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TECHNICAL ASPECTS OF CREATING A REGIONAL DISPOSAL FACILITY FOR RADIOACTIVE WASTE. RETROSPECTIVE OF THE APPROACHES

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The article presents pre-design activities and technical solutions aimed at the development of a near-surface disposal facility for radioactive waste in North-Western Region performed in 1993 – 2010.

Key words: *radioactive waste, disposal, near-surface disposal facility, clay.*

A big number of nuclear facilities are being operated in the Leningrad Region resulting in radioactive waste generation (RW) and having RW storage capacities. Provided below is a list of facilities viewed as the main sources of RW generation:

- Leningrad nuclear power plant (LNPP-1) with 4 RMBK-1000 units;
- North-Western Nuclear Power Research and Industrial Center with ship power units of different types;
- Research reactors located in research centers of Saint-Petersburg and Leningrad Region;
- Leningrad division of North-Western Region (LO SZTO) run by FSUE "RosRAO" (it superseded "Radon") that has been operated since 1962 providing services for collection, processing and temporary storage of RW. LO SZTO provides its services to enterprises and organizations from Saint-Petersburg, Leningrad, Kaliningrad, Pskov and Novgorod Regions, as well as the Republic of Komi and the Republic Kareliya;
- Ekomet-S – center for metal RW recycling;
- Hundreds of industrial enterprises, medical and educational organizations using sources of ionizing radiation.

Operation of all these facilities has resulted in over 100,000 m^3 of radioactive waste that are currently being held in surface structures made of reinforced concrete.

At LNPP-2, construction of one power unit will be soon completed being one of four VVER-1200 power units to be constructed at this site. These units will replace RMBK-1000 units of LNPP-1 subject to decommissioning.

The planned decommissioning of four LNPP-1 units and ongoing operation of existing and planned enterprises suggests that new RW storage facilities are required. Preliminary estimates show that until 2030 the amount of waste intended for storage may amount to some 200,000—250,000 m^3. Most part of them (over 90%) will account for short-lived low- and intermediate-level waste classe 3 and 4 [1].

A question arises: whether we should continue with construction of temporary RW storage facilities or start RW disposal as provided for in the Federal Law 190-FZ On Radioactive Waste Management… and as most European countries do.

The opportunities for developing an RW disposal facility (RW DF) in the Leningrad Region have been investigated for 25 years. The paper presents a brief overview of these studies.

R&Ds and other research activities on the development of an RW disposal facility in the Leningrad Region have been started in early 1990's (table 1).

Formations of "dark-blue" Cambrian clays in the Leningrad Region were proposed as candidate bed rock formation for such a facility by FSUE V. G. Khlopin Radium Institute (Krivokhatskiy A. S.,

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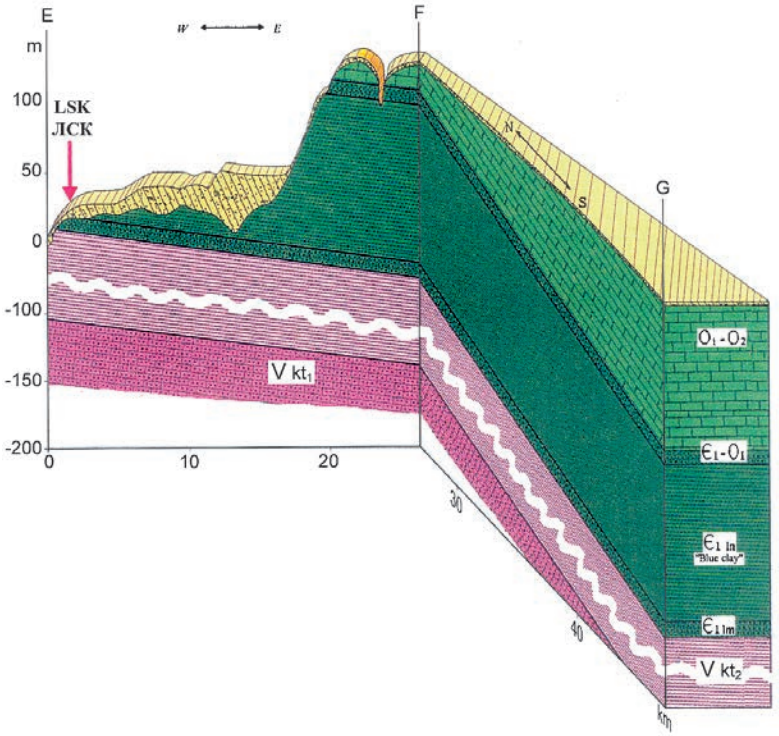
Table 1. Key pre-design activities on the development of RW disposal facility in the Leningrad region

Year	Activity	Contractors	Remarks
1993	R&D "Conceptual designs for the development of RW disposal facility in clays"	FSUE VNIPIET, JSC Lenmetrogidrotrans	Contract with the local government of the Leningrad Region
1997	Conceptual designs for the development of a RW repository for Radon	IVO PE Ltd (Finland), SGN (France), AEA Technology (the United Kingdom), FSUE VNIPIET	Under Tacis 94.405 project
2005–2006	Concepts for the development of a regional RW disposal facility in the Leningrad Region	SKB IC AB (Sweden), DBE Technology (Germany), FSUE VNIPIET	Developed under a cooperation agreement between FSUE VNIPIET and SKB IC AB (Sweden)
2008	Concepts and the program for the development of a disposal facility for short-lived low- and intermediate-level waste in the Leningrad Region	SKB IC AB (Sweden), DBE Technology (Germany), Andra (France), COVRA N.V (Netherlands), NDA (the United Kingdom), FSUE VNIPIET	Under Tacis 94.405 project
2010	Pre-investment feasibility study. Disposal facility for low- and intermediate-level waste at the territories of the Leningrad division of the FSEUE RosRAO's North-Western branch	FSUE VNIPIET	Contract with FSEU RosRAO



Vkt 1 – Gdovian sand formation (Vendian deposits)
Vkt 2 – Lyaminarthous clays of Kothlian formation (Vendian deposits)
€1 ln – blue clays (Lower Cambrian formation)
€1 – O1 – sand deposits of Cambrian-Ordovician age;
O1 – O2 – carbonates, dolomites (Ordovician deposits);
Q – Quaternary deposits;
Pr2 – crystalline basement.

Figure 1. Regional geological profile

Savonenkov V. G., Rogozin Yu. M. and others) [2]. Absolute age of these clays, having a thickness of some 100—130 m, accounts for some 530 million of years [3].

Figure 1 presents the geological profile of the region.

In 1993, Conceptual Project for the Development of a Regional disposal facility in Clays was developed by FSUE VNIPIET, JSC Lenmetrogidrotrans and V. G. Khlopin Radium Institute on the request of Leningrad region local authorities.

The underground structure designed under this project represents a spiral-type underground excavation (the first spiral turn has a diameter of 400 m) drilled with a tunneling machine (with a diameter of 5.63 m) at a depth of 90 m located in so called "clint"[1]. [4, 5]. Spiral-type excavation (figure 2) is intersected by three tunnels enabling better maneuvering capabilities when RW packages are placed inside facility sections. A vertical technological shaft or a ramp will be used for package transfer from the surface structure to the underground facility.

Based on the investigations performed the Leningrad Region's Administration approved a Resolution of January 10, 1995 № 5 On the Establishment of North-Western Regional Center for Radioactive Waste nManagement in the Leningrad Region.

[1] Clint is a Baltic-Ladozhskiy bench extending from the southern shore of the Gulf of Finland to the Ladoga Lake of up to 56 m high. The clint involves Cambrian clays and sandstones overlaid by Ordovician limestones.

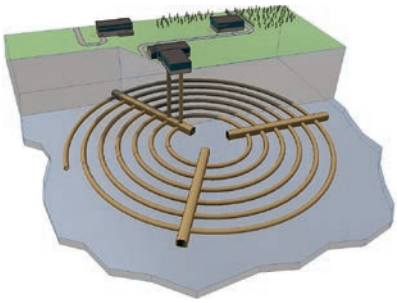


Figure 2. Spiral structure of subsurface RW disposal facility

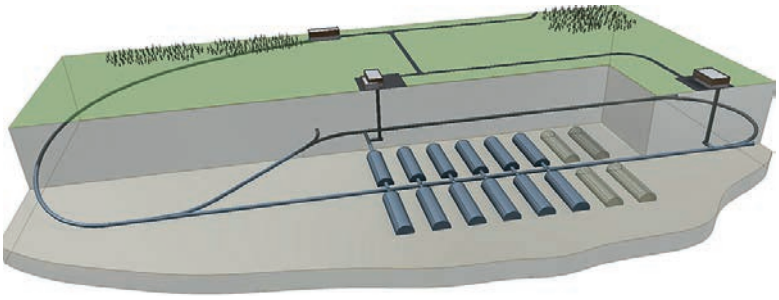


Figure 3. Chamber structure of underground RW disposal facility

The investigations continued, and in 1997 under the Tacis Project involving IVO PE LTD (Finland), SGN (France), AEA Technology (UK); FSUE VNIPIET and JSC Lenmetrogiprotrans (Russia), conceptual designs for the regional RW disposal facility were developed. These designs were based on another underground structure type — large chambers [6].

This underground facility was also planned to be constructed in blue clay deposits (in clint).

According to the designs developed, the underground facility represents a large chamber (figure 3) which is quite similar in its design to a single vault station of Saint-Petersburg metro station which is 100 m long, 25 m wide and 13 m tall, attached to a transportation tunnel.

The underground structure is linked with the surface via two construction shafts and a transportation ramp. 25 large chambers were designed to accommodate 250,000 cubic meters of waste.

In 2008, based on the contract signed between the Consortium and the European Union under the Tacis R4.05/4 project, some activities were performed within the Concept and Program for the Development of a Storage Facility for Short-Lived Low- and Intermediate-Level Waste in the Leningrad Region [6].

The Consortium involved a number of European companies: Andra (France), COVRA N.V. (the Netherlands), DBE Technology (Germany), SKB IC (Sweden) and NDA (UK). A contract was signed between DBE Technology and VNIPIET № LEN-REP-01/2008 on the development of a Declaration of Intentions providing for the construction of a surface and underground RW repository, as well as of the key sections of the Investment Feasibility Study on the construction of a near-surface disposal facility in the Leningrad Region.

Based on the review of available materials, investigations and in keeping with RW repository siting requirements, five potentially suitable sites were studied. All of them were located in the Lomonosovsky area (figure 4). Site № 5 (pre-clint depression) was chosen for detailed investigations and feasibility study on the possibility of constructing a surface and a subsurface repository.

Surface repository designs (figure 5) were similar to those of a structure developed by SKB IC (Sweden) for Lithuania. Similar are the designs of facilities in France, Spain and a number of other countries.

Repository's surface unit consists of module type structures made of reinforced concrete (5) involving a group of cells intended for conditioned RW disposal, administrative and utility structures (1 and 2), a building for RW transfer from internal to in-site transportation systems (3), temporary storage facility for RW packages (4) and other infrastructure facilities.

The surface repository is a reinforced concrete structure of a rectangular shape (440×22.6 m and 8.5 m high). The modular structure is covered with mobile roof protecting it from precipitations. Transportation and handling equipment is installed under this roof. After the module is filled with RW packages, the void space between them is grouted and a slab panel is installed. When the whole

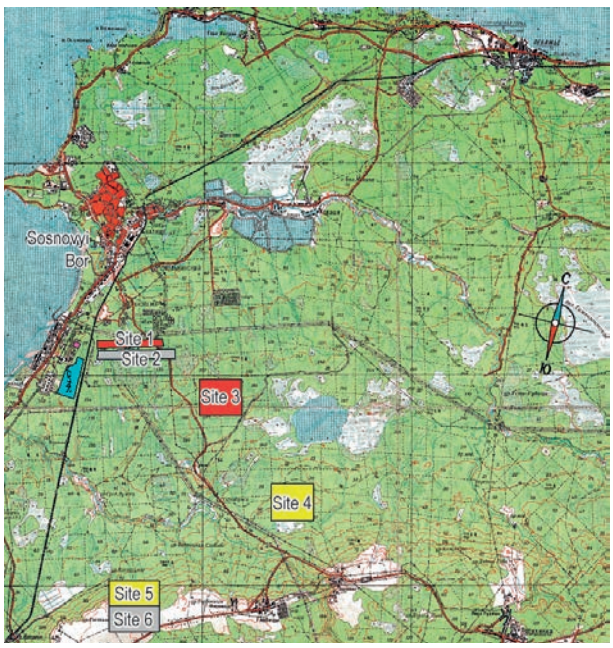


Figure 4. Siting options for a near-surface RW repository
Sites 1 and 2 – territories in the vicinity of the Leningrad division of RosRAO's North-Western territorial branch; site 3 – territories in the vicinity of Rakopezhi village; site 4 – Lubanovo stow; site 5 – Kastivskoe stow

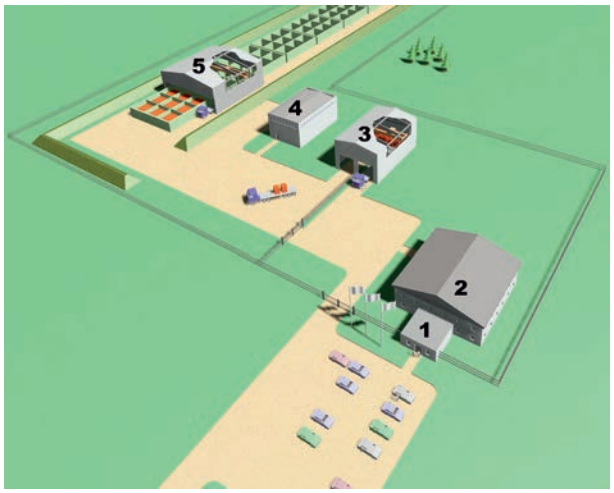


Figure 5. Surface structures of RW repository

structure is filled a capping system is installed. A total area of 34 ha is required for a surface disposal facility with a capacity of 250,000 cubic meters.

Two options are being considered for the sub-surface RW repository: large chambers (similar to those developed under Tacis Nucrus — 94.495 project) and an underground tunnel excavated with a big diameter tunneling machine. According to the first option, 20 chambers are required to dispose of 250,000 cubic meters of waste, whereas five 600 meters long tunnels are needed for the second option. An area of 1 ha will be enough for relevant surface structures.

Comparison of these options under a case study for constructing the first disposal section of the repository with a capacity of 50,000 cubic meters of waste showed that the cost of sub-surface repository is almost twice as high as for the surface one.

In 2010, on the request of FSUE RosRAO, VNIPIET developed the Declaration of Intentions and provided an investment feasibility study for construction of a Disposal Facility for Low- and Intermediate-Level Waste in the Vicinity of the Leningrad Division of RosRAO's North-Western District.

Predesign studies considered a sub-surface disposal option with cotlian clays as the bedrock formation located at a depth of 60—70 m with surface structures constructed at existing operational sites of the State Corporation Rosatom [7,8].

The underground facility for RW package disposal (figure 6) is a lined tunnel of 14.2 m n diameter 1,000 m long divided into 50 m-long sections. Five tunnels will be required to dispose 250,000 cubic meters of RW.

By height, the tunnel is divided into three separate sections: utility line area, RW package disposal area and transportation tunnel (figure 7).

Herrenknecht tunneling machine was planned to be used for tunnel excavation (the tunnel orientation – from the RosRAO's North-Western division site to N-W with an entrance at the territory of LNPP-2 site).

Given the complexity of the excavation process: tunneling machine installation, its high capacity (tunneling rate) and operational resource, as well as other factors and particular features of the site, construction of spiral ramp with a bigger diameter may be seen as a preferable option enabling to dispose of some 250,000 cubic meters of waste.

In January 2011, Declaration of Intentions review resulted in a decision made by the Interdepartmental Commission on Industrial Siting in the Leningrad Region on the possibility of repository siting in the area of Sosnovoborskyi urban district.

On December 27,2013, based on environmental impact assessment performed for the project FSUE NO RAO held public hearings proved to be successful.

Conclusion

50 years long operation of nuclear facilities has resulted in big amounts of radioactive waste now stored at the sites of Sosnovyi Bor settlement (Leningrad Region). Their storage is associated with potential hazards that might affect the public and the environment.

Construction of new LNPP-2 power units and the planned decommissioning of LNPP-1 units pursuant to provisions of the Federal law On Radioactive Waste Management requires the a new RW management framework to be set addressing

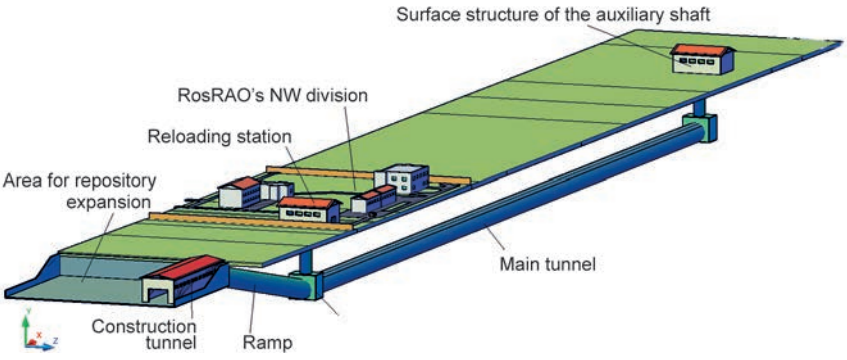


Figure 6. Sub-surface RW repository

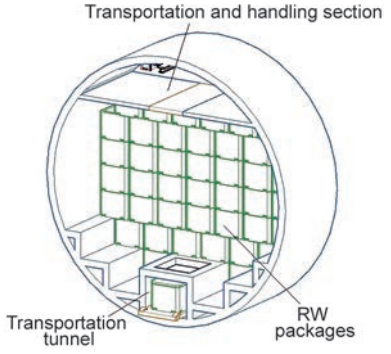


Figure 7. Tunnel cross section

the regional needs. The essence of the changes involved suggests that RW disposal practice has to replace the long-term storage one. This will enable to decrease radiation risks for personnel and public, as well as to reduce waste management costs.

During the last 25 years a big number of feasibility studies, investigations and pre-design activities aimed at the development of an RW disposal facility in the Leningrad Region was performed by Russian and European organizations. Different types on surface and sub-surface disposal structures to be located at different sites of the Region were proposed. Environmental impact assessments during construction, operation and closure of the repository were performed. Due to a number of reasons their findings are considered to be sufficient only for the pre-design stage of development. However, they still could serve a basis for further development of RW disposal facilities.

We believe that the time has come to upgrade technical, financial and social approaches used in the decision making as regards this urgent RW management challenge ensuring that relevant interests of the public, local and regional authorities and the nuclear sector are met and all the measures taken are in full compliance with provisions of the Federal law on Radioactive Waste Management.

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