likely contain all radionuclides for the minimum of several millions of years. However, the possibility of breach of single canisters cannot be completely excluded during this period. In such cases, radioactive substances could slowly be released into the environment. Canister leaks could be caused by the use of a defective canister in the repository, severe earthquake damages (most likely to occur when the ice sheet recedes at the end of an ice age) to a few canisters located in unfavourable places, and erosion of the bentonite clay surrounding the canister, caused by ice melting waters, and resulting in corrosion of the canister.

However, only a few canister damages are expected even in violent rock movements. The radionuclide emissions caused could only have a very minor impact on people and organic nature. The safety assessments have taken into account the uncertainties affecting the release and migration of radioactive substances. The inspection of safety-related factors will be continued in order to reduce the number of uncertainties. The feasibility and adequate quality of technical solutions will be proven with testing. The full-scale safety case to be submitted in 2012, supporting the repository construction licence, will be based on these tests.


9000tU
vs.
12000tU

12 Impacts of non-implementation of the project

The zero option of the project is non-implementation. This means that the condition of the environment and the impact of environmental loads correspond to a situation where 9,000 tons of uranium is disposed of in the repository. In the zero option operations in the repository would be finished earlier than in the main option, i.e. after the disposing of 9,000 tons of uranium.

Non-implementation of the expansion of the repository means that the environmental impacts caused by the expansion of the repository assessed in this report will not materialise. In this case, the condition of the environment and the impact of environmental load correspond to a situation where the volume of spent nuclear fuel to be disposed of in the repository will be 9,000 tons of uranium.

In the zero option, the spent nuclear fuel of six nuclear power plant units can be disposed of in the Olkiluoto repository. As a result, spent fuel from the seventh nuclear power plant unit would be stored in water pools in the interim spent fuel storage at the nuclear power plant until a decision concerning the processing or the permanent disposal of the fuel has been made. The existing interim spent fuel storages in Olkiluoto and Loviisa have been designed so that the storing of fuel assemblies can be continued for decades.

12.1 Interim storage of spent fuel

Spent fuel assemblies are moved from the nuclear power plant reactor to cool off in the power plant unit's water pools. Water both cools and forms effective radiation protection. As the radioactive substances in the fuel assemblies decay, much heat is generated. Therefore, spent fuel assemblies must be cooled. After removal from the reactor, heat production of spent nuclear fuel is directly proportional to its activity, so heat production is quickly reduced during the first years. When removed from the reactor, the thermal power of one ton of uranium is approximately 1,400 kW. After one year, however, it is only around 10 kW.

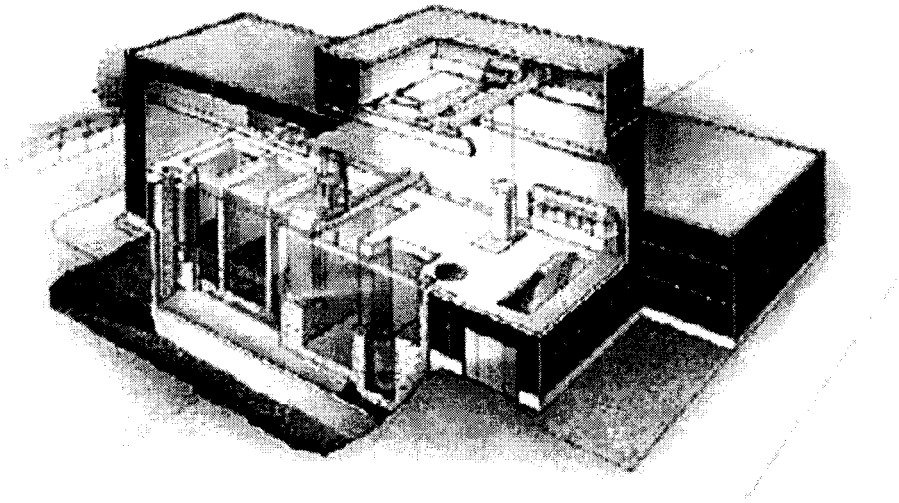


Figure 12-1 Computer image of the interim spent fuel storage of the Olkiluoto power plant.

After a few years of cooling, the fuel assemblies are transferred for interim storage to the interim storage facility for spent fuel located at the power plant site. Transportation to the interim storage is carried out in a transport cask, and the fuel assemblies are kept in water during the entire transportation. Water cools the nuclear fuel and protects from radiation emanating from the nuclear fuel. In the interim storage the heat transferring to water from the fuel is transferred to an intermediate cooling system with a heat exchanger, and from there further to the seawater cooling system through a heat exchanger. All the cooling circuits are separate, and the water in them will not come into contact with the waters in the other circuits.

Interim nuclear fuel storage facility in Olkiluoto

The fuel spent in Olkiluoto is temporarily stored in the power plant units and in the interim spent fuel storage (KPA storage) located at the power plant site.

The Olkiluoto interim storage presently comprises three storage pools and one spare pool. The total volume of the pools is 4,300 m³ and they have storage capacity for approximately 6,800 fuel assemblies, i.e. 1,200 tons of uranium. The KPA storage facility can accommodate the spent fuel of approximately 30 years' production of the OL1 and OL2 units.

The expansion of the interim storage is scheduled for the years 2011 to 2014. The original design of the interim storage includes an option for expansion. The expansion will mean the construction of one or more new storage pools in connection with the existing storage.

Interim storage facilities for spent fuel in Loviisa

The transportation of Loviisa's spent fuel to Russia was finished at the end of 1996 due to a change in the Nuclear Energy Act. Subsequently, storage capacity in Loviisa has been increased in the year 2000.

Spent fuel produced in Loviisa is stored in water pools in the power plant's interim spent fuel storage. The existing storage facilities include the reactor's reloading pools located inside the plant units' reactor buildings as well as storage 1 (two pools) and storage 2 (three pools), located in close connection with the power plant. The capacity of the existing storage facilities will be sufficient for the storing of approximately 3,000 fuel bundle assemblies, equivalent to some 375 tU. By introducing densely loadable fuel racks, the capacity of intermediate storage facilities in Loviisa will be increased so that it is sufficient for the requirements of plant units LO1 and LO2. The interim spent fuel storage of the new power plant unit will be designed to cover the life span of the new power plant unit.

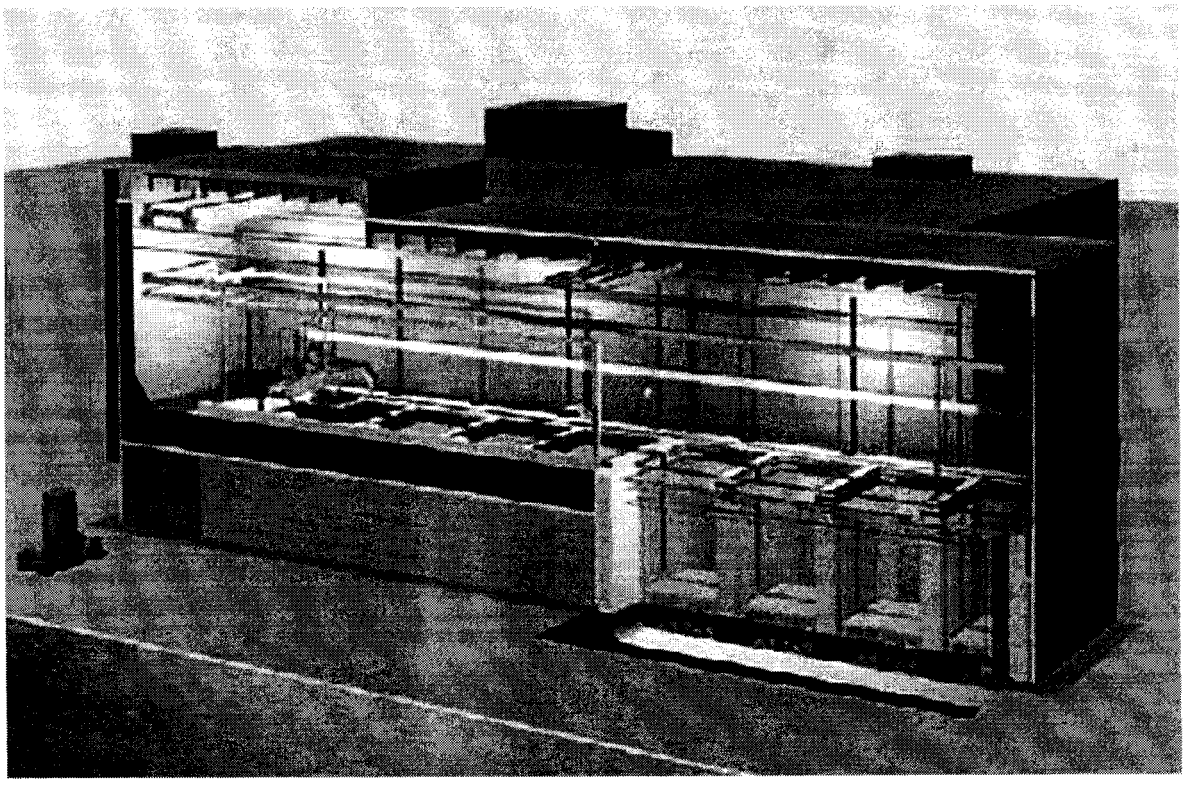


Figure 12-2 Computer image of the interim spent fuel storage of the Loviisa power plant.

12.1.1 Impacts of the interim storage

Interim storages have a central role in the final disposing of spent fuel. During intermediate storing, heat production and activity of the fuel decrease. A longer interim storage time results in lower decay heat and smaller radiation doses. On the other hand, the prevailing global tendency is that discharge burn-ups of the fuel are being increased. This means higher activity and decay heat per spent nuclear fuel mass unit. The impact of higher burn-up can be compensated by storing the assemblies in the interim storage for a longer time before final disposal.

Radioactive releases from the existing interim spent nuclear fuel storages are insignificant. Continuing or expanding the interim storages will not noticeably increase the power plants' radioactive releases. If there are any gaseous emissions, they will be conducted out through filtering, as necessary. Radioactive waters are conducted to the power plant's radioactive water treatment system. During normal operation, the total radiation dose to the population is estimated to be 10-2 manSv at the most, and it is mainly concentrated on people working in the storage. The estimate is applicable to both Loviisa and Olkiluoto interim storages.

If the interim storing of spent nuclear fuel in Olkiluoto and Loviisa is continued and the storage facilities expanded, a larger amount of radioactive substances will be stored in the plants. Most of the spent fuel to be stored is old fuel, which has been cooling off for over five years. From the point of view of security of the handling of spent fuel, the older the fuel is, the easier its handling, as over time heat production and activity of the fuel decrease. Increased storing of fuel over five years old will not have a significant impact on safety issues or accident risks.

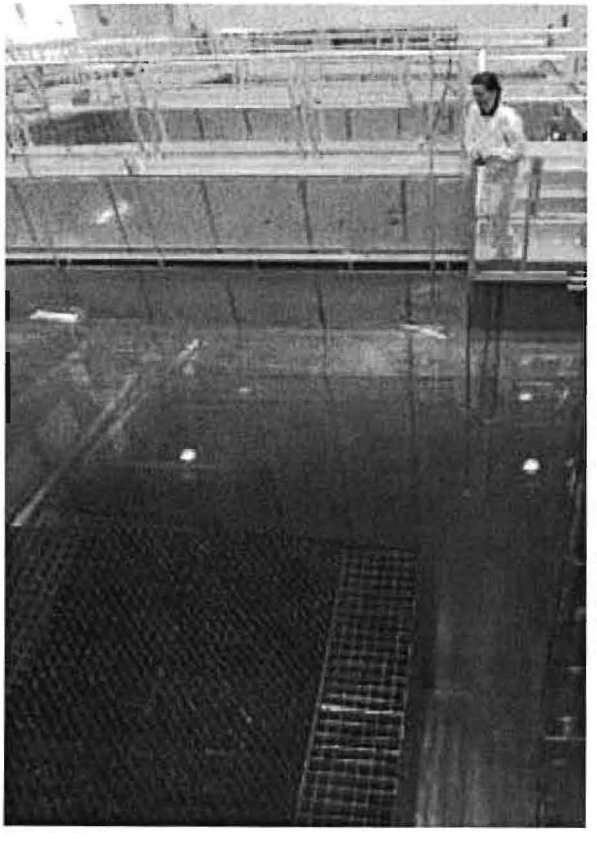
A precondition for safety of the interim storage is that the storages and the fuel are actively managed. Should this management for one reason or another end, the storages would cause a considerable threat to the environment. In the long run, the safety of the interim storage depends on human actions, which means that also future generations must commit themselves to using resources in the management of the waste storages.

Comparing the safety of interim storages and the repository, similar safety and emission standards are applied to them both during operation. Both alternatives provide good protection from radioactive substances for people and the environment.

Other environmental impacts of the interim spent nuclear storage and its continuation are insignificant. As the amount of spent fuel increases, the volume of heat conducted from the interim storage to the sea will slightly increase. However, it is very small compared to the volume of heat of the power plant's coolant water. Compared with power plant buildings, the interim storages are very small and their impact on the landscape is not significant, even after eventual interim storage expansions.

The continuation of storing in water pools cannot be a realistic alternative to a repository as the environmental protection objectives and legislation require that spent fuel be permanently disposed of in Finland. Should the Government and the Parliament, when considering the decision-in-principle of the expansion of the repository, come up with a negative solution, this would mean the implementation of the zero option, and the decision concerning permanent placing would be postponed to the future.

Even if the development of other alternatives, such as nuclide partitioning and transmutation, would be followed, eventually one would have to revert to the repository solution. This is due to the fact that the residual nuclear waste from reprocessing as well as from nuclide partitioning and transmutation would most probably be stored and disposed of in Finland.



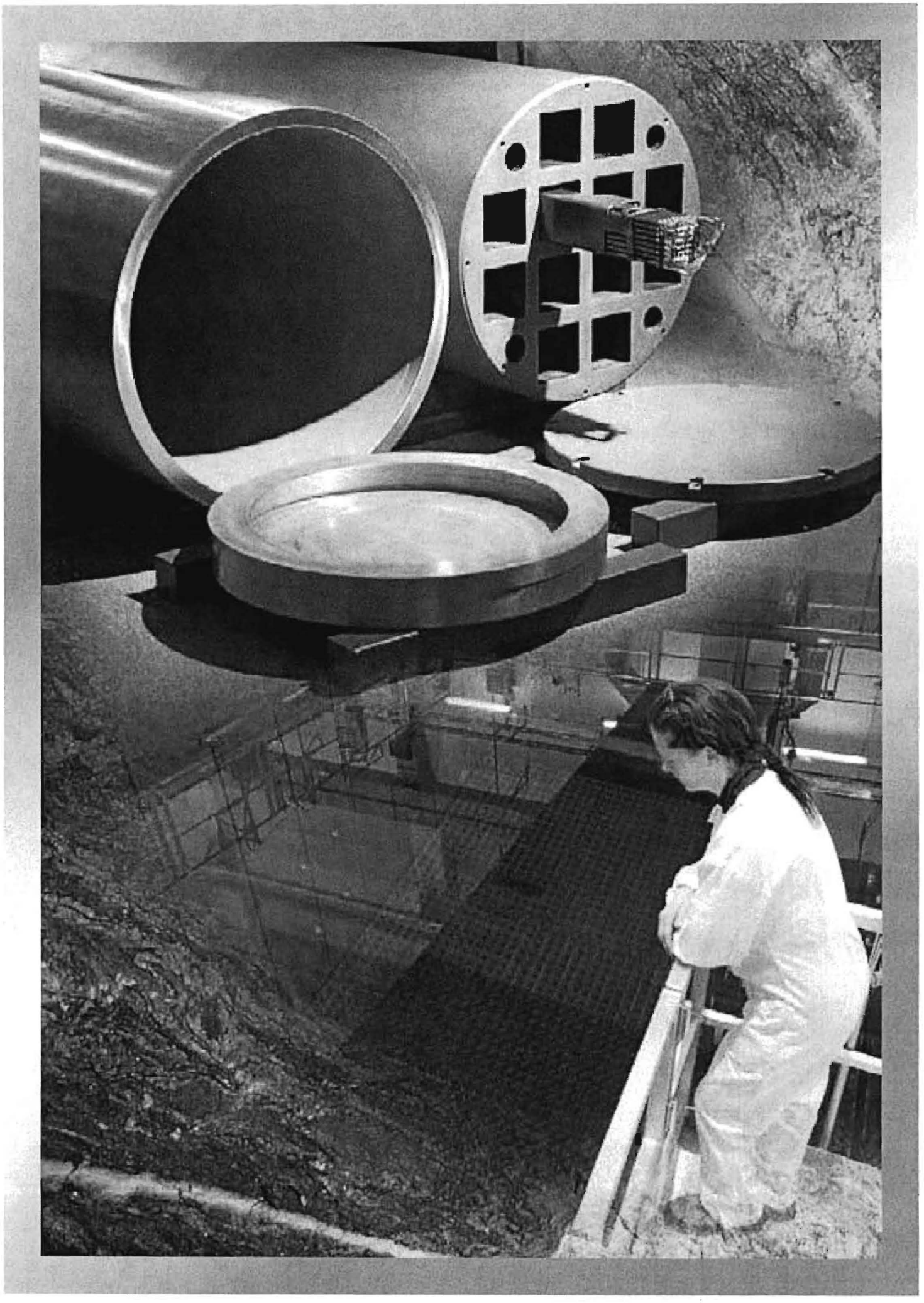

Kola Peninsula
NORWEGIAN SEA
SWEDEN
FINLAND
NORWAY
R U
ESTONIA
LATVIA
DENMARK
LITHUANIA

13 Information on eventual transboundary environmental impacts

This chapter presents a summary of the repository's impacts that may cross Finnish borders. No transboundary environmental impacts associated with the expansion of the disposal facilities from 9,000 to 12,000 uranium-tons have been identified. The only operations or actions that can have an impact on other countries are related to the radionuclide emissions in the final disposal. Doses caused by the assumed malfunction and accident conditions remain, even in the immediate vicinity of the repository area, below the limit value. The doses in neighbouring countries would be smaller by several orders of magnitude as the distance from Olkiluoto to, for example, mainland Sweden is more than 200 kilometres.

Impacts of various types are described in Sections 9, 10 and 11.

The Radiation and Nuclear Safety Authority (STUK), which is the authority that supervises the safety of nuclear power plants in Finland, stated in its statement on the decision-in-principle in 2001 that the operations of the repository do not include any significant safety risks and that the plant's preliminary designs are appropriate and sufficient. STUK also stated that the transportation of nuclear fuel or the disposal operations do not involve the danger of a large accident that could contaminate the environment.



14 Comparison of alternatives and the significance of environmental impacts

14.1 General

Environmental impacts have been inspected by comparing the changes caused by the implementation of the project to the zero option. The significance of the impacts have been assessed on the basis of the size of changes and by comparing the impacts of the construction and operation of the repository expansion to the radiation dose limit values, environmental quality norms and the area's current situation. Special attention has been paid to the investigation and description of the impacts considered important in the feedback received during the EIA procedure, as well as social impacts caused by the project. Relevant factors from the point of view of the significance of the impacts are

- regional scope of the impacts
- the object of the impacts and its sensitivity to changes
- the significance of the object of the impacts
- the recurrence or permanence of the impacts
- the intensity of the impacts and the extent of the change caused by them
- fears and uncertainties associated with the impacts.

14.2 Comparing alternatives

14.2.1 Impacts of the final disposing of larger volumes of fuel

The environmental impact of the repository in the situations where 6,500 tU, 9,000 tU and 12,000 tU, respectively, of spent fuel would be disposed of in the repository is shown in Table 14-1.

14.2.2 Comparison of vertical and horizontal placement

In principle, functional requirements are similar in the horizontal and vertical placement solutions. In the horizontal solution, the accuracy requirements for the drilling of the disposal tunnel and the installation of the waste package and bentonite blocks in the tunnel are technically more demanding than in the vertical placement solution. Due to its smaller size and round profile, the disposal tunnel, on the other hand, is more stable in terms of rock mechanics in the horizontal placement solution than in the vertical placement solution. In horizontal placement, there is not as much open rock facility as in the vertical placement solution. As a result of smaller excavation and filling volumes, material flows are smaller, a fact that may reduce the disposal costs compared to the vertical placement alternative. The tunnel boring method of the final disposal tunnels, on the other hand, may require more water and energy compared with the vertical placement excavations.

14.2.3 Comparison of implementation and zero option

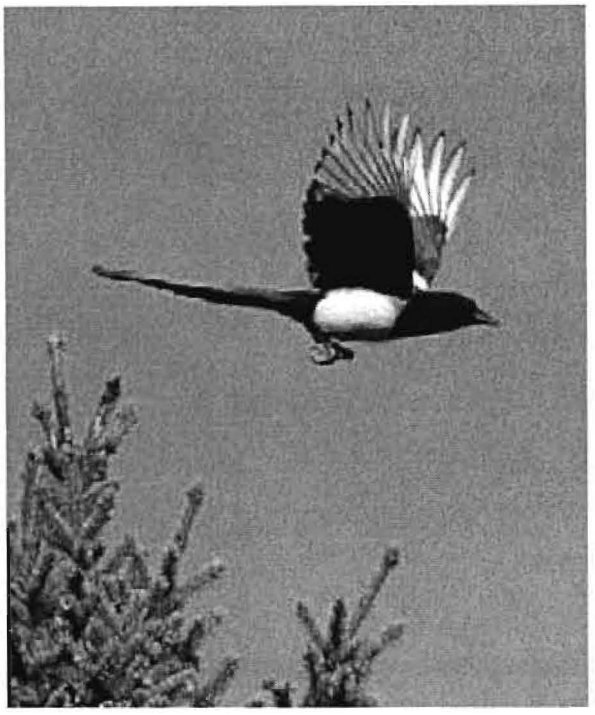
Environmental and human protection requirements can be met in both the zero option and the implementation option. However, safety of the zero option necessitates monitoring of the water pool storages and their continuous maintenance. Operational safety is not a problem in either of the options.

The possibility to avoid continuous maintenance is a factor that especially supports the expansion of the repository. By disposing of spent fuel in accordance with the repository solution, future generations are not obliged to do anything to protect their health or the environment. Despite this, however, the future generations do have alternatives: if they so wish, they can return the spent fuel to the surface.

After comparing the zero option and the project option, the final conclusion is that

- storing in water pools transfers the obligation to continuously maintain the storage to future generations
- storing in water pools does not offer protection for long-term risks caused by social situations.

According to current thinking, the disposing of spent nuclear fuel in a repository is less risky than storing spent nuclear fuel in an interim storage.



14.3 Significance of the impacts

An increased volume of fuel prolongs the operational phase of the repository and postpones the closing phase. The nature of operations remains similar. In addition to the duration of the repository's operational and closing phases, the size of the underground disposal facilities as well as the length and number of tunnels to be built will change. The area with an impact on groundwater possibly widens, and the amount of rock material increases.

The traffic volume pertaining to the repository will be low, and the repository will not have a major effect on the traffic volume or its impacts. Expansion of the repository facilities will not have any impact on the daily traffic volume.

The crushing of quarried materials generated from the excavation of the repository facilities is the largest single noise source in the Olkiluoto area. The fact that the crushing plant is located in the middle of the island will reduce the noise impact outside the island, however. In the eastern parts of Olkiluoto Island, traffic will cause more noise than the crushing plant.

Negative impressions associated with the repository cause suspicion and even fear towards the facility. These impacts can be mitigated to an extent with open and active discussion and communication. According to the survey, the attitudes toward nuclear waste in municipalities containing a nuclear power plant were, as previously, more positive than the average in the country. In recent surveys and interviews, the major concerns associated with the final disposal of spent nuclear fuel have been a possible import of nuclear waste from abroad, transport, and long-term safety. The residents in Eurajoki deemed the economic and employment benefits from nuclear power and the final disposal of nuclear fuel important. People in the region's municipalities are also satisfied with the project's positive impacts on the regional economy.

From the point of view of radiation safety, the expansion of the repository has no significant impact on people living in the vicinity. The increase in the volume of fuel does not have a significant impact on the security of the repository. According to security assessments, it is probable that for millions of years, radioactive substances will not be released from the canisters. The copper canister is designed to completely isolate harmful substances from the environment; thus, the repository can only cause health impacts if one or more canisters are broken. Even in this case, the final impacts depend on how fast the radionuclides dissolve and access the living environment through the repository system's other release barriers (bentonite barrier, bedrock). As the eventual adverse impacts are assessed, attention must be paid to the probability of canisters breaking and, on the other hand, to the absorption and migration of radionuclides.

If a certain probability of a defect in a single canister is assumed, the probability of the existence of a leaking canister in the repository is roughly comparable to the number of canisters. If the amount of fuel to be disposed of in the repository is doubled, the mean value of the number of broken canisters is doubled. However, as the probability of a defective canister in the repository is very small, the doubling of this probability does not cause a significant health risk. Furthermore, attention must be paid to the fact that even if there were several leaking canisters in the repository, it is unlikely that the leaks would take place at the same time and would drift to the same place on the ground surface and be able to affect the same person. If the repository system functions as planned, the increase in the amount of fuel is not significant from the point of view of the repository's health impacts.

As a conclusion it can be stated that the assessment of the environmental impacts of the expansion of the repository facilities did not reveal any remarkable negative environmental impacts that could not be accepted or reduced to an acceptable level.

14.4 Uncertainties of environmental impact assessment

The available environmental data and the assessment of impacts always involve assumptions and generalisations. Final disposal operations are scheduled to begin in 2020 and end in approximately 2120. The report strives to take into account also the long-term safety of the repository, that is, the time following the closing of the repository, which means that the assessment spans to hundreds of thousands, possibly millions of years. Therefore, available technical data is still only preliminary, and under continuous research and development. Lack of sufficient data may cause uncertainty and inaccuracy in the assessment work.

When assessing the environmental impacts of the project, the project's long life span is a problem. Assessment of factors of a distant future is unsure. This applies especially to social impacts that much depend on future generations, their decisions and practical actions. On the other hand, changes in attitudes that may take place in the society, especially general attitudes to nuclear power, may impact socially constructed impacts, and especially how the repository is accepted.

During the assessment work, the potential uncertainty factors have been identified as comprehensively as possible and their impact on the reliability of impact assessments has been considered. These matters are described in this assessment report.

14.5 Environmental feasibility of the project

When appropriately handled, spent nuclear fuel disposed of in the expansion facilities of the repository will not cause adverse effects to the environment or people.

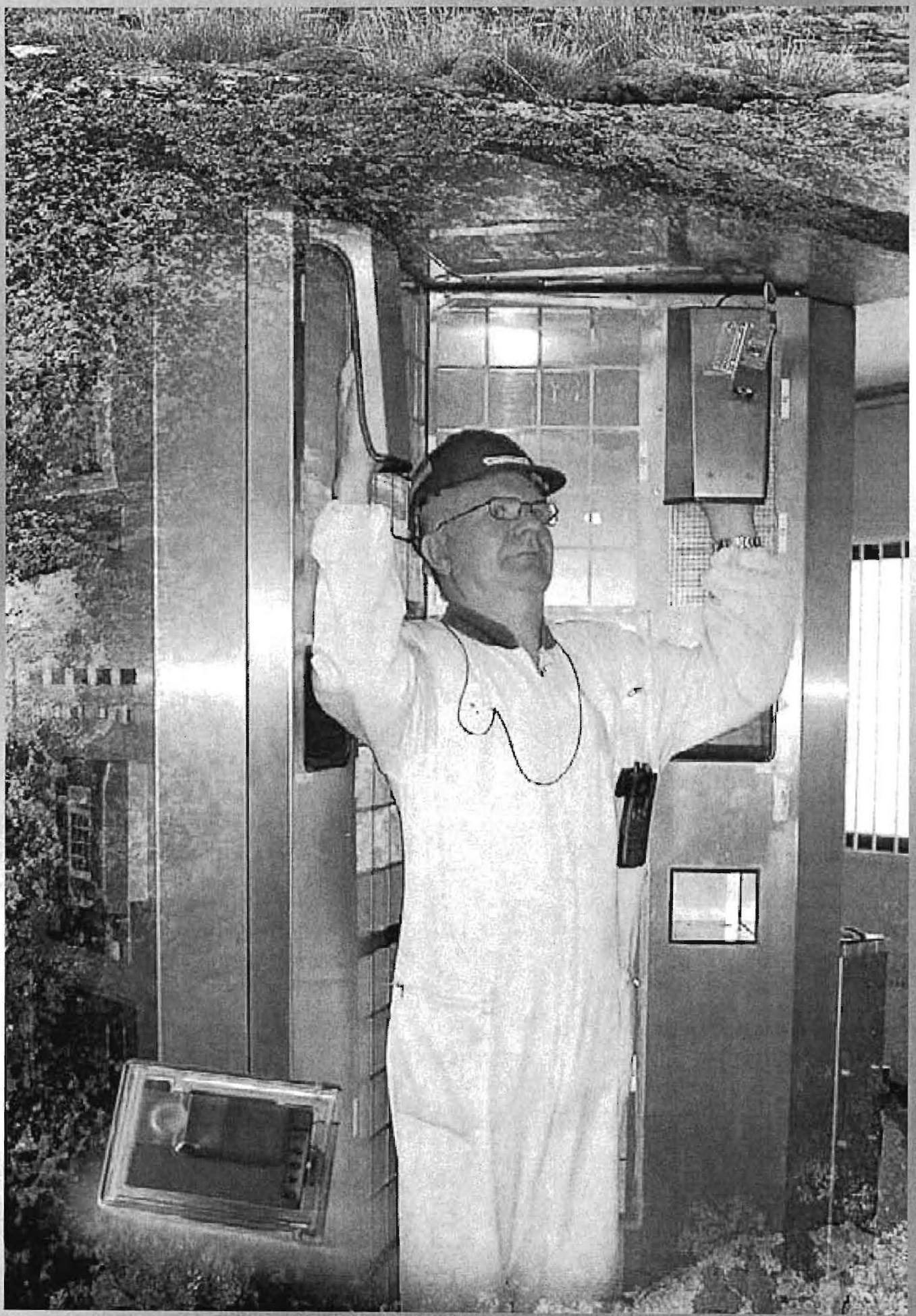
As a conclusion it can be stated that the assessment of environmental impacts of the expansion of the repository facilities did not reveal any remarkable negative environmental impacts that could not be accepted or reduced to an acceptable level.

At the moment, no such methods exist that could be used to completely dispose of nuclear waste, and these methods are not to be expected in the future either. According to current understanding, nuclear waste would exist even in the case that some of the researched nuclide partitioning and transmutation methods would prove to be feasible. The requirement stipulated by nuclear energy legislation to permanently dispose of nuclear waste in the Finnish bedrock has to be solved either now or later, in one way or another. The zero option transfers this solution to the future.

Table 14-1 Environmental impact of the repository when 6,500 tU, 9,000 tU or 12,000 tU of spent nuclear fuel would be disposed of in the repository.

	6,500 tU	9,000 tU	12,000 tU
Impact of transportation and traffic	The traffic volume pertaining to the repository will be low, and the repository will not have a major effect on the traffic volume or its impacts. For transport, an expansion of the repository means that the operation will continue as before, but there will be transportation for a longer period of time. Expansion will not have any impact on the daily traffic volume.		
Impact on land use, landscape and buildings	An area for the underground facilities required by final disposal has been defined in the partial master plan. The final size of the area will be determined by where the best bedrock for the repository purposes can be located at the disposal depth. The expansion of the repository facilities may require construction of new vertical shafts outside the current plant area for the ventilation system and as exit routes. A building of approximately 20 m² would be built at a vertical shaft, and the building would be separated from the rest of the area with a fence. Other above ground buildings will already be built before starting the final disposal operations.		
Impact on the soil and bedrock	Underground quarrying for the disposal facilities will continue for the entire operating period of the repository. An increased amount of quarried material will enlarge the pile of rock waste and, thus, further expand the repository area. If the quarried material will be sold as construction material elsewhere, the repository area will not expand.		
• Size of the underground repository area	150 ha	190 ha	240 ha
• Total length of underground tunnels	64,000 m	82,000 m	104,000 m
• Amount of quarried materials generated	1,450,000 m³	1,670,000 m³	2,080,000 m³
•Impact of heat generation on the bedrock	The total heat production of the repository is roughly in direct proportion to the number of waste canisters in the repository. The temperature in the area immediately around the canisters is not assumed as especially responsive to the total number of canisters stored in the repository since the canisters will in any case be placed separate from each other in order to avoid overly high temperatures. The maximum land uplift after more than 1,000 years will be 7 centimetres.		
Impact on groundwater			
• Amount of water leaking into the tunnel system	The amount of water flowing to the expansion part will be 0.11–0.14 l/min for each 100-metre section of open tunnel. Assuming that the entire tunnel capacity to be excavated is open at a time (an overestimation of consequences), the total volume of water flow will increase 25–30 l/min when implementing the 12,000-tU instead of the 9,000-tU alternative.		
• Decrease in the groundwater level	The most significant decrease in the groundwater level is due to the construction of ONKALO. The impact of the repository expansion is less significant, since the rock cavity volume open at any one time remains more or less constant. Assuming that the entire tunnel capacity to be excavated is open at a time (an overestimation of consequences), there is an average decrease of 2–4 metres in the groundwater level when implementing the 12,000-tU instead of the 9,000-tU alternative.		
Impact on air quality	The traffic caused by the expansion will not have any major impact on the air quality.		
Impact on waters	The expansion will not have any impact on water consumption or the amount of wastewater at a daily level. The facility will simply be used for a longer time if more fuel is to be disposed.		

Noise impact	The crushing of rock waste will cause noise in the daytime. Crushing will end when all spent nuclear fuel has been disposed of. Expansion of the repository will have practically a nonexistent impact on the noise zones. If the amount of fuel to be disposed of increases, the repository will simply remain in operation longer. Some noise may be caused by the excavation and drilling of any new shafts required. This will be short-term due to the fact that the raise boring method will be used, and the excavation and drilling will not take long.
Impact on vegetation, animals and areas of conservation	According to the Natura assessment, the repository will not have a significant impact on the values which have contributed to the fact that the Liiklankari area has been included in the Natura 2000 conservation programme.
Impact on human health	An increase in the amount of fuel to be disposed of or in the length of the operating time will not have a major impact on the radiation doses that an individual member of the public receives as a consequence of normal operation of the plant, anticipated operational occurrences or postulated accidents. However, the total dose received by the public as a consequence of the repository operation, as well as the probability of an operational transient or an accident occurring during the entire operational life are all increased in approximately direct proportion to the increase in the quantity of fuel. An increase in the amount of fuel will not, therefore, cause an increase in the health risks on an individual level. As for the health risks to the entire population, these are increased in approximately direct proportion to the increase in the quantity of fuel.
Attitudes towards final disposal	According to the theme interviews conducted in 2008, the interviewees did not consider the expansion of the repository to have any significant impact. Nearly all of the interviewees had neutral or approving attitudes towards the expansion of the repository from 9,000 tons of uranium to 12,000 tons of uranium. The idea was based on the situation that the repository will, nevertheless, be built in the municipality. There were several arguments in favour of the expansion. The expansion mainly aroused concern because many believed it to include plans to import nuclear waste from abroad.
Long-term safety	The probability of a single faulty canister passing the inspections and being disposed of is considered to be independent of the number of canisters. Similarly, the probability that a bedrock fracture intersects with a final disposal hole, enabling rock movement from an earthquake that results in damage to a canister, is considered to be independent of the number of waste canisters. The number of any damaging canisters in the repository and the resulting volume of radioactive substances released in the bedrock, the total volume of radioactive substances reaching the ground surface and radiation impact on people and the other living environment will roughly be in proportion to the total volume of disposable fuel. Radioactive substances released from the repository for spent nuclear fuel in the long term will not have any significant impact on people and the other living environment. This applies to all of the fuel volumes inspected in the table.



15 Prevention and reduction of negative effects

During the planning of the repository and the assessment of environmental impacts, the work group examined possibilities to prevent, limit or reduce the adverse impacts of the project by means of planning or implementation.

15.1 Planning grounds of radiation protection

The Decision of the Government 478/1999, section 4, requires that the repository and its operation must be so planned that

- when the plant is in operation trouble-free, discharges of radioactive substances to the environment remain insignificantly low;
- the effective annual dose to people who are not part of the staff and who would be the most exposed due to anticipated operational transient remains under 0.1 millisieverts (mSv)
- the effective annual dose to people who are not part of the staff and who would be the most exposed due to a postulated accident remains under 1 millisieverts (mSv).

Under no review period of time may final disposal of nuclear fuel pose any health-related or environmental impacts that exceed the maximum level approved at the time the final disposal is carried out.

The final disposal facility is planned so that the resulting radiation effects of probable developments would not exceed the above stated maximum values.

Limitation of the release of radioactive substances

Operating activities of the final disposal facility and its structures and systems are planned so that the release of radioactive substances to the facilities and the environment is prevented or limited by all practical means. The plant is equipped with systems to collect the radioactive substances released in the processing facilities, to clean radioactive substances from the surfaces and to process and appropriately pack all accumulated radioactive waste.

Facilities where significant doses of radioactive substances may be released are equipped with ventilation and filtering systems, which will

- reduce the concentrations of radioactive substances in these facilities
- prevent the spreading of radioactive substances to other facilities
- prevent access of radioactive substances to the environment.

These ventilation and filtering systems will operate as designed also during an anticipated operational transient or postulated accident.

The planning of the final disposal facility ventilation systems follow the Guide YVL 5.6 "Air-conditioning and ventilation systems and components of nuclear facilities", as applicable.

Limitation of occupational exposure to radiation

Working areas and passageways in regular use in the disposal facility shall be designed and located so that the external dose rate is low and the risk for internal exposure to radiation is as small as possible. Structures, systems and equipment containing significant amounts of radioactive substances are placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding.

The areas in the disposal facility shall be classified based on estimated radiation conditions. Facilities requiring radiation control shall be placed within a specified area to allow appropriate limit and control of access. In setting the protective measures and safety provisions for the underground controlled areas, the specific features concerning work in those areas is taken into account. Such conditions and premises are ensured, by design and planning, for the operation, inspection and maintenance of equipment that the need for and duration of work under radiation is limited.

Devices with an alarm function shall be employed for radiation monitoring so that during the operation of the disposal facility, significant unintentional exposure to radiation will not occur.

In the designing of the repository's radiation protection systems, the Guides YVL 7.9 "Radiation protection of workers at nuclear facilities" and YVL 7.18 "Radiation

safety aspects in the design of a nuclear power plant" are followed, as applicable. The Guide YVL 7.11 "Radiation monitoring systems and equipment of a nuclear power plant" is applied to radiation monitoring systems and equipment.

Radiation survey

The purpose of radiation survey is to protect people, animals and the environment from significant radiation doses by controlling radiation and activity levels. The major source of airborne radioactivity is supposedly radon, which is released from rock to the underground facilities. Besides radon gas, the employees are exposed to radiation doses emanating from disposal canisters.

The radioactivity of exhaust air is continuously measured. If any radioactivity from spent fuel is detected in the air, the exhaust air system of the repository is switched off and the source of the radiation leak inspected. When necessary, the repository's exhaust air is recycled through the exhaust air duct of the controlled area and the ventilation of the encapsulation plant's controlled area. If the radon content of the air exceeds the allowed limit, ventilation is increased.

In practice, people can only be exposed to radiation emanating directly from the fuel canister, not as a result of releases. This means that the fuel canister's transfer route forms an area where people and movements are registered and radiation doses are reliably measured. In practice, this kind of an area is separated as a closed, controlled area, accessed via one checkpoint. Radiation doses to staff and visitors are registered at the checkpoints.

It is not necessary to separate the leak waters of the repository's controlled area from the uncontrolled area's leak waters as it is very unlikely that the leak waters should be contaminated.

15.2 Prevention of incidents and accidents and management of consequences

In the planning of the repository, incidents and accidents have been taken into account. Prevention of accidents is the leading principle covering all the plant's operations.

Compliance with the safety requirements concerning the undisturbed operation of the repository shall be demonstrated by analyses and verified during the commissioning tests of the facility. The performance of safety systems designed for operational transients and accidents shall also be, whenever practicable, tested during the commissioning of the facility. The applicable requirements of Guide YVL 2.5 "The commissioning of a nuclear power plant" shall be followed in the commissioning of the facility.

Compliance with the safety requirements concerning anticipated operational transients and postulated accidents shall be demonstrated with analyses that cover potential transients and accidents of different nature and severity at the disposal facility. With regard to the representativeness of these analyses, it is essential to consider the cases which are the most limiting ones to the performance and dimensioning of each safety system.

Compliance with radiation protection requirements shall primarily be demonstrated by a deterministic safety analysis. Such an analysis shall be attached to the preliminary safety analysis report and the final safety analysis report.

Prevention of canister damage

A quality assurance and inspection programme is applied to the manufacturing, filling and sealing of canisters in order to ensure that the fuel canisters are intact and tight when they are transported to the repository and that their other features also meet the criteria set to them.

The final disposal of canisters takes place in facilities that have been classified as radiation controlled areas, and the construction of the repository takes place in a non radiation controlled area. Controlled and uncontrolled areas are physically separated from each other, and goods and materials are transported via separate routes.

A sufficient safety distance to damp vibration caused by the excavation work is left between the excavated tunnels and repository tunnels where the canisters are placed. Construction materials, machines, explosives and rock waste are transported through an access tunnel. Fuel canisters are transported via the canister shaft or alternatively via the access tunnel. Bentonite blocks of the deposition holes are transported via the canister shaft. If the canisters are transported following the alternative design solution through the access tunnel, transportation events of different type will be separated from each other in terms of time.

Prevention of criticality accidents

The formation of such spent nuclear fuel configurations that would cause an uncontrolled chain reaction of fission shall be prevented by means of the structural design of systems and components.

The transport casks, storage rooms and handling equipment for spent nuclear fuel as well as the waste canisters shall be designed so that no critical fuel configurations may be formed in any operational situations, including any anticipated transient or postulated accident. The disposed canisters shall retain their subcriticality also in the long term, when the canister's internal structures may be corroded and it is partly filled with groundwater.

Criticality safety calculation assumptions (such as the degree of fuel enrichment and burn-up as well as the safety margin of an effective multiplication factor) are chosen conservatively.

Prevention of fire or explosion hazards

The disposal facility is designed so that the likelihood of a fire is low and its consequences are of minor importance to safety. Explosions that would jeopardise the integrity of spent nuclear fuel assemblies, waste canisters, or the components or chambers containing radioactive substances, are reliably prevented.

The objectives for the design of fire safety of the disposal facility include

- prevention of the ignition of fires
- rapid detection and extinguishing of fires
- prevention of the propagation of fires into areas where a fire could compromise the safety of spent fuel handling or storage
- minimisation of explosion hazards.

The prevention of fires and explosions in the disposal facility shall be primarily based on its layout and on the design of fire compartments. Materials are primarily incombustible and heat resistant. Materials or equipment that would increase fire load or that would cause ignition or explosion hazard will not be unnecessarily placed in fire compartments that are important to safety, or in their immediate vicinity. Facilities with significant fire load concentrations are separated into different fire compartments.

The disposal facility shall be equipped with an automatic fire alarm system designed so that a fire can be located with sufficient accuracy. Furthermore, the plant's facilities shall be equipped, as necessary, with suitable fire fighting and first-aid extinguishing equipment. The fire alarm and fighting systems shall be effective also during an anticipated operational transient or a postulated accident. In the design and planning of fire safety arrangements, Guide YVL 4.3 "Fire protection at nuclear facilities" shall be followed, as applicable.

Explosives used in rock construction are stored above ground in separate protected storage facilities. Only the allowed amount of explosives are transported at a time, and storage facilities for explosives are placed so that an explosion will not cause risk to the radiation safety of the repository. Explosives are transported from the ground to the repository by a different route or at a different time from the radioactive substances. Explosives are often made of a material that is safe as such and is blended into exploding combinations only at the site. In excavation work, a sufficient safety distance is always left between the site of explosion and tunnels containing disposal canisters.

15.3 Consideration of external events in planning

Impacts caused by probable natural phenomena and other events external to the plant are considered in the design of the repository. The natural phenomena to be considered include lightning, earthquakes, storms, floods and exceptional external temperatures. Other events external to the plant include electromagnetic interference, light airplane crashes, wildfires and explosions.

The applicable requirements concerning the concrete and steel structures of a nuclear facility in Guides YVL 4.1 "Concrete structures for nuclear facilities" and 4.2 "Steel structures for nuclear facilities" and those concerning earthquakes in Guide YVL 2.6 "Seismic events and nuclear power plants" are complied with in the design of the repository's aboveground part, as applicable.

15.4 Long-term safety

The long-term safety concept of the final disposal solution is based on the multi-barrier principle designed to prevent access of radioactive substances to living nature. The principle is described in chapters 3 and 11.

15.5 Management of impacts of transport of spent nuclear fuel

A separate permit is required for the transport of spent nuclear fuel during the operation of a disposal facility, and the permits required for the transport of nuclear materials and nuclear waste are issued by STUK. Transportation may not begin before STUK has stated that the transportation equipment, the transportation arrangements and safety and emergency arrangements meet the set requirements and that the nuclear liability in the event of nuclear damage has been properly covered (Nuclear Energy Decree, § 56, § 115). The STUK Guide YVL 6.5 "Transport of nuclear material and nuclear waste" defines the detailed regulations on transport security as well as safety and emergency arrangements and monitoring of transports.

High requirements have been set for the transport cask, handling of the casks, provision for accidents and documentation. Transport casks must not lose their radiation protection features even in the worst conceivable accidents. The spent nuclear fuel in the transport cask must remain sub-critical in all situations during transportation. The requirements set for the transport cask are more strict than usual in the event of exceptional situations.

The purpose of regulations concerning the transportation of radioactive substances is to guarantee the safety of the transportation so that each transport cask used at

a time provides sufficient protection to the environment and the transported substances such that the environment will not be exposed to a greater radiation dose than allowed. Regulations set for the so-called B(U) cask type, based on instructions *(IAEA 2005b)* by the IAEA (International Atomic Energy Agency), are applied to the spent nuclear fuel transport cask. The cask type to be used in the transportation must endure tests, which are used to ensure that the cask type is suitable for the transportation of spent nuclear fuel.

For normal transports it is required that the radiation dose rate must not exceed 0.1 mSv/hour within one metre from the outer surface of a transport cask or 2 mSv/hour on the surface. Furthermore, the cask and the fuel within must endure the fatigue load on materials caused by normal transport vibration. The temperature of transport conditions is significant also for the probability of damage occurring to the materials. During transport, the temperature of the surrounding environment must not be too low. In the case of normal transport, only a very small leak flow to the environment is allowed. According to IAEA regulations, the transport cask must withstand the following in normal transport:

- a jet of water for an hour
- a drop from a height of 0.3 to 1.2 metres to a non-resilient base
- a five-fold plate load compared to the weight of the cask
- a penetration test, where a steel bar weighing six kilogrammes is dropped from a height of one metre towards the side wall of the cask.

Activity caused by the surface contamination of the cask (the potentially radioactive substances on the cask surface) must not exceed 4 Bq/cm² or 0.4 Bq/cm² for some radionuclides.

In exceptional situations, the transport cask for spent nuclear fuel must also fulfil substantially stricter requirements, including

- a drop to a nonresilient base at the least favourable angle of incidence from a height of nine metres
- a drop onto a steel bar with a diameter of 0.15 m from a height of one metre
- exposure for a period of 30 minutes to a fire where the average temperature of flames is at least 800°C
- an immersion to a depth of 200 m for a minimum of an hour.

Tests related to exceptional situations strive to cover all mechanical and thermal loads occurring as a consequence of potential accident conditions, such as impacts to the cask caused by collisions and a fire in a vehicle transporting flammable liquids. Furthermore, it must be considered that in practice the item is not steadfast. In the drop test of nine meters the transport cask will reach

a velocity of almost 50 km/h, which is a realistic potential collision speed against another vehicle or a barrier even in real-life accidents. The spent nuclear fuel in the transport casks must remain sub-critical in all situations during transportation.

Road transports are controlled, and the necessary convoy staff always follow the transportation: the truck driver, signal vehicle drivers, police car drivers and other required people such as the radiation protection supervisor. Several police patrols are needed to safeguard the transport through densely populated areas. A security guard is also needed in the transportation of fuel. Transportation speed limits are low and densely populated areas are avoided.

15.6 Management of impacts caused by excavations and crushing

Adverse impacts caused by noise and other disturbances during excavations and crushing can be mitigated by doing the work in the daytime. The pile of rock waste is used as noise suppression during crushing. The crushing plant and the pile of rock waste can be so placed that no buildings in the area are exposed to noise and dust.

The impacts on the bedrock caused by the underground research facility ONKALO construction site have been examined with Olkiluoto's seismic system. So far no significant changes have been detected. The situation in Olkiluoto is continuously measured with measuring devices, and anything that takes place in the work site can be monitored in real time through the system. Blastings at the ONKALO work site have been of 0.7 magnitude at the most. The results are regularly reported and data is transferred to the Radiation and Nuclear Safety Authority.

15.7 Construction of connections to the ground surface

The entry to the access tunnel and the top of the shafts in the uncontrolled area are so located that they are above the surface level of the Korvensuo reservoir and also sufficiently above sea level to ensure that during an external disturbance water will not flood the access tunnel or shafts. Attention has been paid to existing high-power lines, transformer stations, water pools, pipelines, roads and the location of the potential repository in the bedrock in order to ensure that the entry is well located with regard to them. In the bedrock the access tunnel is so located that as few as possible zones of fragmented rock will be penetrated and that all examinations that are necessary for the characterisation of the desired bedrock areas can be implemented.

15.8 Management of impacts caused by the encapsulation plant

The encapsulation plant will be planned in compliance with safety regulations so that the release of radioactive substances into the environment in operational transients and accidents remains negligible. All work phases in the encapsulation plant will be carried out safely without causing significant emissions and radiation doses to the staff. Requirements concerning the control of nuclear material stated in YVL Guide 6.1 "Control of nuclear fuel and other nuclear materials required in the operation of nuclear power plants" are complied with in the facility. Control takes place using the national system of accounting for nuclear material as well as visual and technical control methods in all the phases of the fuel encapsulation process.

Canister transportation from the encapsulation facility to the underground repository

The transferring of a canister from the ground to the disposal depth can be securely done with a lift. With good planning and simple and reliable construction solutions, transportation safety can be raised to a high level. In addition, reliability, usability and safety will be ensured by maintenance and periodic testing as required for a nuclear facility and by preparing for conceivable accident scenarios.

15.9 Underground repository facilities and safety distances of repository tunnels

During the construction and closing of the repository, efforts are made to maintain the bedrock's original properties and to keep changes in as limited an area as possible around the tunnels and shafts. For example, the rock is excavated carefully so as to keep the excavation disturbance zone as small as possible. Water leaks are limited by avoiding water-bearing structures and by sealing leaking points using, for example, grouting. The total amount of seepage flows is also limited by constructing tunnels and closing them after the disposal canisters have been placed. That is, during the operational phase, the number of volumes of rock open at one time is minimised.

When the central and disposal tunnels are excavated during the operational phase of the repository, sufficient safety distance is left between the excavated object and the repository tunnels because of working technique and general safety. This will ensure that the blast shockwave discharging from the tunnel will not damage, for example, the wall between the controlled and uncontrolled area in the central tunnel.

15.10 Criteria for assessing the suitability of a disposal site

In Finland, the requirements for the capabilities of a disposal site have been recorded in Government's decision regarding the safety of final disposal of spent nuclear fuel (478/1999). The basis for safety regulations is that the capabilities of the bedrock at the final disposal site must, as a whole, be favourable for the isolation of the disposable materials from the living environment. The location to be selected as the final disposal site must not have any attributes that are clearly unfavourable in terms of long-term safety.

The unsuitability of the location may be manifested *(STUK 2001)* in such characteristics as the vicinity to exploitable natural resources, unusually strong rock stress, seismic or tectonic irregularities, and exceptional values of some important groundwater characteristics.

The location of the spent fuel repository is based on rock classification made by place and safety investigations and its suitability criteria. The suitability criteria take into account rock splintering, water conductivity and the canisters' decay heat. Currently, these criteria are subject to development, and research on them will be conducted in the underground research facility ONKALO. The decay heat power impact can be managed by means of positioning – the canisters and repository tunnels can be situated further away from each other – and by ensuring that the areas close to the canisters in the repository are able to transfer heat.

The different sections of the repository will be constructed in stages, so that the studies on the suitability of the plate section to be excavated and the classification of the rock will be conducted before the construction of the stage in question begins. The rock surrounding the repository facilities will be defined and classified in terms of its texture and such characteristics that may have significance to groundwater flow, rock movements and other factors that are important to long-term safety. A provision will be made for a potential change in the underground facility plan in the case that the quality of the rock surrounding the planned facilities proves to be significantly less favourable than the design basis.

If, after the repository has been commissioned, a change or further specification is needed for a system, structure, equipment or operation of the facility that has previously been subjected to approval procedures by the Radiation and Nuclear Safety Authority, the new plans must be approved by the Radiation and Nuclear Safety Authority before they are implemented.

Each final disposal canister containing spent nuclear fuel can be transported after the Radiation and Nuclear Safety Authority has verified that the capabilities of the rock surrounding the site in question are acceptable. When any spent fuel is disposed of, the operating licence holder must, at the time of placing each final disposal canister into the facility, inspect the result material from quality controls in order to verify that the final disposal canister and the surrounding barrier material have been installed in an acceptable manner. The Radiation and Nuclear Safety Authority will take part in the inspection.

15.11 Closing of the disposal tunnels

The disposal tunnels and central tunnels will be backfilled after the final disposal (after the installation of the canister and buffer material) and backfilling is carried out in phases throughout the plant's operation. In addition, the technical facilities of the repository and connections to the surface of the ground, such as the access tunnel and shafts, will be backfilled at the end of disposal operations.

The primary purpose of the filling and barrier constructions is to return the repository's circumstances as close to natural as possible, by, for example, preventing the tunnels and shafts from becoming groundwater's main flowing routes and to prevent unauthorised access to the repository facilities.

15.12 Impacts on groundwater

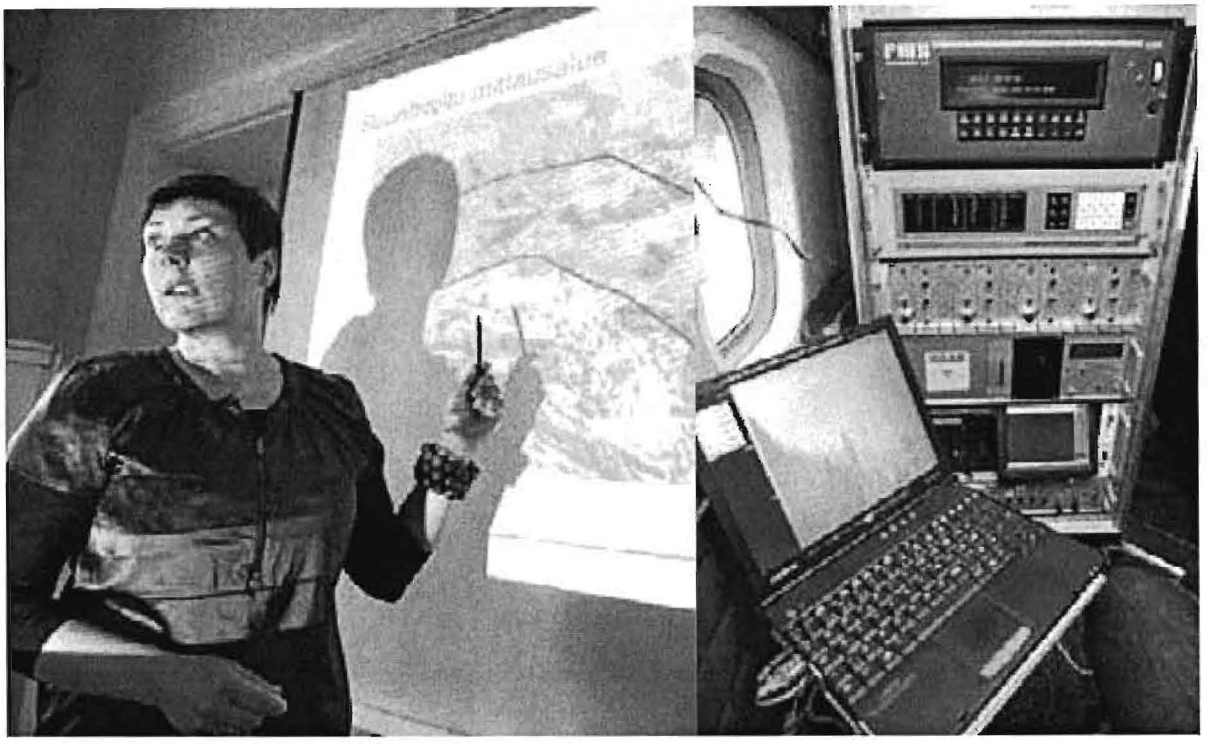
The rock surrounding the repository is sealed with concrete grouting to ensure that the impact of the repository on the groundwater table level remains minor.

15.13 Plant control systems

In the operation phase, the repository is divided into two areas separated from each other: the controlled area and uncontrolled area. Access to the controlled area is monitored due to radiation protection reasons.

All handling of canisters is always carried out in the controlled area. The placing of bentonite blocks in the deposition hole also is performed in the controlled area. The excavation and construction works as well as the filling of the tunnel are done in the uncontrolled area.

Ventilation of the controlled area is separated from the ventilation of the uncontrolled area in order to ensure that the handling and installation conditions of fuel canisters are clean. The radioactivity of the exhaust air in the controlled area is measured, although in normal operation conditions it is not filtered. Exposure to radon is controlled by monitoring radon contents and adjusting ventilation in all the repository's facilities.



Access control in the repository

The purpose of access control is to keep track of who are working in the repository at any given moment and to control access to the controlled area as well as to the uncontrolled area. Modern computer-based access control systems are exploited in access control. In addition to radiation protection related reasons, appropriate access control is associated with the safety of people as the facilities are located deep in the bedrock.

In normal conditions, it is forbidden to cross the boundary between the controlled area and uncontrolled area in the underground facilities. However, in emergency situations such as fire, moving from controlled to uncontrolled areas or vice versa is possible.

Condition monitoring

The purpose of condition monitoring is to monitor the condition of the repository plant and its systems during the operational phase. During final disposal, the condition of the repository is controlled by measuring the amount of leaking water, the rock stress and rock dislocations in the repository. Instrumentation systems are also used for gathering and processing information on the condition of the repository and controlling that working safety is good in the repository.

Control performed by the Radiation and Nuclear Safety Authority

The Radiation and Nuclear Safety Authority (STUK) controls the safety of nuclear waste management, storage and final disposal in Finland. In order to secure appropriate planning for the final disposal of spent nuclear fuel, the authorities have set reporting obligations for nuclear waste producers.

STUK, together with other expert organisations, inspects all research and technical plans aimed at safe disposal of nuclear waste and gives feedback to the implementing party. The most central document is the radioactive waste management research, development and design work programme published by power plants and Posiva every three years.

15.14 Social impacts

Efforts are made to reduce social impacts by minimising the inherently minor impacts of the repository on water, recreational use and landscape. Uncertainties related to safety are reduced through sufficient communication.

16 Monitoring of the project's environmental impacts

16.1 Monitoring of loads and impacts during the operation phase of the repository

On the basis of this assessment report, a proposal on the monitoring of environmental impacts in the Olkiluoto repository has been drawn up. The objective of the monitoring is to

- provide information about the project's impacts
- investigate which changes have resulted from the project implementation
- investigate how the results of the impact assessment correspond with reality
- investigate how the measures for mitigating adverse impacts have succeeded
- initiate the required measures if significant unforeseen adverse impacts occur.

16.1.1 Monitoring of radiation effects

Monitoring of radiation effects is based on the measuring of radioactive releases and concentrations and radiation dose rates. Concentrations and dose rates are also assessed by means of calculation, using information such as release and weather information as it is assumed that, due to the small amounts, radioactive substances cannot be detected in the environment. Anticipated radiation effects are so small that a special monitoring of population health is not deemed necessary: eventual health hazards could not be detected among normal morbidity rates. As necessary, it is possible to compare the health of people living in the area with people from a more remote area with the help of, for example, information from National Public Health Institute.

In order to receive comparative data from various directions and distances, the monitoring of concentrations of radioactive substances and radiation dose rate begins already before the final disposal operations. Concentrations are measured from the air, water, soil, organisms, agricultural products, mushrooms and berries and game. Weather information and other information needed in the assessment of impact calculations is collected, as is already done.

In the final disposal phase, the releases of radioactive substances to the environment are measured. Typical measuring points include ventilation air and wastewater discharge routes. Measurements of concentrations and dose rates already started will be continued.

16.1.2 Monitoring of other impacts

The environmental impacts will be monitored by means of a monitoring programme. Presented here is a tentative list of topics to be included in the programme:

- radiation effects in the environment
- concentration of natural radon gas in underground rock facilities
- groundwater table level in the area around the rock facilities
- vegetation distribution in the groundwater impact areas
- levels of vibration caused by overburden excavations in the nearby buildings
- image of Eurajoki
- occurrence of radiation fears
- socio-economic impacts.

Other monitoring obligations may be imposed on, for example, noise and dust in connection with later licensing processes.

16.2 Monitoring after the closing of the repository

Monitoring measurements carried out by Posiva will be finished once the plant is closed in a manner approved by STUK. In the closing phase, Posiva will draw up a proposal of a monitoring programme for the time following the closing, and pays the state a lump-sum settlement. This money will be used by the authorities for the monitor-

ing and control they deem necessary. However, the final disposal must be carried out in such a manner that it is safe also without follow-up monitoring.

Central to the follow-up monitoring is to examine how the bedrock has returned to the state prior to the construction. Monitoring of bedrock conditions has been examined in several international projects.

Monitoring after the closing may include measuring of radioactivity on the ground and in deep boreholes. The holes may also be used to monitor groundwater table levels, currents, chemistry, temperature etc. On the ground, geophysical measurements could be used to monitor micro-earthquakes. Compromising the untouchability of the nuclear material with illegal activity would involve operations that would be visible above ground. The actions would be detected and internationally monitored from, for example, satellites.

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STATEMENT
22 August 2008 820/815/2008
UNOFFICIAL TRANSLATION

ENVIRONMENTAL IMPACT ASSESSMENT PROGRAMME FOR EXTENSION OF POSIVA OY'S PLANNED FINAL DISPOSAL REPOSITORY FOR SPENT NUCLEAR FUEL

On 13 May 2008, Posiva Oy submitted an environmental impact assessment programme (the EIA programme) to the Ministry of Employment and the Economy (hereinafter also 'the MEE') in accordance with the environmental assessment procedure (the EIA procedure), pursuant to the Environmental Impact Assessment Act (468/1994; EIA Act), on the extension of a planned final disposal repository for spent nuclear fuel. Prepared by the organisation responsible for the project, the EIA programme presents a plan for the necessary studies and implementation of the EIA procedure. The EIA programme also includes a description of the present state of the environment in the area likely to be affected.

Pursuant to the EIA Act, the Ministry of Employment and the Economy will act as the contact authority in the EIA procedure.

A public notice announcing the launch of the EIA procedure was published on 27 May 2008 in the following newspapers: Helsingin Sanomat, Hufvudstadsbladet, Satakunnan Kansa, Länsi-Suomi, Turun Sanomat and Uusi Rauma.

The public notice, the EIA programme, and the comments and opinions received by the MEE are available on the Ministry of Employment and the Economy's website: (address www.tem.fi).

Members of the public were able to view the EIA programme between 27 May and 25 July 2008 in the local government offices of Eurajoki, Eura, Kiukainen, Lappi, Luvia and Nakkila and in the environmental office in Rauma.

Together with the party responsible for the project, the MEE organised a public meeting to discuss the project on 9 June 2008 in Eurajoki.

The comments and opinions invited and presented on the EIA programme are handled in Chapter 3.

The Espoo Convention (SopS 67/1997) will be applied to the assessment of the project's cross-border environmental impacts. The parties to the Espoo Convention have the right to participate in the EIA procedure in Finland, if they so wish and consider the adverse effects of

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the project to have a potential impact on their regions. The Ministry of the Environment, responsible for the practical arrangements for conducting the international hearing, has notified the following countries of the project: Sweden, Denmark, Norway, Germany, Poland, Lithuania, Latvia, Estonia and Russia.

1 Project information

1.1 Organisation responsible for the project

The organisation responsible for the project is Posiva Oy, owned by Teollisuuden Voima Oyj and Fortum Power and Heat Oy. Posiva's consultant for the environmental impact assessment procedure is Pöyry Energy Oy.

1.2 Project and its alternatives

The project involves an extension to the planned final disposal repository for spent nuclear fuel at Olkiluoto in Eurajoki so that after the extension, the facility would allow the final disposal of a total of 12,000 uranium tonnes of spent nuclear fuel instead of 9,000. The extension is related to the planned new nuclear power plant units in Olkiluoto and Loviisa.

The size of the extension would correspond to the space required for final disposal of spent nuclear fuel generated during the estimated operating life of one nuclear power plant unit.

The underground repository will be constructed in bedrock, at a depth of 400 to 700 metres, and the area required for the underground repository will expand from some 190 to 240 hectares.

Construction of the final disposal repository will begin in the 2010s, and the facility will be commissioned around the year 2020. Extension to the repository depends on decisions concerning the construction of potential new nuclear power plant units. Use of the extended facilities would begin at the earliest in the 2070s.

In 1998-1999 an EIA procedure was carried out concerning a final disposal repository of spent nuclear fuel up to 9,000 uranium tonnes, a quantity which covered, in addition to the four active plant units in Finland, the fifth nuclear power plant unit under construction in Olkiluoto, and the final disposal of spent nuclear fuel generated by a potential sixth plant unit, to be constructed later.

The extension currently under assessment prepares for final disposal related to a potential seventh unit to be built. The EIA involves an environmental impact assessment for 12,000 uranium tonnes.

2 Licensing procedures for a nuclear plant, and current status

Under the Nuclear Energy Act (990/1987 NEA), a licensee whose operations generate or have generated nuclear waste, shall be responsible for all nuclear waste management measures and their appropriate preparation, as well as for their costs. According to the Act, spent nuclear fuel is nuclear waste. In compliance with the 1994 amendment to the Nuclear Energy Act, nuclear waste generated in Finland shall be handled, stored and permanently disposed of in Finland. Nuclear waste generated elsewhere than in Finland shall not be handled, stored or permanently disposed of in Finland.

Transports of spent nuclear fuel are subject to a licence under the Nuclear Energy Act. Therefore, a licence in compliance with the Nuclear Energy Decree (161/1988, NED) must be applied to transports.

Pursuant to the Nuclear Energy Act, the decision-making and licensing system is based on a principle of continuous safety reviews, and the specification of assessments throughout the licensing procedure. Final safety assessments will only be made at the operating licensing stage.

The final disposal repository and the encapsulation plant will also be subject to other licences and permits, such as an environmental permit, a building permit issued by the local government, and permits under the Water Act. For the purpose of transporting spent nuclear fuel, e.g. permits in accordance with legislation regulating the transport of hazardous substances will be required.

2.1 Environmental impact assessment

The EIA procedure in compliance with the EIA Act forms one part of the assessment of safety and environmental impacts of the final disposal repository, related to the decision-in-principle in accordance with the Nuclear Energy Act.

Posiva Oy will compile an EIA report on the basis of the EIA programme and the statement issued thereon by the contact authority. The EIA procedure will continue with a public hearing concerning the EIA report. The responsible organisation estimates that the EIA report will be finished in the autumn of 2008.

An EIA procedure was carried out for the final disposal project for spent nuclear fuel in 1998–1999. The basic solution was the final disposal of spent nuclear fuel generated by Olkiluoto plant units 1 and 2, and Loviisa plant units 1 and 2 during 40 years in operation, involving a quantity of approximately 2,600 tonnes of uranium. The assessment was also carried out for a situation whereby the operating life of the aforementioned units was 60 years, in which case the total quantity of spent nuclear fuel amounted to around 4,000 tonnes of uranium. The assessment also included a scenario in which, in addition to the spent nuclear fuel generated by the aforementioned four plant units, the spent nuclear fuel generated by two new plant units to be constructed in Finland, totalling a maximum of 9,000 tonnes of uranium, would be placed in the final disposal repository.

2.2 Decision-in-principle

The final disposal repository of spent nuclear fuel complies with the definition of a nuclear plant of considerable general significance, as laid down in the Nuclear Energy Act, requiring the Government's project-specific decision-in-principle on whether the construction project is in line with the overall good of society.

According to the Nuclear Energy Decree, e.g. the EIA report must be attached to the application for a decision-in-principle. The scope of the project, outlined in the application for the decision-in-principle, may not exceed that described in the EIA report.

Handling of the application for the decision-in-principle is not solely based on the material provided by the applicant. The authorities will acquire supplementary reports, both those required pursuant to the Nuclear Energy Decree and other reports deemed necessary, providing a broader analysis of the project. In preparation for the processing of the application, the MEE will request a statement from the municipal council of the local authority within which it is proposed that the plant site will be located, and from its neighbouring local authorities, the Ministry of the Environment and other authorities, as laid down in the Nuclear Energy Decree. In addition, the Ministry must obtain a preliminary safety assessment for the project from the Radiation and Nuclear Safety Authority (STUK).

The MEE will provide local authorities, residents and municipalities in the immediate vicinity of the nuclear plant with an opportunity to express their opinions in writing before the decision-in-principle is made. The Ministry will arrange a public meeting, where members of the public will have the opportunity to express their opinions verbally or in writing. These responses will be submitted to the Government.

Pursuant to the Nuclear Energy Act, before making the decision-in-principle, the Government shall ascertain whether the municipality where it is planned that the nuclear facility will be located is in favour of the construction, and ensure that no facts indicating a lack of sufficient prerequisites for constructing and using a nuclear facility in a safe manner and not causing injury to people, or damage to the environment or property, have arisen in the statement from the Radiation and Nuclear Safety Authority (STUK) or elsewhere during the processing of the application. The Government's decision-in-principle shall be forwarded, without delay, to Parliament for perusal. Parliament may reverse the decision-in-principle or decide that it should remain in force as it stands.

Decisions-in-principle concerning the construction of a final disposal repository for spent nuclear fuel were made by the Government on 21 December 2000 and 17 January 2002. The decision-in-principle made in 2000 on the construction of a final disposal repository applies to spent nuclear fuel generated by the operations of the four nuclear power plant units currently in use in Finland, totalling a maximum of approximately 4,000 tonnes in all. The decision-in-principle made in 2002 on constructing an extended final disposal repository, applies to spent nuclear fuel from the Olkiluoto 3 plant unit, which involves 2,500 tonnes of uranium at a maximum.

Posiva Oy has submitted an application for a decision-in-principle on spent nuclear fuel management for the Olkiluoto 4 nuclear power plant unit in connection with Teollisuuden Voima Oyj's application for a decision-in-principle on a fourth unit in Olkiluoto.

2.3 Construction licence

The actual licensing procedure follows the Government's decision-in-principle. Construction of a final disposal repository is subject to a construction licence granted by the Government. Prerequisites for granting the construction licence include that the plans concerning the facility be sufficient in terms of safety, that the protection of workers and the population's safety have been taken into account appropriately when planning the operations, that the location is appropriate with respect to the planned operations, and that environmental protection measures have been taken into consideration in an appropriate manner in the planning of operations.

A construction licence for the final disposal repository of spent nuclear fuel must be applied for by the end of the year 2012.

2.4 Operating licence

The operation of a nuclear facility requires an operating licence issued by the Government. Conditions for granting such a licence include the appropriate attention being paid to the protection of workers, safety and environmental protection. A hearing procedure involving the municipalities concerned, authorities and the general public will also be arranged during the handling process of construction and operating licences.

3 Summary of comments and opinions

The following organisations were invited to comment on the EIA programme:

Ministry of the Environment, Ministry of the Interior, Ministry of Social Affairs and Health, Ministry of Defence, Ministry of Finance, Ministry of Transport and Communications, Ministry of Agriculture and Forestry, State Provincial Office of Western Finland, Western Finland Environmental Permit Authority, Finnish Environment Institute, Radiation and Nuclear Safety Authority, Satakunta T&E Centre, South-western Finland T&E Centre, Satakuntaliitto Regional Council, Occupational Safety and Health Inspectorate of Turku and Pori, Regional Environment Centre of Southwest Finland, Regional Environment Centre of Uusimaa, Safety Technology Authority, Municipality of Eurajoki, Municipality of Eura, Municipality of Kiukainen, Municipality of Lappi, Municipality of Luvia, Municipality of Nakkila, City of Rauma, Confederation of Unions for Professional and Managerial Staff in Finland (AKAVA), Confederation of Finnish Industries EK, Finnish Energy Industries ET, WWF, Greenpeace, Finnish Association for Nature Conservation, Natur och Miljö rf, Central Union of Agricultural Producers and Forest Owners

MTK, Central Organisation of Finnish Trade Unions SAK, Federation of Finnish Enterprises, Finnish Confederation of Salaried Employees STTK, Fingrid Oyj, Fortum Power and Heat Oy, and Teollisuuden Voima Oyj.

Comments were not received from the following organisations: Ministry of the Interior, Ministry of Defence, Ministry of Transport and Communications, Ministry of Agriculture and Forestry, Western Finland Environmental Permit Authority, Finnish Environment Institute, South-western Finland T&E Centre, Municipality of Kiukainen, Municipality of Nakkila, WWF, Central Union of Agricultural Producers and Forest Owners MTK, Federation of Finnish Enterprises, Finnish Confederation of Salaried Employees STTK, Fortum Power and Heat Oy.

In the assessment procedure with respect to cross-border environmental impacts, based on the Espoo Convention, the Ministry of the Environment notified the authorities of the following countries about the project: Naturvårdsverket - Swedish Environmental Protection Agency (Sweden), Ministry of the Environment (Denmark), Ministry of the Environment (Norway), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany), Ministry of the Environment (Poland), Ministry of the Environment (Lithuania), Ministry of the Environment (Latvia), Ministry of the Environment (Estonia) and Ministry of Natural Resources (Russia).

Sweden, Norway, Germany and Estonia participate in the EIA procedure and have commented on the EIA programme. Denmark and Poland have replied to the Ministry of the Environment that they will not participate in the EIA procedure. The Ministry of the Environment has not received replies from Latvia or Russia. If any of the potential participants in the cross-border procedure submit a comment later on, it will be delivered to the organisation responsible for the project.

3.1 Comments invited by the MEE

Ministry of the Environment

The Ministry of the Environment only comments on the EIA programme of the project in its statement, but does not comment on the environmental impacts of the project or their acceptability.

The Ministry of the Environment finds the project specification presented in the EIA programme, as well as the description of the zero option and the current status, problematic. The Ministry finds that these should be revised to correspond with the actual current status, describing both legal stipulations and the current decision-making status. The EIA procedure shall examine the final disposal of 12,000 uranium tonnes of spent nuclear fuel, and describe the environmental impacts of this entity.

In the Ministry of the Environment's view, the EIA shall review the following situations:

1. Spent nuclear fuels, totalling up to 6,500 tU, generated by the currently operating nuclear power plants (Olkiluoto 1 & 2 and Loviisa

1 & 2), and Olkiluoto 3, under construction, will be placed in Olkiluoto for final disposal.

2. In addition to the spent nuclear fuels of currently operating nuclear power plants, and Olkiluoto 3, under construction, the spent nuclear fuels of two new nuclear power plant units, totalling a maximum of 12,000 tU, will be placed in Olkiluoto for final disposal.

The zero option shall be redefined in the assessment report, because the starting point cannot be a situation where 9,000 tU of spent nuclear fuel can be placed in the final disposal repository, as suggested in the EIA programme. Examination of the zero option shall be based on Section 6 a of the Nuclear Energy Act (990/1987), stipulating that nuclear waste generated in Finland shall be handled, stored and permanently disposed of in Finland. Decisions-in-principle have been issued on the final disposal of spent nuclear fuel from five nuclear power plant units, totalling some 6,500 tU. The application for a construction licence for the final disposal repository is expected to be submitted in 2012. Therefore, from the legal point of view, the location for final disposal has not been finally decided. The parties concerned have a right of appeal against the construction licence decision. In connection with the zero option, it would also be appropriate to assess whether the research underway in the ONKALO underground characterisation facility might reveal aspects that would prove Olkiluoto unsuitable as the location for a final disposal repository, and what such aspects might entail.

The Ministry of the Environment deems it right and necessary that the EIA report will include a review of the current status of reprocessing and transmutation technologies and their future prospects. This will provide a general overview of the alternative processing methods available for spent fuel.

The Ministry of the Environment points out that the EIA programme (Chapter 5.4) presents the following accumulations of spent nuclear fuel: from Olkiluoto 3 plant unit, around 2,500 tU, from the planned Olkiluoto 4, around 2,500 tU, and from Loviisa 3, around 3,000 tU. The EIA report of Loviisa 3 presents an assessment according to which the prospective plant there would only generate 2,000-2,500 tU of spent nuclear fuel.

The Ministry of the Environment suggests that the description of the different stages of the final disposal repository and technology should be presented in the report in considerably more detail than now, within the EIA programme. The description must clearly indicate the underground areas required for various options. The long-term safety concept of the final disposal repository shall also be presented in more detail in the report, paying attention to e.g. any impacts on the marine environment, and through that, neighbouring countries. The EIA report shall provide an assessment of the situations in which the construction of the extended final disposal repository may prove impossible (e.g. due to technical reasons, environmental impacts or safety reasons).

In the opinion of the Ministry of the Environment, the information on the current status of the plant's environment can mainly be considered adequate, because the environmental status of Olkiluoto has been

monitored relatively closely for over 30 years. However, Olkiluoto is an area undergoing major changes: the commissioning of Olkiluoto 3 in 2011 and the commissioning of the final disposal repository in 2020. If the decision to implement Olkiluoto 4 is made, it is anticipated that its construction will begin around the year 2013. The Ministry of the Environment emphasises that the EIA report must review the interrelationships of the final disposal repository, Olkiluoto 3 and the potential Olkiluoto 4 (incl. schedules, environmental impacts during the construction stages and operational use, traffic volumes and safety) in an illustrative manner so that a clear general view is provided of the status of Olkiluoto and changes thereto. Environmental impact assessment shall be conducted in comparison with the current status, clearly indicating the impacts caused by various options (e.g. the quantitative changes in rock waste, traffic volumes, emissions etc.) This principle shall apply to the assessment of both impacts during construction, and those during plant operation.

According to the Ministry of the Environment, environmental impact assessment must include a review of the impacts that may change, and how, were final disposal needs to change and the total quantity of spent nuclear fuel placed in final disposal in the repository to fall below 12,000 tU. Such a situation could come true for instance if only one new nuclear power plant will be constructed in Finland, or if the power plants for some reason generate less spent nuclear fuel than estimated.

The Ministry of the Environment finds it vital that the assessments of the environmental impacts of the various options of the final disposal repository be presented in parallel, to facilitate the comparison of the options. Also, the assessment of the impacts of exceptional situations and emergencies, and the assessment of long-term safety shall be presented so as to reveal any differences between the alternatives.

The Ministry of the Environment points out that chapter 6.2 of the EIA programme concerning land use planning for the project mentions that currently valid land use plans have not reserved areas for the particular purposes of final disposal operations, but that the revision of Olkiluoto land use plan, currently underway, will reserve areas for that purpose. However, chapter 9.1 states that the extension of the planned final disposal repository will not require the alteration of the land use plan. The Ministry of the Environment requires that this issue be clarified in the EIA report.

The Ministry of the Environment finds the EIA programme's plan on organising participation to be on too small a scale. The plan restricts participation to selected residents only. Correspondingly, the Ministry finds that during the preparation of the EIA report, the party responsible for the project should arrange participation on a wider scale than planned. The EIA report must identify the results of participation and the way they come across in environmental impact assessment, in order to achieve as high a degree of transparency as possible. The choosing of participants, their selection and the composition of groups must be taken into account in planning, and the issue must be recorded in the report.

The Ministry of the Environment finds that, according to the schedule included in the EIA programme (page 18), the party responsible for the

project will submit its EIA report to the contact authority approximately, one month after the contact authority has submitted its statement on the EIA programme. The proposed schedule does not meet the objectives or comply with the spirit of EIA legislation, nor does it appear credible that the party responsible for the project could, within approximately one month, ensure that the contact authority's statement issued on the EIA programme and other comments and opinions will be taken into consideration in the appropriate manner. Moreover, the party responsible for the project suggests in chapter 7.1 of the EIA programme, that when assessing environmental impacts, the focus should be on impacts assessed and experienced as significant.

The Ministry of the Environment points out that the party responsible for the project has submitted the EIA programme so that the public hearing has had to be scheduled for the summer season. However, one of the key goals of the EIA procedure is to increase citizens' access to information and enhance their possibilities to participate in planning and decision-making, and arranging a public hearing in the midst of the holiday season does not promote the fulfilment of these objectives.

In sum, the Ministry of the Environment states that the EIA report shall

- Reformulate the project definition, the zero option and other options,
- Compare the environmental impacts of options with each other,
- Assess the project's relationship with Olkiluoto 3 and Olkiluoto 4, alongside their joint impacts,
- Present the assessment of the impacts of exceptional situations and emergencies and the assessment of long-term safety so as to reveal any differences between the alternatives,
- Assess the situations in which construction of the final disposal repository with an extension can become impossible,
- Include a more detailed description of the final disposal repository and technology, and the long-term safety concept, than those presented in the EIA programme,
- Arrange more extensive participation than planned, and pay attention to the impacts of participation, and selection.

Furthermore, the Ministry of the Environment wishes to stress that when a statement on a potential decision-in-principle is requested, both the EIA report on the project and the contact authority's statement thereon, shall be available.

Ministry of Social Affairs and Health

In its statement, the Ministry of Social Affairs and Health finds that, in the appropriate manner, the EIA programme covers the radiation and nuclear safety issues related to extending the final disposal repository.

The Ministry of Finance

The Ministry of Finance states that the EIA procedure assesses the impacts of expanding the final disposal facilities from several angles,

and that the implementation of the procedure is a prerequisite for obtaining a decision-in-principle as specified in the Nuclear Energy Act. The EIA procedure mainly assesses the environmental impacts of operations conducted in the facility area, but also those of exceptional situations and emergencies. In addition, the impacts of operations extending outside the area, such as transports and other traffic, both on the infrastructure and regional economy, are assessed.

The Ministry finds the EIA programme comprehensive as such, and does not have any comments on it in principle. However, during the preparation of the project, the economic, social and environment-related impacts of the project should be assessed as thoroughly as possible.

State Provincial Office of Western Finland

The State Provincial Office of Western Finland handles the assessment of health impacts, and proposes the following additions. The impacts on ground waters should also include the impacts of the project on household water supply, the private household wells located in the area of impact, and the quality of water in them. Household water quality requirements are listed in the Decrees of the Ministry of Social Affairs and Health, 461/2000 and 401/2001. In connection with assessing the impacts on surface waters, a survey should also be carried out as to whether there are public beaches in the impact area.

According to the statement by the State Provincial Office, attention must be paid to presenting the location of the nearest localities that can be disturbed on maps, such as residences and holiday residences.

The Radiation and Nuclear Safety Authority (STUK)

In its statement, the STUK finds that, in the appropriate manner, the assessment programme covers radiation and nuclear safety issues related to the extension to the final disposal repository, and is suited to its purpose as regards aspects under STUK's authority.

However, on the subject of the so-called zero option presented in the EIA programme, STUK points out that the review concerning alternatives must pay attention to nuclear energy legislation and solutions reached thereunder. Nuclear waste management shall be carried out in a manner based on these. Storage of spent nuclear fuel in water basins does not qualify as such an option for nuclear waste management.

Due to the prolonged implementation period of the project, STUK considers it reasonable that the EIA report include a review of the current state and future prospects with respect to reprocessing and nuclide transmutation technologies. STUK also states that there is no alternative in the short term.

It also emphasises that the issues of final disposal depth and space construction are still at the specifying analysis stage. Therefore, it would not be topical to adhere to a specific planned alternative.

Satakunta T&E Centre

The Satakunta T&E Centre has no comments to make on the EIA report.

Satakuntaliitto Regional Council

Satakuntaliitto Regional Council states that the regional plan 5 of the province of Satakunta has been taken into account in the EIA programme in the appropriate manner, and that the provincial land use plan is being prepared. On the basis of the confirmed regional plan, and the provincial land use plan under preparation, Satakuntaliitto Regional Council has no comments on the EIA programme.

Occupational Safety and Health Inspectorate of Turku and Pori

The Occupational Safety and Health Inspectorate of Turku and Pori has no comments on the EIA programme.

Southeast Finland Regional Environment Centre

The Southeast Finland Regional Environment Centre refers to its earlier statement (18.9.2007, LOS-2007-J-79-53) and finds the proposed project definition and the description of the zero option and the current status problematic, stating that they should be revised to comply with the actual current status. The option in accordance with the programme, whereby the zero option is one planned for future implementation, whose impacts are not clear and cannot be established, and which the general public or authorities have no prerequisites to assess in concrete terms, cannot be the zero option as referred to in the EIA Act. The options remaining "in between" the current status and the extremely large-scale options of the project, resulting in cumulative impacts, shall not be ignored in the project which is now under assessment. Instead, these form a continuum which must be revealed in the EIA report. The options reviewed shall be defined so that options regarding the project remaining unimplemented form the current status alongside such options, already analysed, for whose implementation a permit as referred to in the EIA Act, or a decision comparable with a permit, have been granted.

In the opinion of the Southeast Finland Regional Environment Centre, the EIA report shall examine the following scenarios:

- The current status, whereby intermediate storage of spent nuclear fuel continues in the nuclear power plants,
- Spent nuclear fuels, totalling up to 6,500 uranium tonnes, generated by the currently operating nuclear power plants (Olkiluoto 1 & 2 and Loviisa 1 & 2), and Olkiluoto 3, under construction, will be placed in Olkiluoto for final disposal.
- Spent nuclear fuels, totalling up to 9,000 uranium tonnes, generated by the currently operating nuclear power plants, Olkiluoto 3, under construction, and one new nuclear power plant, will be placed in Olkiluoto for final disposal.
- In addition to the spent nuclear fuels of currently operating nuclear power plants, and Olkiluoto 3, under construction, the

spent nuclear fuels of two new nuclear power plant units, totalling a maximum of 12,000 uranium tonnes, will be placed in Olkiluoto for final disposal.

The application for a construction licence for the final disposal facility is expected to be submitted in 2012. Therefore, from the legal point of view, the location for final disposal has not been finally decided. The parties concerned have the right to appeal against the construction licence decision. In connection with the zero option, it would also be appropriate to assess whether the research underway in the ONKALO underground characterisation facility can reveal aspects that would prove Olkiluoto unsuitable as the location for a final disposal repository, and what such aspects might entail.

The Southeast Finland Regional Environment Centre finds it highly necessary that the EIA report should include a review of the current status and future prospects with respect to reprocessing and nuclide transmutation technologies. Because the extension to the final disposal facility would be implemented after a long period of time, it is theoretically possible that reprocessing would, in future, develop into a realistic alternative for final disposal.

The Southeast Finland Regional Environment Centre finds the description of the final disposal repository and technology, presented in the EIA programme, quite brief, and that it also contains references to several other sources. The final disposal repository must be described in more detail in the EIA report, and in connection with factors creating insecurity, estimates should also be given on the conditions in which the extension to the final disposal facility cannot be implemented, considering the technical aspects, environmental impacts or safety concerns.

The Southeast Finland Regional Environment Centre states that the EIA programme mainly describes the current status of the environment to a sufficient extent. However, the birdlife report dating back to 1997 is quite old. Moreover, the Environment Centre points out that the butterfly species Clouded Apollo (*Parnassius mnemosyne*) is listed in Annexes II and IV of the nature directives, and the EIA programme does not mention whether the appearance of the Clouded Apollo has been surveyed in the area of Liiklankari as well.

As concerns the impacts and their determination, the Environment Centre states the following. Sufficiently intensive participation in the EIA procedure by expert authorities and citizens would ensure the recognition of significant environmental impacts during the assessment. On the basis of the programme, the definitions of the area under assessment cannot yet be commented on, because according to the programme, such an assessment is often based on existing reports, which have not been handled in the programme. As concerns traffic and transport, environmental impacts shall also be assessed in emergencies and exceptional situations. Scenic impacts may also occur as a consequence of the dumping of excavated rock, if the extracted soil cannot be utilised in phase with the excavation. The Environment Centre will comment on the Natura pre-assessment and its sufficiency as soon as the assessment is completed. The assessment shall present both

qualitative and quantitative impacts caused by various alternatives, including the impacts of emergencies and exceptional situations and those of long-term safety, in a form that allows the comparison of various options.

The Environment Centre points out that Chapter 9.5 could mention, for reasons of consistency, that at present, the permit authority for permits under environmental and water legislation is the Western Finland Environmental Permit Authority.

The Environment Centre proposes that the arrangement of participation be revised, stating that one of the key goals of the EIA procedure is to increase citizens' access to information and enhance their possibilities to participate in planning and decision-making. The public hearing on the EIA programme during the summer holiday season will not promote the achievement of the related targets. The Environment Centre would emphasise the importance of arranging the public hearing for the EIA report at a time when citizens have a genuine opportunity to familiarise themselves with the report and assess it from their own perspective.

As a whole, the EIA programme is a clear and well-outlined report, but the EIA report must pay more attention to the clarity and quality of pictures, drawings and maps.

In the Environment Centre's view, the proposed schedule seems too tight to allow the preparation of reports and the EIA report, considering any needs for further clarification that may arise. During the assessment, contacts should be maintained with expert authorities participating in the EIA procedure.

Uusimaa Regional Environment Centre

The Uusimaa Regional Environment Centre states that, for the time being, as a whole this project remains in the planning stage, the impacts of which extend far into the future, and whose construction is estimated to begin in 2013, when the EIA procedure, implemented in 1998-1999, will be almost 15 years old. Also, the need for an extension, appearing at the preliminary planning stage of the facility, is considerable, comprising an extension of 25–45%.

In the Environment Centre's view, the EIA procedure shall examine the environmental impacts of the planned 12,000 tU final disposal repository and those of spent nuclear fuel transports as a whole, not only the impacts of the extension. As an alternative, a situation whereby a maximum of 6,500 tU would be placed in the final repository at Olkiluoto, might be considered. In such a case, too, the assessment of transport impacts should be included. The zero option is the current situation, in which the facility does not exist for the time being.

The Environment Centre proposes that the environmental impact assessment utilise the latest information available, including the results of research conducted in ONKALO. The Environment Centre also enquires whether it is possible that research conducted in ONKALO might reveal facts that would prove Olkiluoto unsuitable as a final disposal location for nuclear fuel.

According to the Environment Centre, it would be important to examine the possibilities of spent nuclear fuel reprocessing in order to provide a general view. In future, it may well be realistic for reprocessing to provide a realistic alternative for final disposal.

According to the Environment Centre, the composition and frequency of meetings of the monitoring group set up to monitor the progress of the EIA procedure should be revised, because the project in question is significant on the national and international scale. Representatives of national bodies should be invited to attend, alongside representatives of the potential impact area (transports of spent nuclear fuel). Moreover, the Environment Centre proposes that in future, public hearings be arranged outside the holiday season.

The Environment Centre points out that the estimated quantity of spent nuclear fuel from the Olkiluoto and Loviisa power plants currently in operation totals some 4,000 tU, and from Olkiluoto 3, under construction, some 2,500 tU. The estimated quantity of spent nuclear fuel from the planned seventh unit is around 3,000 tU, despite the lower estimates (2,000–2,500 tU) given in the reports of Olkiluoto 4 and Loviisa 3.

In the Environment Centre's view, the EIA procedure must anticipate the environmental risks related to various transport forms of spent nuclear fuel. For instance, should a traffic accident occur, the quantity of radioactive waste generated may be substantial, which would necessitate the advance planning of waste management and waste management responsibilities in such situations.

The Environment Centre proposes that during the EIA procedure of the final disposal repository for spent nuclear fuel, the following measures should be taken:

- Assess the aggregate environmental impacts of the planned final disposal repository and transports of spent nuclear fuel
- Revise the composition and meeting frequency of the monitoring group
- Assess the environmental risks of various transport forms of spent nuclear fuel, and prepare a contingency plan, including specified responsibilities, to prepare for environmental risks due to traffic and transport accidents.

Safety Technology Authority

The Safety Technology Authority (TUKES) states in its comment that, on the basis of documentation, the final disposal repository does not involve chemicals whose monitoring TUKES would be responsible for. Tukes therefore has no comments to make on the project.

Municipality of Eurajoki

The Municipality of Eurajoki states that the EIA procedure mainly assesses the environmental impacts of operations within the plant area,

and those of spent fuel transports. Activities extending outside the plant area include spent fuel transports, and other traffic.

The Municipality of Eurajoki finds in its statement that it has no comments to make on in the EIA programme.

Municipality of Eura

The Municipality of Eura proposes in its statement that the impact assessment examination area should be broadened. Operational, technical and economic impacts should be assessed in an area expanding beyond the Municipality of Eurajoki. Impacts on regional economy and image should be analysed within the entire Rauma region at a minimum, while impacts on people should be assessed in the Rauma region or regions of all neighbouring municipalities, and the assessment should comply with instructions issued by Stakes (National Research and Development Centre for Welfare and Health).

Furthermore, the municipality points out that inhabitants should have the possibility to access sufficient information about the project, and to influence the pleasantness of their living environment and its attractiveness. The project must include a plan to remedy and compensate for any disadvantages.

The municipality proposes that any assessment targeted at people should be brought more up-to-date, and the impact assessment should focus on the final disposal of 12,000 tU.

Municipality of Lappi

The Municipality of Lappi comments that enhanced attention should be paid to the environmental safety of final disposal as the quantity of uranium placed increases to 12,000 tonnes, and the area of underground facilities to 240 hectares.

Municipality of Luvia

The Municipality of Luvia states that the structure of the EIA programme mainly complies with the law issued on the EIA procedure. The programme sets forth key potential environmental impacts for assessment.

The municipality proposes that traffic impact assessment should be completed so that highway 8 in the municipality of Luvia would be included in the project's sphere of impact, and the aggregate impacts of traffic related to the entire Olkiluoto power plant area are presented in the EIA report.

The municipality suggests that measures that concern securing the long-term safety of spent fuel, and their impacts during the use of the entire facility, should be presented in the EIA report in as well-justified a manner as possible.

City of Rauma

The City of Rauma proposes that the impact assessment include more extensive examination of the ecological, financial and social impacts of the project throughout the chain of events within final disposal as a whole.

AKAVA, Confederation of Unions for Professional and Managerial Staff in Finland

Akava has no comments to make on in the contents of the EIA programme.

Confederation of Finnish Industries EK

The Confederation of Finnish Industries EK finds the EIA programme comprehensive. It provides a comprehensive and balanced picture of the key issues and reporting needs arising from the EIA procedure under section 9 of the EIA Decree.

Finnish Energy Industries ET

According to ET, the EIA programme handles the extension to the final disposal repository professionally and comprehensively.

Greenpeace

Greenpeace suggests points for completion and presentation in the EIA report. Examples mentioned include the impacts of the glacial period, earthquakes, corrosion of copper capsules, a serious accident in nuclear waste transport, and other emergencies with related impacts. Moreover, the EIA should examine an underground intermediate storage facility as an alternative. The characteristics of spent fuel should be described. In connection with the assessment, reasons for returning waste placed under final disposal to ground level should be handled.

Finnish Association for Nature Conservation

The Finnish Association for Nature Conservation suggests that risk analyses of final disposal should assess all factors affecting safety throughout the disposal process and nuclear waste activity period, and highlight uncertainties in terms of the reliability of research results.

The Association finds the schedule of the EIA procedure unrealistic. Preparation of the EIA report is underway prior to comments being given on the EIA programme, and the contact authority's statement will be unable to influence the assessment for over a month.

In the Association's opinion, the alternatives, 9,000 tU and 12,000 tU, are insufficient to facilitate proper consideration of the implementation decisions of ONKALO. The 9,000 tU zero option is insufficient, because no decisions have been made on its implementation. The continuation of the current intermediate storage, and various options related to the storage of MOX fuel, and the recycling of uranium, must be examined.

The Association considers the description of the environmental impact assessment brief and superficial. It does not reveal, in sufficient detail, the authors, methods, timing and sources of partial research.

As concerns the environmental impacts of traffic, the Association states that safety risks related to nuclear fuel transports should be assessed, paying attention to the risks of violent storms, which are increasingly frequent due to climate change, affecting nuclear waste transport at sea and on land.

The key factor to be assessed in connection with impacts affecting the ground, the bedrock and ground waters, is the impact of excavation on the bedrock, and further on the flow of groundwater. Furthermore, the impact of various quantities of water on the swelling of bentonite, and erosion of copper, should be assessed. The EIA report must reveal whether earthquakes have occurred in the neighbouring area during the previous glacial period or after it, and whether there are fractures in the rock of the neighbouring area. The impacts of the glacial period and its termination must be described in sufficient detail. The EIA report must highlight the advantages and disadvantages of the final disposal depth and compare them with the corresponding characteristics of other depths, highlighting the risks of various final disposal depths. The durability assessments and radiation quantities of spent nuclear fuel disposal capsules should be stated alongside the maximum temperature to which bentonite can be exposed, without altering the operational characteristics of the filling.

The assessment of radiation impacts on people and the environment should be completed so that the EIA report also includes various probabilities for different radiation quantities at different storage times. Also, the environmental and health impacts of emergencies should be assessed.

In connection with the assessment of impacts on vegetation, fauna and various protected species, in particular an analysis should be conducted of whether the road in the Liiklankari Natura area is necessary or whether it would be possible to abandon it.

The assessment of social impacts must pay attention to the opinions of the whole of Finland, and international opinions, while assessing, on local level, even negative impacts on property values, the consequences for tourism, and future prospects for local employment.

In connection with the assessment of long-term safety, a detailed description must be included on how the fuel capsules could be safely uncovered and the costs would this involve. Moreover, the probability of the waste to end up in the wrong hands after the closure of the disposal facility should be assessed.

As an uncertainty factor, climate change and the threats it presents should be assessed. Climate warming may have surprising impacts on sea level rises and the creation of extreme weather phenomena.

The Association proposes that the EIA report state how the condition of capsules will be monitored and the measures available for preventing an

environmental catastrophe should a leak occur. The probability of leaks, the possibilities of monitoring them, and the related environmental and health risks must be disclosed in the EIA report, public meetings, and information bulletins.

According to the Association, the EIA report must describe the opportunities available for the general public as regards rights to participate and right of appeal.

Natur och Miljö rf

Natur och Miljö finds the EIA programme defective, because it does not handle all options available for final disposal, nor the latest methods.

The Association proposes that the assessment be completed as regards the impacts on bedrock, such as fracture cleavage, and states that more information is required on the seismology of the area. As concerns groundwater flow conditions, any migration of radioactive substances to the Baltic Sea or other parts of the biosphere, and the impacts of groundwater on final disposal capsules, should be analysed. The long-term durability of capsules should be assessed.

The association proposes that the EIA report indicate how the durability of capsules will be supervised, and what measures would be taken in case of any leaking capsules. Moreover, the EIA report should describe how the capsules would endure future glacial periods and specify the supervision of other implementation, and the prevention of misuse.

The Association states that the EIA report should describe the risks involved in the transport of spent nuclear fuel, and study climate change in particular, alongside the related storms and exceptional precipitation.

Impacts related to health, the infrastructure, the economy and the image of the area should be surveyed, not only at local level but across a wider area, too.

The Association states that the EIA report should also review a situation where nuclear waste is imported to Finland from other EU countries.

Central Organisation of Finnish Trade Unions SAK

The SAK finds in its statement that several projects have been launched in Finland to construct new nuclear power plants. Even though decisions will be made later, it would be justified for the final disposal plans to prepare for the final disposal of spent fuel generated by any new plants constructed.

SAK states that the observations of safety authorities on the assessment programme deserve special attention. It is essential that, in the assessment of safe final disposal, the impacts on the environment and people be assessed. It would also be vital to assess the impacts of extending the final disposal repository on employment and the economy in the area.

Fingrid Oyj

In its statement, Fingrid Oyj examines the location of the final disposal project in relation to the area reservation made for power lines in the partial master plan of Olkiluoto, and finds the following: if the final disposal implementation alternative concerns only an increase to the extent of the underground final disposal facilities (EIA programme section 4.1), the extension to the project will have no impact on the main grid power lines.

Teollisuuden Voima Oyj

In its comment, TVO states that it has had the chance to comment on the EIA programme. Posiva Oy has paid sufficient attention to TVO's views in the EIA programme.

3.2 Opinions from the international hearing

Sweden: Naturvårdsverket

The Swedish contact authority, Naturvårdsverket, has requested comments from several authorities and organisations.

The Swedish radiation safety authority, Strålsäkerhetsmyndigheten, considers participation in Finland's EIA procedure justified, partly due to the joint sea area, and partly due to the similar final disposal programme. With respect to the project, the EIA procedure shall handle the facility approved in the decision-in-principle, and present an alternative location in case Olkiluoto proves unsuitable. The EIA shall present methods for restricting the migration of radioactive substances into the Baltic Sea, in addition to the current viewpoints on long-term safety.

Other statements suggest that the EIA procedure is useful as concerns the exchange of information. The assessment shall cover the entire facility, including transports, the risk of accidents, and measures to prevent accidents.

Denmark: Ministry of the Environment

The Danish contact authority notifies that Denmark will not participate in the EIA procedure. However, the contact authority requests that it be informed of the results of the EIA procedure.

Norway: Ministry of the Environment

The Norwegian contact authority states in its comment that a hearing has been arranged on the EIA programme. On the basis of comments received, the contact authority suggests that the assessment cover the entire quantity of spent fuel, and an assessment of the impacts of emergencies and exceptional situations on Norway.

Germany: Innenministerium Mecklenburg-Vorpommern

The German contact authority, Innenministerium Mecklenburg-Vorpommern, sets forth questions related to long-term safety and potential cross-border environmental impacts.

Poland: Ministry of Environment

The Polish contact authority announces that Poland does not intend to participate in the EIA procedure. However, the contact authority requests that it be informed of the results of the EIA procedure.

Lithuania: Ministry of Environment

The Lithuanian contact authority notifies that Lithuania will not participate in the EIA procedure. However, the contact authority requests that it be informed of the results of the EIA procedure.

Estonia: Ministry of the Environment

The Estonian contact authority notifies that a hearing has been arranged on the EIA programme. On the basis of comments and statements received, the contact authority states that it will participate in the EIA procedure. The EIA report shall present a detailed assessment of the impacts of unprecedented situations and emergencies, and the possibilities for preventing such impacts. Moreover, the EIA report shall describe methods for supervising final disposal, and assess cumulative impacts.

3.3 Other comments and opinions

A total of 21 other comments or opinions were submitted. Eleven of these were from organisations and associations, and ten from private persons.

The following organisations presented a comment or opinion: The network 'Artists for a Clean Future', the Edelleen ei ydinvoimaa Popular Movement Against Nuclear Energy, Fennovoima Oy, Irish Doctors' Environmental Association, Lappilaiset Uraanivoimaa Vastaan Popular Movement of Lapland against nuclear energy, the Loviisa movement, the movement 'Naiset Atomivoimaa ja uraanilouhintaa Vastaan', the movement 'Women against Nuclear Power', the movement 'Women for Peace in Finland', Réseau Sortir du Nucléaire, Women's network against uranium mining and nuclear power.

Several comments present risks to be taken into account when assessing the long-term safety of spent nuclear fuel final disposal, and uncertainties related to assessment. Moreover, assessment should pay attention to changes that will occur in natural conditions in the long-term, such as climate change.

The comments suggest that the EIA programme assess other alternatives beyond final disposal, such as underground dry storage.

There are also suggestions for completing the EIA programme in such a manner that the assessment consider an area larger than the municipality of Eurajoki. For instance, the impacts of the project on the image of the municipality should also be examined concerning the City of Rauma, and how the information on final disposal will influence people's ideas.

Several comments express the concern that, due to the extension of the final disposal repository, nuclear waste from other EU countries could be transported to Finland.

Fennovoima Oy suggests that Posiva's assessment pay attention to the impacts of Fennovoima's nuclear power plant project on nuclear fuel final disposal activities as a whole.

4 Contact authority's statement

The Ministry of Employment and the Economy states that Posiva Oy's EIA programme mainly meets the content requirements of EIA legislation and has been handled in the manner required by the legislation in force. The comments submitted consider the programme to be, in the main, appropriate and comprehensive. However, the Ministry states that the EIA programme should be reviewed and the EIA report outlined so that all points made by the contact authority in this chapter are given the appropriate level of consideration.

Furthermore, the comments and opinions include questions, remarks and viewpoints that the EIA report must answer appropriately and to a sufficient extent, while correcting any clearly indicated defects or erroneous information.

Moreover, answers to the questions presented in the international assessment must be included both in the EIA report and the summary to be prepared on the international assessment. The material translated into the languages of the countries concerned must be sufficient and must include information given in Annex II of the Espoo Convention. The EIA report shall include, as a specific chapter, a description of cross-border impacts. This material shall indicate how the comments of nations participating in the EIA procedure within the framework of the Espoo Convention have been taken into consideration.

As a general comment, the MEE states that the EIA report must pay attention to the content and extent of descriptions. The particularity of general texts should be revised and, if necessary, the description should be more detailed than the one presented in the EIA programme. Moreover, attention must be paid to the clarity and quality of pictures, drawings and maps.

4.1 Project description and alternatives

According to the EIA programme, the alternative examined for implementation involves extending the final disposal repository by 3,000 uranium tonnes. After the extension, 12,000 uranium tonnes of spent nuclear fuel could be placed in final disposal in the facility instead of the 9,000 uranium tonnes planned earlier. Furthermore, the EIA programme states that the extension is only targeted at the need to increase the scope of the underground final disposal facilities.

As a zero option, the EIA programme presents a situation whereby the final disposal repository would not be extended, which would mean that the maximum quantity of uranium that could be placed there would be 9,000 tU. This would mean that spent nuclear fuel from six nuclear power plant units could be placed in the facility. The spent nuclear fuel from the potential seventh nuclear power plant unit would be stored in the spent fuel storage facility.

The Ministry of the Environment, the Regional Environment Centre of Southwest Finland, the Uusimaa Regional Environment Centre, the Finnish Association for Nature Conservation and the Municipality of Eura consider limiting the environmental impact assessment to 3,000 uranium tonnes to be too small in scale. Also, the authorities of Sweden and Norway give comments on the limitation. The impact assessment shall cover 12,000 uranium tonnes.

The comments consider the zero option problematic, because according to the decisions-in-principle made until now, a maximum of 6,500 uranium tonnes can be placed in the final disposal repository. No decisions-in-principle have been made as yet on the final disposal of spent nuclear fuel from the sixth plant unit, or the sixth nuclear power plant unit itself.

In the MEE's view, the project that is being evaluated by means of the EIA procedure, is the construction of the final repository facilities expanded to the extent that 12,000 tonnes of uranium can be stored in the facilities after the expansion. The assessment applies to extension of the final disposal repository from 9,000 uranium tonnes to 12,000 uranium tonnes. Therefore, the EIA report shall describe final disposal facilities in which 12,000 uranium tonnes will be placed. Considering the decision-in-principle status of the final disposal repository, the EIA report shall also present a description of facilities for the placement of 6,500 uranium tonnes, alongside a description of facilities for the potential placement of 9,000 uranium tonnes of spent nuclear fuel.

The STUK states in its comment that the storage of spent nuclear fuel in water basins does not constitute an option for final disposal in the manner intended by the Nuclear Energy Act. However, the MEE finds that it would be justified for the EIA report to describe intermediate storage as an operation preceding final disposal, and the significance of intermediate storage as concerns final disposal.

The MEE states that the EIA procedure is crucial to communicating on the project, and that the purpose of the EIA procedure is, among others, to enhance citizens' access to information. The Ministry considers it

reasonable that the EIA report include a review of the current state and future prospects with respect to reprocessing and nuclide transmutation technology. The Ministry also finds that, in accordance with Section 26 of the Nuclear Energy Decree, for the purpose of decision-making concerning the decision-in-principle, the MEE must provide the Government with a special review of nuclear waste management methods in use and in the planning stage, and their suitability in Finnish conditions.

The location for the project is Olkiluoto in the municipality of Eurajoki. Following the decision-in-principle made in 2000, planning of the final disposal repository has proceeded to the construction of underground research facilities and location-specific research in Olkiluoto. The research in progress may find Olkiluoto unsuitable for the purpose. The MEE finds that the EIA report should reveal how the suitability of the location is assessed as concerns the construction of the final disposal repository and its expansion.

4.2 Impacts and the assessment

The MEE states that comments on the EIA programme, including those by the countries participating in the international hearing, and others, include proposals for completing and specifying the programme, particularly as regards long-term safety, exceptional situations and emergencies, but also emphasise the significance of impact assessment in terms of the infrastructure, economy, people and the image of the locality. Highlighted factors as regards long-term safety include changes in natural conditions, the impacts of natural conditions on safety (e.g. glacial periods, earthquakes, climate change, groundwaters), the safety of technical solutions in the long term (duration of final disposal capsules, bentonite as a filling material), and, on the other hand, the supervision of facilities and returnability of final disposal capsules. Accidents in the transport of spent nuclear fuel, and traffic accidents, alongside contingency and emergency plans are related to impact assessment in exceptional situations and emergencies. One viewpoint is the retrieval of spent nuclear fuel from the final disposal facilities.

As a general comment, the MEE states that, as regards the EIA procedure, the assessment should provide sufficient answers to the questions and comments presented in the statements and comments.

The MEE expects environmental impacts to be assessed regarding the entire extent of the final disposal repository, taking extensions to the facility into consideration. This means that the EIA report should present the environmental impacts of the final disposal repository in a situation where a total of 12,000 uranium tonnes of spent nuclear fuel would be placed in the facility. To facilitate the comparison of the alternatives, the environmental impacts should be presented for situations whereby a total of 6,500 uranium tonnes, or 9,000 uranium tonnes of spent nuclear fuel would be placed in the facility. These environmental impacts should be presented in an illustrated manner so that the environmental impacts in various situations are clearly disclosed. Moreover, the assessment shall pay attention to cross-border impacts.

Furthermore, the MEE requires that the definition of geographic areas used in the assessment, previously and in the future, be revised and justifications for areas excluded from the assessment be included in the EIA report. The MEE emphasises that impacts on the countries participating in the international hearing shall be assessed.

Impact assessment should also include the total impact and accumulative impact resulting from other projects at Olkiluoto. For instance, aggregate impacts caused by traffic related to the Olkiluoto power plant area should be presented.

The MEE expects certain information presented in the EIA programme to be specified, completed and possibly corrected. This includes the clarification of land use planning issues, completion of impact assessment concerning waters (impacts on household water, private household water wells and water quality therein, and public beaches), the appearance of the butterfly species Clouded Apollo (Parnassius mnemosyne), the assessment of the updating of the birdlife analysis, scenic impacts and the necessity of roads in a protected area.

4.3 Plans for the assessment procedure and related participation

The Ministry of Employment and the Economy finds that participation arrangements during the EIA procedure should be revised and completed, and requests that the party responsible for the project ensure that a sufficient period of time is reserved for preparing the EIA report.

The MEE states that sufficient attention should be paid in communications to the entire affected area of the project, across municipal borders and all population groups, and to interaction with that area.

The Ministry requires that the EIA report clearly point out how comments and opinions given in connection with the hearing, and those presented in the monitoring group, have been taken into consideration. Moreover, the EIA report should present criteria for choosing and selecting participants, and the composition of groups, and cite opportunities to request even national level expert authorities to contribute to the assessment.

When the EIA report is finalised, the MEE will publish a public notice, make the report available and invite various authorities to comment on the report. The statement on the EIA report, prepared by the MEE in its capacity as a contact authority, will be delivered to the municipalities in the affected area and to the appropriate authorities for information.

4.4 The EIA Report, the contact authority's statement on it, and the possible application for a decision-in-principle

In the licensing system in compliance with the Nuclear Energy Act, the EIA procedure is followed by the decision-in-principle procedure. Under the law, the project's EIA report must be attached to the application for a decision-in-principle.

The application for a decision-in-principle can be submitted to the Government before the contact authority has issued its statement on the EIA report in question. However, the Ministry of the Environment considers it advisable to submit any such application for a decision-in-principle only after the contact authority has submitted a statement on the EIA report following the hearings.

The MEE does not consider it appropriate that an EIA report and an application for a decision-in-principle be presented for comments at the same time, since they relate to the same project. Therefore, the Ministry would like the potential application for a decision-in-principle to be submitted to the Government only after the completion of the hearing concerning the EIA report.

5 Communicating the statement

The Ministry of Employment and the Economy will deliver its statement on the EIA programme to those authorities which have submitted comments and communities which have been invited to submit a comment. The statement will be available in Finnish and Swedish on the Internet: (address www.tem.fi).

The Ministry will provide copies of the comments and opinions concerning the EIA programme to the organisation responsible for the project. All comments and opinions received by the Ministry are published on the Internet.

The original documents will be stored in the Ministry's archives.

Minister of Economic Affairs Mauri Pekkarinen

Senior Adviser Jaana Avolahti

FOR INFORMATION Authorities which have submitted comments and the communities which the MEE has invited to comment on the programme

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