



Executive Summary (DRAFT)

**STRATEGIC ENVIRONMENTAL ASSESSMENT REPORT
FOR STRATEGIC MASTER PLAN
OF NORTHERN DIMENSION ENVIRONMENTAL PARTNERSHIP
(NUCLEAR WINDOW)**

Executive Summary

NNC Document Registry Info: 12124/TR/003

April 2005

Client Reference Number: C14073REV

REVISION SUMMARY

Revision Number	Date	Comments
Issue 1	18/2/05	Draft for review by EBRD
Issue 2	24/3/05	Revised in accordance with Draft SEA Issue 2
Issue 3	12/4/05	Revised in accordance with Draft SEA Issue 3
Issue 4	19/4/05	Revised in accordance with Draft SEA Issue 4

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1 PROJECT BACKGROUND

The present *Strategic Environmental Assessment (SEA)* has been undertaken for the *European Bank of Reconstruction and Development* to provide an assessment of the *Strategic Masterplan* for addressing the nuclear legacy in North West Russia.

This report was prepared by the *National Nuclear Corporation Limited* (NNC, UK and Canada) and its subcontractors from the *International Centre for Environmental Safety* (ICES, Russia), with contributions from Golder Associates Limited (Canada) and the Kola Mining Institute (KMI, Russia).

The Strategic Masterplan has been developed within the *Nuclear Window of the Northern Dimension Environmental Partnership*. The goal of this Partnership is to bring solutions to long-standing environmental problems in North-West Russia. The funding for the Northern Dimension Environmental Partnership is provided by the Russian Federation and by Belgium, Canada, Denmark, the European Union, Finland, France, Germany, Netherlands, Norway, Sweden and the United Kingdom.

The purpose of the Masterplan is to dismantle the submarines and the other nuclear propelled vessels, which have been withdrawn from service, and to restore the shore bases that supported the operation of these vessels into an environmentally acceptable condition. Phase I of the Masterplan provided:

- A review of the existing information,
- An analytical review of the current decommissioning stages,
- A preliminary safety assessment and a summary of the constraints and unresolved issues, which require strategic decisions by the Russian authorities, and
- An identification of those critical actions that should be launched quickly.

The Masterplan is a ‘living’ plan, which will be expanded and continuously updated as new information becomes available and the work proceeds.

The purpose of the SEA is to complement this Masterplan by providing the Masterplan decision-makers with additional relevant information. The SEA seeks to do this by

- Reviewing the assessments of the potential hazards that are provided within the Masterplan. This involves an analysis of the available information on both nuclear and non-nuclear risks to both people and to the environment.
- Making proposals to mitigate the potential impacts on the environment. This is required if either potential risks to the environment are identified as a result of implementing the Masterplan strategies or there are cases where there are gaps in the available information.
- Reviewing the priority that is associated with each of the measures that are identified in the Masterplan, based on the risks to the environment that would result from not implementing the Masterplan strategies.

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- Providing information to the public through a one-month scoping consultation, which took place in the end of 2004 and a 120-day consultation, which will commence once the current draft SEA report has been made available to the public.

2 THE NUCLEAR LEGACY IN NORTH WEST RUSSIA

2.1 Nuclear Navy

According to the Masterplan, Russia built over 450 naval nuclear reactors with a total power output that is comparable to the total capacity of all the Russian civil nuclear power plants. Approximately two thirds of these reactors are located in North West Russia, which represents approximately 20% of all the nuclear reactors in the world.

Since 1958, the Soviet Union, and later Russia, have built 248 nuclear powered submarines, 5 nuclear powered military surface vessels, 8 nuclear icebreakers, and a nuclear powered transport ship.

One hundred and forty nuclear submarines and all the surface nuclear powered vessels used to be based at the Northern Fleet and Atomflot naval bases in the Murmansk region of North West Russia.

According to the Masterplan, as of January 1st 2004, North West Russia had 121 nuclear-powered vessels that have been withdrawn from active service including

- 117 nuclear powered submarines. This includes
 - 56 non-dismantled submarines including 31 with Spent Nuclear Fuel (SNF) on board and
 - 62 reactor compartments from dismantled submarines including 2 that still contain their SNF
- The cruiser ‘Ushakov’,
- Two icebreakers and
- One transport ship.

The designs of the submarines were grouped by ‘generations’ that were based on the design of the reactors and their auxiliary systems. The Soviet Union built three generations of submarines that were powered by pressurized water reactors. All the submarines of the first generation and the majority of those in the second-generation have been withdrawn from active service or ‘laid up’ as is the case with a small number of third-generation submarines.

In addition, the Soviet Union commissioned ‘Alpha-class’ submarines, which used lead-bismuth cooled reactors. All of these have been withdrawn from active service.

There are also a small number of submarines of other types, which may have to be decommissioned in the near future.

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2.2 Infrastructure

The infrastructure created in North West Russia to service the nuclear navy includes

- Shipyards, which are involved in the commissioning, repair, and now, the decommissioning of nuclear-powered vessels and in the management and storage of SNF and radioactive waste (radwaste).
- Coastal Maintenance Bases and Naval Bases, which serviced nuclear-propelled vessels as well as the management and storage of SNF and radioactive waste.
- Technical support vessels, which serviced nuclear-powered ships and were used for the transfer and storage of SNF and radwaste.

Table ES-1. Overview of Northern Fleet Bases and Shipyards Located in the Murmansk and Arkhangelsk Regions

Location	Role	Submarines withdrawn from active service, SNF and radwaste
On the Kola Peninsula	Naval Bases	<ul style="list-style-type: none"> • Waste from operational submarines • 2 nuclear cruisers which have been withdrawn from active service • 31 submarines which have been withdrawn from active service • More than 200 m³ of liquid radioactive waste • More than 2000 m³ of solid radioactive waste
<i>ZATO Zaozersk</i>		
Andreeva Bay	Former Coastal Maintenance Base	<ul style="list-style-type: none"> • Partly damaged fuel in Buildings 2a, 2b, 3a. In total, approximately 22000 spent fuel assemblies from first and second-generation submarines. • 3300 m³ of liquid radioactive waste, some of it in underwater tanks off the coast. • 17600 m³ of solid radioactive waste

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Table ES-1. (Cont)

Location	Role	Submarines withdrawn from active service, SNF and radwaste
<i>ZATO Ostrovnoy</i>		
Gremikha	Former Coastal Maintenance Base	<ul style="list-style-type: none"> • Open-air fuel store-containing approximately 800 assemblies from first-generation submarines in casks and/or canisters, many are badly damaged. • 6 cores from Alpha-class submarines in Building 1B. • <250 m³ of liquid radioactive waste • <750 m³ of solid radioactive waste • 2 submarines which have been withdrawn from active service
<i>ZATO Skalistiy</i>		
Sayda Bay	Storage of reactor compartments	<ul style="list-style-type: none"> • 50 reactor compartment units from defuelled and dismantled submarines, which are being stored afloat (as of 01.01.05). • A reactor compartment storage facility, which is land-based, is under construction
<i>ZATO Polyarny</i>		
Shipyard SRZ-10	Shipyard, involved in dismantling	<ul style="list-style-type: none"> • Storage of spent nuclear fuel afloat (one vessel, >500 assemblies) • Storage and processing of solid radioactive waste (>680 m³) • Storage of liquid radioactive waste (>20 m³)
<i>Murmansk</i>		
RTP Atomflot	Base for ice-breakers and civilian vessels	<ul style="list-style-type: none"> • Spent nuclear fuel storage afloat >5500 assemblies in 3 vessels • A land-based SNF storage facility is being built • Solid radioactive waste management • Storage and processing of liquid radioactive waste
Sevmorput	Shipyard, involved in dismantling	<ul style="list-style-type: none"> • Storage of solid radioactive waste • Storage of liquid radioactive waste

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Table ES-1. (Cont)

Location	Role	Submarines withdrawn from active service, SNF and radwaste
<i>ZATO Snezhnogorsk</i>		
Shipyard Nerpa	Shipyard, more than 20 submarines dismantled	<ul style="list-style-type: none"> • Storage of SNF afloat, 2 vessels, 11 000 assemblies • Storage of solid radioactive waste, 300 m³ • Storage of liquid radioactive waste, about 200 m³ • Storage of spent nuclear fuel in submarines awaiting defuelling • Storage of three-compartment reactor units prior to transfer to Sayda Bay
<i>Severodvinsk</i>		
Zvezdochka	Shipyard, more than 20 submarines dismantled	<ul style="list-style-type: none"> • Storage of spent nuclear fuel ashore (typically up to 500 assemblies) and afloat about 650 assemblies • Storage and management of solid radioactive waste, 3200 m³ • Storage and processing of liquid radioactive waste, 3000 m³ • Storage of spent nuclear fuel in submarines awaiting defuelling, out-of-service nuclear cruiser Admiral Ushakov • Storage of three-compartment reactor units prior to transfer to Sayda Bay
Sevmash	Shipyard, 7 submarines dismantled (as of 1/1/04)	<ul style="list-style-type: none"> • Storage and management of solid radioactive waste, >200 m³ • Storage and processing of liquid radioactive waste, over 1000 m³

Most facilities in the Murmansk region are close to Closed Administrative Towns (ZATOs, see Table ES-1), which is where the workers and their families live. Only two shipyards are located in the Arkhangelsk rather than the Murmansk region. These are the Zvezdochka and Sevmash shipyards, which are both in the town of Severodvinsk. The locations of the Closed Administrative Towns, Murmansk and Severodvinsk are indicated on the regional map, Figure ES-1.

Table ES-1 provides an overview of the quantities of spent nuclear fuel and radioactive waste that are located at the coastal maintenance bases and shipyards, which are located in the Murmansk and Arkhangelsk regions of North West Russia. All of these sites also handle and store conventional non-radioactive wastes, some of which are highly hazardous materials.

All the inventory data in Table ES-1 and the subsequent tables in this summary apply to the situation as it was in January 2004 and are based on the estimates that are given in the Masterplan

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unless stated otherwise. In most cases, the total amounts of radioactivity were estimated by the authors of the Masterplan using typical isotopic ratios and information on reactor shutdown dates.

From Table ES-1, it can be seen that the coastal maintenance base, **Andreeva Bay** in the North West of the Murmansk region, contains by far the largest nuclear inventory. Significant quantities of radioactive materials are also stored in the coastal maintenance base, **Gremikha**, to the east of Murmansk. The Northern Fleet used these two coastal maintenance bases for the management and storage of spent nuclear fuel and radioactive waste.

The Masterplan stated that these two sites contain a large number of facilities that are in unsatisfactory condition. There are major gaps in knowledge with regard to the inventory of radioactive materials and the extent of the contamination that surrounds the storage facilities at Andreeva Bay and Gremikha.

The coastal maintenance base at **Sayda Bay**, which is used for the storage of reactor compartments after the submarines have been defuelled and dismantled, also contains a large radionuclide inventory.

Five shipyards – **Zvezdochka** and **Sevmash** in the Arkhangelsk region and **Nerpa**, **SRZ-10** and **RTP Atomflot** in the Murmansk region, play major roles in dismantling submarines and the management and temporary storage of spent nuclear fuel and radioactive waste.

As indicated in Table ES-1 a number of other **naval bases** contain submarines that have been withdrawn from active service. All of them have smaller facilities for managing and storing radioactive and non-radioactive wastes.

The Masterplan states that stored radioactive materials include:

1. **Spent Nuclear Fuel (SNF)** - almost 500 PBq (5×10^{17} Bq) or **90%** of the total inventory
2. **Reactor Compartments** (representing a special class of solid wastes due to their large size) – almost 30 PBq (3×10^{16} Bq) or **5%** of the total inventory
3. Other **Solid Radioactive Wastes** - almost 30 PBq (3×10^{16} Bq) or **5%** of the total inventory
4. **Liquid Radioactive Waste** - 10 TBq (1×10^{13}) or **0.002%** of the total inventory

The amounts of SNF and the places where they are stored are summarized in Table ES-2. Most of this fuel is stored in unsatisfactory conditions, either in leaking stores, as shown in Figure ES-2, laid-up submarines or within maintenance vessels afloat. A significant, but unknown fraction of the fuel that is stored in Andreeva Bay and in some of the Maintenance Vessels, is damaged.

Summaries of the inventories of solid and liquid radwaste are given in Tables ES-3 and ES-4.

With a few exceptions, there are no data on the inventory of conventional waste stored in these locations.

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Table ES-2. Spent Nuclear Fuel in North West Russia

Location	Number of Spent Fuel Assemblies (SFAs)	Equivalent number of reactor cores	Total activity in Jan 2004, 10¹⁵ Bq
<i>Afloat</i>			
Out-of-service submarines with pressurized water reactors	12 000	59	170
Out-of-service submarines with liquid metal coolant reactors	not known	2	10
Reactor compartments with liquid metal coolant	not known	2	5
Technical Support Vessels based at Zvezdochka	More than 600	More than 2	24 (at 3 shipyards)
Technical Support Vessels based at Nerpa	More than 1100	More than 4	
Technical Support Vessels based at SRZ-10	More than 500	More than 2	
Technical Support Vessels based at Atomflot	More than 5000	More than 20	144
<i>Gremikha</i>			
Reactor cores from liquid metal cooled submarines	N/A	6	13
Dry storage in containers	800	3	5
<i>Andreeva Bay</i>			
Storage in facilities 2a, 2b, 3a	22 000	88	130

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Table ES-3. Solid Radioactive Waste in North West Russia (Excluding Reactor Compartments)

	Location	Amount (m³)	Total activity (Bq)
1	Andreeva Bay	~17,600	6.6x10 ¹⁴
2	Gremikha	~734	~ 3.7x10 ¹³
3	Maintenance Vessels ¹ including:	32	1.9x10 ¹¹
	PM-63	20	1.3x10 ⁹
	PM-12	4	1.8x10 ¹¹
	PM-78	3	1.9x10 ⁹
	PM-128	5	4.7x10 ⁸
4	Dismantling shipyards, including:	4,389	7.2x10 ¹⁴
	PA Sevmash	222	4.3x10 ¹⁴
	Zvezdochka	3,191	3.9x10 ¹³
	Nerpa	296	2.4x10 ¹⁴
	SRZ-10	681	7.1x10 ¹²
5	RTP Atomflot	1137	2.5x10 ¹⁶
6	Maintenance Vessel Volodarski (located at Atomflot)	328	4.1x10 ¹⁴
	Total	~ 24,000	~ 2.7x10¹⁶

¹ These vessels are based at Atomflot.

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Table ES-4. Liquid Radioactive Waste in North West Russia

	Location	Amount (m³)	Total activity (Bq)
1	CMB in Andreeva Bay	3042	4.5x10 ¹²
2	CMB in Gremikha		Not known
	<i>Bottom sediments of spent fuel stores</i>	200	
	<i>Floating tanks (PEK)</i>	32	
3	Maintenance vessels	1734	1.2x10 ¹²
	PM-63	115	2.6x10 ⁹
	PM-124	121	3.4x10 ¹¹
	PM-78	72	6.8x10 ¹¹
	PM-128	24	1.6x10 ⁹
	TNT-12	499	4.6x10 ⁷
	TNT-19	903	1.9x10 ¹¹
4	Dismantling shipyards, including:	4216	2.8x10 ¹²
	PA Sevmash	1050	3.9x10 ⁹
	Zvezdochka	2960	2.4x10 ¹²
	Nerpa	183	3.8x10 ¹¹
	SRZ-10	22.5	6.8x10 ⁸
5	RTP Atomflot	300	8.5x10 ¹¹
6	Ship Serebryanka (Atomflot)	850	6.5x10 ⁹
7	Ship Lapse (Atomflot)	65	1.1x10 ¹⁰
	Total	~ 10,438	~9.4x10¹²

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Figure ES-1. Regional Study Area



Figure ES-2. Spent Nuclear Fuel Stores at Andreeva Bay. Facilities 2a and 2b (Top) and 3a (Bottom)

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3 ASSESSMENT PROCESS

The SEA involves an iterative process of collecting information, defining alternatives, analysing environmental effects, developing mitigation measures and revising proposals in the light of the predicted effects on the environment.

The SEA process is illustrated in Figure ES-3. It can be seen that it involves the following principle phases:

1. Scoping consultations.

The objective of this phase was to ensure that the following tasks are completed and that a full account is taken of stakeholders' views:

- **Logistical arrangements** for the preparation of the scoping consultations, the distribution of information and the identification of potential stakeholders
- **Definition of the objectives of the SEA study** to provide a focus for the assessment and to help establish a basis for the subsequent evaluation of alternatives by setting out the initial boundary conditions to allow the definition of the 'best' environmental strategy. The overall objective is consistent with Objective 2 of the Northern Dimension Environmental Partnership, namely: "to address urgent nuclear safety and security issues related to the decommissioning of submarines and associated support facilities in North West Russia".
- **Generation of a comprehensive list of alternatives** as required by the Guidance on the Implementation of the European Directive 2001/42, which is as follows: "Information on the selection of alternatives is essential to understand why certain alternatives were assessed and their relation to the draft plan or programme". Alternatives will include the projects that are specified in the Masterplan and additional feasible strategies for addressing the main objective. "Business as usual" alternatives are also addressed so that the implications of not implementing the Masterplan can be assessed and the projects can be prioritised.
- **Definition of feasible alternatives** for improving safety in North West Russia. The alternatives that have been identified will be screened to identify representative projects that are reasonably practical, technically feasible and which satisfy Russian and international regulations.
- **Definition of a series of 'assessment criteria' or 'indicators'** that will be used to assess the key safety, environmental, technological and social characteristics and consequences of each defined option that are thought to be important and relevant at the level of detail that is being considered. These are given in Table ES-5. Once the initial assessment has been completed, the same group of indicators can be used to monitor the environmental performance of the strategy on a regular basis.
- **Definition of a scoring scheme** that allows the effects of each alternative to be evaluated against the assessment criteria and for the various technological and environmental characteristics and consequences of the alternatives to be compared.

2. Preparation of the Draft SEA report

The objective of this phase is to assess the strategies in accordance with the above by completing the following tasks:

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- ***Evaluation of the effects of each alternative strategy, using*** qualitative and quantitative information, and expert opinion where necessary, to score each of the options against every criterion using the defined scoring scheme. All significant effects will be identified in accordance with item (g) of Annex I of the SEA Directive. They will include secondary, cumulative, synergistic, short, medium and long-term, permanent and temporary, positive and negative effects.
- ***Selection of the ‘best’ environmental strategy*** in support of the Masterplan on the basis of the results of the assessment. A logical justification for the selection will be based on the comprehensive assessment approach detailed above. The best strategy will be selected on the basis that it will not have any major negative impacts. It is not always possible to uniquely identify a single ‘best’ option and, therefore, mitigation measures may be suggested for each project that is identified within the Masterplan to achieve the best environmental performance as explained further below.
- ***Recommend Mitigation.*** The recommendation of mitigation measures and the evaluation of the effectiveness of any mitigation that is proposed is embedded in the process discussed previously. The SEA is fundamentally a planning tool, and it one of the main purposes of the SEA is to be able to plan feasible mitigation measures, which reduce or eliminate detrimental effects.
- ***Report on the Significance of the Residual Environmental Effects.*** Residual adverse effects are those likely **detrimental** environmental effects that may remain after the mitigation measures have been implemented in order to achieve their elimination, reduction or control.

3. Public Consultation.

The objective of this phase is to seek public views on the Draft SEA report that is prepared in the second phase. A summary of the key points that were raised during the scoping consultations is provided in Appendix A of the Draft SEA Report.

4. Preparation of the Final SEA report.

This is a repeat of Phase 2, which takes into account the comments that will be made by stakeholders in Phase 3.

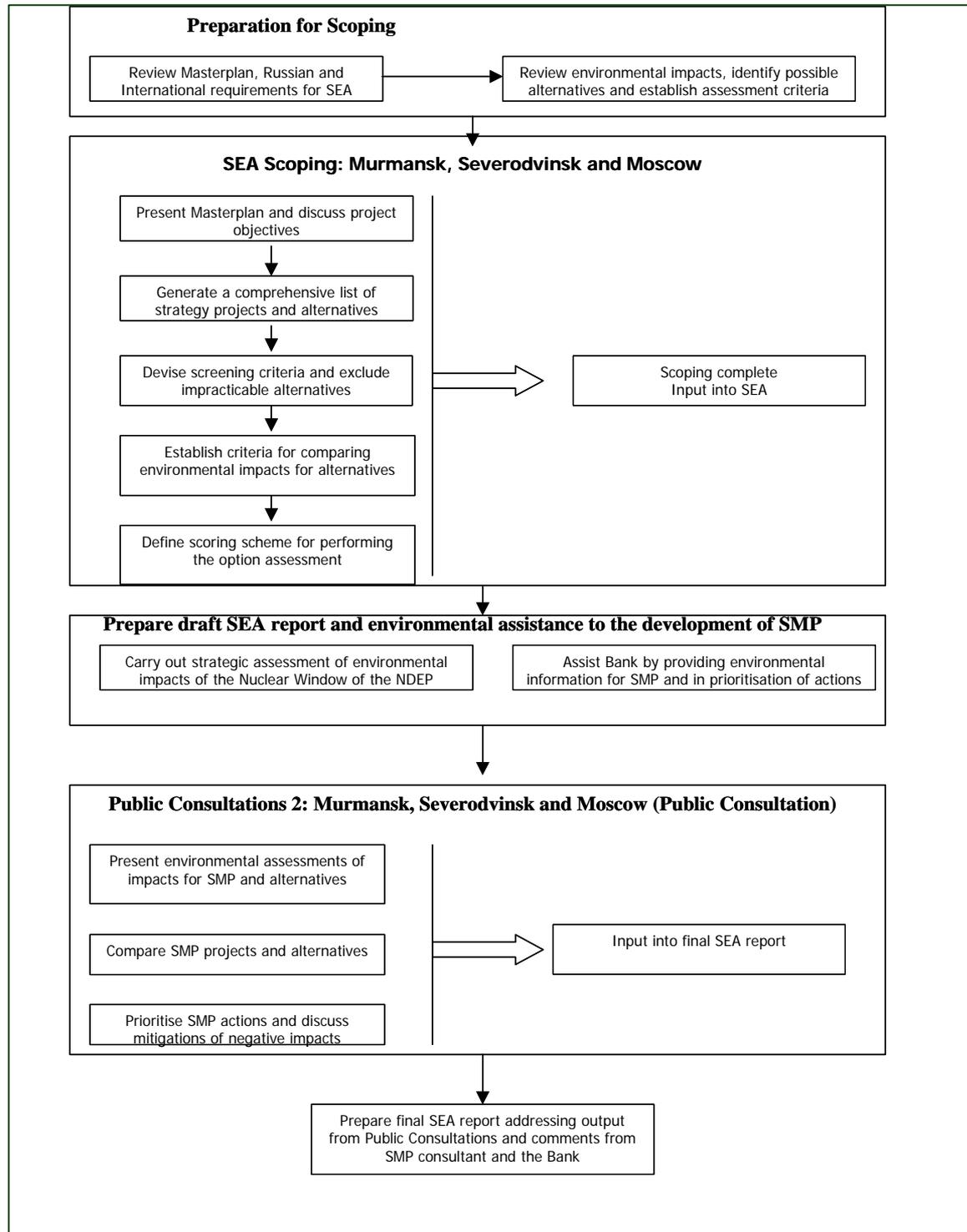


Figure ES-3. SEA Process

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Table ES-5. SEA Objectives And Indicators Selected Largely on the Basis of Public Priorities Identified During the Scoping Consultation

SEA Objective	SEA Indicators
Limit radiation exposure to workers	<ul style="list-style-type: none"> • Individual doses • Collective doses
Limit radiation doses to members of the public	<ul style="list-style-type: none"> • Individual doses • Risk of nuclear (criticality) accidents • Risk of other accidents
Minimise quantity of radioactivity potentially accessible to people and the environment	<ul style="list-style-type: none"> • Total inventory of SNF and waste requiring decommissioning
Limit radiation exposure of biota	<ul style="list-style-type: none"> • Radionuclide concentrations in biota • Radionuclide concentrations in physical environment
Improve worker health and safety	<ul style="list-style-type: none"> • Accident frequency (number of lost time accidents) • Accident severity (number of fatalities or serious injuries)
Avoid, remove or reduce sources of air pollution	Emission rates or loadings of non-radiological contaminants to the atmosphere: <ul style="list-style-type: none"> • Dust • Carcinogens • Non-carcinogens • Greenhouse gases • Ozone depleting substances
Avoid, remove or reduce sources of water pollution	<ul style="list-style-type: none"> • Releases of non-radiological contaminants to surface water • Releases of non-radiological contaminants to groundwater
Avoid contamination of biota with toxic substances	Concentration of toxic contaminants in biota
Maintain or enhance biodiversity	Consideration of potential impact on habitats and species
Maintain or improve natural resources	Consideration of effects on: <ul style="list-style-type: none"> • Forestry • Fishery • Agriculture • Tourism

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Table ES-5. (Cont.)

SEA Objective	SEA Indicators
Improve physical protection	Risk of theft of nuclear materials and terrorist attacks
Maintain or improve level of economic growth	<ul style="list-style-type: none"> • Employment level • Median income
Maintain or improve human health	<ul style="list-style-type: none"> • Life expectancy
Maintain or improve cultural and heritage resources	<ul style="list-style-type: none"> • Consideration of impacts on cultural and heritage resources

4 MASTERPLAN STRATEGIES

Four strategies have been identified in the Masterplan to address the urgent nuclear safety and security issues and the environmental concerns in North West Russia:

1. **Nuclear Submarine decommissioning**
2. **Nuclear-powered Surface Ship decommissioning**
3. **Maintenance Vessels decommissioning**
4. **Coastal Maintenance Bases rehabilitation**

These strategies were identified on the basis of the available information on the present situation and a comprehensive analysis of the potential threats to human health and the environment that result from the present situation. The first three cover decommissioning as defined in the Masterplan and the fourth covers rehabilitation also as illustrated in Figure 15 of the Summary of the Masterplan [SMP, 2004]. In the Masterplan decommissioning has five components. The strategy of decommissioning submarines above refers to both the decommissioning of the submarines themselves and the storage of reactor units. The second strategy covers the decommissioning of NPSS as in the Masterplan. The third strategy covers the decommissioning of both maintenance vessels and vessels which were previously operated by the Murmansk Shipping Company such as the Lepse. Finally the fourth strategy covers the rehabilitation of coastal maintenance bases as in Figure 15 of the Summary of the Masterplan.

At present, only submarine decommissioning strategy is being implemented and can be formulated in terms of the phases of actual projects. The remaining three strategies are being developed and are mainly described in the Masterplan in terms of their objectives.

The scoping consultations identified an overall consensus among the general public, the authorities, experts, industry and non-governmental organizations that the concept of having a Masterplan for addressing environmental problems at shipyards and coastal maintenance bases in North West Russia is beneficial [Gerchikov, 2005]. There was broad support for the approach proposed in Phase I of the Masterplan. Therefore, the main alternative to the Masterplan Strategy is the *'Business as usual'* approach, which, for the purposes of the SEA, is taken to be equivalent to long-term storage in the existing conditions without undertaking any decommissioning projects. This strategy was assessed based on the available environmental data for the current situation

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complemented by the information on the assessment of accidents that is provided in the Masterplan.

In addition, the scoping consultations identified the regional storage of SNF as an alternative to transportation for reprocessing at Mayak, which is a phase envisaged within the Masterplan for all four strategies.

5 CURRENT SITUATION

The current situation was evaluated in terms of the available information on the following environmental components:

- 1.* Radioactivity in the environment
- 2.* Non-radioactive contaminants
- 3.* Socio-economic impacts
- 4.* Physical protection

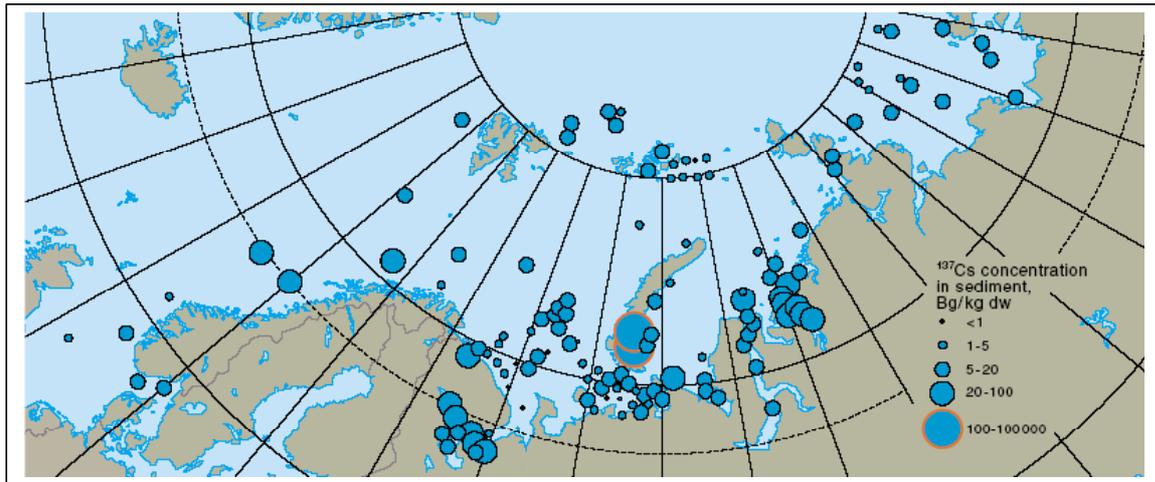
The main findings are summarised below:

5.1 Radioactivity in the environment

Generally, radioactivity concentrations in the open seas adjacent to the regional study area are consistent with or below the levels that are observed elsewhere as illustrated in Figure ES-4.

However, in certain locations in the vicinity of the coastal maintenance bases at Andreeva Bay and Gremikha, environmental concentrations exceed background levels by several orders of magnitude as shown in Figure ES-5. It can be seen that surface marine sediments in the vicinity of Andreeva Bay and Gremikha have levels of radioactive contamination, which are at least three orders of magnitude higher than the background levels. They are comparable to or exceed the levels of radioactivity in sediments in locations adjacent to the major western nuclear facility at Sellafield.

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Source: AMAP Assessment 2002: Radioactivity in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

Figure ES-4. Distribution of ¹³⁷Cs In Surface Sediments from 1993 to 1998

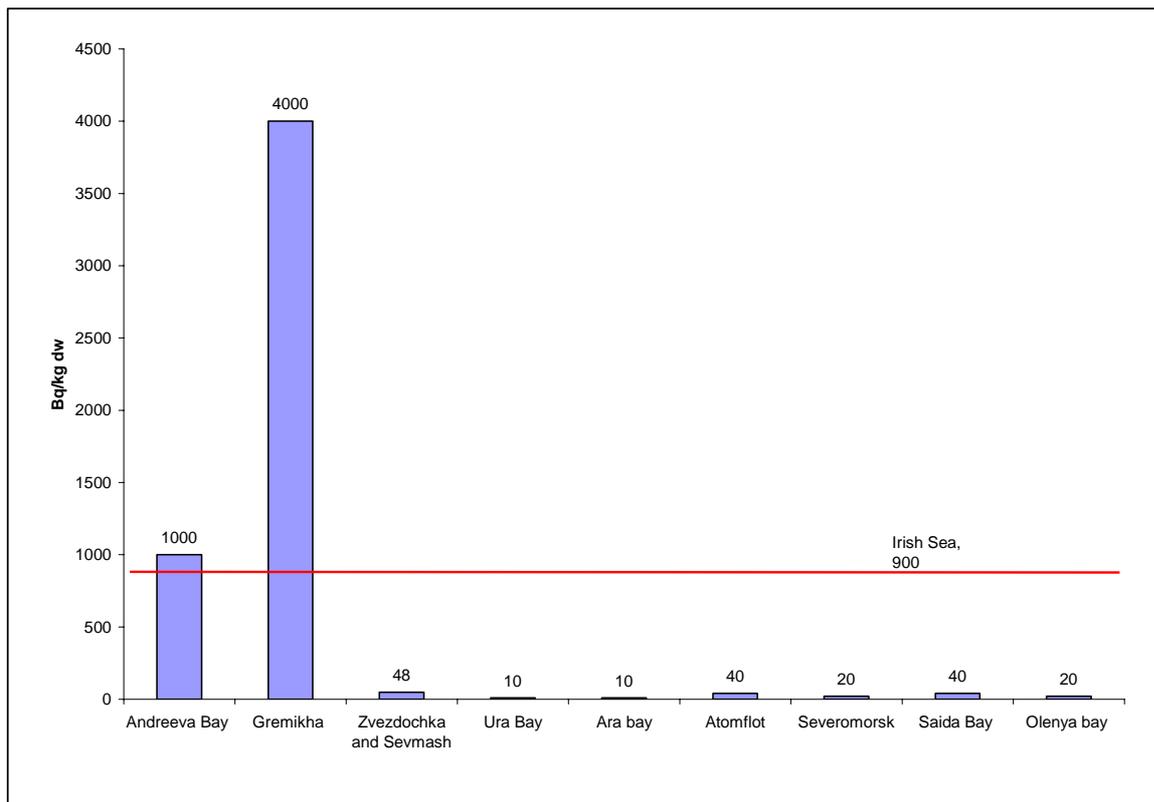


Figure ES-5. Maximum Cs-137 Concentrations in Sediments (Bq/Kg Dry weight). Data from the Masterplan for Local Study Areas in North West Russia compared to Averaged Irish Sea Concentrations for 1989-1999

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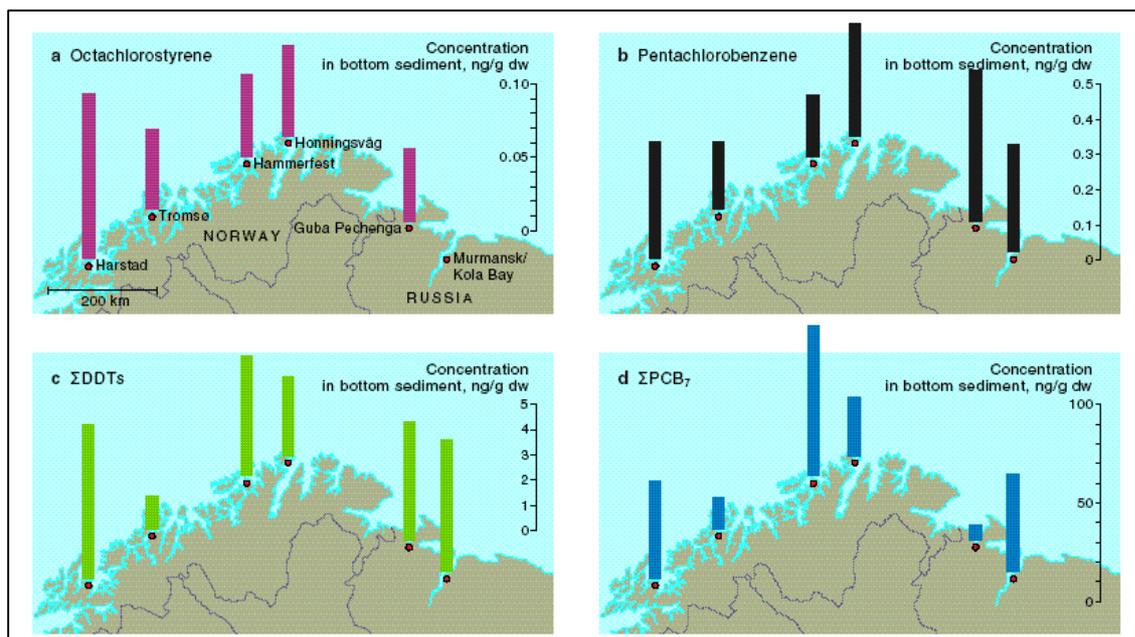
The current levels of radioactivity in the soil and the ambient dose rates in the Kola Peninsula and Severodvinsk are within the permissible Russian limits, except in limited areas that are within the boundaries of the shipyards and coastal maintenance bases. Radiation levels in the vicinity of old spent nuclear fuel and radwaste storage facilities at Andreeva Bay, Gremikha and Building 162 at Zvezdochka are many orders of magnitude above background levels and require controlled access to prevent the overexposure of personnel to radiation.

There is no information on the actual doses to critical groups of the population that result from environmental radionuclide concentrations close to the maintenance bases and the shipyards. This is the actual measure of risk to the most exposed groups of the population and the deficiency in such information should be addressed.

5.2 Non-radioactive contaminants

Data for non-radioactive contaminants are very patchy and largely limited to the Zvezdochka shipyard and, to a lesser extent, the Nerpa shipyard. There are a number of cases where the concentrations of conventional contaminants exceed Russian limits, particularly for marine concentrations.

Limited data on the concentrations of Poly-Chlorinated Biphenyls (PCBs), Polycyclic aromatic hydrocarbons (PAHs) and organochlorides (OC) in the Kola and Zapadnaya Litsa Bays indicate levels that are significantly above background levels but they are comparable to contamination levels at Norwegian ports as shown in Figure ES-6.



$\Sigma\text{DDT} = p,p'\text{-DDE} + p,p'\text{-DDD} + p,p'\text{-DDT}$; $\Sigma\text{PCB}_7 = \text{CB28} + \text{CB52} + \text{CB101} + \text{CB118} + \text{CB138} + \text{CB153} + \text{CB180}$.

Source: AMAP Arctic Monitory and Assessment Program Assessment 2002: Persistent Organic Pollutants in the Arctic

Figure ES-6. Geometric Mean Concentrations of Octachlorostyrene, Pentachlorobenzene, ΣDDT, And ΣPCB7 in Bottom Sediments in some Harbours of Northern Norway and the Kola Peninsula

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5.3 Health

There are serious concerns about the health of the population in Severodvinsk. There is some evidence to suggest that the number of cases of certain diseases in children in this town is significantly higher than in surrounding areas. The cause is not clear and requires further investigation.

Similar problems may exist at the other shipyards, coastal maintenance bases and naval bases, but the information is lacking.

5.4 Physical Protection

There are substantial measures to ensure the physical protection of the radioactive materials at the dismantling shipyards and naval bases. However, several cases of theft have been reported in recent years, including the theft of radioactive materials.

6 PRIORITY ISSUES

6.1 Environmental Priorities

The main threats to human health and the environment from the nuclear material in the Murmansk and Arkhangelsk Regions are due to the potential for an accidental release of radioactivity.

The SEA evaluated which strategies should be given priority in the Masterplan based on the consequences and likelihood of nuclear accidents for the situation as it is today, that is if the Masterplan strategies are not implemented.

The basis for deciding the priority that should be given to the proposed measures in the Masterplan was identifying which remove the risk of accidents with the highest probability of occurrence and with the highest impacts. Accidents, which are judged to have a low probability or which can be mitigated if certain measures are implemented, have been assigned a lower level of priority. This is to ensure that the programme is focused on the immediate hazards as opposed to events which are unlikely to occur or will have low consequences.

It will be seen from Table ES-6 that the accident that is judged to have a both a high frequency and a high impact for all the assessment criteria is a criticality accident that results from the ingress of water into the cores of alpha class submarines that are stored on land at Gremikha. This is because the Masterplan has identified that these are stored in poor conditions and a relatively small amount of water in the core may lead to a prompt criticality accident.

Thus, improving the storage conditions of these cores as a matter of urgency is assigned the highest priority (**Priority 1**)². It will then be necessary to ensure that long-term safety is achieved by dismantling the cores and transferring the fuel to a storage configuration that would not result in a prompt criticality accident, even if water were to penetrate into the storage or disposal facility.

² It is understood that recent Russian studies found that the ingress of water into the cores of the Alpha-class submarines is not feasible. If confirmed, then addressing the state of storage of these cores would be a lower priority.

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The next level of priority is assigned to accidents that are judged to have a potentially high impact with evidence that the probability of an accident is high. Of these, there are two types:

- **Leakage of radioactivity from spent nuclear fuel stored at Andreeva Bay and Gremikha.**
- **Sinking of Maintenance Vessels, including the Lepse**

The fuel stores at Andreeva Bay and Gremikha contain the largest amounts of radioactivity and are known to be causing an environmental impact.

The sinking of a vessel that contains damaged fuel will allow sea water ingress to the fuel and allow soluble fission products, such as Cs-137, to be released to the sea and, thus, the remediation of vessels, such as the Lepse, is a priority.

Thus, decommissioning the fuel storage facilities in Andreeva Bay and Gremikha and decommissioning the Lepse and other maintenance vessels that are being used to store damaged spent nuclear fuel is assigned **Priority 2**.

The leakage from radioactive waste stores has a lower impact than is predicted to occur as a result of the accidents that have been given a higher priority ranking above, because they all involve spent nuclear fuel. However, a number of stores do not provide protection from the ingress of water and such an accident is believed to have high probability. Thus, the decommissioning of radioactive waste stores and out-of-service vessels on which radioactive waste is stored is assigned **Priority 3**. Within this category, radioactive waste stores and vessels in Severodvinsk and Murmansk should be decommissioned first because of the high density of the potentially affected population in these locations.

It is judged that there is a high probability of an accident involving the nuclear-powered cruiser Ushakov, which nearly sank two years ago. This is due to the difficulty of heating this ship in winter and the poor state of its hull. Once sunk, the retrieval of this vessel may be very difficult due to its size. The Ushakov is located in Severodvinsk and up to 200 000 people may be affected if the Ushakov were to sink. However, it is believed that the fuel within Ushakov's reactors is not damaged and environmental impacts will be lower than for higher ranked accidents. Decommissioning this cruiser to prevent this accident is assigned **Priority 4**.

The submarines that have been out of service for more than 15 years are subject to a higher risk of sinking than those that were laid-up more recently and dismantling these is given **Priority 5**. It is assumed that the state of the hull and reactor pressure vessel can be monitored and tested and that the hulls can be regularly serviced to prevent sinking or ingress of water into the core.

Dismantling the remaining submarines is given **Priority 6**.

The consequences from the sinking of reactor compartments, which do not have spent nuclear fuel or liquid radioactive waste on board, are lower than the consequences from accidents that involve submarines with spent nuclear fuel on board. The transfer of the compartments, which are currently stored afloat, to a land-based storage facility is given **Priority 7**.

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Table ES-6 Expert Assessment of Radiological Impact for Accidents considered within the Masterplan

	Location	Magnitude	Extent	Duration	Frequency/ Probability	Permanence	Population	Priority Raking
Sinking of out-of service submarines stored afloat Age following reactor shut down: - 1-10 years; - 10-15 years; - over 15 years.	Naval bases and Shipyards	Low	Low	Low	Low	Low	Low	6
		Low	Low	Low	Low ³	Low	Low	6
		Low	Low	Low	Moderate ⁴	Low	Low	5
Sinking of reactor compartments	Sayda Bay	Low	Low	Low	Low	Low	Low	7
<i>Sinking of nuclear-powered cruisers</i>	<i>Zvezdochka</i>	<i>Moderate</i>	<i>Moderate</i>	<i>Moderate</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>4</i>
<i>Sinking of Maintenance Vessels, including Lapse</i>	<i>shipyards</i>	<i>High</i>	<i>Unknown</i>	<i>Unknown</i>	<i>High</i>	<i>Unknown</i>	<i>High</i>	<i>2</i>
<i>Leakage of radioactivity from spent nuclear fuel stored at Andreeva Bay and Gremikha</i>	<i>Andreeva Bay and Gremikha</i>	<i>High</i>	<i>Moderate</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>Low</i>	<i>2</i>
<i>Land-based storage of cores from Alpha-class submarines (SCR accident)</i>	<i>Gremikha</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>1</i>
Leakage resulting from poor storage conditions of radioactive waste	Andreeva Bay, Gremikha, Zvezdochka, maintenance vessels	Moderate	Moderate	High	High	High	Low for Andreeva Bay and Gremikha; high elsewhere	3

³ Probability reduced to Low compared to Masterplan. This is assuming that the state of the hull can be monitored and repaired on a regular basis.

⁴ Probability reduced to Moderate compared to Masterplan. This is assuming that the state of the hull can be monitored and repaired on a regular basis.

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6.2 Implications for the Strategic Masterplan

The identification of the seven priorities above has implications for the priority that should be assigned to the 45 measures that are proposed in the Masterplan. These are reproduced in Table ES-7. However, it should be noted that the Masterplan does not identify priorities within the categories ‘High Priority Measures’ and Priority Measures’. The numbering in Table ES-7 is purely for ease of reference.

Table ES-7 The Priority Measures that are Identified in the Masterplan

High priority measures:	
1.	Performing a Feasibility Study (FS) to determine the optimum strategy for the safe management of Spent Nuclear Fuel (SNF) at the Coastal Maintenance Base (CMB) at Andreeva Bay.
2.	Integrated Engineering and Radiation Survey (IERS) of buildings, structures, territory and water area of CMB in Andreeva Bay. Inventory taking of SNF and SRW.
3.	Restoration of infrastructure for SNF management in CMB storage facilities in Andreeva Bay (irrespective of the ultimate option of SNF management in North-West Region).
4.	Development of Functional Specification (FS), required design and engineering documentation. Creation of the regional centre for reprocessing, conditioning and storage of SRW in North-West Region.
5.	Development and implementation of projects to ensure physical protection at CMB in Andreeva Bay.
6.	Implementation of measures to support radiation safety of the personnel in the territory of CMB in Andreeva Bay.
7.	IERS of buildings, structures, territory and water area of CMB in Gremikha. Inventory taking of SNF and SRW.
8.	Development of FS to select optimum and safe options of SNF management in CMB storage facilities in Gremikha.
9.	Development of FS to select optimum and safe options of managing reactor cores from Alpha-class submarines in CMB storage facilities in Gremikha.
10.	Development of FS and implementation of project to eliminate the open-air pad for SNF and RW storage at CMB in Gremikha.
11.	Implementation of measures to support radiation safety of the personnel in the CMB territory in Gremikha.
12.	Development and implementation of projects to ensure physical protection of CMB in Gremikha.
13.	Restoration of infrastructure of the facility in Gremikha for unloading Spent Removable Cores (SRCs) from reactors of Alpha class NS.
14.	Development and implementation of project for reconstruction of SRC storage facility at CMB in Gremikha.
15.	Restoration of infrastructure for management of SNF located in storage facilities at CMB in Gremikha (irrespective of the ultimate option of SNF management in North-West Region).
16.	Development of FS and design, engineering and process documentation for decommissioning of FMB Lapse.

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17. Development of the project and implementation of work to reconstruct the railway bridge over Nikolskoije Ustie in Severodvinsk.
18. Drafting of the working documentation of forming RC and their long-term storage.
19. Completion of works to create a surface RC long-term storage facility.
20. Creation of site-wide, regional monitoring and emergency systems in Murmansk Region.
21. Creation of site-wide, regional monitoring and emergency systems in Arkhangelsk Region.

Priority measures

22. Development of FS for RW management in Andreeva Bay. Creation of necessary technical capabilities.
23. Removal of SRW from open-air pads in Andreeva Bay.
24. Development of FS for rehabilitation of buildings, structures, territories and water areas in Andreeva Bay.
25. Development of FS for RW management in Gremikha. Creation of necessary technical capabilities.
26. Development of FS for rehabilitation of buildings, structures, territories and water areas in Gremikha.
27. Development of a special technology and manufacturing of tooling for safe removal of SRC from reactors of Alpha class NS No 901 where there is an unfavorable radiation situation in the reactor compartment.
28. Design and fabrication of specialized pontoons or lease of transportation vessel.
29. Continuous maintenance and recovery repairs at FMB and reloading equipment.
30. Creation of special mobile reprocessing installations for LRW of complex chemical composition;
31. Manufacturing and supply of installations for filling NS DBT with polystyrene as well as modular diesel compressor installations.
32. Scheduled decommissioning of NS.
33. Radiation survey of MV. Development of EDOD for sealing, preparing and waterborne storage. MV sealing.
34. Inventory taking and removal of RW from MV.
35. Development of equipment and infrastructure at PA Mayak for handling TUK-108/1 containers.
36. Repair of existing and building of new piers in Sayda Bay.
37. Development of projects for forming units for storage of SFA at FMB and their long-term storage in LSF.
38. Development of EDOD for decommissioning of NPSS and forming a reactor hall unit (RHU). Execution of the work. Transfer of RHU to LSF.
39. Development of the concept and technology for management reactor unit № 900 of Alpha class NS.

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40. Development of FS and implementation of projects for management of toxic waste and for creation of their storage pads.
41. Development of the concept and technologies, selection of location and drafting of design documentation on facilities for ultimate elimination and disposal of toxic waste.
42. Development of the concept, selection of location and drafting of design documentation for creation of the regional RW repository.
43. Creation of the buffer container storage facility at PA Mayak.
44. Conditioning of non-reprocessable SNF at MV of MSC.
45. Creation of the temporary container storage facility for non-reprocessable SNF at Atomflot.

The priorities that have been identified in Section 6.1 provide a guide to the priority that should be assigned to each of the above measures.

This report has assigned the highest priority to constructing a safe store for the cores of the Alpha-class submarines that are currently stored ashore at Gremikha. This was based on the opinion stated in the Masterplan that there is a serious risk of an uncontrolled chain reaction associated with the current storage of such cores.

The stores for spent light water reactor fuel at Andreeva Bay and Gremikha also pose nuclear safety concerns but they are less sensitive to the ingress of water, which is why they have been assigned Priority 2. However, the risks associated with both types of storage have not been fully evaluated and the condition of both the eutectic solution, in which the Alpha submarine cores are encapsulated, and the light water reactor fuel in the stores at Andreeva Bay and Gremikha stores are not known. Therefore, the selection of the higher priority can only be based on expert judgement and, in the absence of better information, both strategies are regarded as having an equally high priority.

The decommissioning of damaged radioactive waste stores is addressed by several high-priority measures in the Masterplan. However, these measures only appear address the facilities at Andreeva Bay and Gremikha whereas similar facilities exist at the Severodvinsk and Murmansk shipyards.

It is therefore recommended that:

1. The overall list of high priority measures that is identified in the Masterplan be implemented,
2. Priorities are assigned to the Masterplan measures on the basis of the priorities that have been determined in this SEA and
3. All the damaged waste facilities are addressed by the proposed measures rather than just those located at Andreeva Bay and Gremikha.

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Based on the priorities that have been identified in the SEA, the associated Masterplan measures are listed in Table ES-8 below.

Table ES-8 The Master Plan Measures that are Associated with each SEA Priority

SEA Priorities	Related Masterplan Measures
<p>1. An initial refurbishment of the storage facility and the subsequent decommissioning of the reactor cores from the defuelled Alpha class submarines, which are stored ashore at Gremikha, is the highest priority. This is due to the high risks of a nuclear accident, which would result if a relatively small quantity of water were to leak into this storage facility.</p>	<p>The principle measure is the construction of a new storage facility for the Spent Removable Cores at Gremikha (No 14), but a Feasibility Study (FS) would be required first (No. 9) and the necessary infrastructure would need to be in place before work on the store could start (Nos. 7, 11, 12, 20 and 26).</p>
<p>2. The decommissioning of the spent nuclear fuel storage facilities in Andreeva Bay and Gremikha is the second highest priority due to the poor storage conditions, the high radionuclide inventory, the leakage of radioactivity into the environment and the risk of nuclear accidents at these facilities.</p>	<p>The principle measures are the decommissioning of the storage facilities at Andreeva Bay and Gremikha (Nos. 3 and 15), but feasibility studies would be required first (Nos. 1 and 8) and the necessary infrastructure would be required (Nos. 2, 4, 5., 6, 7, 10, 11, 12, 20, 24, 25, 26, 35, 44 and 45)</p>
<p>2(b) The removal of spent nuclear fuel from the Lapse and other technical support vessels with damaged non-containerized fuel on board and from submarines that have suffered an accident is also given 2nd highest priority. This is because of their state of disrepair, the high probability of accidents and the potential impact of sea water ingress allowing the fast release of soluble fission products, such as Cs-137, into the environment</p>	<p>The principle measures are the decommissioning of the Lapse and other technical support vessels (No. 34), but a feasibility study would be required first (No. 16) and the necessary infrastructure would be required (Nos. 4, 20, 37, 40, 41, 44 and 45)</p>
<p>3. The decommissioning of the damaged radioactive waste stores at Andreeva Bay, Gremikha, Zvezdochka, Sevmash, is important due to the environmental contamination that results from these facilities.</p>	<p>The principle measures are the decommissioning of the damaged radioactive waste stores (No. 23 and 26), but feasibility studies would be required first (No. 22 and 25) and the necessary infrastructure would be required (Nos. 2, 3, 4, 5, 6, 7, 10, 11, 12, 16, 20, 21, 24 and 42 (note – the Masterplan priority measures focus on decommissioning of damaged waste stores only at Andreeva Bay and Gremikha)</p>
<p>4. The decommissioning of the nuclear cruiser Admiral Ushakov is important due to the difficulty of keeping this vessel afloat and the potential difficulties of retrieving it if it were to sink.</p>	<p>The principle measures is the decommissioning of the cruiser (No. 38), but the necessary infrastructure would be required (Nos. 4, 17, 21, 35, 40, and 41)</p>

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Table ES-8 (Cont.)

SEA Priorities	Related Masterplan Measures
<p>5. The decommissioning of nuclear submarines was assigned a lower level of priority based on the assumption that the hulls can be regularly inspected and maintained. It should be noted that in the past adequate maintenance of the laid-up hulls has not been achieved as a result of the large number of submarines at the naval bases. It has also been taken into account that nuclear fuel aboard the laid-up submarines is contained within three containment boundaries:</p> <ul style="list-style-type: none"> • Fuel cladding; • Reactor pressure vessel and primary circuit; and • Reactor compartment and submarine pressure hull <p>Submarines that have been out of service for more than 15 years are subject to higher risk of sinking than those that were laid up more recently and so is given a priority of 5.</p>	<p>The decommissioning of the submarines with light water reactors has been ongoing for some years but new facilities are required for the Alpha cores (Nos 13 and 27) and the necessary infrastructure required to sustain both the current facilities and the new ones (Nos. 4, 17, 20, 21, 28, 29, 30, 31, 32, 33, 35, 36, 39, 40, 41 and 43).</p>
<p>6. Dismantling submarines that have been out of service less than 15 years.</p>	<p>Again, the necessary infrastructure is required to sustain both the current facilities and the new ones (Nos. 4, 17, 20, 21, 28, 29, 30, 31, 32, 33, 35, 36, 39, 40, 41 and 43).</p>
<p>7. The transfer of compartments, which are currently stored afloat, to a land-based storage facility. The consequences of sinking reactor compartments, which do not have spent nuclear fuel or liquid radioactive waste on board, are lower than the consequences from accidents that involve submarines with spent nuclear fuel on board.</p>	<p>The principle measure here is the completion of the surface reactor unit storage facility (No 19). This will need to be preceded by the drafting of working documentation for forming reactor compartments units (No 18).</p>

This list of priorities does not contradict those identified in the Masterplan. Rather, it provides additional information that can be used to determine priorities in the future.

It will be noted that either a regional monitoring and emergency system in the Murmansk Region, which is Measure No. 20, or in the Arkhangelsk Region, which is Measure No.21, or both is required for every one of the SEA priorities that is identified in this report.

7 RECOMMENDATIONS FOR MITIGATING ADVERSE EFFECTS FROM THE IMPLEMENTATION OF MASTERPLAN STRATEGIES

7.1 Prioritisation

The analysis undertaken as part of the SEA shows that the strategies that are proposed in the Masterplan correctly identify the issues that should be addressed as a matter of priority and they remove the major threats to human health and the environment that are associated with the present situation. In particular, the high priority and priority

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measures that are proposed in the Masterplan will result in major improvements that will achieve the objectives that were defined in Section 3.

Based on the analysis of the SEA, the main elements of the strategies in the Masterplan are listed in order of priority in Table ES-8 above, where they are used to identify the priority that should be assigned to each of the 45 measures that are identified in the Masterplan so that the major threats to human health and the environment are addressed in the order of their importance.

A number of further recommendations are made, which are based on the analysis that is provided in the SEA report.

7.2 Strategic Recommendations:

- During the scoping consultations, the construction of a regional spent nuclear fuel storage facility in North West Russia was proposed as an alternative to transporting the spent nuclear fuel to Mayak for reprocessing. The regional storage of spent nuclear fuel in North West Russia is believed to be the best environmental option, unless the discharges from reprocessing at Mayak can be significantly reduced. The storage option also minimises the need to transport spent nuclear fuel with its associated concerns on preserving the security of the fuel during transport and transportation accidents. However, the transfer of spent nuclear fuel to Mayak should continue until a regional storage facility is constructed to prevent the temporary storage of spent fuel at Atomflot and Zvezdochka becoming a bottleneck.

The Mayak option is the current policy of the Russian Federation and is justified by Rosatom on the basis that the uranium and plutonium in the spent fuel represent a resource that can be used as a source of energy.

- It is necessary to assess the long-term impacts and develop and implement a long-term strategy for the regional storage and final disposal of radioactive wastes, including those that originate from submarine dismantling.

7.3 Summary of the Environmental Impact of the Masterplan

This section summarises the environmental impact of the Masterplan in terms of the SEA objectives that are presented in Table ES-5.

1. Exposure of Workers to Radiation

The potential impact of the Masterplan on the safety of the workforce is one of the major concerns that were expressed at the scoping consultation in Murmansk and the scoping consultation in Moscow identified nuclear safety as the main criterion that should be used when evaluating the strategies in the Masterplan. This issue is in the basis of Recommendation 1:

- 1. It is necessary to carry out quantitative safety assessments for the facilities considered within the Masterplan project. Such assessments can then be used to*

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confirm or update the priorities identified within the SEA report. Detailed safety cases should be completed for all implementation projects.

The evidence from Zvezdochka indicates that individual doses are controlled so that they do not exceed the average annual limit of 20 mSv/year that is specified in Russian and international recommendations. However, there are no available data on individual worker doses by operation, there are no data from the other shipyards where dismantling is taking place, there is no extremity dosimetry and there is no direct evidence that the necessary management structures and procedures are in place to control doses in accordance with the ALARA principle⁵. This should be a requirement of projects that are implemented as part of the Masterplan and is the basis of Recommendations 2 to 5 namely:

2. *There is a need to apply the ALARA principle across the industry to control doses to workers to modern standards.*
3. *It is necessary to ensure that data on worker doses data are properly collated and analysed.*
4. *It is necessary to ensure adequacy of equipment used to measure individual doses should be reviewed. This should include the need to use extremity dosimeters for certain operations.*
5. *There is a need to ensure that the staff and workers are appropriately qualified by*
 - *providing training*
 - *ensuring that there are suitably qualified resources when planning decommissioning projects*
 - *ensuring that there is sufficient funding to keep and attract qualified staff and workers.*

2. Exposure of Members of the Public to Radiation

It has been noted above that the scoping consultation in Moscow identified nuclear safety as the main criterion that should be used when evaluating the strategies in the Masterplan.

The SEA report shows that the dose to any member of the public as a result of dismantling operations at the Zvezdochka shipyard is less than 10 micro Sv/y, roughly 100 times below of natural background. Furthermore, monitoring at the Zvezdochka,

⁵ ALARA principle – the essence of this principle is that all work with radiation should be undertaken in a manner to so that doses are as low as reasonably achievable.

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Sevmash and Nerpa shipyards shows that there has been no increase in the levels of radioactivity in the area surrounding these shipyards during the last 10 years of dismantling submarines.

The proposed collection and treatment of both gaseous and liquid radioactive waste and the monitoring of radioactive discharges will ensure that the exposure of members of the public to radiation will not worsen. In the case of Andreeva bay, Gremikha and the other sites, where spent nuclear fuel and radioactive waste are stored in contact with water, the implementation of the Masterplan will lead to a reduction in the environmental concentration of radionuclides which, in turn, will result in a reduction in the release of radioactivity to the environment and thus in the concentration of radioactivity in all biota including fish, which is one of the main routes by which the public are exposed to radiation. In addition, the removal of the main sources for the accidental release of radioactivity to the environment will remove the main threat to the health of the general public.

All the strategies require the transport of spent nuclear fuel from the shipyards or coastal maintenance bases to Mayak or a regional store and many require the transport of solid radioactive waste to a regional store in the short term and to a repository in the longer term. Some of the containers for the storage and transport of SNF and radioactive waste are certified but some are not. The requirement to protect of human health and ensure safety during these operations is the basis for Recommendation 6, namely:

6. *It is necessary to ensure that the transport of both SNF and radwaste by both sea and rail is carried out in strict compliance with the Russian and international regulatory guidance using appropriately certified containers.*

Although the strategies of the Masterplan will remove the major threats to the safety of people that live close to the existing facilities, there is a requirement to ensure that people are adequately protected by modern radiation monitoring equipment and emergency management centres over the period that the Masterplan is implemented. Indeed all elements of the emergency systems have to be reviewed at each nuclear facility in North West Russia. The review should cover: on- and off-site organisation and responsibility, procedures and training and the availability of monitoring and alarm equipment. Based on available information, there are major gaps in staffing, in organisational arrangements in the event of an emergency and in equipment at the sites considered with the exception of Atomflot. If confirmed, these gaps should be addressed by the provision of appropriate planning, training, resources and equipment. This is the basis for Recommendation 7 namely:

7. *There is a need to ensure that modern radiation monitoring and emergency management centres are available in the cities and settlements that are adjacent to the facilities.*

According to Russian regulations, the detailed measures to protect both human health and the environment must be addressed in separate environmental impact assessments known as 'State Expert Reviews' and, in some cases, public hearings and 'Public Expert Reviews' will be required. This is the basis for Recommendation 8 namely:

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8. *There is a need to ensure that in accordance with Russian laws and regulations, construction and decommissioning projects that are implemented within the four strategies are subject to separate environmental impact assessments, namely 'State Expert Review', and, in some cases, public hearings and 'Public Expert Review'.*

Although the available evidence shows that the current exposure of members of the public is low, there is no information on the dose to members of the public, who are most likely to be exposed to radiation (the critical group) near any of the shipyards including Zvezdochka, Sevmasht, Nerpa, Atomflot and SRZ-10 or the coastal maintenance bases. This is the basis of Recommendation 9, namely:

9. *Critical group doses should be evaluated at all the sites where the Masterplan proposes that work is carried out. These estimates should be based on actual habit data and will provide the baseline for the Environmental Impact Assessment that will be required for individual projects. The doses to the critical groups should be monitored throughout any project that is implemented and the results of the monitoring programme should be made available to members of the public in the form of a summary.*

3. Accessibility of Radioactive Material

Ensuring that radioactive material is maintained in secure facilities that prevent it falling into unauthorised hands is an important component of ensuring nuclear safety. One of the objectives of all the strategies of the Masterplan is to improve the current situation in this respect and transfer the large amount of radioactivity that is associated with spent nuclear fuel and radioactive waste into secure and passively safe conditions.

One of the most difficult types of radioactivity to control is that associated with the sealed sources that are used in radiography and other small radioactive items. This is the basis of Recommendations 10 and 11, namely:

10. *The installation of automatic radiation monitoring equipment at the exits from the shipyards and coastal maintenance bases should be considered as an additional physical protection measure in accordance with the recommendations of the IAEA.*
11. *The physical protection at the sites where sealed radioactive sources are stored should be reviewed.*

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4. Exposure of Biota to Radiation

The potential impact of the Masterplan on the radioactive contamination of fish in Northern waters and the consequential impact on the fishing industry is one of the major concerns that were expressed at the scoping consultations in Murmansk and Severodvinsk.

The baseline data show that the current concentrations of Cs-137 in fish in the Barents, Pechora and White Seas are similar to or lower than those that are found elsewhere in the North-east Atlantic with the exception of the inland area of the Kola Peninsula, where the higher concentration is attributed to the fall out from the Chernobyl accident.

The proposed collection and treatment of liquid radioactive waste and the monitoring of radioactive discharges will ensure that the above environmental conditions will not worsen. In the case of Andreeva bay, Gremikha and the other sites, where spent nuclear fuel and radioactive waste are stored in contact with water, the implementation of the Masterplan will lead to a reduction in the environmental concentration of radionuclides which, in turn, will result in a reduction in the concentration of radioactivity in all biota including fish. In addition, the removal of the main sources of the accidental contamination of Northern waters, and therefore of the fish stocks, will remove the main threat to the fishing industry.

However, there is a need to carry out a comprehensive environmental programme, including establishing an accurate baseline, for any project that is implemented as part of the Masterplan, which is part of the basis of Recommendation 12, namely:

12. With the notable exception of the Zvezdochka, and, to a lesser extent, Nerpa shipyards, there is lack of data on environmental contamination in the vicinity of the facilities. Environmental monitoring programmes should be developed and implemented to address the gaps identified in Section 5 of the SEA report in co-operation with the appropriate health, environmental and fishery authorities. These data will provide the baseline for the Environmental Impact Assessment that will be required for individual projects. The results of the monitoring programme should be made available to members of the public in the form of a summary.

5. Worker Health and Safety – Non-radiological

The importance that is attached to ensuring the safety of workers has already been noted above.

The data shows that the major risk to the workers from the current dismantling operations is greater than that due to the exposure to radiation and high concentrations of toxic gases and suspended solids during cutting operations have been identified as one of the important contributors. It is therefore important that before each project is implemented, the appropriate safety procedures, organisation, engineered protection means and personal protection equipment is identified and put in place to ensure that the workers'

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safety record is improved and that non-radiological risks are brought down to acceptable levels. This is the basis of Recommendation 13, namely:

13. There is a need to review the relevant safety procedures, organisational arrangements and safety culture, the engineered protection and the personal protection equipment that is provided to ensure that the safety of the workers is improved and that non-radiological risks are reduced to acceptable levels. In particular, the use of mechanical cutting for the dismantling of metal structures must be maximized. There is a need to ensure that the environmental conditions to which the workers will be exposed during the course of each project is monitored and regularly reported to the workforce.

6. Air, Water and Soil Pollution

The release of toxic gases to the atmosphere and toxic substances to the groundwater and marine environments are the routes that affect the health of humans and biota, as summarised in Items 5 and 7 of this section.

The proposed collection and treatment of gaseous and liquid waste and the monitoring of the toxic content of the discharges that will result from activities associated with the Masterplan will ensure that the operations can be carried out without significant contamination of the environment.

However, the available data on the non-radioactive impact of current operations on the environment is sparse and there will be a need to establish a complete and accurate baseline before each or the projects is implemented. There will then be need to monitor the environmental conditions during the course of each project and report the results to the local communities. This reinforces Recommendation 11 above.

It is noted that, where there are data, such as at Zvezdochka, levels of non-radioactive contaminants in liquid discharges and soil in a small number of cases exceed Russian permissible levels.

7. Contamination of Biota with toxic substances

As stated above, the potential impact of the Masterplan on the contamination of fish in Northern waters and the consequential impact on the fishing industry is one of the major concerns that were expressed at the scoping consultations in Murmansk and Severodvinsk. In addition, the potential loss of forests was one of the major concerns that were expressed at the scoping consultation in Murmansk.

The contamination of biota, including fish, in the Barents and White Seas are broadly similar to that found in the Norwegian and Greenland seas although increased contamination is found in Atlantic cod and harp seal. The data indicates that the presence of pollutants in the sea is limited to the immediate vicinity of the source. There are no forests in the territories close to Severodvinsk and, in the Murmansk region, it is tundra

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that predominates near the coast. However, there is considerable forestation in the regions away from the coastal maintenance bases.

There is currently sparse information on the concentrations of toxic substances in biota close to the existing dismantling shipyards and there is clearly the potential for the release of toxic substances during the environment from the dismantling of vessels and the decommissioning of the coastal maintenance bases. Thus, as in the case of controlling air and surface water pollution above, specific measures to control the release of toxic substances will have to be considered for each project that is implemented as part of the Masterplan. Thus Recommendation 14 is:

14. There is a need to consider specific measures to control the release of toxic substances will have to be considered for each project that is implemented as part of the Masterplan. There is a need to carry out a comprehensive environmental programme, including establishing an accurate baseline for toxic substances, for any project that is implemented as part of the Masterplan, which reinforces Recommendation 12 above

8. Biodiversity and Natural Resources

The Barents Sea contains rare and endangered species of whale and zooplankton is the main source of food for herring, capelin, mackerel and other fish. Fish do not spawn in the vicinity of Zvezdochka due to the adverse environment caused by the hydrological and hydrological conditions in Nikolsky Mouth. There are no marine mammals or rare animals or birds in the area of Severodvinsk. The measures to protect these species are the same as discussed in the sections above. However, there are no data on the biodiversity of the Murmansk area and these will need to be obtained to provide a baseline on which to monitor the environmental impact of any projects that are implemented in that area. Again this reinforces Recommendation 12 above.

The main natural resource is the forests of the Arkhangelsk and the Murmansk regions, although the latter are less extensive.

9. Physical protection

Physical protection systems are well established at the shipyards where dismantling is taking place and that considerable work has been completed to improve the physical protection at the coastal maintenance bases of Andreeva Bay and Gremikha. However, there is a need for further improvements at the two coastal maintenance bases, improvements to the Sayda Bay complex for storing reactor compartments and a need to develop a physical protection system for the maintenance vessels that have been taken out of service, which is the basis for Recommendation 15 as follows:

15. There is need to ensure that an adequate protection system is implemented at the two coastal maintenance bases, the Sayda Bay complex for storing reactor compartments and

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for the maintenance vessels that have been taken out of service when projects are implemented at these facilities. Further improvements are required at the shipyards.

10. Economic Growth

The data on the economic impacts of the Masterplan are inevitably sparse because the amount of work that will be involved can only be determined when specific projects are specified. However, it is clear that the work that will be carried out at the shipyards where the dismantling will occur will be similar to that which is being carried now. It will therefore be carried out by the same workforce and will sustain the employment of the local community until it is complete.

The work that will be carried out at the coastal maintenance bases and at the reactor compartment storage facility will be major new programmes of work in areas where there has been little decommissioning or construction activity in recent years. The projects in these areas will involve an increase in the workforce and the impact will need to be assessed in the environmental assessments for each project, which is Recommendation 16:

16. There is a need to assess the economic impact on the local community in the environmental assessments that will be carried out when projects are implemented at the coastal maintenance bases and at the reactor compartment storage facility.

11. Human Health

The scoping meetings in Severodvinsk and Moscow considered that there is a need to monitor the health of both the workforce and the local population in the areas where work will be carried out during the implementation of the Masterplan.

There are no available data on the health of the workforce but the project identified concerns about the health of the local populations in both the Murmansk and Severodvinsk regions. Some of this concern can be attributed to high rates of alcoholism and the stress of living in remote communities. One indication of the health of the local populations is the infant death rate and in both the Murmansk and Severodvinsk regions, this is lower than in the Russian Federation as a whole. However, there is some evidence to suggest that, in Severodvinsk, the number of cases of certain diseases in children is significantly higher than in surrounding areas. The cause is not clear and requires further investigation, which is Recommendation 17:

17. There is a need to evaluate the concerns about the health of children in the Severodvinsk area and determine if there are implications that would affect the implementation of the Masterplan here and at the other bases.

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In order to provide a baseline for the health of both the workforce and the local populations, indicators need to be identified and the current state of health needs to be determined in collaboration with the local health authorities. A monitoring programme needs to be implemented so that the health of both the workforce and the local population can be monitored during the lifetime of the Masterplan, which is Recommendation 18:

18. There is a need to implement a programme in collaboration with the local health authorities that identifies suitable health indicators for both the workforce and the general population in any area where work is being carried out so that a baseline can be established and the health of both sectors can be monitored during the implementation of any project.

12. Culture and Heritage

The implementation of the Masterplan will mainly require work at four types of facilities, the dismantling shipyards of SRZ-10, Nerpa, Zvezdochka and Sevmash, the facility for handling spent nuclear fuel and radioactive waste at Atomflot, the facility for storing reactor compartments at Sayda Bay and the coastal maintenance bases at Andreeva Bay and Gremikha. In the case of the first two types of facility, the work will be a continuation of that which is being carried out at present. It will therefore continue to support the economy of the two regions and support the cultural activities that have been established since the time that the shipyards were built. In the case of the last two types of facility, the work will require a larger workforce than at present but, since these are remote areas, it is unlikely that there is a strong tradition of culture and heritage that can be affected. However, detailed considerations of the affect on the local culture and heritage will be required for the Environmental Impact Assessments that will be performed for the individual projects, which is Recommendation 19:

19. There is a need to assess the potential affect on the local culture and heritage of any project that is carried out at the coastal maintenance bases and Sayda Bay to support the relevant Environmental Impact Assessments.

7.4 Recommendations Common to all Masterplan Strategies

The above recommendations are listed below:

1. It is necessary to carry out quantitative safety assessments for the facilities considered within the Masterplan project. Such assessments can then be used to confirm or update the priorities identified within the SEA report. Detailed safety cases should be completed for all implementation projects.

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2. There is a need to apply the ALARA principle across the industry to control doses to workers to modern standards.
3. It is necessary to ensure that data on worker doses data are properly collated and analysed.
4. It is necessary to ensure adequacy of equipment used to measure individual doses should be reviewed. This should include the need to use extremity dosimeters for certain operations.
5. There is a need to ensure that the staff and workers are appropriately qualified by
 - providing training
 - ensuring that there are suitably qualified resources when planning decommissioning projects
 - ensuring that there is sufficient funding to keep and attract qualified staff and workers.
6. It is necessary to ensure that the transport of both SNF and radwaste by both sea and rail is carried out in strict compliance with the Russian and international regulatory guidance using appropriately certified containers.
7. There is a need to ensure that modern radiation monitoring and emergency management centres are available in the cities and settlements that are adjacent to the facilities.
8. There is a need to ensure that in accordance with Russian laws and regulations, construction and decommissioning projects that are implemented within the four strategies are subject to separate environmental impact assessments, namely ‘State Expert Review’, and, in some cases, public hearings and ‘Public Expert Review’.
9. Critical group doses should be evaluated at all the sites where the Masterplan proposes that work is carried out. These estimates should be based on actual habit data and will provide the baseline for the Environmental Impact Assessment that will be required for individual projects. The doses to the critical groups should be monitored throughout any project that is implemented and the results of the monitoring programme should be made available to members of the public in the form of a summary.
10. The installation of automatic radiation monitoring equipment at the exits from the shipyards and coastal maintenance bases should be considered as an additional physical protection measure in accordance with the recommendations of the IAEA.
11. The physical protection at the sites where sealed radioactive sources are stored should be reviewed.

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12. With the notable exception of the Zvezdochka, and, to a lesser extent, Nerpa shipyards, there is lack of data on environmental contamination in the vicinity of the facilities.
Environmental monitoring programmes should be developed and implemented to address the gaps identified in Section 5 in co-operation with the appropriate health, environmental and fishery authorities. These data will provide the baseline for the Environmental Impact Assessment that will be required for individual projects. The results of the monitoring programme should be made available to members of the public in the form of a summary.
13. There is a need to review the relevant safety procedures, organisational arrangements and safety culture, the engineered protection and the personal protection equipment that is provided to ensure that the safety of the workers is improved and that non-radiological risks are reduced to acceptable levels. In particular, the use of mechanical cutting for the dismantling of metal structures must be maximized. There is a need to ensure that the environmental conditions to which the workers will be exposed during the course of each project is monitored and regularly reported to the workforce.
14. There is a need to consider specific measures to control the release of toxic substances which will have to be considered for each project that is implemented as part of the Masterplan.
15. There is need to ensure that an adequate protection system is implemented. At the two coastal maintenance bases, the Sayda Bay complex for storing reactor compartments and for the maintenance vessels that have been taken out of service when projects are implemented at these facilities.
16. There is a need to assess the economic impact on the local community in the environmental assessments that will be carried out when projects are implemented at the coastal maintenance bases and at the reactor compartment storage facility.
17. There is a need to evaluate the concerns about the health of children in the Severodvinsk area and determine if there are implications that would affect the implementation of the Masterplan here and at the other bases.
18. There is a need to implement a programme in collaboration with the local health authorities that identifies suitable health indicators for both the workforce and the general population in any area where work is being carried out so that a baseline can be established and the health of both sectors can be monitored during the implementation of any project.
19. There is a need to assess the potential affect on the local culture and heritage of any project that is carried out at the coastal maintenance bases and Sayda Bay to support the relevant Environmental Impact Assessments.

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20. There is a need to publish and distribute a non-technical brochure summarizing the starting point and the objectives of the Masterplan as well as Rosatom's vision and programme for achieving these objectives.

Subsequently it will be necessary to ensure that information on the progress of each of the four strategies is communicated on a regular basis to the population in the areas that surround the facilities. This may be achieved through a combination of the following:

- Website in both the Russian and English language
- Regular e.g. annual meetings with the public to report progress
- Publication and distribution of brochures.
- Providing information at public reference centres in Murmansk and Severodvinsk.

7.5 Recommendations for dismantling

Unlike the other three strategies, which are only defined in terms of general objectives and initial steps, submarine-dismantling is being implemented at present. Therefore, a number of strategy-specific recommendations are made as follows:

1. The technology and facilities that are required to ensure the safe storage or disposal of the cores from the out – of – service Alpha-class submarines should be developed as rapidly as practicable so that the defuelling of these submarines can proceed.
2. Priority should be given to ensuring that the hulls of the submarines that have been withdrawn from active service are regularly inspected and treated to preserve their buoyancy.
3. The emissions of hazardous gases to the environment should be controlled so that they approach the standards embodied in MARPOL as closely as possible. Achieving this requirement includes the regular inspections of the engines of tugs and barges. High quality, low-sulphur fuel is recommended whenever feasible. Measures to control emissions, such as water injection, are available to avoid adverse effects on air quality.
4. It is necessary to verify that adequate facilities exist for managing the conventional wastes that originate at naval bases where out-of-service submarines and nuclear vessels are prepared for the transfer to the dismantling shipyards.
5. It is necessary to mitigate the potential loss of employment at the naval yards that will result from the dismantling of out-of-service submarines.

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6. There is a need to assess the level of physical protection for the off-shore storage of spent nuclear fuel and radioactive wastes
7. It is therefore recommended that safety cases should be prepared to analyse the safety of the:
 - continued storage and transfer of spent nuclear fuel using PM vessels and
 - continued defuelling of submarines using defuelling vessels.

7.6 Conclusion

As a result of the environmental assessment that has been carried out in this report and taking the mitigation measures that have been identified into account, it is concluded that the implementation of the strategies that are proposed in the Masterplan will result in a major reduction in the present threat to the environment. In addition, it is unlikely that these strategies will result in any significant adverse effect on the environment. Specific environmental assessments, as required by Russian regulations, should be carried out for each appropriate project to confirm this conclusion. In any case, it is the policy of the EBRD that all projects funded by the Bank, or where the Bank's policies apply (e.g. co-operation and special funds), are in compliance with national regulations (in this case OVOS) and EU regulations (i.e. an EIA based on the EU EIA Directive might be required for certain projects under the Masterplan).

The available information has not identified any significant adverse affects associated with implementing the Masterplan, provided that all the proposed mitigation measures and the recommendations of this report are implemented. However, this report has identified several areas where the baseline data are lacking and these will need to be obtained so that the absence of adverse affects can be monitored when the individual projects are implemented.

It is also necessary to carry out quantitative safety assessments for the facilities considered within the Masterplan project. Such assessments can then be used to confirm or update the priorities identified within the SEA report. Detailed safety cases should be completed for all implementation projects.

The low probability of significant adverse effects is complemented by two key benefits from the implementation of projects, namely

1. The transfer of spent nuclear fuel from unsafe storage conditions ashore and on board submarines and other vessels to secure management facilities ashore, which ensures appropriate safeguards.
2. The elimination of risks to the environment that are associated with the long-term storage of radioactive waste in poor conditions.

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8 REFERENCES

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9 ACRONYMS

Acronyms	Description
ALARA	As Low As Reasonably Achievable
AMEC	Arctic Military Environmental Co-operation
ARL	Admissible Release Limit
CCTV	Closed Circuit Television
CMB	Coastal Maintenance Bases
DBT	Dedicated Ballast Tanks
EBRD	European Bank of Reconstruction and Development
EDOD	Engineering Documentation
EIA	Environmental Impact Assessment
EU	European Union
FMB	Floating Maintenance Vessels
FRCS	Floating Radiation Control Station
FS	Feasibility Study
IAEA	International Atomic Energy Agency
ICES	International Centre for Environmental Safety (Russia)
ICRP	International Commission on Radiation Protection
IERS	Integrated Engineering and Radiation Survey
KMI	Kola Mining Institute (Russia)
LMC	Liquid Metal Coolant
LRW	Liquid Radioactive Waste
LSF	Long-term Storage Facility
MAL	Maximum Allowable Level (Russian Standards)

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Acronyms	Description
MARPOL	International Convention for the Prevention of Pollution from Ships
MPC	Maximum Permissible Concentrations (Russian Standards)
MSC	Murmansk Shipping Company
MT	Maintenance Tanker
MV	Maintenance Vessels
NDEP	Northern Dimension Environmental Partnership
NF	Nuclear Fuel
NNC	National Nuclear Corporation Limited (UK and Canada)
NPI	Nuclear Power Installation
NS	Nuclear Submarines
OC	Organochlorides
PA	Production Association
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Poly Chlorinated Biphenyls
PM	A type of Maintenance Vessel
PPE	Personal Protective Equipment
PWR	Pressurised Water Reactor
RC	Reactor Compartment
RHU	Reactor Hall Unit
RU	Reactor Unit
RW	Radioactive Waste
SCR	Self-sustained Chain Reaction
SEA	Strategic Environmental Assessment
SMP	Strategic Master Plan

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Acronyms	Description
SNF	Spent Nuclear Fuel
SPA	Sanitary Protection Area
SPW	Sewage Purification Works
SRC	Spent Removable Core
SRW	Solid Radioactive Waste
SS	Surface Ship
TUK (TP)	Transportation Package (transportation and packaging set)
ZATO	Closed Administrative Zone