IMPROVEMENT OF THE SAFETY REGULATIONS IN THE MANAGEMENT OF RADIOACTIVE WASTE ACCUMULATED IN THE LIQUID RADIOACTIVE WASTE WATER BASINS OF THE PO "MAJAK" (OZERSK), THE SIBIRIAN CHEMICAL PLANT (SEVERSK) AND THE MINING-CHEMICAL PLANT (ZHELEZNOGORSK)

XA0202883

Y.G. Vishnevski[a], A.I. Kislov[a], V.M. Irushkin[a], B.G. Gordon[a], N.S. Pronkin[a], R.B. Charafoutdinov[a], A.G. Levin[a], A.A. Smetnik[a], O.M. Kovalevich[a], O.L. Masanov[b], I.Y. Shishits[b], S.A. Kabakchi[b]

[a] Scientific and Engineering Centre for Nuclear and Radiation Safety
of Gosatomnadzor of Russia
Moscow, Russian Federation

[b] Minatom of Russia
Moscow, Russian Federation

Abstract. One of the most important problems of radiation safety in Russia is the decommissioning of the liquid radioactive waste water basins of the PO "Majak" (Ozersk), Siberian Chemical Plant (Seversk) and Mining-Chemical Plant (Zheleznogorsk). The liquid radioactive waste water basins were constructed in 1950-1960 for the collection and storage of liquid waste from the radiochemical plants. The potential hazards of the liquid in the radioactive waste water basins are: migration of radionuclides into the soil of the liquid radioactive waste water basin floors; wind-induced carry-over of radionuclides from the liquid radioactive waste water basins; hazards (radiation included) to the environment and population arising in case physical barriers and hydraulic structures are damaged; and criticality hazards. The classification of the liquid radioactive waste water basins were developed based on the collection and analyzes of the information on liquid radioactive waste water basin characteristics and the method of multicriterion expert assessment of potential hazards. Three main directions for the improvement of safety regulation in the management of radioactive waste accumulated in the liquid radioactive waste water basins were defined: 1. Common directions for the improvement of safety regulation in the area of rehabilitation of the territories contaminated with radioactive substances. 2. Common directions for the improvement of safety regulation in the area of rehabilitation of the territories, such as the liquid radioactive waste water basins. 3. Special directions for the regulatory activities in the area of operation and decommissioning of the liquid radioactive waste water basins of the PO "Majak" (Ozersk), Siberian Chemical Plant (Seversk) and Mining-Chemical Plant (Zheleznogorsk). As a result, concrete recommendations on safety regulation for the management of radioactive waste accumulated in the water basins were developed.

INTRODUCTION

The main global ecological problems of the second half of the 20th and the beginning of 21st century are in many respects associated with the consequences of the implementation of nuclear defense programmes. Impetuous, unprecedented rapid implementation of the programmes determined accepted methods for solution of many scientific, engineering and production problems. It is also the reason why mankind failed to avoid severe radiation accidents, which have changed our attitude to the safety problems, environmental and health protection. One of the most important problems is safety regulation in the management of radioactive waste (RW) accumulated as a result of previous activities [1].

At present, 480 km^2 are contaminated with radionuclides at 22 facilities of Minatom of Russia. This includes 376 km^2 of contaminated land and 104 km^2 of water surface of contaminated ponds. Contamination is distributed by the following types of areas: industrial sites – 63 km^2, control areas – 220 km^2, observation areas – 197 km^2. Most of the territory (about 98%) has been contaminated as a result of the discharge of radioactive substances into the Techya River and due to accidents at PO "Majak".

The total area of the water basins at the PO "Majak", the Siberian Chemical Plant (SCP) and the Mining-Chemical Plant (MCP) is ~ 91 km^2, including ~ 88 km^2 at PO "Majak" [1, 2, 3].

The following facilities were investigated in the frame of project 1353:

- The water basin at PO "Majak" - B-2, B-3, B-4, B-6, B-9, B-10, B-11, B-17;
- The water basin at SCP - BX-1; Water basin B-1, B-2; pulp storage facilities ПХ-1, ПХ-2; basin-25; water storages BX-3, BX-4; and
- The water basin at MCP – Water basin 365, 366, 354, 354a.

The parameters of the above water basins were investigated, which defined the safety state of the water basins.

The work performed enabled the following:

- to identify specific safety regulation needed in the management of the radioactive waste accumulated in the water basin of PO "Majak", SCP and MCP;
- to formulate proposals for special requirements to be included in license conditions for water basin operation and decommissioning.

INDICES OF THE POTENTIAL HAZARD OF THE WATER BASIN

In the development of approaches to finding a solution of the safety regulation problem in the management of RW accumulated as a result of previous activities, those used in risk management [1, 2] could be applied. Within stages A-5, A-6 and A-7 of project 1353, the following studies were performed:

- Analysis of water basin parameters;
- Identification of hazardous situations, which could be initiated by the water basins;
- Development of a classification of the water basins by the level of their potential hazard; and
- Analysis of compliance of the water basins safety state with the current regulatory legal documents, which regulate safety in RW management.

Classification of water basins by their potential hazard

The WATER BASINS of PO "Majak", Siberian Chemical Plant and Mining-Chemical Plant could be subdivided into 3 groups according to the level of accumulated activity.

Water basin of PO "Majak"

The water basins of PO "Majak" could be subdivided into *three groups of hazard* according to the specific activity of alpha- and beta-emitting radionuclides, i.e., the total content of long-lived radionuclides (Pu-239, U-235 and so on), in water and bottom sediment.

The first group includes the water basins B-9 and B-17. The total content of radionuclides in them is ~ 4400 PBq; and ~ 74 PBq, respectively, while the average specific activity of the water phase amounts to ~15 and ~2.2 GBq/dm^3. The level of specific alpha-activity of the bottom sediment of the water basin B-9 is ~ 0.4 – 4 MBq/l, the level of beta-activity of bottom sediment is ~63 GBq/l.

The second group includes the water basins B-3, B-4 and B-10. The total content of radionuclides in them comes to: B-3 – 1.6 PBq; B-4 – 0.3 PBq; The specific activity of water in the above water basins is ~ ·0.04 – 0.4 MBq/dm^3.

B-10 is attributed to the second group of water basins because of the high accumulated activity (8.5 PBq), though specific alpha- and beta-activity of bottom sediment is much lower that in water basins B-3 and B-4.

The third group includes water basins B-2 (total activity ~810 TBq). B-6 (total activity ~11 TBq), and B-11 (total activity ~960 TBq), could be included. Specific activity of water in these water basins comes to 0.4 – 4 KBq/dm^3 [7,8,9].

Thus, water basins of PO "Majak" could be subdivided into three groups:

First group of water basins: B-9 and B-17.

Second group of water basins: B-3, B-4 and B-10.

Third group of water basins: B-2, B-6 and B-11.

Water basins of the Siberian Chemical Plant (SCP)

At SCP, a significant amount of generated low and intermediate level liquid waste has been injected into the underground water-bearing horizons. In the water basins, low level of radioactive waste with high content of alpha-emitting radionuclides and different types of pulp are being stored.

Processed intermediate level waste, discharged into artificially made water basins B-1 and B-2, contained significant amount of alpha-emitters. The bottom and the edges of these water basins are covered with a clay layer, which prevents migration of radionuclides. The total amount of radionuclides accumulated in water basins B-1 and B-2 is more than 3 EBq.

According to the evaluation, water basins B-1 and B-2 shall be included in the *first group of water basins* by the levels of total activity accumulated in water basins, by specific activity of bottom sediment, and by the alpha- and beta-activity.

Water basins BX-3, BX-4, B-25, and the pulp storage facilities ПХ-1 and ПХ-2 could be included in the *second group of water basins*.

The SCP BX-1 should be included in the *third group of water basins*.

Thus, water basins of SCP could be subdivided into three groups:

First group of water basins: B-1, and B-2.
Second group of water basins: B-25, BX-3, BX-4, ПХ-1, ПХ-2, B-3, B-4, and B-10.
Third group of water basins: BX-1.

Water basins of the Mining-Chemical Plant (MCP)

At MCP, as well as at SCP, low and intermediate level liquid radioactive waste has been injected into the underground water-bearing horizons for many years; therefore there are only four contaminated water basins on the surface. The level of radioactive contamination of these water basins is much lower than that of the PO "Majak" and SCP water basins. Late in the 1980s, a decision was made to backfill the water basins. At present water basin 354 is almost completely backfilled. All water basins, in spite of availability of a clay seal (layer), represent a certain radiation hazard, in particular water basin 366 due to its location close to the Yenisey River.

According to the proposed above classification, *all water basins of MCP could be attributed to the second group of facilities.*

Nevertheless, classification of water basins by their potential hazard basing on the quantitative indices of accumulated activity only is one-sided and it doesn't take into account all other hazardous factors created by the facilities under consideration.

Analysis of water basin parameters enabled us to single out a number of basic factors, which are peculiar to some extent to all water basins and to determine their hazard – i.e. generalized list of hazards:

- High content of radionuclides.
- Presence of long-living radionuclides.
- Large open water surface subjected to impacts of different meteorological phenomena (wind, tornado, precipitants, temperatures and so on). Potential dewatering of edges and bottom of water basins can result in wind-induced carry-over of radionuclides.
- Lack of a system of barriers on the path of potential migration of radionuclides with underground water. The bulk of radionuclides accumulated in the water basins are concentrated in bottom sediment. Most water basins are not equipped with reliable protective shields of the edges and the bottom to prevent radionuclide migration into underground water-bearing horizons. Even those water basins that are equipped with physical barriers (clay shields) are not provided with reliable isolation of LRW from the environment.
- More than 95% of all radionuclides accumulated in water basins are concentrated in the bottom sediment. Presence of uranium or plutonium in the bottom sediment could be a reason for criticality.
- Practically all water basins are equipped with hydraulic structures (HS) – (dams and dyking of water basins, by-passing channels, water pump stations), their damage or rupture being one of the hazardous factors.

For example, the following are the most hazardous events from the point of view of potential radiation impact, which can occur as a result of accidents at water basins of the PO "Majak":

- Activity carry-over from the Karachai Lake water area (water basin B-9) as a result of a tornado;
- Dewatering of Karachai Lake side exposing the mud;
- Migration of radionuclides with underground water under the Karachai Lake;
- Rupture of dam 11 and carry-over of radioactive water outside the cascade of water basin on the Techya River (TCW);
- Processes resulting in local increase of concentration of fissile nuclides up to the hazardous values (criticality).

For quantitative assessment of hazards created by water basins, a multi-criterion method of expert evaluation was used [10].

The experts were provided with the following criteria for assessment of the water basin hazard:

- Total activity in the water basin;
- Specific activity of the water phase of the water basin;
- Specific alpha-activity of the water phase and bottom sediment;
- Contamination of the environment and radiation consequences due to hydro-meteorological conditions (wind-induced carry-over of radionuclides, precipitants, temperature impacts and so on);
- Contamination of underground waters and radiation consequences at present and in the future;
- Effect of hydraulic structures on the state of safety of the population and environment; and
- Probability of criticality with radiation consequences.

Experts from different organizations of Minatom of Russia, Ministry of Science of Russia and Gosatomnadzor of Russia took part in carrying out the multi-criterion assessment. The tables with assessments received from the experts were depersonalized and given conditional numbers. A group of

other experts identified normalized coefficients of the expert competence. As a result of the expert assessment, a **hazard index** (HI) was calculated for each water basin.

Processing and analysis of obtained results demonstrated the following:

- Water basin B-9 (PO "Majak") got the highest hazard index HI= 16.8. The next is water basin B-1 (SCP) (HI=12.3). Water basin B-2 (SCP) is at present backfilled, nevertheless, due to the amount of radionuclides in the bottom sediment its HI=9.6.
- Water basin B-17 (PO "Majak") got HI=7.8 due to accumulated total activity and being before discharges of tritium condensate and alpha-active radionuclides. Besides, there is a probability of a rupture of the water basin dam. Water basin B-25 (SCP) contains long-living radionuclides, therefore its HI= 4.83.
- Cascade of the water basin on the Techya River (PO "Majak") B-3 (HI=3.5), B-4 (HI=3) and especially B-10 (HI=5.2) and B-11 (HI=5.8), according to the experts' opinion, deserve most rapt attention of their safety state.
- Water basins BX-3, BX-4, ПХ-1 and ПХ-2 (SCP), 365 and 366 (MCP) have rather close HI: 3.74, 3.15, 3.6, 3.5, 2.5 and 2.6, respectively.
- The water basins of reverse water supply B-6 (PO "Majak") and BX-1 (SCP) have low hazard indices (1.4 and 1.1, respectively).

Table 1. Classification of water basins by the level of their potential hazard

Nuclear fuel cycle plant. Water basin, its origin and stage of the service life		Group according to the hazard index		
		1	2	3
PO "Majak"				
B-2 (natural)	***Operation***			2.3
B-3 (artificial)	Operation		3.5	
B-4 (artificial)	Operation		3.0	
B-6 (natural)	Operation			1.4
B-9 (natural)	Operation	16.8		
B-10 (artificial)	Operation		5.2	
B-11 (artificial)	Operation		5.8	
B-17 (artificial)	Operation	7.8		
Siberian Chemical Plant (SCP)				
BX-1 (artificial)	Operation			1.1
B-1 (artificial)	Decommissioning	12.3		
B-2 (artificial)	Decommissioning	9.6		

ПХ-1 (artificial)	Operation		3.6	
ПХ-2 (artificial)	Operation		3.5	
B-25 (artificial)	Operation		4.83	
BX-3 (artificial)	Operation		3.74	
BX-4 (artificial)	Operation		3.15	
Mining Chemical Plant (MCP)				
365 (artificial)	Operation		2.5	
366 (artificial)	Operation		2.6	
354 (artificial)	Decommissioning		3.4	
354a (artificial)	Operation		4.13	

Results of the expert assessment enabled us to classify the water basins by potential hazard (table 1). It should be mentioned, that the cascade of water basins on the Techya River is attributed to the first group of potentially hazardous facilities, as far as its total hazard index is 17.5.

ACTIVITIES OF THE OPERATING ORGANIZATIONS ON ENSURING SAFETY OF WATER BASINS. ASSESSMENT OF COMPLIANCE OF WATER BASIN SAFETY WITH THE CURRENT REGULATORY LEGAL DOCUMENTS, WHICH REGULATE SAFETY IN RADIOACTIVE WASTE MANAGEMENT.

The operating organizations have taken a number of measures to improve the safety of water basins. The measures taken enable assurance of current safety levels for the personnel and population during operation and decommissioning of water basins to be in compliance with requirements of the sanitary regulations and departmental documents.

Performed analysis also enabled us to mark out the following main directions of activities being accomplished at the PO "Majak", SCP and MCP to improve the safety level of water basins:

- Upkeep of hydraulic structures in compliance with requirements of technical documentation;
- Control of the water level in water basins to prevent exposure of the banks and bottom sediment;
- Discharge of LRW into water basins in compliance with regulations approved by the sanitary and environmental authorities;
- Taking measures to minimize the amount of LRW being discharged into water basins;
- Development of LRW conditioning and solidification methods;
- Carrying out of preparatory work for decommissioning of water basins under operation;
- Environmental monitoring in the areas impacted by water basins;
- Research activities aimed at solving safety assurance problems during operation and decommissioning of water basins.

For example, at the SCP and MCP, a decision was made to decommission all water basins, operation of some of them have already been terminated. Currently, SCP discharge of LRW into water basin B-1 has been stopped, and water basin B-2 has been completely backfilled. WATER BASIN 354 at MCP is at the stage of liquidation (most part of its water area is backfilled. The water basins mentioned have been taken out of the plant process cycle of radioactive waste management and their decommissioning

is in planning. At the PO "Majak", no decision has yet been made on water basin decommissioning.

It should be mentioned that as of now, there are no projects available for water basin decommissioning. Proper attention is not paid to the development of methods of low and intermediate level radioactive waste management without the use of water basins. The work on conservation of water basin B-9 (PO "Majak"), B-2 (SCP) and 354 (MCP), consisting of backfilling, practically comes to the creation of near surface repositories for radioactive waste containing long-living radionuclides. The solution of the problem of water basin long-term safety has been postponed.

At present the water basins are being operated and decommissioned (or conserved), mainly in compliance with Minatom documents, which establish the following requirements: water balance, fluctuation of the water surface level, permissible discharges, prevention of contamination of the environment with aerosols, prevention of wind-induced carry-over of radionuclides from the shoreline of the water basin, conservation methods, arrangements for and carrying out of observation of the environment during conservation and after conservation is completed. [11, 12]. However, Minatom documents, which regulate the activities above, as a rule do not describe approaches to safety assurance in solving the problems of rehabilitation of the territories from the point of view of the current requirements, established by the legislation of the Russian Federation, international legal documents and recommendations provided by the international organizations. Operation of water basins is accomplished with violation of the legislation of the Russian Federation, including violation of a number of articles of the Federal Laws: Federal Law "On the Use of Nuclear Energy" (art. 48), "Water Code of the Russian Federation" (art.104), Federal Law "On Environmental Protection" (art.51, it.2), Russian Federation Law "On Safety of Hydraulic Structures" (art.10-12), and also violation of a number of provisions of the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management".

PECULIARITIES OF SAFETY REGULATION OF WATER BASINS

Peculiarities of safety regulations for water basins and rehabilitation of the territories are defined by the following main factors:

- the use of a number of water basins in the plant technological process up to now; and
- lack of sufficient experience (both Russian and foreign) on safe management of large volumes of LRW containing significant amount of radionuclides including long-lived radionuclides.

Ensuring the safety of water basins shall consist in the rehabilitation of the water basin areas contaminated with radionuclides and of the territories being under the impact of the water basins [13]. Analysis of foreign and Russian scientific and technical literature, regulatory legal documents, standard technical and operational documentation, related both to general issues of safety regulation in rehabilitation of the territories contaminated with radioactive substances and to water basin operation and decommissioning, enabled us to define the main directions of activities on improvement of safety regulation in the field.

Regulatory activity aimed at the development and implementation by the authority controlling the use of nuclear energy of programmes for rehabilitation of contaminated territories

To solve the problems of safety assurance, it is required to use programme target methods, significant scientific, technical and financial recourses are needed. Activities accomplished by the US Department of Energy for rehabilitation of contaminated territories could serve as an example of approaching these problems [14].

Under the circumstances, when it is not possible to stop operation and to decommission water basins,

solutions shall be found for accident prevention and protection of the personnel, population and environment against consequences of potential accidents. Measures covered by the programmes shall be based on analysis of hazard (risk) caused by water basins and on optimization investigations aimed at risk reduction (assessment of impact of alternative variants on safety and environment).

Regulatory activity aimed at the development and implementation by the operating organizations of water basin safety improvement measures

Rehabilitation of territories of nuclear fuel cycle facilities contaminated with radioactive substances covers two interconnected tasks:

- Short-term and medium-term measures on rehabilitation of the environment, which shall be aimed at reduction or, if possible, elimination of the most significant hazards (risks) associated, for example, with wind induced carry-over and migration of radionuclides in the soils and ground water.
- Long-term measures related to the problems of management of radioactive waste generated in result of previous activities, and also management of radioactive waste generated as a result of rehabilitation of the territories.

The work on radioactive waste management and rehabilitation of the territories shall be planned in such a way, so that to combine reduction of short-term risks with the minimization of long-term risks.

If methods for rehabilitation of the territories and relevant resources required for rehabilitation are not available, intermediate measures shall be taken, such as restricted access to the territories and investment in research activities and design activities aimed at the development of required methods.

Regulatory activity aimed at carrying out research activities for water basin safety improvement

It has been revealed that operating organizations do not have complete information on water basins. For example, data on total activity accumulated in water basins, specific activity of individual radionuclides, radionuclide composition of the water phase and bottom sediment have not been studied enough. The resulting data is presented in different forms and do not coincide.

Ensuring the current safety and long-term safety of water basins belong to science intensive problems. To solve these problems, in particular, research activities should be accomplished:

- To study in detail qualitative and quantitative radionuclide composition of LRW in water basins, as well as hydrological, biological and other parameters of water basins;
- To investigate radionuclide behavior in water basins, to study migration of radionuclides through protective barriers and water basin bottoms into the surface drainage network and underground water-bearing horizons;
- To investigate processes of radionuclide propagation from the surface and banks of water basins under normal climatic conditions and in extreme hydro-meteorological situations;
- To study a mechanism of radiation-chemical reactions between radioactive waste macrocomponents in the liquid phase and bottom sediment;
- To investigate efficiency of physical barriers, providing required safety of radioactive waste repositories on the site of former water basins within a long term.
- To forecast long-term behavior of artificial and natural barriers as well as potential radiation consequences in the normal evolution of closed water basins and in case of unfavorable scenarios.

Besides, it is necessary to solve a number of scientific, technical and engineering problems such as:

- To develop methods and to design facilities for processing and conditioning of LRW accumulated in water basins;

- To develop methods of processing of bottom sediment and/or the water phase;
- To develop methods and techniques for water basin decommissioning taking into account the harm-benefit principle;
- To define methods and scope of radiation monitoring at all stages of water basin decommissioning and after decommissioning.

MAIN DIRECTIONS OF REGULATORY ACTIVITY IN LICENSING OF WATER BASIN OPERATION AND DECOMMISSIONING

The basic document justifying safety assurance in operation and decommissioning of water basins is a safety analysis report (SAR). It shall contain rather complete information for adequate understanding the water basin design and basic principles of safety assurance.

The preliminary content of an SAR, showing specifically the water basin safety justification, is presented below:

1) Description of the current state of the water basin (morphology, hydrology, engineering geology, climate, biology, and other required information).
2) Description of the technological process of the water consumption system.
3) Qualitative and quantitative radionuclide composition of the water phase and bottom sediment in the water basin.
4) Behavior of radionuclides in the water basin and analysis of factors, which effect variation of radionuclide concentration in the water and bottom sediment. Physical and chemical processes in water and bottom sediment and the assessment of the risk of initiation of the chemical exothermal reaction in bottom sediment.
5) Analysis of the state of barriers, preventing migration of radioactive substances to the environment, and monitoring of the barrier's state.
6) Arrangements for water basin monitoring.
   a) Monitoring of environmental contamination in the area of the water basin.
   b) Monitoring of water contamination in the water basin.
   c) Monitoring of underground water contamination.
   d) Monitoring of the state of hydraulic structures.
   e) Monitoring of bottom sediment contamination.
7) Analysis of radionuclides propagation from water basins to the environment.
   a) Assessment of wind-induced carry-over of radionuclides from water basins:
      i) ingress of radionuclides to the atmosphere;
      ii) pollution of the surface air layer with radionuclides in the water basin area;
      iii) radionuclide fallout on site;
      iv) areas impacted by wind induced carry-over of radioactive aerosols from the water basin; and
      v) measures to reduce wind induced carry-over of radioactive aerosols from the water basin.
   b) Assessment of the migration of radionuclides with underground water and measures to reduce propagation of radionuclides with underground water.
8) Justification of radiation safety of the personnel and population in the area being under impact of the water basin.
   a) Evaluation of the personal dose.
   b) Evaluation of the population dose in the area under impact of the water basin.
9) Safety analysis.
   a) List of initiating events of design basis accidents.
   b) List of beyond design basis accidents.
   c) Results of deterministic and probabilistic safety analyses.
10) Justification of stability of hydraulic structures.
11) Justification of nuclear safety.
12) Water basin decommissioning.
   a) Decommissioning concept.

b) Decommissioning programme.
c) Results of complex survey.
d) Design solutions.
e) Safety analysis.
f) Radiation monitoring in decommissioning.
g) Information supply for decommissioning.

13) Analysis of the long-term safety concerns of the water basin after its decommissioning.

The SAR shall be based on information supported with observations, experimental studies and calculations.

Special requirements included in license conditions for the types of activities related to operation and decommissioning of water basins represents one of the basic ways for regulatory activity. They shall be aimed at the development and systematic implementation by the operating organizations of engineering and administrative measures, including research activities directed toward water basin safety improvement.

In establishing special requirements to be included in license conditions, it is possible to apply a method of checkpoints, which is used by foreign safety regulatory authorities. If measures implemented by the operating organization for safety assurance are as a whole approved by the safety regulatory authority in licensing of types of activities, a regulator establishes a number of checkpoints, which are important from the point of view of the safety regulatory authority, and follows work progress at the checkpoints. Finally, special requirements included into license conditions will be aimed at decommissioning of water basins and rehabilitation of contaminated territories.

It seems expedient to license the types of activities (operation, decommissioning) for each water basin or for a group of functionally connected water basins, but not for a water basin as a part of nuclear facility, as it used to be before.

It is proposed to subdivide water basins into the following groups:

- At PO "Majak": B-9; B-17; group - B-3, B-4, B-10, B-11 (TCW); B-2; B-6.

- At SCP: B-1; B-2; Б-25; group - ПХ-1, ПХ-2; group - ВХ-3, ВХ-4; ВХ-1.

- At MCP: 354; group – 365, 354a; 366.

CONCLUSION

Under the work performed as part of the Project 1353, a complex assessment of the current safety level of water basins was carried out at the PO "Majak", SCP and MCP.

The groups of the most hazardous water basins were defined and a set of scientific, engineering and administrative tasks was proposed for developing a solution, which is necessary for operation and decommissioning of water basins.

Classification of water basins by their potential hazards was elaborated. Generalized quantitative indices of water basins were developed on the basis of multi-criterion assessment of hazards. This allows a comparative assessment of WATER BASIN by their hazard indices to be performed.

Peculiarities of water basin safety regulation were considered and the main directions of regulatory control were defined.

A preliminary list of special requirements to be included in license conditions for types of activities at

water basins was formulated.

REFERENCES

[1] CHARAFOUTDINOV, R.B., System Approach to Safety Regulation in Radioactive waste Management, Bulletin of Gosatomnadzor of Russia (2002). № 1 (20), 19-32.

[2] SHATALOV, V.V., The State of the Environment at the Facilities of Nuclear Energy. (GUP VNIIHT), Ecology of Nuclear Industry, The Second Scientific and Technical Ecological Conference. (Coll. of reports), M., Minatom of Russia, 06 June 2001, 4.

[3] ALEXAKHIN, R.M., On the Basis of Ecological Policy of Ministry of Russian Federation on Nuclear Energy, Ecology of Nuclear Industry, The Second Scientific and Technical Ecological Conference. (Coll. of reports), M., Minatom of Russia, 06 June 2001, 10.

[4] DROZHKO, E.G., MOKROV, Y.G., KONDAKOV, V.M., REVENKO, Y.A., Rehabilitation of Territories Subjected to Radioactive Contamination, Ecology of Nuclear Industry, The Second Scientific and Technical Ecological Conference. (Coll. of reports), M., Minatom of Russia, 06 June 2001, 79.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Working material of Technical Committee meeting on "Risk Informed Decision Making", IAEA, Vienna (2001).

[6] BURKOV, V.N., GRITSIANSKY, Y.V., DZYUBKO, S.I., SCHEPKIN, A.V., Models and Mechanisms of Safety Management, Moscow, SINTEG (2001) 153 p.

[7] GLAGOLENKO, Y.V., DZEKUN, Y.G., MEDVEDEV, G.M., and others, Processing of the NPP Spent Nuclear Fuel and Liquid Radioactive Waste at PO "Majak", Nuclear Power Engineering (1997) V.83, № 6, 446-452.

[8] Source contributing to radioactive contamination of the Techya River and areas surrounding the "Majak" production association, Urals, Russia, Programme of investigation of possible impacts of the "Majak" PA activities on radioactive contamination in the Barents and Kara Seas, Joint Norwegian-Russian Expert Group for Investigation of Radioactive Contamination in the Northern Areas, ISBN 82-993079-6-1, Norway (1997) 134 p.

[9] SADOVNIKOV, V.I., GLAGOLENKO, Y.V., DROZHKO, Y.G., MOKROV, Y.G., STUKALOV, P.M., The Current State and Ways for Solution of the Problems of a Cascade of Water Basins on Techya River, Radiation Safety Issues (2001) № 1, 1-11.

[11] KHOLOD, N.I., KOUZNETSOV, A.V., ZHIKHAR, Y.N., and others, Economical and Mathematic Methods and Models, edition 2, Minsk, BGAU (2000) 412 p.

[12] Temporary Sanitary Rules of Conservation of Near-surface Liquid Radioactive waste Storage Facilities of SCP, VSP KHRO-96.

[13] Sanitary and Hygienic Requirements and Measures to Ensure a Safe Mode of Operation and Regulation of Industrial water basins at PO "Majak" (SGT APV-M) M. (1997).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Cleanup of areas contaminated by past activities and accidents. Safety Series No WS-R-X (DS162) (in preparation), IAEA, Vienna (2002).