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THE CURRENT STATE AND PROSPECTS OF THE RW MANAGEMENT SYSTEM DEVELOPMENT IN THE RUSSIAN FEDERATION

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Issues of the radioactive waste (RW) management in the Russian Federation are considered taking into account the complexity of the nuclear power industry and a large number of nuclear legacy objects. Analysis of the state and prospects of the RW management system development is given for all components basing on the prescriptively adopted stages of establishment of the Unified State System of RW management (USS RW). The results of successfully completed first stage, including the works of FTP NRS-1 and NRS-2, are considered in greater details. Review of the problems defining the dynamics of USS RW development is given; it includes the problem of development and harmonization of regulatory basis after adoption of the Law on RW management and a number of decrees and resolutions of the Government of the Russian Federation in this area. A special attention is paid to establishment of RW management infrastructure in the State Corporation "Rosatom" as a whole and RW disposal facilities of various classes, in particular. Based upon the presented material, the principal changes of the situation in the field of RW management over the last ten years are demonstrated, and the priority problems for the next years are defined.

Keywords: *radioactive waste (RW), Unified State System of RW management (USS RW), Federal target program "Nuclear and radiation safety for 2008 and for the period till 2015" (FTP NRS-1), "Nuclear and radiation safety for 2016–2025 and for the period till 2030" (FTP NRS-2).*

To understand the modern state and perspectives of the Unified State System of RW management (USS RW) in the Russian Federation one shall take back to the history of the nuclear industry development.

At the initial stages of nuclear technology development aimed at the creation of the nuclear shield of the country, taking into account the tight timeline for solution of set problems, scale and top-priority of these problems, the simplified, in many respects, decisions on RW management were made. This resulted in nuclear legacy objects of various origins (surface LRW storage ponds, off-design RW repositories, sites of deep LRW disposal) and period of potential hazard (from hundreds to tens thousand years). This is basically a common situation for all major nuclear countries.

Up to the middle of 1990s, the national nuclear industry operated in the mode of deferred decisions on these objects. The USSR collapse also did not contribute to the effective and safe RW management.

Up to recent times, the RW management at the nuclear facilities was carried out on the principle of current industrial necessity, without a long-term system approach oriented on the obligatory safe RW disposal, the consequences of which are as follows:

- using simplified technologies that were directed at the RW storage;
- risk of new legacy formation;
- nefficient expenditure of resources;
- absence of responsibility differentiation for the legacy RW between the facilities and the state;
- absence of financial and structural mechanisms for RW disposal.

Ratification of the Joint Convention [1], elaboration and adoption of the development program for the nuclear power complex of the Russian Federation, as well as the concept and the Federal Target Program "Nuclear and radiation safety for 2008 and for the period till 2015" (FTP NRS-1) [2] crucially changed the status of the RW management problem in the Russian Federation. Discussions of necessity and desirability of changes

were transformed to the documented obligations and intentions of the state to create a modern system of RW management. Adoption of the Federal law dated 11 July 2011 No. 190-FZ "On the management of radioactive waste" allowed developing long-term system solutions on the RW management:

- differentiate the responsibility of the facilities and the state for newly generated and accumulated RW;
- define the final target state of RW — processing, conditioning and disposal;
- prevent accumulation of legacy problems, define the scenario of their consecutive solution, increase the efficiency of resources designation for these purposes in long-term prospective, and ensure their stage-by-stage solution;
- include the cost of the RW management in the product cost in the current rather than the future period;
- create a fund for RW disposal, thus having removed the burden of the RW disposal from the future generations;
- establish a specialized organization — the national operator, whose mandate is to create an infrastructure required for safe RW disposal.

The RW management strategy in the Russian Federation is aimed at the solution of problems on newly generated RW and legacy RW based upon the international obligations undertaken by the Russian Federation, and in-force legislation and standards.

For newly generated RW, the strategy is to achieve a target state, at which:

- RW management is carried out according to the in-force standards and rules; and reduction of the RW generation and the costs of an operating facility for this activity is ensured during the entire life cycle;
- RW reprocessing and conditioning facilities are constructed and put into operation;
- volumes of processed RW exceed the volumes of generated RW;
- all newly generated RW are processed, conditioned in accordance with the acceptance criteria for disposal, transferred to disposal facilities;
- RW disposal infrastructure is created and used;
- RW disposal is funded by enterprises generating RW.

For the legacy RW:

- additional engineered safety barriers are created and a safe in situ disposal is provided for the disposal facilities of non-retrievable RW, for which the RW extraction has been proved to lead to higher ecological and financial risks in comparison with the risks of in situ RW disposal;
- if the risks of in situ RW disposal prove to exceed the risks of RW extraction from such storage facilities, RW is extracted, processed and disposed at newly constructed RWDF. For some legacy objects, the safest way of management from the social and economic acceptability points of view is a monitored storage prior to removal of the facility from the regulatory control. The disposal of accumulated RW is carried out using the federal budget funds.

A stage-by-stage establishment of the Unified State System of RW Management (USS RW) in the Russian Federation is based upon the Federal law of 11 July 2011, No. 190-FZ, Article 11.

The Governmental decree of 19 November 2012, No. 1185, "On order and terms of establishment of the Unified State System of RW Management" defines three stages of USS RW establishment:

1) Elaboration of regulatory and organizational basis of the system, primary inventory of RW and facilities for their disposal;
2) Development of a system for disposal of low-level and intermediate level RW;
3) Establishment of a system for disposal of high-level RW, transfer of facilities with non-retrievable RW into facilities of non-retrievable RW isolation, and facilities of non-retrievable RW isolation — into RW disposal facilities, commissioning of disposal facilities for low-level and intermediate level radioactive waste, and disposal of the waste, whose volume reaches 200,000 m^3.

By present, the first stage of the USS RW establishment has been successfully completed. This stage was marked by quite a high speed of implementation in many areas. Let's summarize the results of this stage.

The following actions were implemented while establishing the regulatory and organizational basis of the Unified State System of RW Management:

- criteria to designate the solid, liquid and gaseous waste as RW, criteria to designate RW as non-retrievable RW, classification criteria of retrievable RW [3] were set, and a procedure of RW transfer for disposal was defined [4];
- changes were made to the federal norms NP- 055-04 "Disposal of radioactive waste, principles, criteria and basic safety requirements"; NP-069- 06 "Near-surface disposal of radioactive waste, safety requirements"; NP-058-04 "Radioactive waste management safety, general provisions"; NP-002-04 "Safety rules for management of radioactive waste of nuclear powers plants";
- NP-093-14 "Criteria for acceptance of radioactive waste for disposal" were developed;
- The following documents were revised: NP-020-2000 "Accumulation, processing, storage and conditioning of solid radioactive waste. Safety requirements"; NP-021-2000 "On gaseous radioactive waste management. Safety requirements"; NP-019-2000 "Accumulation, processing, storage and conditioning of liquid radioactive waste. Safety requirements";
- Sanitary rules SP 2.6.1.2612-10 "Basic Sanitary Rules for Radiation Safety" (OSPORB-99/2010) and SP 2.6.6.1168-02 "Sanitary rules of radioactive waste management (SPORO-2002)" were changed.

In 2012, at the first stage, a new organization, FSUE of "National operator on RW management" and the corresponding management structures, including the design office "Creation of USS RW" were established. They are the key system participants who should ensure design, construction, operation and subsequent closure of the RW disposal facilities.

Since 2013, the essentially new processes related to USS RW development that were required by the RW Law were launched:

- The State Corporation "Rosatom" annually issues the orders approving the volume of RW generation by the enterprises with especially radiation and nuclear hazardous manufactures and objects;
- Fees for RW disposal were set by the order issued by the Ministry of Natural Resources of Russia No. 89 dated 13 March 2013 "On the initial setting of fees for radioactive waste disposal", and fees for disposal of class 5 RW were set by orders No. 248 dated 18 July 2013 and No. 406 dated 16 September for 2014 and 2015 years, correspondingly;
- The State Corporation "Rosatom" formed a reserve fund to finance the expenses on establishment of the system of disposal facilities and RW disposal itself.

Let's note the principal importance of the last fact. The enterprises of the State Corporation agreed on delayed service, when the RW disposal payment is considerably remote in time from the moment the service is granted (receipt for disposal). Accumulation of these monetary resources in a special reserve fund allows funding the activities on construction of disposal facilities, and only after their construction, starting to receive RW for disposal.

The second important area of activities became the initial registration of RW; the procedure and terms of this process were defined by the Government of the Russian Federation [5]. In 2013, the State Corporation "Rosatom" made a decision on the list of enterprises, in which the initial registration of RW had to be conducted; as well as schedules of inspections of the storage facilities holding RW generated before the Law was enacted. According to the schedule, 177 commissions were set up for carrying out the initial registration of RW; they conducted inspections of 809 RW storage facilities. 137 organizations were involved in those activities. The methodological guidance [6] was developed for justification of RW designation as non-retrievable RW.

Based upon the results of the initial registration, the proposals were prepared on assignment of the status of the RW disposal facilities, long-term RW storage facilities, non-retrievable RW disposal facilities, and non-retrievable RW isolation facilities. It is necessary to note that one of the important results of the initial registration was identification of the owners of RW and RW storage facilities as well as volumes of accumulated RW.

A specialized part of the plan ensured an approval of the scheme of territorial planning of the RW disposal facilities localization. The corresponding documents were developed, coordinated and taken into account in the scheme of the Russian Federation territorial planning regarding the siting of RW disposal facilities. In 2014, the scheme was added into the federal state information system of territorial planning.

The following actions have been completed or are being finalized at the second stage of USS RW development:

- the list of enterprises that generate VLLRW in their operation (article 27, para. 1, No. 190-FZ) (Decree of the Government of the Russian Federation No 2499-r dated 7 December 2015) has been approved;
- the list of RW disposal facilities, long-term radioactive waste storage facilities, non-retrievable radioactive waste disposal facilities, non-retrievable radioactive waste isolation facilities (article 26, para. 5, the Federal law No. 190-FZ dated 11 July 2011) has been approved;
- the plan of measures on decommissioning of long-term radioactive waste storage facilities (article 24, para. 4, the Federal law No. 190-FZ dated 11 July 2011) has been developed;
- the draft of disposal acceptance criteria for spent sealed ionizing radiation sources (article 8, item 1, sub-para. 1, the Federal law No. 190-FZ dated 11 July 2011) has been developed;
- the plan of measures to upgrade the facilities with non-retrievable radioactive waste into facilities for non-retrievable radioactive waste isolation or disposal (article 24, para. 3, the Federal law No. 190-FZ dated 11 July 2011) has been developed;
- the draft of the safety guidance regulating the development of safety case for deep disposal of liquid radioactive waste (article 30, para. 2, the Federal law No. 190-FZ dated 11 July 2011) has been developed;
- the draft of norms and rules defining the categories of facilities with non-retrievable radioactive waste and facilities for isolation of non-retrievable radioactive waste, and establishing the safety requirements for facilities with non-retrievable radioactive waste and facilities for isolation of non-retrievable radioactive waste of various categories (article 8, para. 1, sub-para. 1, the Federal law No. 190-FZ dated 11 July 2011) has been developed;
- the first batch of the near-surface disposal facility for solid radioactive waste in the vicinity of JSC "UECC" has been commissioned (Novouralsk, the Sverdlovsk Region);
- the design specifications and estimates for construction of three disposal facilities for solid radioactive waste of classes 3 and 4 has been developed;
- the pre-construction activity for the second stage of the near-surface disposal facility for solid

radioactive waste in the vicinity of JSC "UECC" is in progress (the commissioning time has been reconsidered in FTP NRS-2 for 2020).

At present, the proposals to be included into the plan of the 3rd stage of USS RW have been prepared. The main efforts in the draft plan for the third stage are aimed at:

- commissioning of an underground research laboratory to conduct research confirming the safety of construction of a deep disposal facility for high-level RW;
- commissioning of RWDF for RW of Classes 3 and 4 and disposal of RW volumes that meet the country needs;
- design of disposal facilities for non-retrievable RW in order to convert them to isolation facilities for non-retrievable RW, as well as to upgrade the facilities with non-retrievable RW to the facilities of non-retrievable RW isolation;
- decommissioning of long-term RW storage facilities.

It should be noted that practical measures on the USS RW development, the beginning of actual RW disposal practice, the complex set of tasks to justify the long-term safety of RW disposal, especially regarding the RW of Classes 1 and 2, the social aspects of disposal activities all suggest introduction of certain adjustments in the directive documents on USS RW establishment.

In this regard, the proposals have been submitted to the Government of the Russian Federation for amendment of Resolution No. 1185 of the Government of the Russian Federation dated 19 November 2012 "On Determining the Procedure and Timeframes for the Establishment of a Unified State System for Radioactive Waste Management", namely: timing to implement the 3rd stage of USS RW, the basic of which is commissioning of an underground research laboratory to conduct research confirming the safety of construction of a deep disposal facility for high-level RW.

These proposals correspond to the timeframe of the FTP NRS-2 activities implementation. The period of implementation of the 3rd stage of the USS RW establishment was extended to January 1, 2025, by the Decree of the Government of the Russian Federation No. 1099 dated 13 September 2017 "On Amendments to the Provision on Establishing the Procedure and Timeframes for Creation of the Unified State System of Radioactive Waste Management".

It is recognized that the sustainable development of USS RW is based on the readiness of the state to solve the most challenging legacy problems. This readiness was expressed in financing the activities of the Federal Target Program NRS-1 in the field of radioactive waste management, successfully completed in 2015, and the acceptance by the Government of the Russian Federation of FTP NRS-2 as a logical continuation of activities on the systematic solution of the legacy problems. To address the priority tasks in the field of radioactive waste management, 87 activities were accomplished with amount of financing over 27 bln rubles. The work carried out under the Program made it possible to accelerate the creation and ensure future sustainable operation of the Unified State System for Radioactive Waste Management.

Obviously, this will primarily be achieved through infrastructure development.

Within the framework of the FTP NRS, design and survey activities for the disposal facilities of various classes of RW have been and are being implemented. The comprehensive survey and design have been carried out for the DRWDF construction for RW of classes 1 and 2 within the Nizhnekansk rock massif. In accordance with internationally recognized approaches, the facility construction strategy envisages an underground research laboratory (URL) creation. As a result, the basis for the URL construction as the first DRWDF stage was prepared. The URL construction began in 2016 within the FTP NRS-2 framework. The issue of the long-term safety case for the geological RW disposal facility will for many years be one of the most complex interdisciplinary problems to be solved by the National Operator basing on the scientific support organizations and foreign experience [7]. Currently, the State Corporation is taking measures to organize a long-term cooperation of the scientific institutions of the nuclear industry and the Russian Academy of Sciences on this topic.

In addition, within the framework of FTP NRS-1, the front-end engineering and design was carried out to select the sites for the construction of DRWDF of Class 3 and 4 RW. Within the framework of the FTP NRS-2 in 2016, the first stage of the disposal facility for RW of Class 3 and 4 was put into operation in Novouralsk (the Sverdlovsk Region). Besides, the design is carried out for similar facilities in the vicinity of FSUE "PA "Mayak" and JSC "SCC".

Extensive efforts to put into operation new RW storage facilities, including FSUE "RosRAO" allowed creating a capacity reserve before launching the disposal system. In addition, new facilities for storage of radioactive waste were put into operation at FSUE "PA "Mayak" and FSUE "SCC" (1st stage), reconstructions of existing RW storage facilities at FSUE "SCC", JSC "ChMP", JSC "Bochvar VNIINM", FSUE "Plant "Electrokhimpribor" and a number of other facilities were carried out.

Development of technology for dissolving and recovering sediments and decontamination of internal surfaces of containers intended for storage of LRW with high and medium activity was started at FSUE "SCC". In some cases, despite using specialized equipment and technological methods, it was not possible to achieve the desired result. This tough work is to be continued at both "SCC" and FSUE "PA "Mayak". The foreign experience, mainly the US experience [8], also demonstrates the long duration, complexity and high cost of such efforts.

The reconstruction of three LRW underground disposal facilities created 50 years ago was the activity of extreme importance. Disposal of LRW in underground horizons using the method of waste isolation within the mining subsoil allows solving the issues of disposal of radioactive waste with minimal extraction of natural resources for these purposes. However, one cannot but recognize that this approach is not supported by all countries. In the period 2011—2013, an attempt was made to achieve the international recognition of this practice; a specialized IAEA peer review mission was conducted to assess a possibility of classifying the practice of deep LRW injection as one of the so-called best practices. Following the review results, the experts ascertained a satisfactory state of the current operation safety of the facilities. At the same time, certain inconsistencies with the current international safety requirements were noted for the stage of the disposal facility closure.

To address the IAEA mission concerns, the additional studies were launched; the program of remedial actions was developed, justified, adopted and is being implemented now; the results will be reported to the Meetings of the Contracting Parties on the fulfillment of obligations arising from the Joint Convention (2015). To date, some of the IAEA mission comments have been addressed, and for the rest, the studies are in progress.

Based on the results of the initial registration, the deep LRW injection facilities were recognized as disposal facilities and transferred to FSUE "RW NO". For this reason, justification of safety of the facilities closure become another major scientific task of the National Operator, the solution of which is also supported within the framework of the Federal Target Program NRS-2.

In the program, much attention has been paid to development of new technologies and facilities for radioactive waste reprocessing, including LRW treatment technologies, RW conditioning, processing and immobilization of heterogeneous LRW. New facilities have been commissioned at more than 10 enterprises.

In more detail, we will focus on the task of isolation (elimination) of the open RW water reservoirs. Among the nuclear legacy problems, LRW in the surface water ponds requires a special attention. At present, strategies have been developed and implemented for all LRW surface water reservoirs (Table 1).

As can be seen from the presented data, the main LRW volume is concentrated in the Techa Cascade of Reservoirs (TCR), R-2, R-6 (PA "Mayak") and WR-3, WR-4 (SCC). The main activity was concentrated in the industrial reservoir R-9. The current levels of radioactive contamination of the water phase and bottom sediments of R-2 and R-6 reservoirs at PA "Mayak" do not hinder the use of water for industrial purposes. There is a similar situation with the WR-3 and WR-4 at SCC, which will be used for a long time to receive and average

Table 1. Management strategies for the LRW near surface disposal facilities

Plant	Pond, volume	Strategy
PA «Mayak»	TCR, 360 mln m^3	Level management
	R-2, 86 mln m^3	Use as a reservoir of circulating water supply
	R-6, 19 mln m^3	Use as a reservoir of circulating water supply
	R-9, 0,4 mln m^3	Isolated (2015)
	R-17, 0,36 mln m^3	Isolation (2020)
SCC	P – 1, 500 thous. m^3, (bottom sediment volume — 71 thous. m^3)	Reconstruction of protective and hydraulic structures (2015), shut-down (2036), decommissioning (2055)
	WR-3, 2,1 mln m^3	
	WR-4, 2,8 mln m^3	
	SD-1, 73 thous. m^3	Prepared for decommissioning (2015), shut-down (2016), isolation (2020)
	SD-2, 148 thous. m^3	Prepared for decommissioning (2015), shut-down (2020), isolation (2025)
	P-1, 65 thous. m^3	Prepared for decommissioning (2015), isolation (2020)
	P-2, 135 thous. m^3	Conserved (2012)
	P – 25, depth – 2,5 m, thickness of pulp deposits — 2,25 m	Prepared for decommissioning (2015), isolation (2019)
MCC	pool 354, SRW (former bottom sediment)	Isolated (2008)
	pool 354a, 150 thous. m^3, (bottom sediment volume — 27 thous. m^3)	Reconstructed and prepared for decommissioning (2015), shut-down (2020—2025), decommissioning (2030)
	pool 365, 204 thous. m^3, (bottom sediment volume — 3,4 thous. m^3)	
	pool 366, 360 thous. m^3, (bottom sediment volume — 16,4 thous. m^3)	

non-technological discharges before they are sent to a disposal facility. Let us dwell in more detail at two sites, on which the principal results were achieved in the framework of several strategies. These are the most challenging reservoir in terms of accumulated activity — R-9 and the largest (in terms of contaminated water) — TCR.

The reservoir R-9 (the Karachay Lake) is the most complex object of the nuclear legacy not only in Russia, but in the whole world. The risks and threats associated with the R-9 existence became clear as early as in 1967. Within the first and second work stages, the water mirror area was reduced from 36 hectares (in 1973) to 11 hectares (in 2007) (Fig. 1). The activities on the third stage were implemented within the program. The facility isolation was complicated by the need to put into operation new radioactive waste processing facilities, the dependence of the water level in the reservoir on weather conditions and the need to completely eliminate the possibility of LRW overflows beyond the reservoir boundaries.

Among the R-9 principal distinguishing features are the following factors:

- the complicated radiation situation, requiring the use of specially protected equipment;
- the lack of possibility to set up gravity-flow drainage channels;
- the presence of old communication lines and additional objects;
- relatively small volume of liquid phase and high concentrations of radioactive substances and salts.

The R-9 isolation has been made possible by: application of decontamination of the equipment used; the arrangement of access roads; the preparation of necessary volumes of rocky soil; the construction of the so-called highland channel that frames the object and two pumping stations; the isolation arrangements for the gravity-flow line, through which LRW came to R-9, and isolation of a storage tank in building 190.

By the end of 2015, the open water area of the reservoir was completely eliminated with a provision of the required porosity of the backfill massif to prevent the aqueous phase release to the backfill surface. In the period after 2017, a full-fledged waterproofing screen will be formed, taking into account the commissioning of the cementing complex, the actual water level and clarification of the waste behavior parameters during dehydration.

Thus, as a result of the program implementation, the activities on the water area closure that lasted almost 40 years have been completed.

With regard to TCR, the activities have been carried out within the program frames in two areas: reconstruction of the hydraulic structures and construction of the LRW treatment facilities, and strategic planning. We will dwell on the last area in more detail, with an emphasis on the fact that during the activities on the legacy sites, the long-term planning is the basis and a required condition of an effective approach. The Techa Cascade of Reservoirs, consisting of reservoirs R-3, R-4, R-10 and R-11, of dams D-3, D-4, D-10, D-11 and of bypass left-bank and right-bank channels, is located in the territory of the sanitary protection area of PA “Mayak”. The step-by-step construction of the TCR dams (D-10 in 1956 and D-11 in 1964) made it possible to almost completely stop the discharges into the Techa River. For a long period of time, the TCR operation caused practically no concerns. But since the 1980s, the water level in R-11 began to rise dangerously (due to the regional increase in water content, and then — due to shutdown of industrial uranium-graphite reactors) and approached the critical level, while there were no real mechanisms for managing the facility. With a large number of uncertainties, the facility, accumulating more than 360 million m^3 of LRW with low and medium activity level, became extremely hazardous. In 2003, the Russian President Vladimir V. Putin encharged with a task to "develop a set of additional measures aimed at preventing the threat of an ecological catastrophe in the Techa Cascade of Reservoirs."

Within the framework of the program, a number of additional measures were implemented to improve the safety level of the TCR (Figure 2). Their implementation made it possible to reach strategic decisions on the TCR problems, developed by the specialists of IBRAE RAN, FSUE "PA Mayak" and FSBE “Hydrospetsgeologiya”.

To solve the task, it was necessary to:

- determine the desired final state of TCR (strategic goal);
- solve a set of interrelated tasks (including assessment of all risks and development of technical solutions for their management, solution of regulatory issues, development of necessary models and calculation and forecasting tools, and creation of initial data for the strategy development);
- develop long-term strategies for ensuring the TCR safety and identify the priority strategies;
- develop a plan of organizational and technical measures for their implementation and monitoring. The work was carried out in accordance with the logic and structure adopted for strategic planning and project management, and with the principles defined in the IAEA documents.

As the strategic goal, the following final states of the objects were chosen:

- Reservoirs R-10 and R-11 — safe and removed from the regulatory radiation control.
- Reservoirs R-3 and R-4 — converted to surface disposal facilities for SRW.
- The Techa River — returned to all types of domestic water use.

A number of conditions [9] were set as priority and boundary conditions for the development of the Strategic Master-Plan (SMP), among which there was ongoing operation of the Mayak defense production facilities.

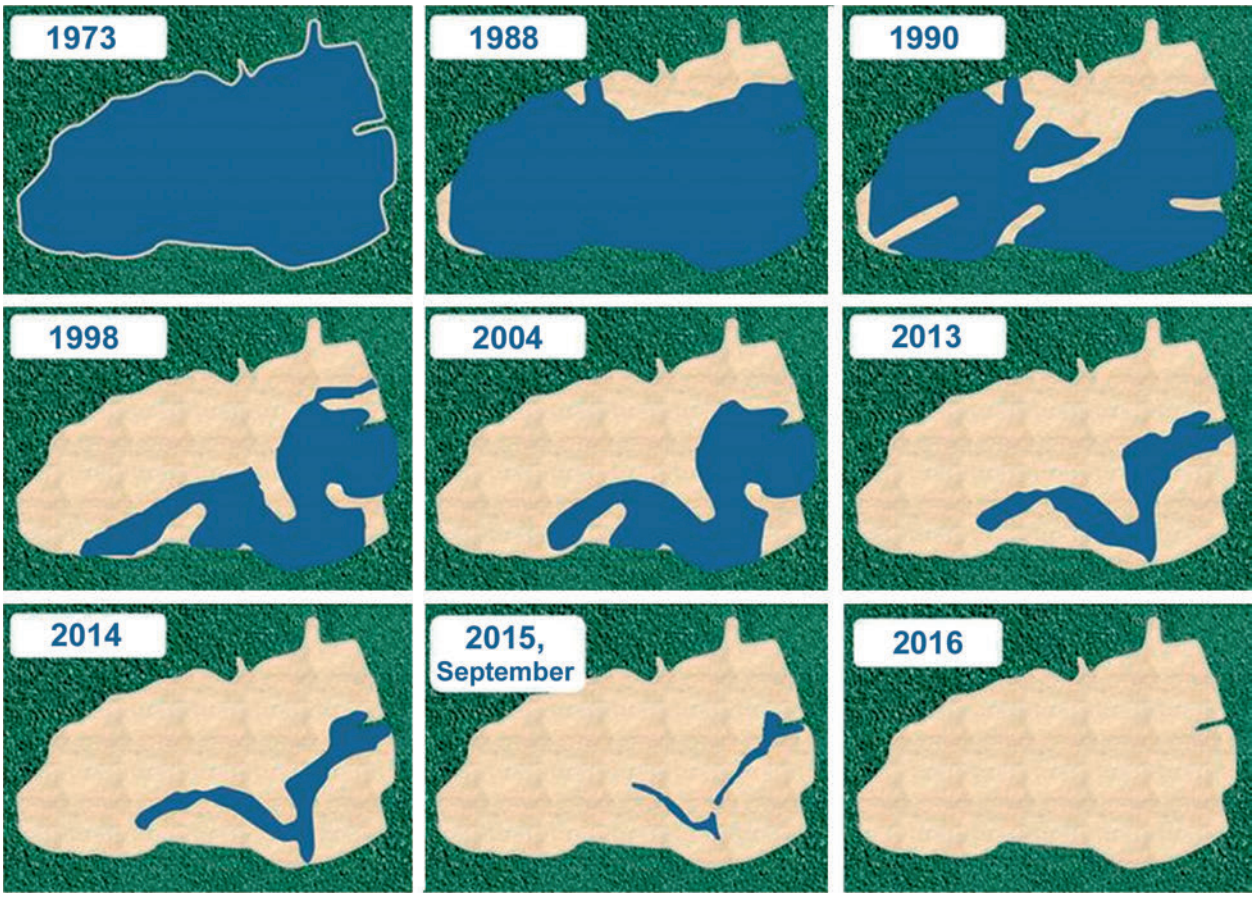

Fig. 1. Stages of the water body closure of R-9 (the Lake Karachay)

As a result, a strategic planning document was created and approved, which contains the Roadmap and the plan of organizational and technical meas- ures. The TCR SMP provides three basic strategies (Fig. 3) to achieve the final state of TCR (control of the level, active use of treatment and discharge facilities, and use of water for cooling of nuclear power installations). For each of these strategies, an action plan was developed and the work was de- composed into three levels.

The first strategy (control of level) is recommended for implementation, and is currently being implemented. The main project risks are identified for the strategy, as well as mitigation options for them and the criteria for transition to a standby strategy, which is chosen as strategy 2 (treatment and dis- charge facilities).

Concluding the review of the implementation of the FTP NRS activities, it should be noted that the State Corporation "Rosatom" pays substantial attention to creation of the RW management infrastructure at its enterprises.

By now, the radioactive waste reprocessing complexes are operating or are being created at the Russian nuclear power plants. The capacities of the units put into operation and planned for com-missioning exceed the amount of radioactive waste generated annually during the NPP operation; this has allowed proceeding to the processing of waste previously accumulated at the plant sites. Significant results have also been achieved in solving the problem of managing the radioactive waste generated during the activities on decommissioning of nuclear submarines and performing work on rehabilitation of coastal maintenance bases in the North-West and Far Eastern regions. Centers for processing and storage of radioactive waste have been created at the Saida-Bay department of the North-West Center for Radioactive Waste Management "SevRAO", the liquid radioactive waste processing complex has been commissioned at the "DalRAO" site in the Sysoev Bay. In 2019, the Center for Conditioning of Solid Radioactive Waste is planned to be put into operation at "DalRAO".

Another important problem that defines the development dynamics of the RW state system management is the evolvement and harmonization of the legislative and regulatory framework after starting the RW disposal practice. The operational realities of the USS RW have revealed a number of regulation aspects that require more detailed elaboration:

- at the legislative level, the responsibility between enterprises and the state for radioactive waste resulting from the nuclear facilities decommissioning and rehabilitation of radiation-contaminated territories remains undivided;

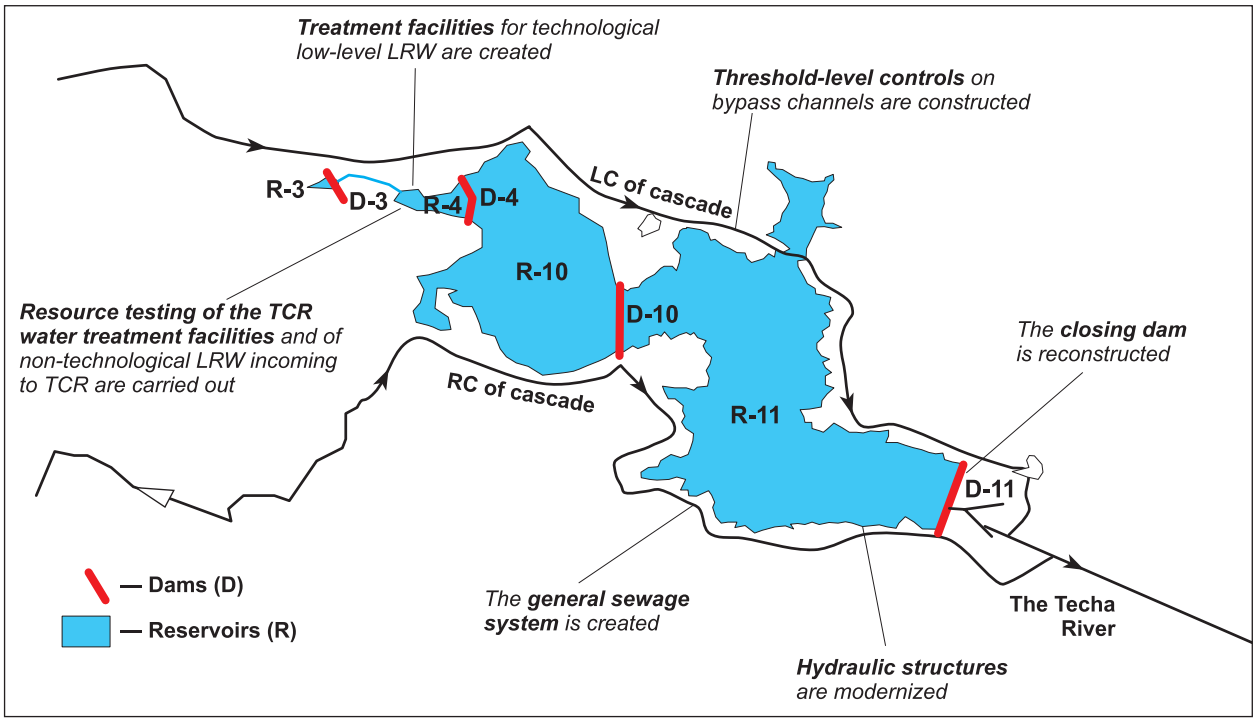

Fig. 2. Measures to ensure the TCR safety

- a number of legal issues related to the ownership of orphan radioactive waste have not been settled yet, including those that have not passed the initial registration, and PNE (peaceful nuclear explosion) objects;
- some of the RW storage facilities have not been included in the list approved by the Government of the Russian Federation following the results of the initial registration;
- classification of radioactive waste for disposal purposes needs to be clarified;
- despite the opportunity given to a number of enterprises to dispose at their sites VLL RW and RW generated during uranium mining and milling,

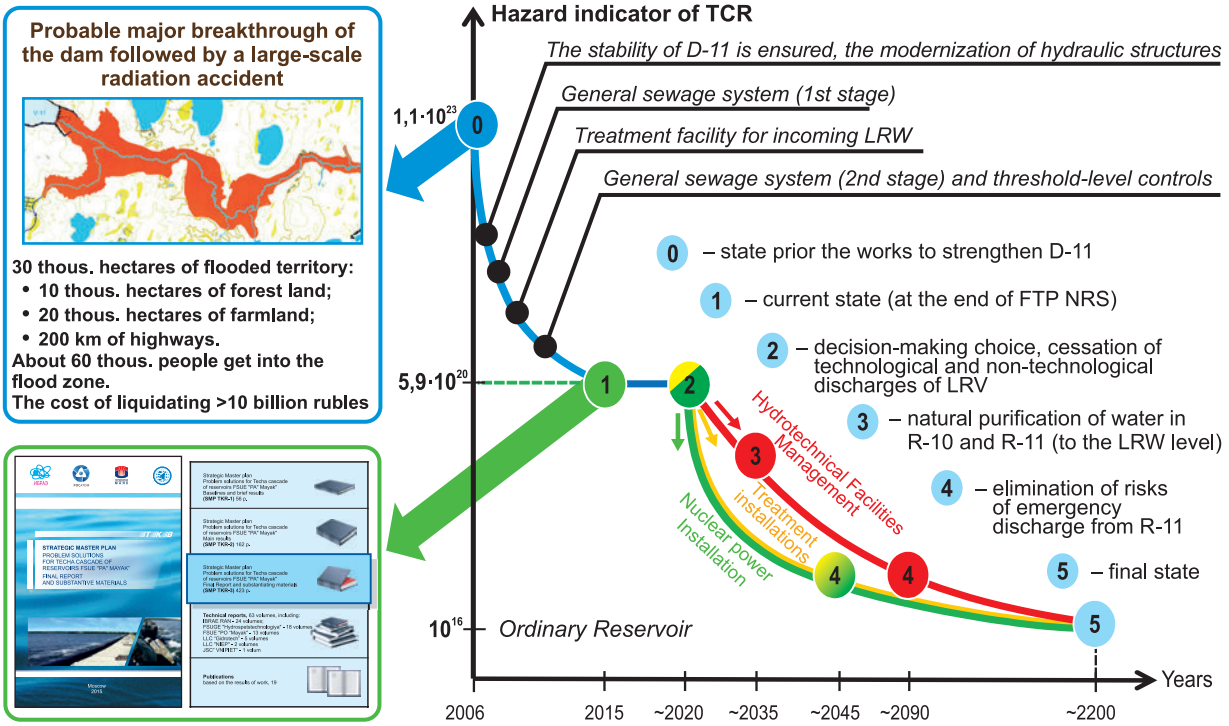

Fig. 3. The TCR life cycles in terms of risks

the property issues remained unresolved and the future condition of the disposal facilities was not specified, including liability for their closure and monitoring;

- the procedure of forecasting the RW generation, which is necessary for infrastructure planning and calculation of disposal fees, the control mechanisms for the RW management at enterprises requires some clarification;
- intensive research is needed to develop approaches for RW conditioning, formulating acceptance criteria for disposal purposes, verification of methods and their validation;
- creation of an infrastructure for RW disposal requires settling a range of issues, including support of the facility siting in the regions, logistics and the transport routes planning;
- it is necessary to regulate at the legislative level the possibility and procedure of using non-retrievable RW disposal facilities for placing newly generated RW, as well as RW from decommissioning activities;
- it is also necessary to regulate the possibility and expediency of transferring the disposal of non-retrievable RW from one category to another, since in some cases an observation stage is sufficient before release from regulatory control.

Special attention should be paid to the specificity of the financial model of the RW management.

It is based on a combination of two types of financial relations between entities: targeted financing and payment for services according to the state regulated fees.

Due to this specificity, the management of the reserve fund, mutual settlements between the parties, as well as the tariff model of regulation are stringently tied to the RW volumes, their producers and the year of generation.

In addition, there is no possibility of leveling the fund inflationary losses; this also requires adoption of legislative measures. Generally, RW is paid for at the time of generation; therefore, there is a temporary "gap", when the money paid for RW is on the Central Bank's account and is depreciated. For certain categories of radioactive waste, this is of great importance. The longer the period of the RWDF construction, the more impact of the inflation process and, in fact, the enterprise is forced to overpay, so that by the time of the RWDF construction there is the required amount in the special reserve fund. Especially heavy financial burden is placed on enterprises which generate RW of Class 6, for which, according to the technology (transfer of the tailing dump into RWDF) disposal will begin only upon termination of RW generation; and also the enterprises where RW of classes 1 and 2 are generated, as the DRWDF commissioning timing is far off as well.

A number of activities in the RW management are not covered by the financial mechanism, and therefore the sources and the procedure for their financing were not defined.

Therefore, it is necessary to adopt amendments to the legislation aimed at improving the efficiency of management, accumulation and disbursement of the fund's resources.

Obviously, in parallel, it is necessary to improve the sanitary norms and rules related to the RW management – NRB (Radiation Safety Norms), OSPORB (Basic sanitary rules for radiation safety), SPORO (Sanitary rules for the RW management). It is essential to harmonize timely the development of these documents, taking into account the expected changes.

Thus, the further work to improve the legislative regulation of the RW management will resolve the remaining unsettled aspects of this activity. Summing up the analysis of the status and development prospects of the RW management system in the Russian Federation, let us once again return to the initial thesis about the fundamental change in the situation in this field in the past 10 years. Ideas and intentions, set ten years ago, have formed the basis of fundamental reforms directed at sustainable development of USS RW, ensuring environmental, social, financial, international acceptability of domestic practices for the RW management.

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