Progress in Norwegian-Russian Regulatory Cooperation in Management of the Nuclear Legacy – 8289

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ABSTRACT

The Norwegian Radiation Protection Authority (NRPA) and the Federal Medical-Biological Agency (FMBA) of the Russian Federation have a collaboration programme which forms part of the Norwegian government's Plan of Action to improve radiation and nuclear safety in northwest Russia. The background to the NRPA-FMBA collaboration programme has been described in previous WM presentations. This paper presents the substantial progress made within that programme, describes on-going progress within specific projects and sets out the value arising from wider involvement in the programme of other organisations such as NATO and the technical support derived from other national agencies such as the IAEA, and regulatory authorities from the USA, the UK and France. The main activities of the cooperation projects are concerned with the management of the nuclear legacy in northwest Russia, in particular the remediation of facilities, and related spent fuel and radioactive waste management, at the former Shore Technical Bases at Andreeva Bay and Gremikha Village. New regulatory guidance documents have been developed, necessary because of the special abnormal situation at these sites, now designated as Sites of Temporary Storage (STS), but also because of the transition from military to civilian regulatory supervision and the evolving regulatory system in the Russian Federation. The work has involved major technical inputs from the Russian Federation Institute of Biophysics, as well as review and advice on international recommendations and good practice in other countries provided by other technical support organisations. Projects on-going in 2007 are described which involve regulatory guidance on very Low-Level Waste management, specifically for the licensing and operation of new VLLW disposal facilities; optimisation of operational radiation protection, particularly in areas of high ambient radiation dose rate as are found in some parts of the STSs; determination of factors which can be used to identify when to apply emergency procedures before the full emergency is obvious; and development of the radio-ecological basis for identifying radiation supervision area boundaries.

INTRODUCTION

In the 1960's, two shore technical Navy bases were built in Northwest Russia, one at Andreeva Bay and another in Gremikha on the Kola Peninsula on the Barents Sea coastal strip. These facilities supplied

operational support to nuclear submarines of the Northern fleet, including storage of spent nuclear fuels (SNF) and radioactive waste (RW). After two decades, the Treaty on the Non-proliferation of Nuclear Weapons called for functional decommissioning of a large number of nuclear submarines within a relatively short period, from the late 1980's to early the 1990's. This gave rise to increased attention from the international community to the circumstances in northwest Russia.

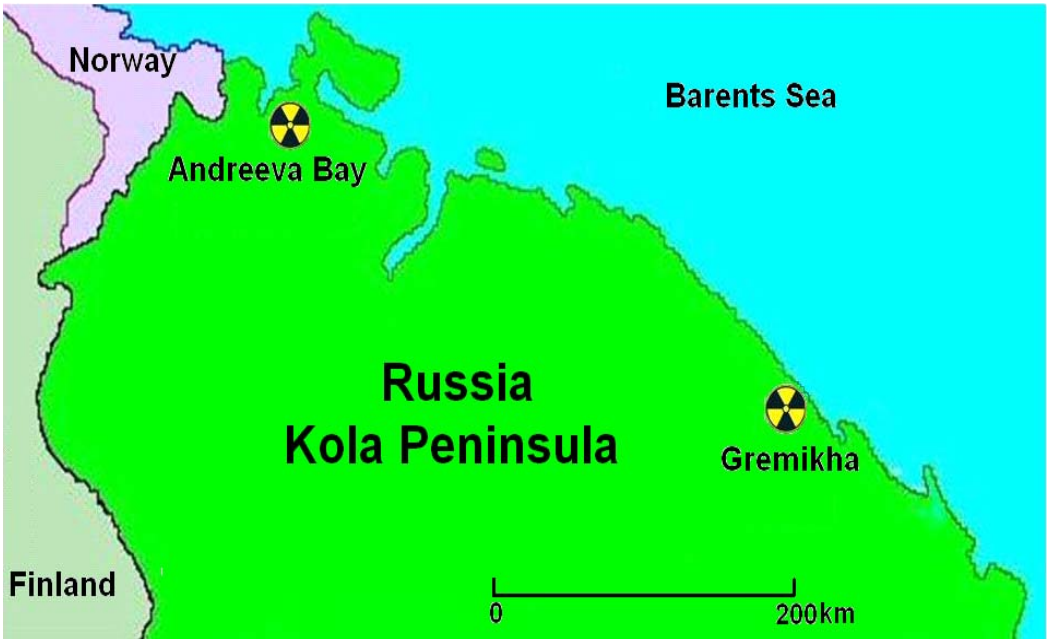

Fig. 1 Location of Andreeva Bay and Gremikha sites on the Kola peninsula

In addition to the high concentration of radiation-hazardous facilities in the region, the following factors exacerbate the problem of legacy management:

- Damage to the SNF and the engineered barriers of the storage facilities, leading to the threat of radioactive contamination of the environment.
- Gaps in regulations on procedures connected with specific aspects of SNF and RW management, including insufficient definition of requirements for remediation activities.
- Justified public concern that environmental safety may be jeopardized not only in the area of the Kola Peninsula and in the European part of Russia, but also in other countries of northern Europe.

In 2000, by Decree of the Russian Government, the Federal State Unitary Enterprise SevRAO was established with the purpose to conduct the full set of operations for management of the SNF and RW accumulated in the process of NS decommissioning, and to carry out environmental rehabilitation of radiation hazardous facilities in the Northwest Russia. The main SevRAO activities are centered on the former shore technical bases in Andreeva Bay and Gremikha, now designated as Sites of Temporary Storage (STS).

The following circumstances critically characterize these sites:

- Unsatisfactory technical condition of the STS facilities, hampering safe SNF and RW management,
- Radioactive contamination dispersion from the areas of STSs in the adjacent marine environment,
- Lack of regulatory requirements and guidance to deal with the existing abnormal radiation conditions, and
- Lack of relevant standards for the complete management of radioactive waste.

GENERAL CHARACTERIZATION OF THE SITES AND FACILITIES AT ANDREEVA BAY AND GREMIKHA

The site of temporary storage of SNF and RW in Andreeva Bay is situated in Northwest Kola Peninsular in the coastal strip of the Barents Sea (Motovsky bay, west bank of Zapadnaya Litsa bay). The nearest settlements to the STS are: Bolshaya Lopatka (2.4 km) and Nerpitchiye (1.8 km) villages and Zaozersk city (8 km). The Zaozersk urban area is 520 hectares. There are 15,700 inhabitants, according to data for 1.1.2002.

The STS in Andreeva Bay consists of the following main technological constructions:

- fixed-site technological berth;
- blocks of dry storage – three partly underground 1000 m^3 stores, re-equipped to serve as facilities for the SNF storage;
- service site for the SNF store, including some buildings;
- basin-type SNF storage facility – building 5 being decommissioned after the SNF removal;
- liquid radioactive waste (LRW) storage facilities;
- building intended for water purification;
- storage facility for high level concentrates of LRW after treatment;
- numerous constructions and sites for solid radioactive waste (SRW) store.

Since 2002, construction of new and reconstruction of available infrastructural components has been carried out at the STS.

The site of SNF and RW temporary storage in Gremikha is located on the Northwest Kola Peninsular in the coastal strip of the Barents Sea (Svyatonosskiy bay). The nearest settlements are Gremikha village, located 0.7 km from the site, and the closest administrative territorial formation is Ostrovnoy city, located 1.2 km from the site. 3500 inhabitants live in these settlements.

The STS in Gremikha consists of about 30 buildings, and 19 of them have technological functions: SNF, SRW, LRW, containers with control rod, 8 spent extracted parts from nuclear submarines with liquid-metal fuel are stored here. In addition to the buildings and systems, there is a dry dock, obsolete service ships and floating tanks at the STS.

Natural ponds serve as a water supply source for both STSs. The station of domestic-drinking water supply performs water supply and delivery; stationed at a distance of a few kilometers from the STSs. Soils at both STSs and in their vicinities are not suitable for agriculture. Flora and fauna of this region are

typical for the tundra zone: lichen, 1.5 - 2 m birches, bushes (heather, berry-bushes etc), permanent grasses (hair-grass), and deer, elk, and seals live here.

a) b)

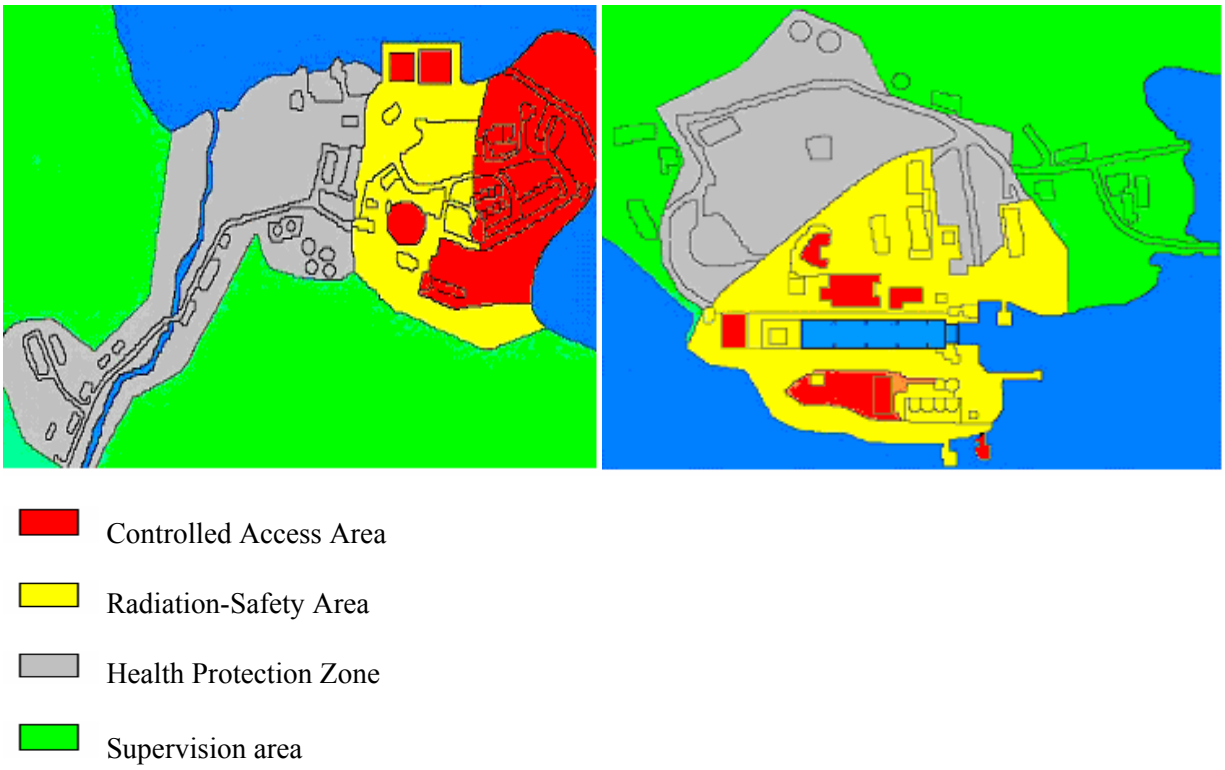

Fig. 2. Area categorization at Andreeva Bay (a) and Gremikha (b)

The sites at Andreeva Bay and Gremikha (fig. 2) consist of four separate radiation protection areas.

Controlled Access Area. The facilities are located within this area, where SNF and RW are stored and where radiation-hazardous operations are carried out. The facilities in this area are the main subjects of remediation. The RW and SNF inventory and radioactive contamination of buildings, constructions and the area of this zone existed before the beginning of the STS remediation operations. They were generated following the RW and SNF management, performed by the Navy. This activity had been implemented in compliance with the special “Norms and Rules of nuclear and radiation safety guaranteeing”. With the purpose of radiation protection of workers according to the requirements of the main sanitary rules of the radiation safety in Russia, the red section of the CAA is equipped with decontamination facilities and a special regime of work is defined within the area. Personal protective equipment is applied in CAA to provide radiation protection of personnel.

Radiation Safety Area (RSA). Facilities are located in this zone, which support work implementation in the controlled access area. Any radiation-hazardous operations are not performed within this area.

Health Protection Zone (HPZ). This is an area of the STS administrative and technical provision. The external border of this area is limited by the system of physical protection of the engineered area.

Supervision Area (SA). This area with radius of about 10 and 3 km, respectively, in Andreeva Bay and Gremikha, is subject to supervision of the facility impacts on the environment and the public.

MAIN TASKS WITHIN THE FMBA/NRPA COOPERATION

These consist of:

- Independent detailed analysis of the radiation situation at and near the SevRAO STSs.
- Radiological threat assessment to determine priority issues for regulatory attention, including requirements for additional documents and improved regulatory procedures.
- Classification of technological operations on SNF and RW management at SevRAO facilities and development of regulatory priorities concerning technical-engineering and organizational measures.
- Radiological control and monitoring of the occupational exposure and environmental conditions, including medical and sanitary support of the emergency response system.
- Development of a regulatory documentation system ensuring radiation protection observance of workers and the public, including radiation-hygienic criteria and standards of rehabilitation of contaminated territories.

Three completed projects within the NRPA-FMBA cooperation have been devoted to:

- Development of the criteria and regulatory guidance document to provide for safe working conditions at SevRAO facilities during performance of SNF and RW removal.
- Development of the norms and standards on rehabilitation of STS facilities at Andreeva Bay and Gremikha during and after principal operations connected with SNF and RW removal.
- Development of regulatory issues on preparedness for medical and sanitary measures control in the event of radiological emergencies (accidents) at SevRAO facilities.

These are described further below, along with new project work and wider international cooperation.

INDEPENDENT CHARACTERIZATION OF ANDREEVA BAY AND GREMIKHA

The STS Andreeva Bay is located on Kola Peninsula in the Barents Sea coastal strip (Motovsky gulf, west bank of Zapadnaya Litsa bay). The nearby settlements are: Bolshaya Lopatka (2.4 km); Nerpitchie village (1.8 km); Zaozersk city (8 km). The population is 15 700, the majority of which are military estates. The facility holds about $1.3 \cdot 10^{17}$ Bq of SNF and $6{,}0 \cdot 10^{14}$ Bq of RW.

Up to now, a large amount of SNF contained in 88 unloaded cores (UC), as well as 17558 tons of solid radioactive wastes (SRW) and 3042 tons of liquid radioactive wastes (LRW) have been accumulated in Andreeva Bay and Gremikha. After termination of operations in the 1980's, the infrastructure of the bases degraded and poor conditions of some building constructions led radioactive contamination of some parts of STS territory. It is evident that the process of SNF and RW management and remediation of STS territories will take many years and will require, apart from developing a new infrastructure, the efficient control over observance of radiation protection requirements.

Russian legislation recognises three RW categories: high level radioactive waste (HLW) – its specific activity is higher than 10^7 kBq/kg; intermediate level radioactive waste (ILW) – its specific activity is from 10^3 to 10^7 kBq/kg; and low level radioactive waste (LLW) – its specific activity is less than 10^3 kBq/kg.

The largest component by volume of all the radioactive wastes is LLW. With regard to the least active radioactive waste, it is necessary to develop and test criteria for classifying wastes as the industrial wastes containing man-made radionuclides with specific activity lower than LLW group, but which still require management taking account of their radioactive content, e.g. to be called very LLW (VLLW). Also required are operative control methods for their identification and health and safety requirements for storage conditions.

RADIATION SITUATION ON-SITE THE STS IN ANDREEVA BAY

The accomplished examinations showed that gamma dose rates within the STS territory varied over a wide range: in CAA - from 0.2 to 140 μSv/h; in UA - from 0.2 to 12 kBq/kg; in HPZ - from 0.1 to 0.2 kBq/kg. Within SA, gamma dose rates varies from 0.063 to 0.14 μSv/h with an average value of 0.12 μSv/h, which does not differ from the levels typical for the territories of Northwest Russia and in the Murmansk region, in particular. The results of selective personal dose monitoring show that external exposure gamma rates of the public and workers are, respectively, equal to 0.8 and 0.9 mSv/y. Internal public radiation doses associated with intake of radionuclides with food are 14 μSv/y. The total effective radiation doses to the public living in the STS's SA of Andreeva Bay are estimated to be approximately 0.8 – 0.9 mSv/y, that is not more than the actual norms.

The highest level radioactive contamination of soil on-site induced by man-made radionuclides is observed in the area of the old technological pier and around some SNF store facilities, where Cs-137 specific activity reaches $5.7\ 10^7$ Bq/kg, and that of Sr-90 is $5.7\ 10^6$ Bq/kg. Cs-137 and Sr-90 concentrations in soil within HPZ and SA is at the background level typical for "clean" Russian Northern areas and does not exceed 36 Bq/kg and 4 Bq/kg, respectively.

RADIATION SITUATION ON-SITE THE STS IN GREMIKHA

Gamma dose rate within CAA varies from 0.2 to 500 μSv/h (maximum values are 4 times more than those in Andreeva bay); in UA – from 0.2 to 12 μSv/h and levels within approximately 80% of the territory do not exceed 5 μSv/h. In HPZ and SA (in Ostrovnoy and Gremikha) it varies from 0.09 to 0.2 μSv/h, i.e., within fluctuation limits of natural background of this region. The results of selective personal monitoring of the people living and working (workers group B) in the STS area show that the external exposure gamma dose rates are 0.7 mSv/y (for public) and 0.9 mSv/y (for workers). Internal public radiation doses due to intake of Cs-137 and Sr-90 with food are approximately 14 μSv/y, which is significantly lower than acceptable levels.

Within the industrial site, man-made contamination is observed in top-soil due to Cs-137, Sr-90 and, in small concentrations, Co-60, Eu-152, and Eu-154. In SA (including Gremikha and Ostrovnoy), Cs-137 and Sr-90 contents in soil are mainly within background level (1 – 50 Bq/kg). In local parts outside the settlements, observed levels exceed background values by up to 100 Bq/kg of Cs-137.

ADDITIONAL RESULTS OF RADIATION SITUATION ASSESSMENT AT STSs

The results of neutron radiation rate measurements in SNF location areas showed that neutron radiation exposure of workers is not significantly high. The neutron radiation levels are close to the background values of 10^{-2}-10^{-3} μSv/h (dose rate of neutron component of cosmic radiation at the sea level is about $9 \cdot 10^{-3}$ μSv/h), while the intensity ratio of gamma radiation to neutron radiation reaches 10^4 - 10^6.

Radiation monitoring of the environmental media showed considerable exceeding of typical background values of Cs-137 and Sr-90 radionuclide concentrations (in the SSZ coastal strip) in seaweeds, bottom sediments and vegetation. An exceeding is also observed in some cases in the STS SA environmental

media in comparison with background values. Preliminary results of sorption experiments of radionuclides on local soil and ground waters suggest that radionuclide migration from highly contaminated areas on site, via groundwater flow pathways, is possible. This leads to permanent entry of radioactive substances into the off-shore marine environment.

According to radiation monitoring of catches in the STS off-shore marine environment, the concentration in fish is in the range 0.7 - 13 Bq/kg for Sr-90 and 0.4 – 35 Bq/kg for Cs-137, being significantly lower than actual Russian accepted radiation contamination levels. With the purpose of radiation exposure restriction during large-scale STS remedial work, FMBA of Russia established a public radiation dose quota; this quota is 100 μSv/y due to effluents and 30 μSv/y due to radioactive discharges.

CLASSIFICATION OF TECHNOLOGICAL OPERATIONS AT SEVRAO FACILITIES

The technological operations on SNF management and following remedial works can be considered as radiation-hazardous operations, which are ranked as follows:

- Operations carried out according to the design and approved by process regulations, in the established order;
- Operations, which are performed with deviations of some radiation situation parameters from the design and risk of abnormal situation occurrence, but not leading to a radiation emergency situation;
- Operations, which are performed upon detection of a radiation emergency event and focus on mitigation of its consequences.

Among the arrangements aimed to ensure personnel radiation safety is control over the workers exposure by means of identification of the category of planned radiation hazardous operations (RHO), according to possible occupational exposure. The operations performed under conditions of existing or potential radiological threat, with the individual effective radiation dose of a worker at his working place (without any protective actions) exceeding the specified value of 20 $mSv \cdot y^{-1}$, are referred to the radiation hazardous operations. Actions to reduce dose are to be elaborated for each RHO category.

The work associated with SNF and RW management requires application of efficient personal and collective protective equipment against external radiation, intake of radioactive substances with inhalation and skin contamination. The applied means must not hamper the workers' movements, narrow the field of view, nor create excess load on human physiological systems, thus reducing their working capacity. Moreover, they must allow for the specific conditions during possible emergencies.

Classification of technological operations by their status (categorization according to potential radiation hazard of the work fulfilled) and type (routine, abnormal and emergency/remediation) is an integral part of the regulatory system of radiation protection of personnel. To assess possible exposure doses to personnel in emergency situations and to plan the technological operations for mitigation of their consequences, a preliminary forecast was developed, based on possible emergency scenarios, including a comprehensive listing of initiating events, and definition of the time and sequence of mitigation measures required in emergency response.

Taking account of specific radiation conditions at STS facilities, special attention should be paid to the improvement of the emergency response system and related medical and sanitary support. The "Emergency Medical and Radiation Dosimetry Center" (EMRDC) of FMBA of Russia, operating at the premises of SRC IBPh has accumulated experience in the sphere of medical and sanitary support activities for crisis management and expert support in the event of radiation emergencies. Using its funds, facilities and personnel, including medical and radiation monitoring teams providing urgent emergency

response, the EMRDC of FMBA coordinates work of the regional medical institutions integrated in the FMBA structure. Accordingly, a specialized medical response-training course was successfully arranged at the STS site in Andreeva Bay. The training course was of a great importance for assessment of the preparedness of SevRAO emergency response teams and FMBA medical institutions; the obtained skills allowed identification of further requirements for development and improvement of medical emergency response.

REMEDIATION OF CONTAMINATED TERRITORIES

The analysis of radiation-hygienic situation taking account of the data obtained, leads to the conclusion that a long and extensive rehabilitation program is necessary after the removal of SNF and RW from the STS's. Having in mind up-to-date approaches to radiation protection, the identification of remediation strategies has focused on justification of reduction of the occupational and public exposure arising from of residual contamination. The following have been defined.

1. Conservation (storage under surveillance) – excludes the potential threat of contamination of the STS territory, water area and air media. A guarded area is arranged and continuous radiation monitoring is carried out.
2. Conversion (renovation) – suggests subsequent use of the STS territories and facilities in compliance with the existing regulatory documents regulating the radiation impact on personnel and public under normal conditions of operation with radioactive sources. Limited use of the territory in combination with rehabilitation measures and radiation monitoring ("brown field" concept) is envisaged.
3. Liquidation – suggests stage-by-stage dismantling and removal of equipment, removal of RW, including contaminated environmental objects, and guarantees of limited exposure dose for critical group of public at the level 1 mSv/y ("Greenfield" or unlimited use concept).

The STS in Andreeva Bay is not likely to be used for direct purpose in the future. The planned operations are associated with preparations and removal of SNF and RW from the territory with subsequent liquidation or conservation of the buildings and other constructions, and decontamination of the territory. We assume that at STS in Gremikha, apart from environmental rehabilitation operations, the remediation and reconstruction of the infrastructure for unloading and following interim storage of NS core reactors with liquid-metal coolant, is required.

NORMS OF REMEDIATION

FMBA of Russia approved norms for the main variants of the STS remediation. They were developed on the basis of actual Russian laws and standards, taking account of radiation situation existing currently at the STS as well as contemporary international recommendations and experience in the field of contaminated area remediation in other States. The dose standards are set out in table 1.

Variant of remediation	Category of persons	Dose constraint, mSv/y			Dose limit from (NRB-99)
		Due to residual contamination	Due to new operation involved radiation sources	Total	
Conservation	Workers	2	-	2	20
	Public (SA territory)	0,1	-	0,1	1
Conversion	Personnel group A	3	7	10	20

("brown lawn")	**Personnel group B**	**1**	**1**	**2**	**5**
	Public (SA territory)	**0,1**	**0,15**	**0,25**	**1**
Liquidation ("green field")	**Public (former STS territory)**	**1**	**-**	**1**	**Lack of norms in current standard**

Table 1. Dose standards for alternative remediation strategies

INTERNATIONAL EXCHANGE OF REGULATORY EXPERIENCE

To improve the efficiency of joint co-operations carried out by NRPA and within the framework of the NATO Project "Exchange of experience in the sphere of regulation of reduction of the risks associated with operations at nuclear facilities", FMBA and SRC-IBPh experts visited different organizations in the USA and the UK. The objective of the above working visits was to get a better idea of what challenges and solutions of radiation protection different regulatory authorities in the above countries have, their interaction with nuclear facility operators, and the process of decommissioning, RW management, and rehabilitation of contaminated territories.

During the visit to the United Kingdom the Russian experts visited:

- Radiation Protection Department of the Health Protection Agency (HPA),
- Nuclear Installations Inspectorate, Health Safety Executive;
- United Kingdom Atomic Energy Authority (UKAEA) and BNFL;
- Scottish Environmental Protection Agency (SEPA);
- Industrial sites in Windscale and Sellafield, as well as the scientific-research site Dounreay;

and in the USA:

- US Department of Energy – DOE;
- Nuclear Regulatory Commission – NRC;
- Environmental Protection Agency – EPA;
- Industrial sites in the Idaho National Laboratory, Idaho Falls, and the Pacific Northwest National Laboratory, Hanford.

In September 2007, a NATO sponsored international work was held near Moscow, at which experiences in the regulatory development and application were shared among participants from the Russian Federation, USA, UK, France and representatives from the IAEA and NATO. Differences in approach and reasons for them were explored, and it was noted that:

- The Russian Federation has responsibility to manage its own nuclear legacy, but it is also one of several countries in the global network of nuclear activities. Harmonisation of approaches is valuable in building future cooperation. Accordingly, furher exchanges should be encouraged.
- Development of a broader and deeper safety culture should be a long term objective, while at the same time maintaining the highest standards of radiation protection and nuclear safety as possible.
- There are many complex issues to be addressed and they cannot all be solved at once. Clear recognition of the major threats, as well as weakness in regulatory processes, can be useful in directing future resources. However, at this stage it is clear that there are specific regulatory issues to address with respect to regulatory requirements and guidance for SevRAO and possibly

other sites concerning: site remediation; waste forms for long term storage and disposal, and disposal facilities.
- In turn, such work is dependent on better radioactive waste and contamination characterisation, as well as site characterization information.

CONCLUSIONS

The work carried out under joint FMBA/NRPA Project is an important step forward in the improvement of regulation of radiation and nuclear safety during SevRAO operations. Current output has included the following regulatory guidance and documents:-

- InitialThreat Assessment for the situation at SevRAO sites: NRPA Rapport 2005:17 [1].
- Guidance "Criteria and norms on remediation of SevRAO sites and facilities contaminated with man-made radionuclides".
- Guidance «Hygienic requirements for personnel and public radiation safety guaranteeing at the stage of designing the work with SNF and RW at FSUE "SevRAO" Branch № 1 ››.
- Guidance "Application of personal protective equipment at operations at SevRAO facilities. Selection and application".
- Report on "Development of criteria and norms on remediation of facilities and territories of STS at Andreeva Bay and Gremikha", and 4 scientific published articles.
- Report on "Substantiation of organizational emergency response duties".
- Information report on "Medical response emergency training at «SevRAO» enterprise in Andreeva Bay".

Projects on-going are due to result in regulatory documents within the following topical and critical areas:

1. Personnel Radiation Safety:
   - Methodical guidance "Requirements for performance of personal radiation monitoring for personnel of FSUE SevRAO Branch № 1";
   - Methodical document "Regulation for performance of radiation monitoring at FSUE SevRAO Branch № 1";
   - Methodical guidance "Special features in application of ALARA principle in the work on SNF and RW management at FSUE SevRAO Branch № 1".
2. Control of environmental contamination:
   - Development of radioecological criteria of marine environmental monitoring and control in the course of STS rehabilitation, taking account of possible end-state of the object.
   - Development of draft methodical guidance documents "Radioecological monitoring on-site and in supervised area in the course of conversion activities at STS of SevRAO."
3. Criteria for on-site management of Very Low Level Waste (VLLW):
   - Development of sanitary hygienic requirements for collecting, categorization, treatment, temporary storage, transportation and disposal of VLLW in the territory of the SevRAO facility at Andreeva Bay.
   - Draft "Safety norms on VLLW management containment safety requirements for the period of operation of the facility and upon its closing, as well as the criteria for waste acceptance".
4. Criteria development for emergency preparedness and response:
   - Report "Analysis of Russian and international approaches in evaluation of operating radiological and medical criteria at an early stage of emergency response".
   - Guidance on application of radiological and medical criteria by MSU-120 and RM-120 emergency response teams as part of emergency response system.

These documents are necessary to:

- Create a system covering the entire range of the objectives related to medical-hygienic regulation of radiation and environmental protection of the personnel, public and environment at SevRAO facilities;
- Optimize the order of the works, by means of selection of acceptable technologies, and assess the radiological, economical and social factors, and accordingly, provide for and guarantee a series of preventive and operative measures;
- Guarantee a socially acceptable level of radiation protection and public health during and after termination of operations at SevRAO facilities, basing on common approaches to the national normative documents and international recommendations.
- Identify the perspectives in improvement of the regulatory system within the framework of international co-operation, basing on a detailed assessment of the scale of potential threats.

The work completed and in progress will allow many problems to be solved. However, as the engineering project plans are developed in more concrete detail, additional data on the site conditions will become available, and prognostic assessments will become more accurate. An effective regulatory response to new information is vital for the FMBA and others to carry out their responsibilities, and all involved are working to provide such good results. Much of the work already completed is quite new to the organizations involved, and though no-one can foresee all the problems in the future, confidence is growing from the knowledge and experience gained. Continued close collaboration will promote further good progress within the Russian-Norwegian co-operation in the field of radiation protection regulation.

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