

Projects proposals for radioactive waste management, remediation of buildings, structures and territory of temporary SNF and RW storage facility in Gremikha

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List of abbreviations

CERS	- comprehensive engineering and radiation survey
CPS	- reactor control and protection system
DDNF	- Directorate for Decommissioning of Nuclear Facilities
FS	- feasibility study
HOF	- handling operations flowsheet
ICES	- International Center for Environmental Safety of Minatom of Russia
LMC	- liquid metal coolant
LRW	- liquid radioactive waste
MTD	- Main Technical Department of the Navy
NIKIET	- Research and Development Institute of Power Engineering named after N.A. Dollezhal
NPI	- nuclear power installation
NS	- nuclear submarine
RMS	- radiation monitoring service
RRC KI	- Russian Research Center “Kurchatov Institute”
RW	- radioactive waste
SevRAO	- Northern Federal Enterprise for Radioactive Waste Management
SFA	- spent fuel assembly of the VVR reactor
SNF	- spent nuclear fuel
SRC	- spent reactor core of the LMC reactor
SRW	- solid radioactive waste
TC	- transportation cask
TSF	- temporary storage facility
VNIPIET	- All-Russian Research and Design Institute of Power Technology
VVR	- water cooled and water-moderated nuclear reactor
23 GMPI	- 23 rd State Marine Design Institute

1. Background

In the past SNF and RW temporary storage point (TSF) in Gremikha settlement, i.e. affiliated branch No. 2 of SevRAO, used to be an Northern Fleet Naval base established for providing:

- refueling of NS reactors with water and liquid metal coolant (LMC);
- storage of spent reactor cores (SRC) of the LMC reactors;
- storage of SFA from the first generation NS with water-cooled and water-moderated reactors (VVR);
- SRW storage;
- LRW storage and processing.

The TSF buildings and structures were mainly built in 1961-1966.

In the course of TSF operation in Gremikha certain amount of SNF and RW was accumulated, which, for different reasons, was not removed for reprocessing and storage to other places. As a rule, the state of most SNF and RW remaining on engineering site is evaluated as defective one. In the entire period the buildings and structures did not undergo thorough repair and most of them are in a very unsatisfactory state. Meanwhile, deviations are observed from the regulations prescribing procedure for RW and SNF storage. Besides, radioactive contamination of some places (~ 25%) on the TSF territory was pointed out.

Previously, a survey of the buildings, structures and territory was conducted for ascertaining the radiological situation and developing proposals for their further use. In 1996 the survey in Gremikha was performed by VNIPIET by request of the Navy MTD. Relying on the survey, development of a concept of SNF (defective SNF, first of all) and RW handling was started.

The activities undertaken by a joint team of NIKIET, RRC KI and Ekoatom specialists in 1999 permitted gamma-beta survey of the base territory, analyzing about 100 soil samples and ascertaining specific content of Cs-137, Sr-90 and Co-60 radionuclides in them. Radiation survey of tanks with LRW was performed, specific activity and physicochemical composition of the LRW were determined.

Subsequently, owing to inadequate funding, the remediation activities were undertaken in the scope that proved much smaller than the one required. As a result, further deterioration of the buildings state, degrading of SNF and RW protective barriers, contamination of the territory around SRW and LRW storage places occurred. Major portion of LRW was reprocessed.

In 2003 an opportunity for real funding of remediation in Gremikha appeared due to assistance of donor countries. Development of a detailed program of activities with highlighting the priority trends, when each Euro invested yields maximum contribution to improvement of the radioecological situation, proved necessary for maximum effective use of the assistance. But for the purpose knowledge of the actual situation at TSF was required. That is why DDNF of Minatom arranged a survey of TSF, adjacent territory and water area in the bay in August-September, 2003. The effort was made by a joint team of NIKIET, RRC KI, SevRAO, VNIPIET and ICES specialists. The data obtained along with previously developed documents and reports issued by VNIPIET, NIKIET, SevRAO, 23 GMPI, etc. were used in drawing up this report.

2. Description of the TSF site

The specialists involved in construction and subsequent operation of the buildings and structures designed for handling SNF and RW were guided by regulatory and technical documentation effective at that moment, which differs from the modern one. The absence of some modern devices and equipment gave rise to violation of process regulations for handling SNF and RW and, accordingly, to radioactive contamination of the buildings, structures and a part of TSF territory.

Layout of the TSF buildings and structures is provided in Fig. 1. It incorporates the following buildings and structures pertinent to issue of RW management:

2.1. Storage for nuclear submarine SFA - Building 1.

Operation of the storage facility was prohibited since 1986 due to loss of its pool leak tightness. At present SFA from all the pools have been unloaded; water from pools No. 1, 2, 3 and 4 has been actually drained. A small amount of water with silt-like sediments is retained on the bottom of pool No. 2. Sixteen canisters containing SFA from water-cooled reactors are stored in the pool sumps.

2.2. Building for refueling NS with LMC reactors - Building 1A. The relevant project was developed in 1982; the building was erected in 1989.

2.3. Storage for spent removable parts (SRC) of NS with LMC - Building 1B. The relevant project was developed in 1959; the building was erected in 1961 and reconstructed in 1988.

Purpose: receipt and long-term storage of SRC.

At the moment 6 SRC are stored there. The building has 8 places permitting arrangement SRC for long-term storage.

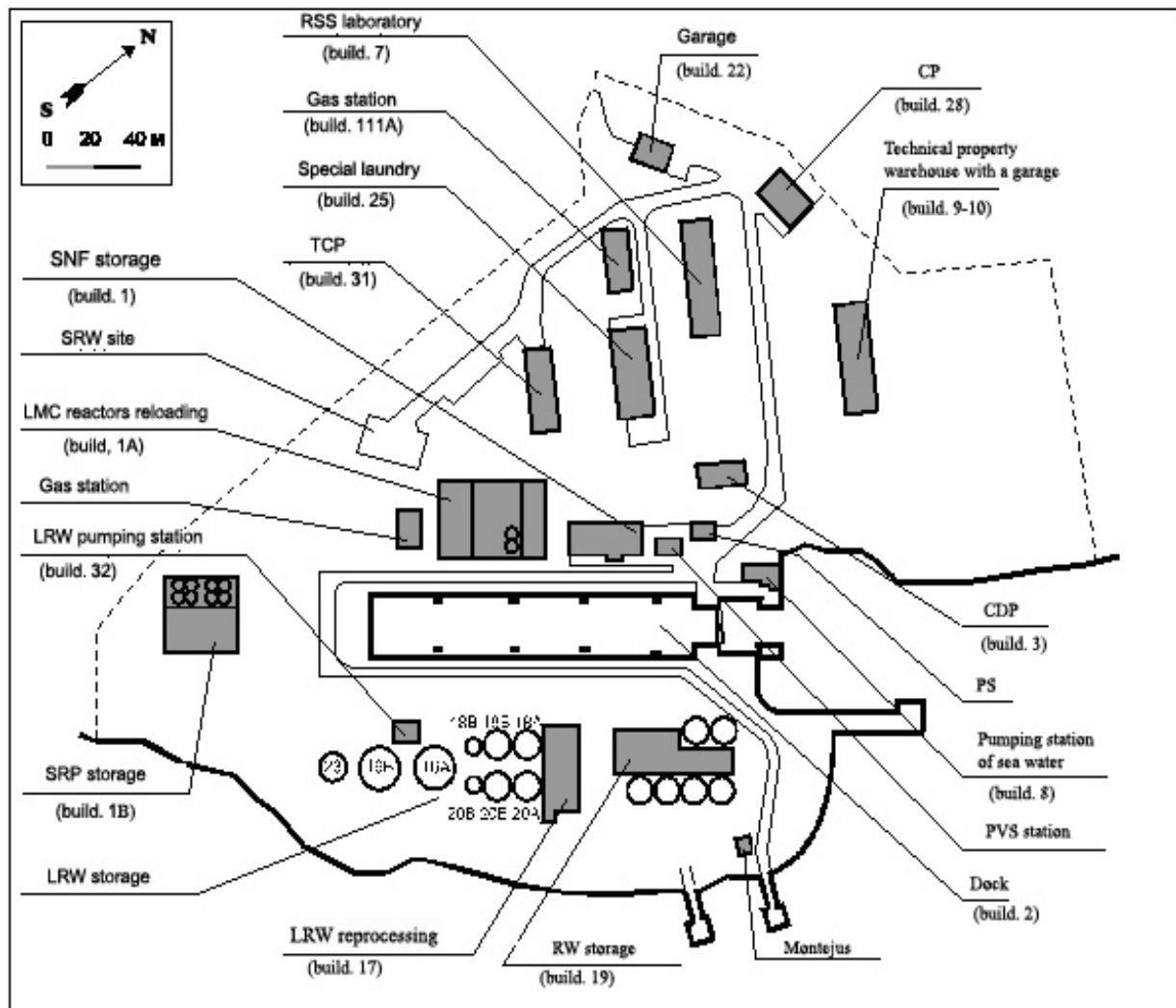


Fig. 1. Layout of the buildings and structures

2.4. A pad for SRW temporary storage. The pad was constructed without relying on any design, by household efforts. Purpose: temporary storage of SRW. It is used for storage of

SRW and SNF of the VVR reactors within type 6 and type 11 casks. The pad is a concreted site, its area 300 m² (20 x 15 m), surrounded on its three sides by a 3 m high wall made of reinforced concrete blocks and fenced by barbed wire over perimeter at a distance of 5 –10 m from the wall. There is no protective roofing structure above it. The pad hosts more than 100 casks loaded with canisters containing SFA, which make up ~85% of all SNF of the VVR reactors stored in Gremikha, as well as reinforced concrete and steel containers with high-level SRW and SFA fragments.

2.5. Building 17. The building was intended for accommodating a LRW treatment plant. It was never operated in that mode. Now it hosts two facilities, i.e. “Potok” facility for LRW treatment and a cementation facility for LRW and sludge deposit.

2.6. Building 19. It was built in 1966. The building was designed for storage of LRW concentrate formed as a result of LRW treatment in Building 17. However, as the latter has never been done, now it is used for temporary storage of SRW. It is made up of 6 reservoirs each of 400 m³ holding capacity buried in the ground and a process hall, its area 430 m².

2.7. LRW storage – (reservoirs No. 16, 18, 20).

2.8. Dry dock – Building 2. It was built in 1961. Its purpose is placing of NS with LMC reactor on a solid base during SRC unloading. The dock functioning is necessary for unloading the remaining NS with LMC reactors and for providing SNF and RW removal from the site.

2.9. A warehouse for materiel with a garage – Buildings 9 and 10. Their initial purpose is storage of fresh nuclear fuel. Employment of the buildings for transshipment of SNF and SRW stored on the SRW site is possible.

3. Characteristic of RW stored

3.1. Waste origin

Solid and liquid RW temporarily stored in specialized buildings and reservoirs was formed:

- as a result of naval nuclear power installations (NPI) operation;
- during maintenance of vessels with NPI or their removal (retirement) from the Navy fleet;
- during radiochemical analyses and support of activities at the site;
- in the course of decontamination activities at the site;
- during sanitary decontamination of personnel after the activities.

At the facility the following waste was temporarily stored:

- LRW - low- and intermediate-level waste (its specific activity up to $1.9 \cdot 10^{-5}$ Ci/l ($6.9 \cdot 10^5$ Bq/l));
- SRW – low-, intermediate- and high-level waste.

About 2000 m³ of LRW is stored in coastal reservoirs for receipt and temporary storage of LRW, which are:

- low-salt (drainage water of NPI circuits, circuit washing water, water from ion-exchange filters reloading in the primary and third circuits);
- salt (decontamination water, sanitary pass water, radiation monitoring service (RMS) laboratory water).

The waste activity reached $1.9 \cdot 10^{-5}$ Ci/l, Sr-90 – Y-90 being largely (by 90%) responsible for the level. Currently, most of LRW was processed in the “Potok” facility. The cementation facility located in Building 17, is designed for handling sludge deposits arising from drainage of LRW storage reservoirs. Total amount of the sludge deposits makes up 200 m^3 .

3.2. Coastal reservoirs for LRW temporary storage

LRW was stored in coastal reservoirs. After reprocessing LRW a sludge mass, its activity from tens to hundreds of millicurie, remains on the bottom of the reservoirs. Precise amount and composition of the waste will be determined after performing a detailed CERS, as well as examining the state of the reservoirs and ascertaining their purpose in future.

Buildings 16A, 16B (reservoirs for LRW) Purpose: temporary storage of polonium-containing drainage water formed in the course of handling LMC reactors.

The reservoirs are solid reinforced concrete structures buried in ground and lined by steel, each of 1000 m^3 holding capacity. Each reservoir is made up by two 500 m^3 capacities, i.e. a central one intended for high-level LRW and periphery one – for intermediate- and low-level LRW. The relevant isolation valves are inoperable.

Buildings 18A, 18B, 18V (LRW reservoirs).

Purpose: temporary storage of laundry and shower wash water. They are solid reinforced concrete reservoirs lined with steel each of 200 m^3 holding capacity (18A, 18B) and 100 m^3 – 18V. Their isolation valves are unfit for operation.

Buildings 20A, 20B, 20V (LRW reservoirs).

Purpose: storage of low-level LRW. They are solid reinforced concrete reservoirs lined with steel. The holding capacity of reservoirs 20A and 20B is 200 m^3 , reservoir 20V – 100 m^3 . The isolation valves are now unserviceable.

Building 23 (reservoir for polonium-containing shower water).

Purpose: temporary storage of polonium-containing shower water. It is a solid reinforced concrete reservoir lined with steel, its volume 200 m^3 . It is used as a temporary SRW storage facility.

Building 32 (special sewage pumping station).

Purpose: the building is intended for transfer of special sewage from the reservoirs to the pier and further to the sea vessels for removal beyond the facility. It is not used in line with its designation, as the pier operation was stopped. The building structures are in a satisfactory state. Radiation checkpoint of the building after repair can be used for its purpose. Heating, water supply and sewage, specialized sewage, lighting, power supply and radiation monitoring are to be repaired and recovered for the purpose. After a detailed study in CERS it shall be taken into consideration while making FS on the infrastructure modernization.

In 1987 the pipelines connecting coastal reservoirs 18A, 18B, 18V, 20A, 20B, 20V, 23 were dismantled and plugged. Receipt of LRW in the reservoirs and its pumping off are possible solely via non-standard, temporary lines.

In 1993 operation of the coastal reservoirs was forbidden, as their service life was exhausted in 1987, whereas delivery of LRW from them to the vessels is impossible, as there are no standard service lines and due to dilapidated state of the pier No. 8.

Decontamination of the equipment, containers, casks and building structures, as well as radiation checkpoint operation will give rise to LRW generation. The waste is to be poured in a reservoir, whence it could be pumped for treatment in a modular facility. For this purpose, reservoir 16 BC, which was certified in 2002 with granting the appropriate license, can be used for the next 3 years. The purpose of the rest reservoirs will be determined after CERS during FS development.

3.3. SRW storage

A small pad, its area 300 m² (20 m x 15 m) was constructed for SRW temporary storage by household effort, i.e. without any design. It is fenced on its three sides with a 3 m high wall made of reinforced concrete blocks (biological shielding). The pad was arranged in the upper point of the terrain relief and it is not fitted out by a drain system and stationary load-hoisting devices for container handling. On the outside at a distance of 5-10 m from the wall the site is fenced by barbed wire.

In terms of quality the stored SRW consists of:

- metalwork and tools;
- plastic compounds, rubber, electric cables, hoses;
- building structures and timber;
- glass and porcelain laboratory glassware;
- hard to decontaminate special overalls, special footwear, rags;
- radionuclide sources with expired life or damaged.

For over 20 years spent nuclear fuel, unloaded from the three pools in Building 1 within old (TK 6 and TK 11) transportation casks (TC) is stored in the open air. Service life of the casks expired in 1999. The cask manufacturer does not provide any conclusion about possibility of further safe storage of SNF in the casks mentioned. Water penetrates into the casks, freezing in winter and inflicting damage on SNF, sometimes squeezing out the cask lid. At the moment it is impossible to open the upper lid in 12 casks using standard devices, and the problem will have to be solved during development of a process for SNF handling.

In 2003 the casks were covered by old iron barrels protecting TC contents from water ingress. Members of a large French delegation, who visited Gremikha on July 18, 2003, saw the "hats".

Non-standard metal containers weighing 7 and 9 t, which are loaded with fragments of SFA damaged during transshipment (21 pcs.) are stored on the same pad. Besides, the pad accommodates:

- 14 reinforced concrete non-standard containers weighing 9.5 t, each of them containing fragments of SFA;
- 20 reinforced concrete lead-plated non-standard containers weighing 8, 5 and 9.5 t with fragments of SFA and other high-level waste (formed during cleaning of pool No.1).

The containers elevated radiation background (hundreds of $\mu\text{Sv/h}$), being unsafe from the viewpoint of their leak tightness.

45 traps with ion-exchange resins of the primary and tertiary circuits, containers with diverse SRW (54 pcs. of $\sim 1.5 \text{ m}^3$ in volume) are arranged on the pad within waste, that does not contain fissionable materials.

Waste, which was not put into containers, mainly large-size parts of freight transportation means, has by now been almost completely removed, fragmented and placed within metal boxes of 1.5 m^3 in volume transhipped to Building 19.

Besides the pad, high-level SRW is also stored in Building 1A (ionisation chambers – 12 pcs.) and in Building 1 (CPS rods within jackets). In one of reservoirs in Building 19 (its volume 400 m^3) contaminated construction waste and ground were arranged, which can be referred to low-level waste.

Total amount of SRW at TSF makes up $\sim 1600 \text{ t}$.

The SRW pad is responsible for elevated radiation background at a distance up to 100 - 180 m from it, being a constant source of the base territory contamination, as rain and melted snow running from it contain long-lived radionuclides. As a result, the ground near the pad contains radionuclides of Cs (up to $5 \cdot 10^7 \text{ Bq/kg}$) and Sr (up to $6 \cdot 10^6 \text{ Bq/kg}$). Even behind

the external barrier γ -background reaches 10 - 12 $\mu\text{Sv/h}$, while contamination in terms of Cs-137 is up to $1.5 \cdot 10^5$ Bq/kg and in terms of Sr-90 up to $4 \cdot 10^5$ Bq/kg.

Therefore, liquidation of the pad, shipment of SNF and SRW into a closed compartment and removal of contaminated ground with its placing into containers for temporary storage in Building 19 can be mentioned among top-priority measures. The choice of the closed compartment, its retrofitting and equipping with appropriate hardware will be subjects of specific design development.

It will permit essential improving of the radioecological situation on the entire territory of the TSF.

4. Radiation-hazardous buildings and structures

Most buildings at the TSF were constructed according to the designs developed by VNIPIET and 23 GMPI in the early 60-s. In the 40 elapsed years under severe climatic conditions (strong humid winds, with velocity more than 15 m/s, abrupt variations of temperature) and in the absence of appropriate upkeep they became noticeably dilapidated. The building structures in some cases lost their strength, the walls and foundations being covered with cracks, the reservoirs, SNF storage pools inclusive, lost their leak tightness, so, ingress of ground water is possible.

The following buildings and structures are primarily classified as radiation-hazardous ones:

- SFA storage facility (Building 1);
- building for LMC reactor refueling (Building 1 A);
- SRC storage facility (Building 1B);
- LRW storage facilities (reservoirs No. 16, 18, 20, 23);
- LRW pumping station (Building 32);
- SRW storage facility (Building 19);
- Building 17 (LRW treatment building).

After removal of SNF and RW from the building, the structures will necessitate decontamination and, in some cases, utter liquidation with removal of secondary RW (walls, building structures, contaminated soil under the building and around it).

As it has been already pointed out, the open pad for SNF and SRW temporary storage is an extremely radiation-hazardous structure.

Elevated contamination of soil is observed in the vicinity of the pad, near LRW storage facilities and in the pier near the dry dock (due to spills in the process of LRW pumping).

Figs. 2 - 4 present results for γ -radiation measurement points in Building 1, on the open pad for SNF and RW temporary storage and on the base territory taken by NIKIET specialists in August, 2003 along with results of the TSF water area and near-shore zone obtained by RRC KI experts in August, 2003.

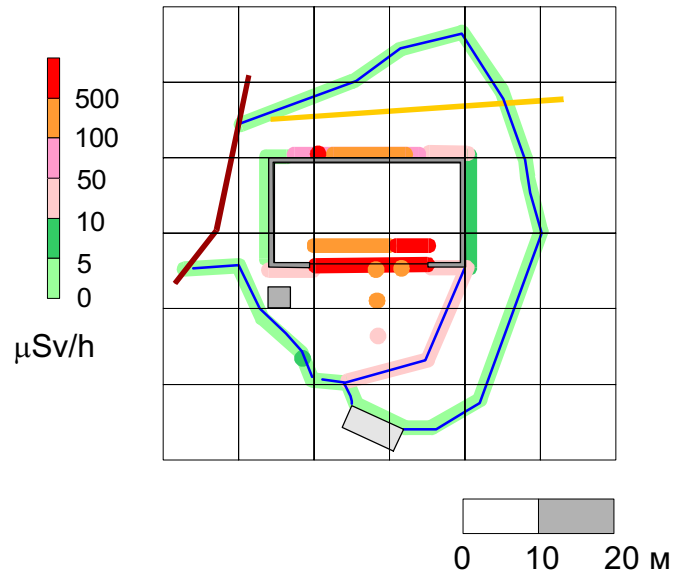


Fig. 2a. SRW site - Density of β -radiation flux on the ground surface

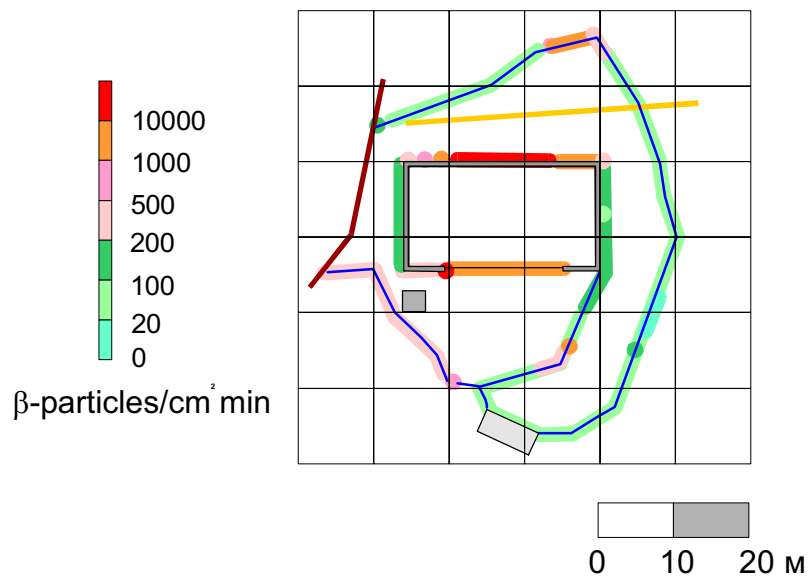


Fig. 2b. SRW site - γ -radiation dose power at the distance of 10 cm from the ground surface

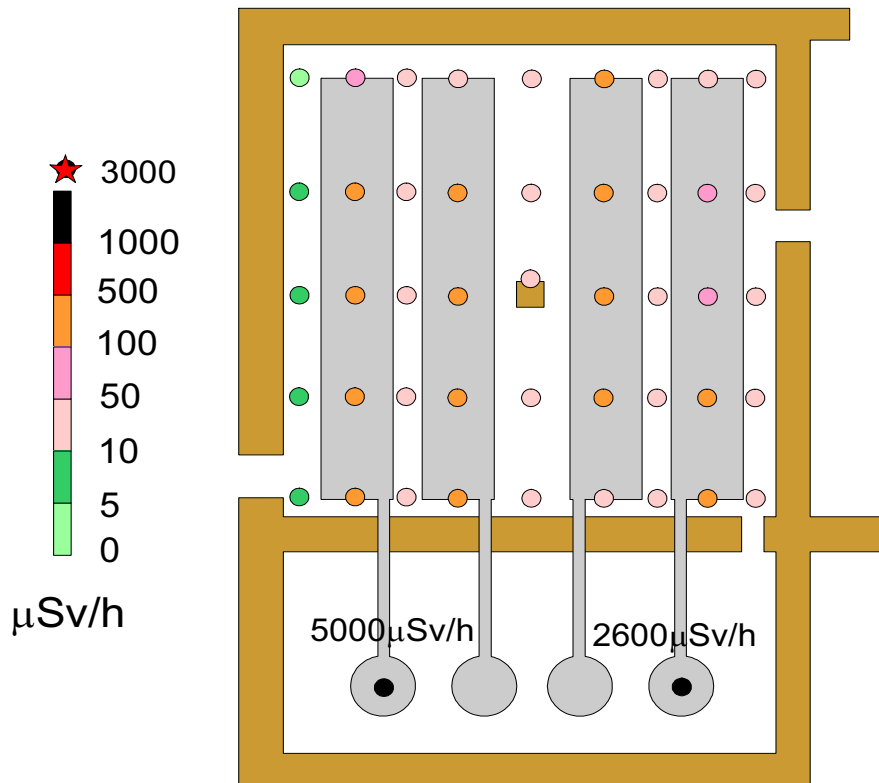


Fig. 3a. γ -radiation dose power near the floor in the process hall of building 1

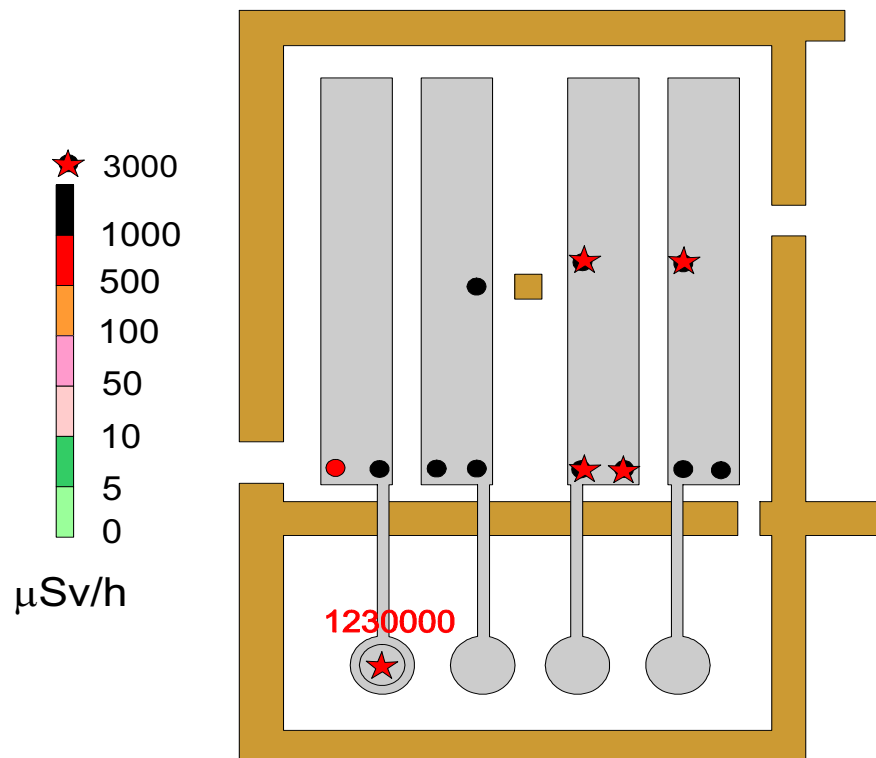


Fig. 3b. γ -radiation dose power in the pool of building 1

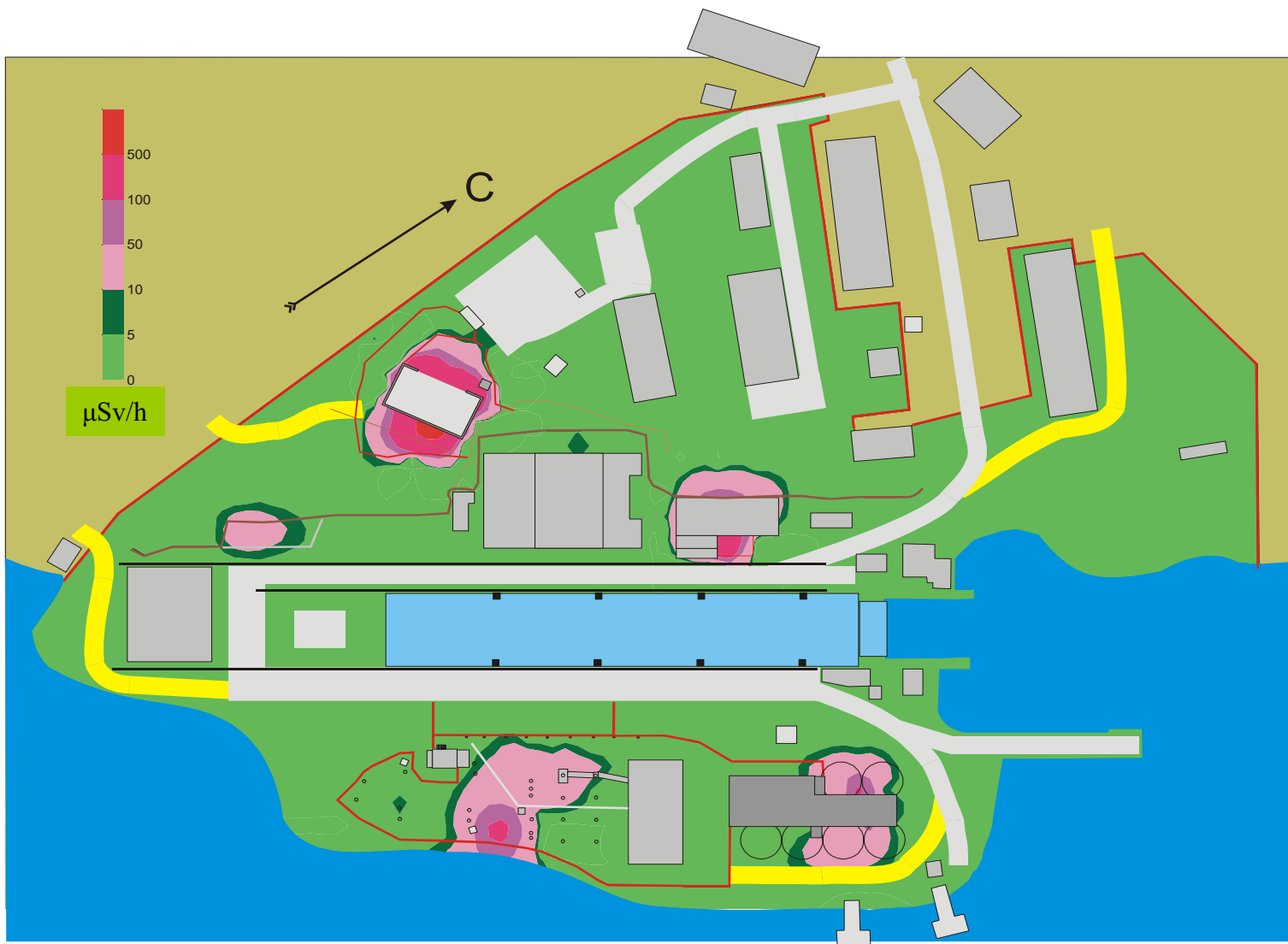


Fig. 4a. γ -radiation dose power on the RW and SNF TSF territory in Gremikha



Fig. 4b. Density of β -radiation flux on the RW and SNF TSF territory in Gremikha

5. Gremikha TSF radiation surveys conducted in 1999 and 2003: preliminary comparison of results obtained for RW and SNF

In 1999 the survey was carried out by FSUE NIKIET, RRC “Kurchatov Institute” and RPE “Ekoatom”. In 2003 the survey was conducted by FSUE NIKIET and RRC KI.

5.1. Radiation survey of the TSF territory, conducted by NIKIET in 2003 comprised:

- survey of the TSF buildings and structures, including gamma radiation dose rate and beta contamination measurements inside the buildings and along their perimeter (Buildings 1, 1A, 1B, 9/10, 32, partially 17 and 19, RSW site, dry dock);
- radiation survey of the TSF territory, gamma radiation dose rate and beta contamination measurements at a step of 10 m inclusive;
- sampling and spectrometric studies of soil, building materials and bottom sediments;
- spectrometric studies on the TSF territory.

A similarity between results obtained in 1999 and 2003 was revealed.

Buildings 1, 1A and 1B are maintained by the TSF personnel and their state is satisfactory. Gamma radiation dose rates inside the buildings, except for the process hall of Building 1, its hold, an open site at elevation +3.3 in Building 1A and entresols near the rock behind Building 1A, are 0.3-0.5 μ Sv/h on the average, very rarely being in excess of 5 μ Sv/h, whereas the value of beta contamination makes up 20 particles/cm²min.

No survey of the hold in Building 1, open site at elevation +3.3 of Building 1A was made in 1999.

The process hall in Building 1 is in acceptable state. The hall floor and cooling ponds were decontaminated. Water in insignificant amounts penetrates into pool No. 1 from behind the rear wall. The value of gamma radiation dose rate on the floor is 200 μ Sv/h, that of the pools – 3000 μ Sv/h, beta contamination on the floor being up to 50000 particles/cm²min, which corresponds to the order of values measured in 1999.

The dry dock is under repair (the gate was replaced, the dock-floor and by-pass routes were grouted with new concrete, etc.). The radiation situation inside and outside the dock has been improved essentially.

The major changes were observed in the area of SRW site and Building 19. Changes in the radiation state of the SRW site were possibly caused by washing out of radionuclides by rain and melted snow water from under the concrete wall surrounding the site. It involved increase in the area of contaminated zone behind the rear wall of the SRW site, its gamma radiation dose rate reaching ~800 μ Sv/h with beta particles flow up to ~70000 particles/cm²min. Water flows from the SRW site to the corner of Building 1A, where, compared with the year of 1999, gamma radiation dose rates increased from 3 to 7-8 μ Sv/h, beta particles flow density increased from 100 to 1400 particles/cm²min, activity of Cs-137 in soil samples - from 10⁴ to 10⁶ Bq/kg.

Changes in the radiation situation around Building 19 is determined by a container with a powerful radiation source arranged inside it. The values of gamma radiation dose rate opposite to the immured windows are in excess of 10000 μ Sv/h .

Changes in the SRW site and in Building 17 are caused by cleaning of LRW reservoirs and presence of the equipment contaminated as a result of the cleaning in Building 17. In general the values of radioactive contamination remained at the former level.

The spectrometric studies permitted ascertaining the presence of Eu-152:

- in the point of CPS items cutting near Building 1 – up to 1.7 \times 10⁵ Bq/kg;

- along container movement route near Building 1 – up to 3.5×10^4 Bq/kg;
- along container movement route near Building 1B – up to 3.3×10^2 Bq/kg;
- at the entrance to the SRW site – up to 10^6 Bq/kg.

5.2. Radiation survey of off-shore waters and coast land near TSF territory

For the first time it was carried out in August, 2003 by RRC KI specialists.

In course of the survey the following activities were performed:

- direct measurement of sea water and bottom sediments radioactivity with the help of immersion gamma-spectrometers;
- selection of bottom sediments samples;
- determination of Cs-137 content in sea water by means of its concentration on selective sorbent;
- selection of soil and bottom sediments samples in the coast land and ebb land;
- dosimetric exposure in the coast land and along the site perimeter.

A diving ship was used to provide implementation of activities in the off-shore waters.

Places of measurements performing (see Fig. 5) in the off-shore waters were determined in accordance with the program-methodology and the support ship's potential. Because of significant ship's draft (~ 3 м) and absence of reliable information about the depths in the coast land it was impossible to carry out measurements with the help of immersion spectrometers on the southern side of the site in Chervyanaya bay (however soil samples were selected in this area in the ebb tide) and measurements in the area of pier No. 8 were handicapped.

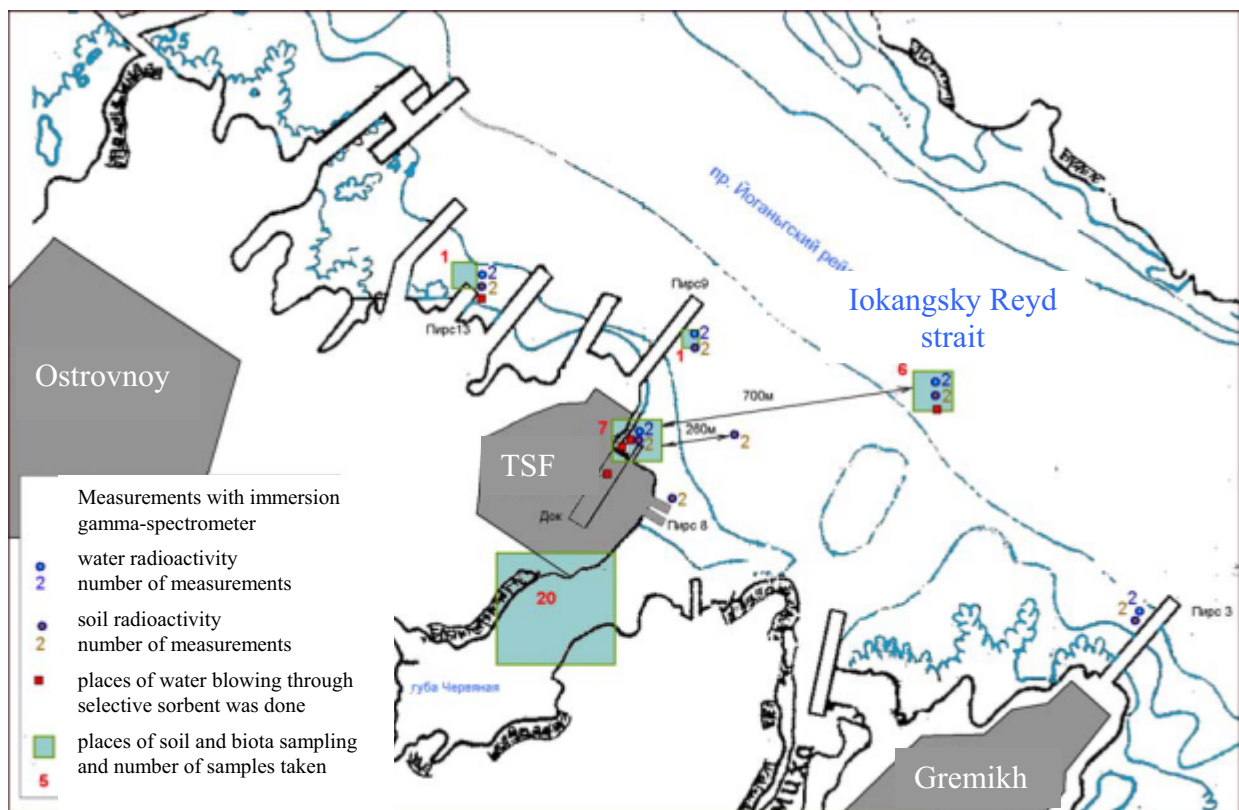


Fig. 5. Places of measurements and soil sampling

Selection of bottom sediments samples and sea bioobjects (seaweeds, crustaceans, shell-fish) was carried out from the board by the diver and also where possible with the help

of soil sampler. In the coast land adjacent to the enterprise's territory the use of pipe soil sampler for bottom sediments samples taking was handicapped by soil rocky character.

Totally 25 direct measurements of water and bottom sediments gamma-radioactivity were carried out using the support ship and with the help of immersion gamma-spectrometers, 5 concentrated sea water samples were occluded, 11 bottom sediments samples and 6 bioobjects samples were selected by the diver, 2 bottom sediments samples were selected with the help of soil sampler, one of them was non-destroyed soil core sample with the depth of 18 cm (in the pier 13 area).

The following areas were most thoroughly surveyed:

- the area near the dock exit and the pier No. 8;
- the area in the middle of the Iokangsky Reyd strait at the distance ~ 700 m from the site for finding out possible radioactive contamination distribution.

In order to define areas, through which radionuclides flow into the environment, the coastland survey was carried out; it is a border through which radionuclides can flow into the offshore waters. In the coast land and tide area of Chervyanaya bay, adjacent to the TSF territory on the southern side 20 soil samples and one seaweeds sample were selected. Upper soil layer ~ 3 cm was selected. The samples' selection was carried out on August, 26, 2003 at the water level 110 cm – one of the lowest during the activities carrying out. It should be noted that at the maximum ebb (- 40 cm) Chervyanaya bay dries almost completely.

Processing of received results is being currently implemented in RRC "Kurchatov Institute".

6. Methods for solving the RW handling and facility remediation problems

Activities aimed at remediation of SNF and RW in Gremikha are being undertaken several years after the relevant activities at Andreeva Bay. Therefore, the experience gained can be used. It also embraces the processes used during SNF and RW handling and safety assurance of the activities and, which is no less important, coordination of interaction between various organizations, both Russian and foreign ones.

We know from the experience gained during the work at Andreeva Bay that one cannot rely on the information received from the former proprietor of the coastal technical base, which is also not sufficient. The actual composition and state of the SRW and LRW stored can be determined solely as a result of detailed studies using up-to-date hardware and the relevant software. Whereas the actual state of the buildings and structures, potentialities for their temporary use for this or that purpose (storage of SNF and SRW in them, arrangement of reloading into standard certified containers, etc.), their future purpose (renovation or complete demolition) can be defined only after conduct of comprehensive engineering and radiation survey (CERS). It is noteworthy that the certified transportation casks for SNF and containers for SRW can be delivered to Gremikha solely by sea. In conformity with regulatory and technical documentation removal of SRW within temporary overpacks beyond the TSF boundary is forbidden.

One more very important conclusion from the grave past experience is appropriate. By request of the Navy (prior to transfer of the base under the jurisdiction of Minatom) and on demand made by DDNF after the base was transferred to Minatom, VNIPIET, 23 GMPI and NIKIET were engaged in devising of technical proposals and process approaches, relying on the infrastructure and information about the technical state of the buildings, load-hoisting and transport equipment, radiation situation at SNF and RW storage facilities available at that moment.

However, as V.D. Safutin, VNIPIET Director General, put it in his letter to the address of SevRAO and ICES of June 23, 2003 "...despite the great scope of the work done in advance for assuring the environmental safety of the facility, no real work aimed at improving conditions of SNF and RW storage, reduction of radiation hazard on the territory of the coastal technical base in Gremikha was performed in the period. The state of SFA within type 6 and type 11 casks and of the RW storage facilities continue to deteriorate, thus impairing the facility environmental danger. Practically the entire infrastructure has been destroyed, making the previously developed technological approaches to SNF and RW management of little use".

That is why at the moment well-coordinated and well-timed effort shall be made, so as no breaks between the links making up the operation procedure of SNF and RW handling flowsheet appear. Delays and lead-time in the relevant activities will result in loss of time, increase in exposure dose burden on the personnel and cost overrun.

6.1. Personnel safety assurance

As indicated by the experience of the Andreeva Bay work, assurance of the personnel safety necessitates:

- providing the personnel with the required individual protective means (clothes, footwear, respirators);
- preparation of radiation checkpoints; repair of the radiation checkpoint in Building 22 is underway now, but works on the open pad for SNF and SRW temporary storage will probably require an individual mobile radiation checkpoint with cabins for changing, fitted out with warm water and dosimeter monitoring means;
- providing the personnel with individual dosimeters and a system of radiation monitoring during operations in nuclear- and radiation-hazardous places;
- set-up of well-equipped and certified radiochemical and radiobiological laboratories for prompt processing of measurements results, besides portable dosimeters and spectrometric instruments; the equipment set is similar to the one used at Andreeva Bay.

For reducing the dose burden on NIKIET personnel during survey of the storage facilities at Andreeva Bay in July-August, 2003, the following measures were taken, which could be used in Gremikha, as well:

- providing of all the employees with individual protective means;
- individual radiation exposure monitoring;
- development of a schematic map of measurements and optimal sequence of jobs on its basis;
- development and manufacture of contrivances for remote dose measurements;
- personnel training in saving time for preparation and taking of measurements;
- development of a mathematical program, that will permit ascertaining the composition and activity of SRW, their distribution over the container volume, including location and type of point sources, on the basis of several measurements by a γ -spectrometer with a collimator.

When drawing up the work program, potential emergencies, which may give rise to increase of dose burden on the personnel or result in injuries, negative impacts on the environment and public inclusive, shall be taken into consideration. It is of special importance for Gremikha, as residential settlements are located near the industrial sites.

Analysis of the situations mentioned will permit taking measures for their prevention or mitigation of after-effects. Mandatory analysis is required in the regulatory and technical documentation, being specified for all the activities performed at Andreeva Bay.

6.2. Liquidation of the open pad for SNF and RW temporary storage

The pad is a constant source of radiation-environmental hazard, which enhances as SNF degrades within the un-tight casks. Containers with SRW containing SNF fragments loaded into them after cleaning of pools in Building 1, have an elevated γ -background (up to 1 R/h at the surface of some containers), which impedes essentially the activities aimed at survey and inventory taking of the container contents, besides problems in their further handling.

While drawing up FS, the option of SRW removal, the containers placed in additional protective containers, should be considered versus the option of SRW reloading into protective containers, the options cost effectiveness being compared.

Rain and melted snow spread radionuclides over the nearby territory, as the pad was arranged on the highest elevation.

Various options of SNF and RW handling were considered. Construction of a roofing above the site will permit protecting it against rain and snow and preventing further washing of radionuclides from the site on surrounding territory up to the moment of its liquidation. However, loading of SNF and SRW into certified containers will be impossible there, bearing in mind Gremikha climatic conditions. A special building will be needed.

Use of Building 17 after its modernization in line with currently effective regulatory documents can be one of the options for arranging the SRW from the temporary storage site.

The proposal on SNF containers removal to a separate building (Building 10, for instance) and arranging a post for its reloading into new cases was considered.

Anyway, the work shall be started from comprehensive engineering and radiation survey of the buildings and structures, as well as radiation and geological survey of the territory.

Removal of the containers from the pad will permit cleaning its concreted cover and removing the soil around the pad (very likely under the pad, as well, but it will be clear solely after SNF and RWE removal from it). According to estimates the volume of the soil, which is to be placed, like SRW, into containers, will make up 100-200 m³. Accomplishing of the work will permit improving essentially the radiation-environmental situation and preventing further spread of radioactivity over the base territory.

6.3. Remediation of the buildings, structures and territory

The available data suggest that major structures hosting or used to host SNF and RW, shall be liquidated, giving rise to additional and quite considerable amount of secondary LRW and SRW.

However, in the next few years (at least up to 2010) some of the buildings and structures shall be used for handling SNF and RW. Their repair and partial modernization will be required for the purpose. For ascertaining the range and scope of the work required, it is necessary to conduct CERS, after that FS and modernization projects for the buildings and structures can be developed.

Reconstruction of the dry dock (Building 2), which is the only hydraulic and engineering facility providing standard transport-process operations for SNF and RW removal, is a very important task. SevRAO has already started to cope with it and in the nearest future the task will be accomplished. Radiation survey revealed local sources of soil contamination on the dock territory. Removal of the contaminated soil (~10 m³) will permit improving safety of the remediation activities.

Repair and recovery will give rise to formation of secondary LRW (during water drain from containers and casks with SNF and RW, during decontamination of the container surfaces and building structures) and SRW (the containers and casks, which used to host SNF and RW, their rigs, etc.) at all the stages of SNF and RW handling.

LRW treatment is possible in the “Potok” facility, while temporary storage – in some of the available reservoirs, 16 BC, for instance. To this end, engineering survey of all the reservoirs is required along with renovation of the reservoirs fit for use, adjustment of isolation valves and installation of the relevant instrumentation. The rest reservoirs shall be cleared from LRW residues, decontaminated and moth-balled. It means that the reservoirs will be emptied and decontaminated, tested for leak tightness, their inlet and outlet piping being plugged, the lids being sealed, etc.

Arrangement of a modular facility for salt concentrate cementing after LRW reprocessing will require replanning and repair of several compartments within Building 17.

Inventory taking of SRW, its sorting and compacting with packing into certified containers for temporary storage and subsequent removal from Gremikha to a regional center for SRW management is necessary during the SRW management.

Unfortunately, the issue of location and type of the long-term center for SRW storage and disposal in the North-West of Russia has not been clarified as yet. No answer was received to the question about the appropriate level of SRW processing in Gremikha. All the aforesaid affects both the choice of handling operations flowsheet and the number/type of containers required for SRW handling in Gremikha.

Development of projects for utilizing the auxiliary buildings and systems, dry dock and other facilities of the infrastructure, completion of the territory remediation will be the final stages. By that moment neither SNF nor RW must remain in Gremikha.

7. Proposed plan of actions

The results of the radiation and engineering survey of the main buildings and structures, as well as of Gremikha territory, obtained in August, 2003, along with already available data obtained by SevRAO, VNIPIET, NIKIET, 23 GMPI and RRC KI permit starting the development of a detailed CERS program, i.e. comprehensive engineering and radiation survey of the buildings, structures, radiation-ecological and radiation-hydrological survey of the territory, including the base outskirts and its water area.

CERS objective is obtaining initial data for FS and choice of the optimal variant of the TSF remediation.

Relying on the data obtained the problem of potential use of the existing buildings and structures for different purposes, their demolition or renovation, will be solved, the volume and composition of secondary SRW and LRW will be evaluated, etc.

Below the components of the survey and their approximate cost are provided.

7.1. Engineering survey

7.1.1. Engineering-geological survey:

- analysis of the available archive materials and reconnaissance survey of the TSF territory, development and coordination of the “Program and Methods of Implementation”;
- topographical survey;
- comprehensive engineering and geological studies of the territory as applied to the 1:2000 scale;

- hydrological survey of the TSF territory;
- drawing up of engineering-geological, hydrological, geologo-ecological maps and issuing of a consolidated report.

7.1.2. Engineering and construction survey:

- examination of the building structures state;
- ascertaining of the technical state of the existing process and engineering systems;
- verification of actual availability of the equipment versus design data;
- sampling of diverse sections of the building structures and study of strength characteristics;
- ascertaining of the pipelines, heat insulation, cables, etc. degree of wear (corrosion and physical);
- assessment of the state of the life support systems.

7.2. Radiation survey of the TSF buildings, structures and territory

- dosimetric and radiometric (α - β surface contamination) measurements inside and outside of the buildings and structures on the TSF territory;
- sampling of soil, smears and scrapings from the walls, equipment and structures for defining their contamination with radionuclides and for ascertaining their composition;
- radiation-geological and radiation-hydrological studies are conducted in parallel with the activities mentioned in item 7.1.1.;
- drawing up maps and data bases by radiation levels, surface and soil contamination by radionuclides migration with ground water;
- development of the TSF territory zoning and making of recommendations for bringing the TSF into radiation-safe state for the personnel and public.

Examination of SNF state within the casks on the open pad without opening the casks will be one of the most important and complicated task. There is a danger that, owing to SNF degrading, its fragments can accumulate on the container bottom, which increases the risk of a nuclear incident, especially in case of unpremeditated penetration of water inside the container.

For the purpose, measurements are to be taken by a small-sized γ -spectrometer with a collimator in several points on different sides of the cask and at different height and then, using a special code developed by NIKIET, the activity and distribution of radiation sources inside the cask are to be determined.

The same should be done for the SRW containers with fuel fragments and γ -sources, CPS rods inclusive.

Without the studies, opening of the casks may give rise to excessive radiation exposure of the personnel.

The method is now being finished off at Andreeva Bay in the framework of a RF-Swedish project on FS and SRW handling.

7.3. Radiation survey of the TSF water area and near-shore zone:

- direct measurement of sea water and bottom sediments gamma activity using immersion gamma spectrometers in the TSF coast land and water area;
- ascertaining of specific activity and radionuclide composition of natural environment samples taken in the TSF coast side and water area;
- drawing up maps of radioactive contamination of the water area and coast side including the Chervyanaya Bay, area of piers No. 8 and 9, area of LRW storage

facilities, exit from the dock and general radiation situation in the Yokangsky Reyd strait adjacent to Ostrovnoy town territory.

7.4. Purchase of the required devices, instruments and equipment.

CERS hardware must include:

- drilling rigs for geologo-hydrological studies;
 - instruments for ascertaining physical, chemical and radiation characteristics of samples of building materials, soil and liquid ground formations;
 - non-standard equipment and contrivances permitting remote sampling of the necessary materials, structures and media, entailing the lowest dose burden;
- metrological certification of the hardware, power supply and providing of the relevant premises for taking measurements.

7.5. Conduct of CERS

Outline scheme of CERS conduct is given in Fig.6.

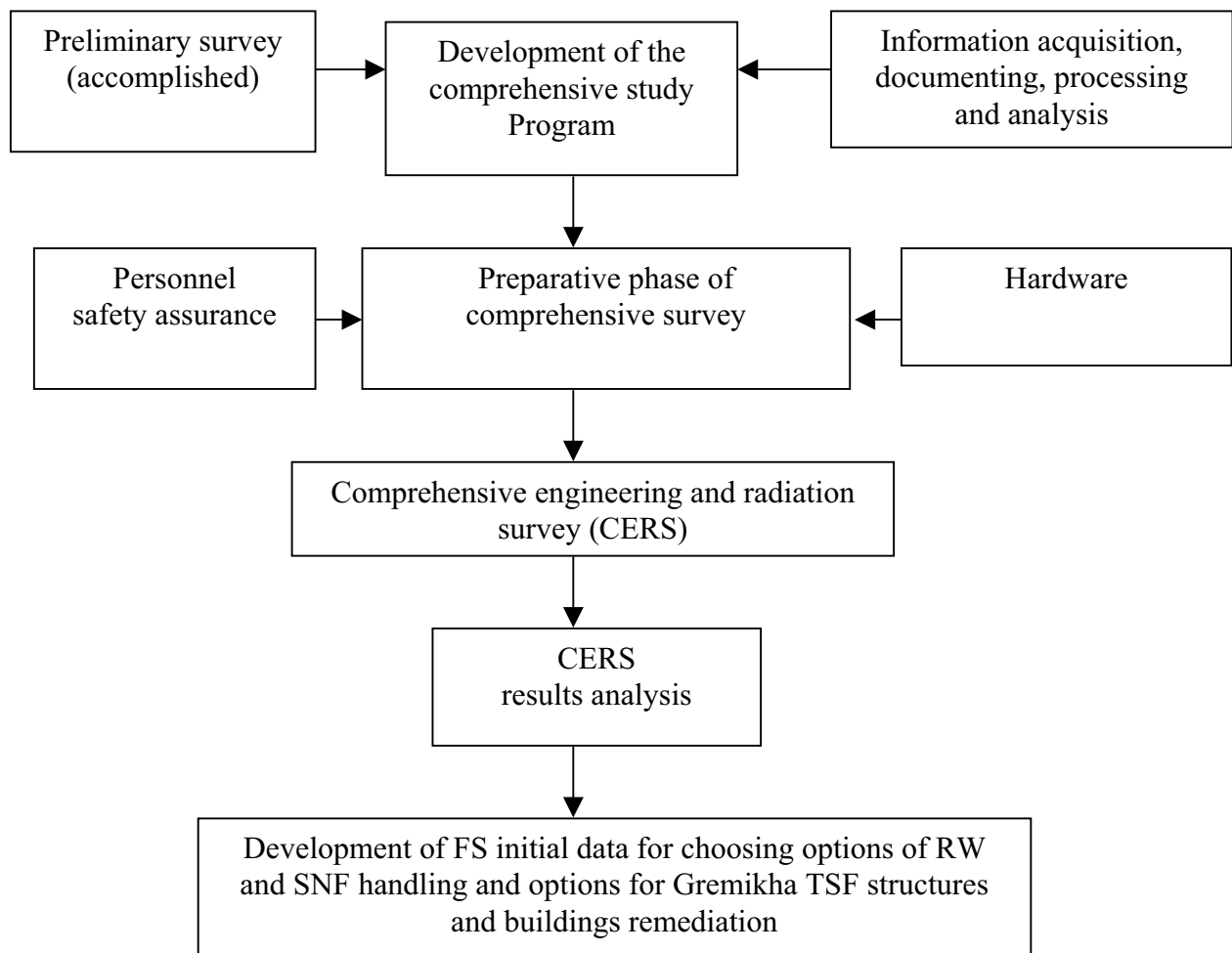


Fig. 6. Outline scheme of CERS conduct

CERS implementation period is ~12 months, its cost ~\$ 2.1 M.

7.6. FS Development

FS will be developed relying on CERS in reference to SNF and RW management, liquidation of radiation-hazardous buildings and structures and remediation of the remaining buildings and structures, as well as TSF territory. During FS development the following options for remediation of the facility buildings and structures can be considered:

SFA storage facility (Building 1) – mothballing. Removal of RW from the pools, decontamination and fixing of the remaining radioactivity, decrease in the building height to the pool level, filling of the pools with grouting mass, water-proofing against precipitate and ground water.

Building for refueling NS with LMC (Building 1A) and storage facility for SRC from LMC (Building 1B) – mothballing, as removal of SRC is completed.

Dry dock (Building 2) – use in line with its design purpose after accomplishing the repair.

LRW storage facilities (Buildings 16, 18, 20) – use as secondary LRW storage facilities (with initial mothballing, if necessary, of leaky reservoirs) and further mothballing, as operation draws to a close, for compliance with the functions performed by the facility or its remediation aspects.

RW storage facility (Building 19) – renovation of the building overland part for storage of filter traps with activity filter sorbent from the primary and third circuits up to the moment of decision-making about their removal for processing, mothballing of buried reservoirs after SRW and LRW removal.

The building for special water treatment (Building 17) and LRW pumping station (Building 32) – renovation for providing operation of a mobile facility for LRW treatment and cementation of salt concentrates yielded by LRW processing, as well as arrangement on its basis of a SRW storage facility hosting waste from the SRW site, Building 19 and other places.

SRW temporary storage pad – liquidation after SNF and SRW removal.

Development of FS will result in:

- description and evaluation of the status in SNF and RW handling and the state of TSF facilities;
- analysis and evaluation of possible engineering approaches (process part) and choice of the optimal option for project development;
- substantiation of radiation safety and environmental protection;
- calculation of investment needs and schedule of the project implementation.

According to preliminary estimates development of FS will cost ~ \$ 3.2 M.

On condition of stable and timely funding of the measures proposed, CERS can be accomplished within 2004, while FS can be prepared in the period, which will permit starting the practical measures aimed at liquidation of the open pad for SNF and RW storage already in 2005.

7.7. Remediation of the open pad for SNF and SRW storage

Liquidation of the open pad for SNF and SRW storage, which is the major contamination source of the TSF territory, is one of the most urgent tasks. The relevant work phases are briefly described below.

7.7.1. SNF management

1. Development of HOF for removing casks with SNF from the open storage pad:

- selection of the building for SNF location (Building 1 or Building 10 or construction of a storage facility near the open storage pad) and its preparation for SNF receipt;

- choice of transport vehicles, development, manufacture or purchase of the necessary auxiliary equipment.
2. Elaboration of the work procedures, including radiation-ecological safety assurance during shipment. Coordination of the operating procedure with the relevant organizations.
 3. Development of safety analysis report and cost estimates.
 4. SNF transportation and arrangement for safe temporary storage.

7.7.2. SRW management

1. Examination of the state of containers with SRW using a robotic complex.
 2. Selection of methods for reducing their radiation hazard (cover with a film, additional radiation shielding, etc.).
3. Development of HOF for removing containers with SRW from the open storage pad:
- selection of a place for the waste location for safe temporary storage (Building 1, Building 10, Building 19 or existing SRW storage facility);
 - selection of transport vehicles, development, manufacture or purchase of the necessary auxiliary equipment.
4. Elaboration of the work procedures, including radiation-ecological safety assurance during transportation. Coordination of the operating procedure with the relevant organizations.
 5. Development of safety analysis report and cost estimates.
 6. SRW transportation and arrangement for safe temporary storage.

7.7.3. Remediation of the pad

Survey of the open storage pad, proposals made for its remediation and the first phase of the remediation consist in:

- ascertaining the radioactive contamination of the pad territory, concrete walls, ground around the pad and under the concrete slab;
- decontamination of the concreted slab;
- removal of contaminated soil (and, possibly, concrete slab) into containers and their shipment to Building 19 for temporary storage.

Total cost estimates of all activities under item 7.7 is ~\$ 2.45 M.

7.8. General estimates

Later on, as SNF and RW is removed from the buildings and structures, additional engineering and radiation surveys will be conducted and designs of their remediation (moth-balling, liquidation or renovation) will be developed.

Removal or in situ disposal of contaminated construction waste and soil, i.e. the last SRW in Gremikha, will be performed at the final phase.

Estimates of total cost of the entire effort for Gremikha remediation, as well as the cost of individual activities, were made at different times by VNIPIET and Minatom commissions of experts.

The scope of the work to be done, its complexity and the relevant risks increase, as the buildings and structures become dilapidated, SNF degrades and container and storage pools lose their leak tightness. The requirements for safety assurance during the activities, for the transport and storage facilities equipment grow more stringent with time. Uncertainty of many parameters contributes to the range and scope of the work to be performed.

According to recent estimates total cost of the Gremikha TSF remediation will make up ~\$250 – 300 M, including CERS cost of ~\$2.1 M. FS development cost ~\$3.2 M.

Each year of delay in the onset of the activities will increase both hazards and costs of the work.

8. Conclusion

Data on the radiological situation in SNF and RW TSF in Gremikha are provided, allowance made for the results of radiation survey conducted in August, 2003.

Description of major radiation-hazardous buildings and structures is provided, information about the number and types of RW, its origin and storage conditions being given.

Removal of SNF and RW, remediation of the buildings, structures and territory of the TSF is the final aim of the remediation effort.

The efforts mentioned necessitate implementation of the four top-priority projects:

1. Assurance of safe labor conditions for the personnel during implementation of all the projects.
2. Conduct of comprehensive engineering, hydrogeological and radiation survey of the buildings, structures and territory of the TSF in Gremikha (CERS). CERS objective is obtaining initial data for FS and choosing the optimal variant of the TSF remediation.
3. Liquidation of the open pad for SRW and RW storage, which is the main contamination source for the entire TSF territory, being largely responsible for the radiation background in a considerable portion of the TSF.
4. Development of FS for SNF and RW handling, liquidation of radiation-hazardous buildings and structures on the TSF territory.