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

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1.0 INTRODUCTION

This report describes the Strategic Environmental Assessment (SEA) that has been carried out for the European Bank of Reconstruction and Development (EBRD) to evaluate the Strategic Master Plan (Masterplan).

The Masterplan was developed within the Nuclear Window of the Northern Dimension Environmental Partnership. The goal of this Partnership is to provide an international framework, backed by adequate financial resources, for governments, donors, international financial institutions and all concerned to work together in bringing solutions to long-standing environmental problems in North-West Russia.

The purpose of the Masterplan is to dismantle the submarines and the other nuclear propelled vessels, which have been withdrawn from service, and to restore the shore bases that supported the operation of these vessels into an environmentally acceptable condition.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.
- 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 be implemented once the current draft SEA report has been made available to the public.

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), the Kola Mining Institute (KMI, Russia) and a number of additional experts.

The Masterplan Phase I report [SMP, 2004] was the main source of information used in the SEA study. It was complemented by

- Information on public priorities that were identified in the course of the SEA scoping consultations, which took place from the 15th November –15th December 2004 and included public meetings in Murmansk, Severodvinsk and Moscow (see Appendix A) [Gerchikov, 2005].

- Information from the recent Canadian Environmental Assessment for the dismantling of 12 nuclear submarines at Zvezdochka shipyard [Moffett, Gerchikov et al 2004].

- Data on the environmental concentrations of radionuclides and toxic substances from the Arctic Monitoring and Assessment Programme (AMAP) [AMAP, 2004]

- Reports on North West Russia published by the Bellona Foundation.

- Other referenced literature.

1.1 Structure of the SEA report

The SEA report is structured as follows:

- Section 1.0 - Introduction
- Section 2.0 - Description of the current facilities and the background to the Masterplan.
- Section 3.0 - Description of the scope of the SEA including the assessment methodology.
- Section 4.0 - Description of the Masterplan strategies.
- Section 5.0 – Description of the relevant characteristics and sensitivities of the existing environment that could potentially be affected by projects that will be implemented under the Masterplan;
- Section 6.0 - Consideration of the priority that should be assigned to the measures that have been identified in the Masterplan on the basis of potential accidents.
- Section 7.0 – Assessment of, at an appropriate level of detail, the likely environmental effects of the Masterplan strategies. Identification of mitigation measures and residual effects.
- Section 8.0 - Consideration of the responses received during the public consultation and the public consultation process.
- Section 9.0 - Summary of the recommendations and conclusions of the assessment.
- Section 10.0 - References
- Section 11.0 - Acronyms

2.0 BACKGROUND

During the years of the Cold War and the accompanying arms race, the former Soviet Union created an unprecedented nuclear fleet that was supported by a wide sea- and land-based infrastructure.

According to the Masterplan [SMP, 2004], 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.

The Cold War legacy in North West Russia includes

- The Shipyards, which are involved in the commissioning, repair, and now, the decommissioning of nuclear-propelled vessels; and in the management and storage of Spent Nuclear Fuel (SNF) and radioactive waste (radwaste).

- The Coastal Maintenance Bases and Naval Bases which serviced nuclear-propelled vessels, as well as the management and storage of SNF and radioactive waste.

- The Nuclear-powered vessels themselves; submarines and certain military and civil surface ships. Some of these have been decommissioned, others are awaiting decommissioning and a few are still in operation.

- The Technical support vessels, which serviced nuclear-powered ships and were used for the transfer and storage of SNF and radwaste.

2.1 Naval Bases and Shipyards in North West Russia

Most facilities in the Murmansk region are close to Closed Administrative Towns (Zatos, see Table 2.1-1) which is where the workers and their families live. Only two shipyards are located in the Arkangelsk rather than the Murmansk region. These are the Zvezdochka and Sevmash shipyards, which are both in the town of Severodvinsk. The locations of Murmansk, Severodvinsk and of the Closed Administrative Towns are indicated on the regional map, Figure 2.1-1.

Table 2.1-1 provides an overview of the quantities of spent nuclear fuel and radioactive waste that are located at the naval 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 2.1-1 and the subsequent tables apply to the situation as it was in January 2004 and are based on the estimates that are given in the Masterplan unless stated otherwise. In most cases, the total amounts of radioactivity were estimated by the authors of the Masterplan using typical isotopic ratios and dates for the shutdown of the reactors.

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 ***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 in an unsatisfactory condition. There are major gaps in knowledge relating to the inventory of radioactive materials and the extent of the contamination that surrounds the storage facilities at Andreeva Bay and Gremikha.

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.

A number of naval bases in the region also 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 500PBq (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 30PBq (3×10^{16}Bq) or **5%** of the total inventory

3. Other **Solid Radioactive Wastes** – almost 3×10^{16} Bq or **5%** of the total inventory

4. **Liquid Radioactive Waste** 10TBq (1×10^{13}Bq) or **0.002%** of the total inventory.

The amounts of SNF and the places where they are stored are summarized in Table 2.1-2. Most of this fuel is stored in unsatisfactory conditions, either in leaking stores, laid-up submarines or within maintenance vessels afloat. A significant, but unknown fraction of the fuel 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 2.1-3 and 2.1-4.

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

Figure 2.1-1. Regional Study Area: Murmansk and Arkhangelsk regions

Table 2.1-1. Overview of northern fleet bases and shipyards located in Murmansk and Arkhangelsk regions

Location	Role	Submarines withdrawn from active service, SNF and radwaste
On the Kola Pennisula	Naval Bases	• Waste from operational submarines • 2 nuclear cruisers which have been withdrawn from active service • 31 submarines which have been withdrawn from active service • > 200 m^3 of liquid radioactive waste • > 2000 m^3 of solid radioactive waste
		ZATO Zaozersk
Andreeva Bay	Former Coastal Maintenance Base	• Partly damaged fuel in Buildings 2a,2b,3a. In total, approximately 22000 spent fuel assemblies from first and second-generation submarines. • 3300 m^3 of liquid radioactive waste, some of it in underwater tanks off the coast. • 17600 m^3 of solid radioactive waste
		ZATO Ostrovnoi
Gremikha	Former Coastal Maintenance Base	• 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 m^3 of liquid radioactive waste • <750 m^3 of solid radioactive waste • 2 submarines which have been withdrawn from active service
		ZATO Skalistiy
Sayda Bay	Storage of reactor compartments	• 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

Table 2.1-1. (cont)

Location	Role	Submarines withdrawn from active service, SNF and radwaste
		ZATO Polyarny
Shipyard SRZ-10	Shipyard, involved in dismantling	• Storage of spent nuclear fuel afloat (one vessel, >500 assemblies) • Storage and processing of solid radioactive waste (>680 m^3) • Storage of liquid radioactive waste (>20m^3)
		Murmansk
RTP Atomflot	Base for ice-breakers and civilian vessels	• 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	• Storage of solid radioactive waste • Storage of liquid radioactive waste
		ZATO Snezhnogorsk
Shipyard Nerpa	Shipyard, >20 submarines dismantled	• Storage of SNF afloat, 2 vessels, >11 000 assemblies • Storage of solid radioactive waste, 300 m^3 • Storage of liquid radioactive waste, 200 m^3 • Storage of spent nuclear fuel in submarines awaiting defuelling • Storage of three-compartment reactor units prior to transfer to Sayda Bay
		Severodvinsk
Zvezdochka	Shipyard, >20 submarines dismantled	• Storage of spent nuclear fuel ashore (typically up to 500 assemblies) and afloat >650 assemblies • Storage and management of solid radioactive waste, 3200 m^3 • Storage and processing of liquid radioactive waste , 3000 m^3 • 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)	• Storage and management of solid radioactive waste, 200 m^3 • Storage and processing of liquid radioactive waste, 1000 m^3

Table 2.1-2. Spent nuclear fuel in North West Russia

Location	Number of Spent Fuel Assemblies (SFAs)	Equivalent number of reactor cores	Total activity in Jan 2004, 10^{15} Bq
Afloat			
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	>600	>2	24 (at 3 shipyards)
Technical Support Vessels based at Nerpa	>1 100	>4	
Technical Support Vessels based at SRZ-10	>500	>2	
Technical Support Vessels based at Atomflot	>5 500	>20	144
Gremikha			
Reactor cores from liquid metal cooled submarines	N/A	6	13
Dry storage in containers	800	3	5
Andreeva Bay			
Storage in facilities 2a, 2b, 3a	22 000	88	130

Table 2.1-3. Solid Radioactive waste in North West Russia (excluding reactor compartments)

	Location	Amount (m^3)	Total activity (Bq)
1	Andreeva Bay	~17,600	6.6×10^{14}
2	Gremikha	~730	~ 3.7×10^{13}
3	Maintenance Vessels[1] including:	32	1.9×10^{11}
	PM-63	20	1.3×10^{9}
	PM-12	4	1.8×10^{11}
	PM-78	3	1.9×10^{9}
	PM-128	5	4.7×10^{8}
4	Dismantling shipyards, including:		7.2×10^{14}
	PA Sevmash	~ 220	4.3×10^{14}
	Zvezdochka	~ 3,200	3.9×10^{13}
	Nerpa	~ 300	2.4×10^{14}
	SRZ-10	~ 680	7.1×10^{12}
5	RTP Atomflot	1100	2.5×10^{16}
6	Maintanance Vessel Volodarski (located at Atomflot)	328	4.1×10^{14}
	Total	~ 24,000	**~ 2.7×10^{16}**

[1] These vessels are based at Atomflot.

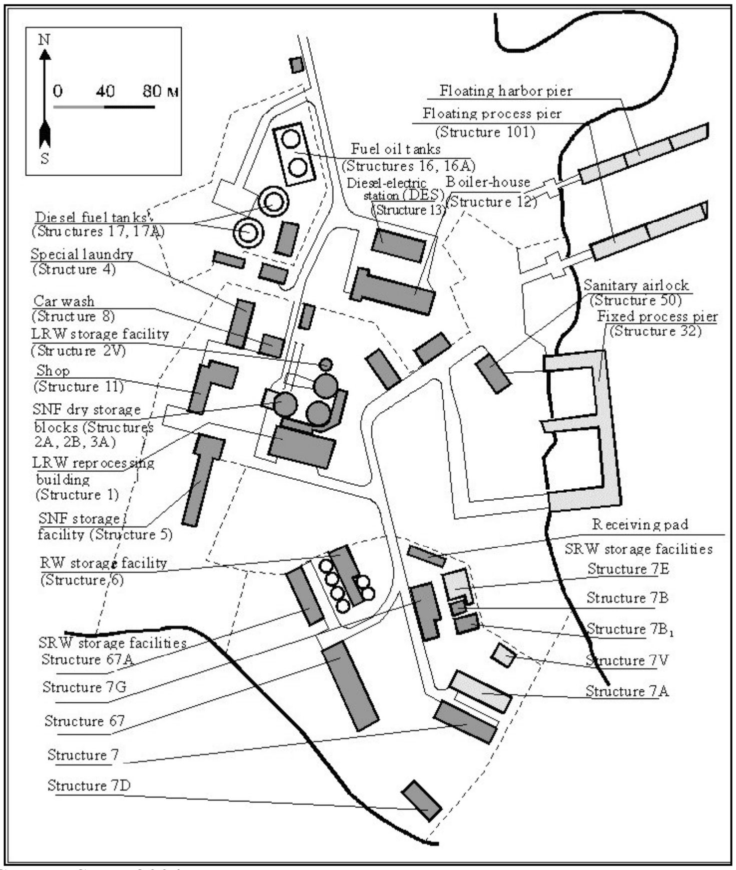
Table 2.1-4. Liquid Radioactive waste in North West Russia

	Location	Amount (m^3)	Total activity, Bq
1	CMB in Andreeva Bay	3042	$4.5x10^{12}$
2	CMB in Gremikha		Not known
	Bottom sediments from spent fuel stores	200	
	Floating tanks (PEK)	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 Lepse (Atomflot)	65	$1.1x10^{10}$
	Total	**~ 10,438**	**$\sim 9.4x10^{12}$**

More detailed information is given in the following subsections:

- Sections 2.1.1 to 2.1.3 provides further information on the three major spent nuclear fuel and waste management facilities: ***Andreeva Bay, Gremikha, Sayda Bay.***
- Sections 2.1.4 to 2.1.7 provides information on the four shipyards involved in dismantling: ***Zvezdochka, Sevmash, Nerpa and SRZ-10.***
- Section 2.1.8 provides information on the civil nuclear fleet base and waste management facility at **RTP Atomflot**.
- Sections 2.2 and 2.3 provides information on submarines and other vessels stored afloat.

2.1.1 Andreeva Bay



Source: SMP, 2004

Figure 2.1.1-1. Sketch of Andreeva Bay Coast Maintenance Base

Andreeva Bay is the largest store of spent naval fuel and radioactive waste in Russia (Figure 2.1.1-1). It is located in the North East of the Murmansk region, only 45 km from the Norwegian border.

ZATO Zaozersk is the nearest town, which is located 5 km to the south across Zapadnaya Litza Bay. The town has a population of 30 000 people, which are mostly officers and their families. Recently a residential complex 'the Norway Village' has been built at the Andreeva Bay site, which provides accommodation for the workers.

Spent Nuclear Fuel

The Dry Spent Nuclear Fuel storage ***facilities 2A, 2B and 3A*** are cylindrical near-surface vaults, built in 1965 (See Figure 2.1.1-2). Each has a volume of 1000m^3 and is 18m in diameter.

Figure 2.1.1-2. Spent nuclear fuel stores at Andreeva Bay. Facilities 2A and 2B (top) and 3A (bottom)

The spent nuclear fuel is stored in canisters within these tanks. In each tank there are approximately 1000 canisters, each continuing up to 7 assemblies. The canisters are stored within vertical metal channels.

According to the Masterplan the design life of these storage facilities expired in the mid-1990s and precipitation is penetrating through the roofs and between the cells.

The ***Open pad,*** which is adjacent to Facilities 2A, 2B and 3A has 52 TK6 containers, containing a total of 364 assemblies, stored upon it.

Building 5 used to contain a fuel pond. In the mid-1980s, after an accident most of the fuel was retrieved from the facility. However the sediments of the facility still contain high-level radioactive waste. A stream, which had been running through the building and discharging activity into the sea, was diverted within the framework of a Norwegian-funded project.

A large proportion of the fuel contained within Andreeva Bay is damaged and cannot be reprocessed at Mayak using the existing facilities. Andreeva Bay also contains non-reprocessable fuel from the icebreaker Lenin.

Solid Radioactive Waste

From Table 2.1-3, it can be seen that Andreeva Bay has the largest inventory of solid waste. It is contained within several storage facilities, including

- Seven vaults, which contain waste within metal containers and as individual discrete items;
- Two metal storage tanks;
- One vault containing contaminated equipment;
- Three open-air pads with large unpackaged items.

A number of these facilities are in an unsatisfactory condition with waste potentially leaching to the sea [Bellona, 2001].

Liquid Radioactive Waste

Andreeva Bay also has the highest inventory of liquid radioactive waste (Table 2.1-4).

According to the Masterplan, liquid waste is stored or present within the following facilities:

- The dry fuel stores 2A, 2B and 3A
- The facility 2V, which stores storm-water run-off
- the radwaste storage facility No 6.

. Contaminated water is also present within other facilities, including building 67A [SMP, 2004].

With the exception of Facility 2V, all liquid waste is stored in an unsatisfactory condition within facilities whose design lives have expired. There are no means of processing liquid waste at Andreeva Bay.

2.1.2 Gremikha

Gremikha is the second largest coastal maintenance base in the region (Figure 2.1.2-1). It specializes in the management of reactor cores from submarines with liquid-metal-cooled reactors. It is located 300km east of Murmansk and 350 km from Kola Bay. Iokanga Straight, which is 500 to 600 m wide, separates the base from the Iokanga Islands.

The nearby town of Ostrovnoy is a closed administrative territorial formation (ZATO) with some 10 000 inhabitants. Gremikha is not linked to Murmansk by road and can only be reached by sea or by air.

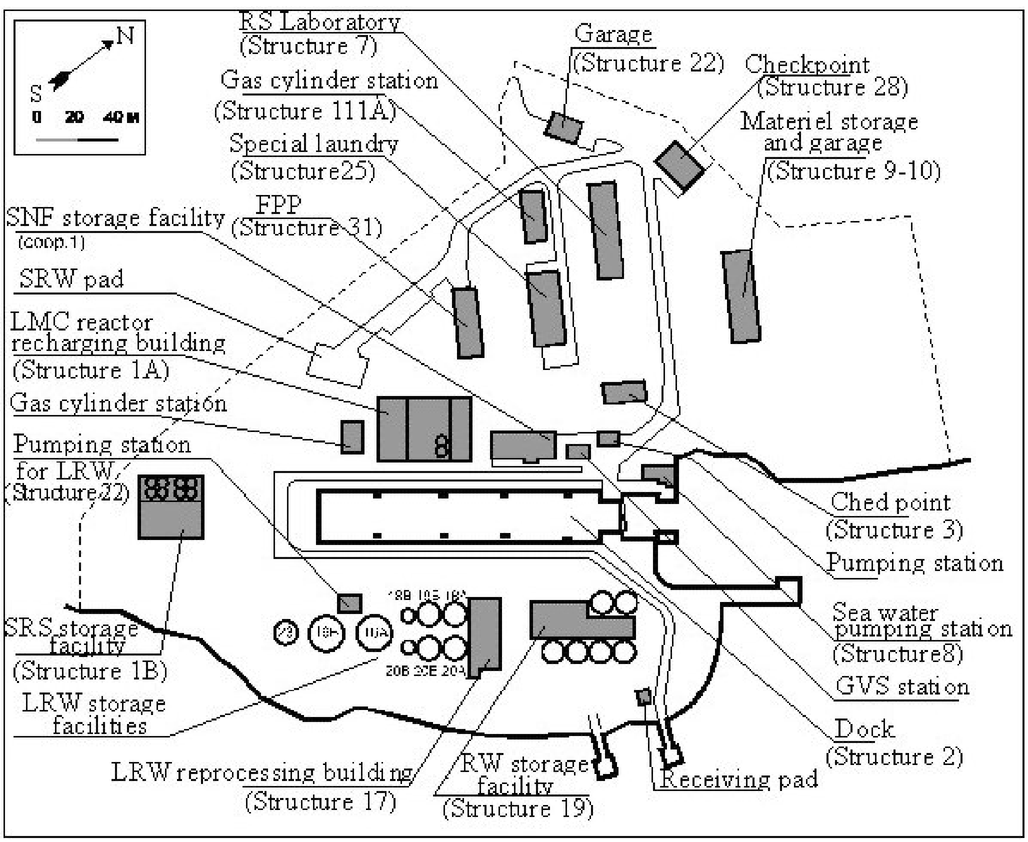
Spent Nuclear Fuel

The spent nuclear fuel storage facilities contain fuel from first-generation submarines. The fuel is stored within two facilities:

- A Fuel Pond within Building 1, containing fuel in 16 canisters and
- An Open-air storage pad, containing 107 TK-6 and 9 TK-11 storage containers.

The containers and at least some of the fuel is damaged due to the ingress of water and as a result of corrosion [SMP, 2004].

Six fuel cores removed from reactors of Alpha-class submarines, are stored in Building 1B. The cores are within steel tanks filled with non-contaminated lead-bismuth eutectic. The building is suffering from cracking and subsidence [SMP, 2004].



Source: SMP, 2004

Figure 2.1.2-1. Sketch of Gremikha Coast Maintenance Base

Solid Radioactive Waste

Over 700 m^3 of solid waste is stored within the following facilities [SMP, 2004]:

- The open-air pad (Figure 2.1.2-2), which is 20 x 15m in size and surrounded by a 3 m concrete wall. The pad contains:
    - 220 concrete containers, each with 6 canisters containing high level waste such as reactor control rods and fuel fragments;
    - 370 m^3 of unpackaged contaminated equipment;
    - 22 packages of filter sorbents from the primary and tertiary circuits of submarine reactors.
- Building 19, which contains 70 containers of filter sorbents from the primary and tertiary circuits, contaminated equipment, concentrate from processing of liquid wastes, as well as unpackaged waste.

According to the Masterplan some solid radioactive waste is also stored within sunk or floating PEK-50 tanks.

Source: SMP, 2004

Figure 2.1.2-2. Open-air pad for solid radioactive waste storage at Gremikha

Liquid Radioactive Waste

Gremikha has 11 tanks for the receipt and storage of liquid radioactive waste in Structures 16, 18, 20 and 23. The total capacity of these tanks is about 3200 m^3 [SMP, 2004]. According to the Masterplan, all liquid waste arisings are processed using the 'POTOK' facility and there is currently no backlog. However, the effluent treatment facility 'POTOK' is not currently operational at Gremikha [Rosatom, 2005].

2.1.3 Sayda Bay

Sayda Bay is located 2.5 km from Skalysty town (sometimes also called Gadjeevo, see Figure 2.1.3-1). Until 1990 Sayda Bay village was populated by fishermen and their families. After the villagers vacated the site, it was redeveloped to manage submarine reactor compartments.

Source: http://www.minatom.ru/News/Main/view?id=2393&idChannel=65

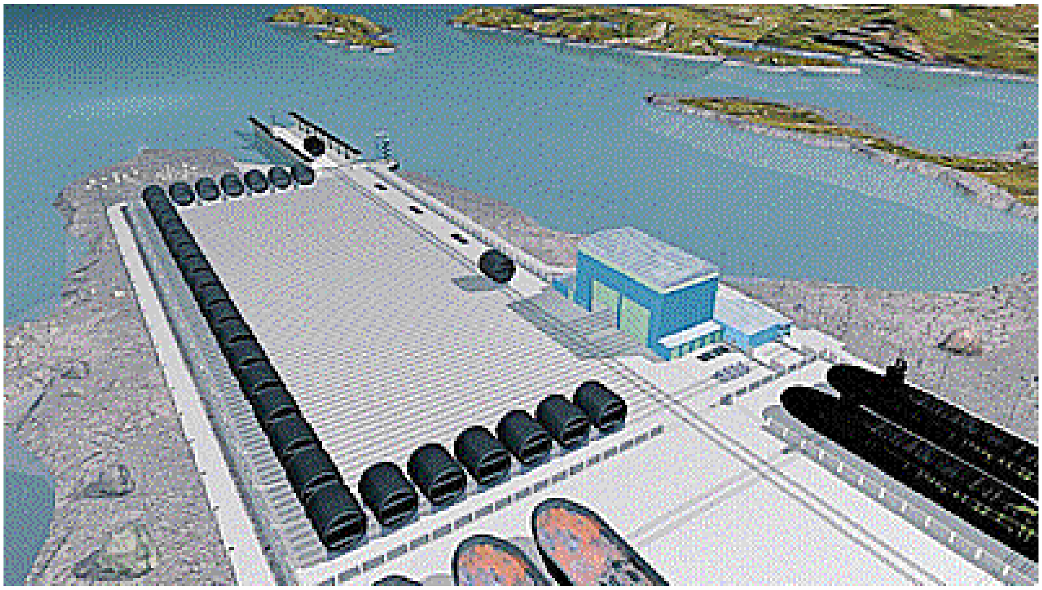
Figure 2.1.3-1. Storage of reactor compartments at Sayda Bay, Spring 2004

Reactor compartment units are moored next to five floating piers, consisting of 3-and 2-pontoon modules. They comprise of the reactor compartment itself and the adjacent compartments to ensure that the unit does not sink.

As of January 2004, Sayda Bay held 50 submarine reactor compartments, mostly defuelled, but 2 reactors from Alpha-class submarines still contain spent nuclear fuel.

At present , Sayda Bay is not accepting any further reactor compartment units from dismantling shipyards as it is full. The shipyards are therefore being forced to store the reactor compartments themselves.

A new land-based storage pad is being constructed at Sayda Bay with the assistance of the German Government. It will store only the reactor compartments, all other compartments will have to be removed from each unit prior to storage. The facility will be capable of storing 120 compartments and is due to be commissioned in 2008 (Figure 2.1.3-2).



Source: http://www.minatom.ru/News/Main/view?id=2393&idChannel=65

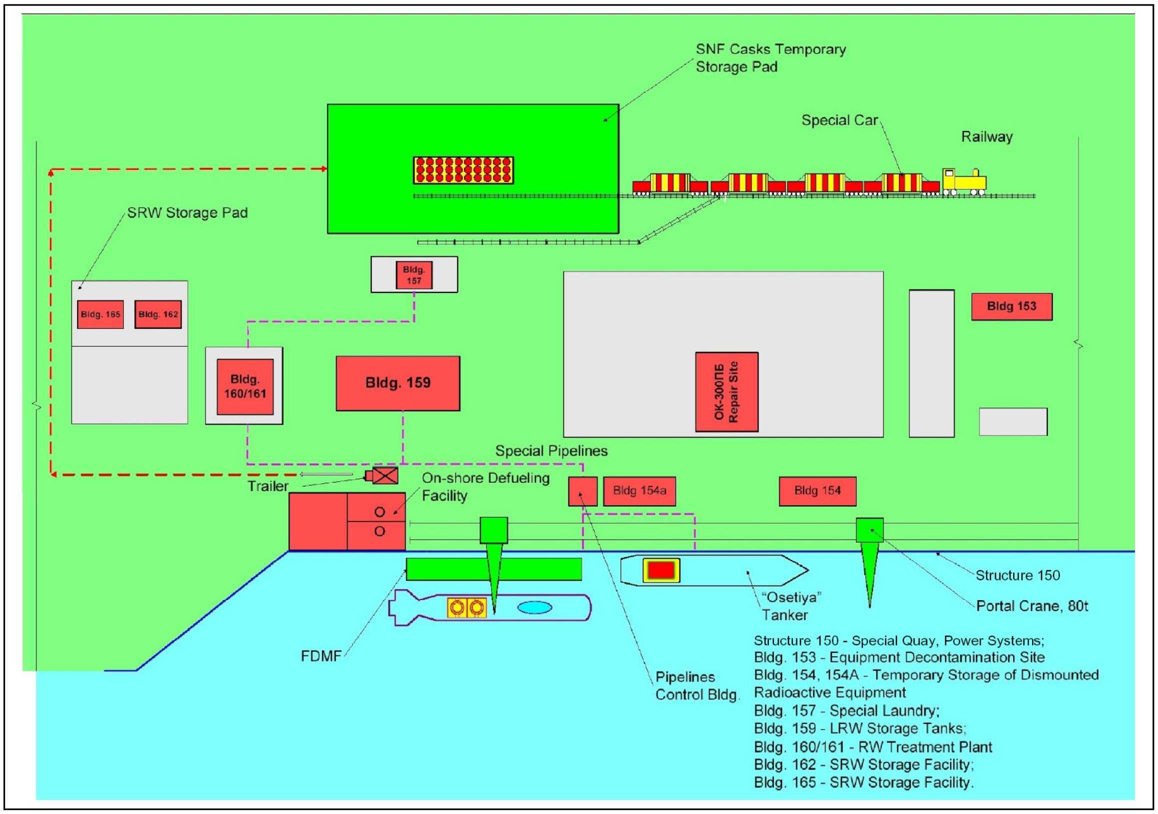
Figure 2.1.3-2. Planned facility for land-based storage of reactor compartments at Sayda Bay

2.1.4 Zvezdochka Shipyard

The Zvezdochka shipyard is an extensive facility (147 hectares) situated on Yagry Island in Severodvinsk. Sevmash shipyard, which is described in Section 2.1.5, is an even bigger facility, also located in Severodvinsk, on the mainland across the Nickolkoye Ustiye from Zvezdochka. Severodvinsk shipyards are the only facilities within the Masterplan that are located in the Arkhangelsk rather than Murmansk region.

Severodvinsk is a large town on the shores of the White Sea (Dvinskaya Bay) with over 200 000 inhabitants.

Figure 2.1.4-1 presents a schematic site layout for Zvezdochka and identifies key facilities involved in the dismantling project. The figure shows the location of defuelling, dismantling and waste management areas.



Source: Severodvinsk, 2004

Figure 2.1.4-1. Layout of Zvezdochka Shipyard

Spent Nuclear Fuel

The ***land-based defuelling facility*** is the only one in the region. It was constructed with US funding in 2003 to unload SNF from nuclear powered submarines and place it into licensed storage and transport containers for buffer storage at the shipyard and subsequent shipment by rail to Mayak. The defuelling complex is located in a special operations area for radioactive work at the westernmost end of the shipyard (see Figure 2.1.4-1). The complex allows Zvezdochka to defuel up to four submarines per year.

Defuelling operations can also be carried out ***afloat,*** as elsewhere in North West Russia, using PM 'Malina' maintenance vessels. This brings the shipyard's total defuelling capacity up to eight submarines a year.

Figure 2.1.4-2. Spent Nuclear Fuel Storage Pad at Zvezdochka shipyard. Transfer of TK-108 fuel cask.

The onshore defuelling complex consists of a portal crane which has a capacity of 80 tonnes and is used to position the defuelling tools on a submarine's reactors and then remove the spent fuel; and an onshore defuelling building for the placing of the SNF in secure transport containers. A tractor and trailer is used to move the transport containers to a second building which is by a rail spur. This second building, an enclosed ***spent nuclear fuel storage pad*** (Figure 2.1.4-2) for up to 30 transport containers (casks), contains the facilities necessary to load the specialized railcars for SNF transport to Mayak (Figure 2.1.4-1). Each cask holds 7 canisters with up to 7 assemblies per canister, thus providing Zvezdochka with a storage capacity of about 1500 spent nuclear fuel assemblies, equivalent to 3 submarines or 6 reactor cores. This building is currently being extended to provide Zvezdochka with a total buffer storage capacity of up to 60 casks.

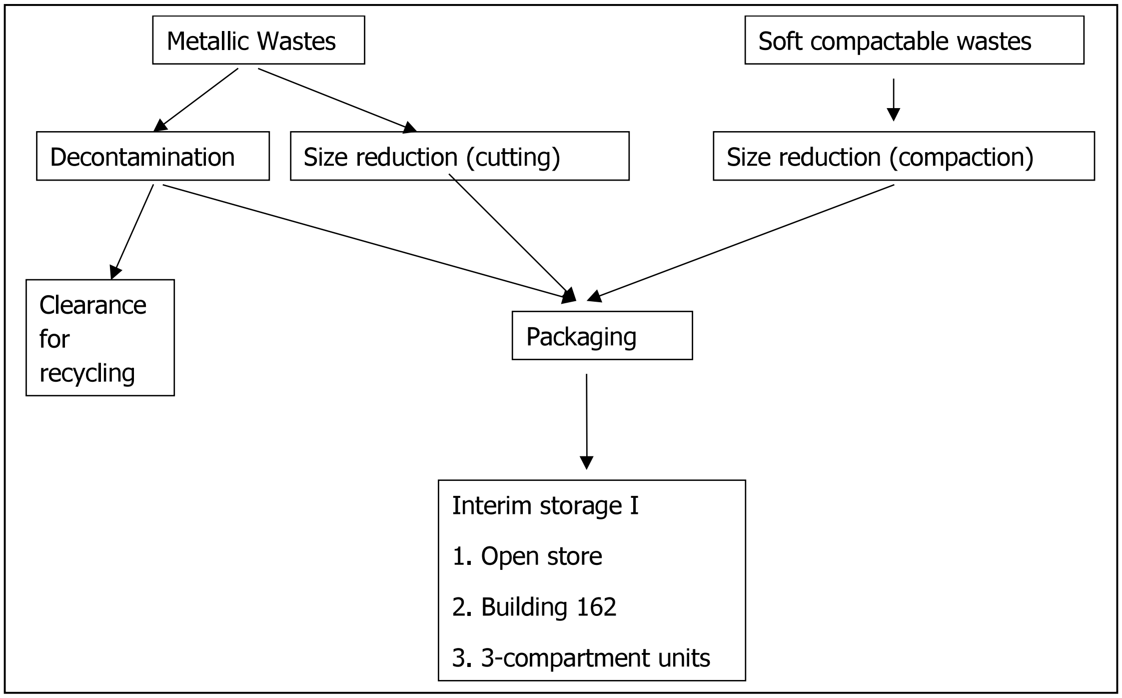
Presently, due to the regular transfer of casks to Mayak, there is no backlog and the store has no more than 2 cores worth of fuel at any one time.

Waste Management

Radioactive and non-radioactive wastes are produced as a result of construction, maintenance and decommissioning operations for nuclear powered submarines and nuclear and non-nuclear powered surface ships. Zvezdochka is also engaged in a number of activities unrelated to submarines, most notably, ***refurbishment of oil platforms****,* which also results in the generation of radioactive and non-radioactive wastes. In addition, sealed radioactive sources are used for X-ray examinations of equipment and for the calibration of radiation monitoring equipment.

Solid Radioactive Waste

All solid radioactive wastes are processed within a designated area at the facilities illustrated in Figure 2.1.4-1. The overall management process is further described below and is illustrated in Figure 2.1.4-3.



Source: Moffett, Gerchikov et al, 2004

Figure 2.1.4-3: Solid Radioactive Waste Management Scheme at Zvezdochka

All solid radioactive wastes are packaged (Figure 2.1.4-4) and placed into the ***Building 165***. Some solid waste containers are placed within the submarine reactor compartment. This practice is constrained by space availability and the weight of the waste containers, which, if excessive, could result in the loss of buoyancy of the three-compartment unit.

Figure 2.1.4-4: AMEC Radioactive Waste Storage and Transport Container

In the past, combustible wastes were separated and directed to the incineration facility (***Building 163***). This facility is currently being refurbished.

Altogether Zvezdochka has accumulated approximately 3 200 m^3 of solid radioactive waste, which is more than any other shipyard in North West Russia. Although all radioactive waste storage facilities are designed for short-term buffer storage, there are currently no plans to direct these wastes to national long-term storage and disposal facilities in the foreseeable future.

Zvezdochka also has an old store of radioactive wastes in ***Building 162*** (Figure 2.1.4-5) which is no longer being used for waste disposal and requires decommissioning. It contains unpackaged and highly radioactive reactor components. Water leaks into the facility due to large cracks in the building and in its roof.

Source: Zvezdochka, Onega, 2004

Figure 2.1.4-5: Unpackaged solid radioactive waste within Building 162 at Zvezdochka shipyard

Liquid Radioactive Waste

The overall liquid waste management process, which is described further in the following paragraphs, is illustrated in Figure 2.1.4-6.

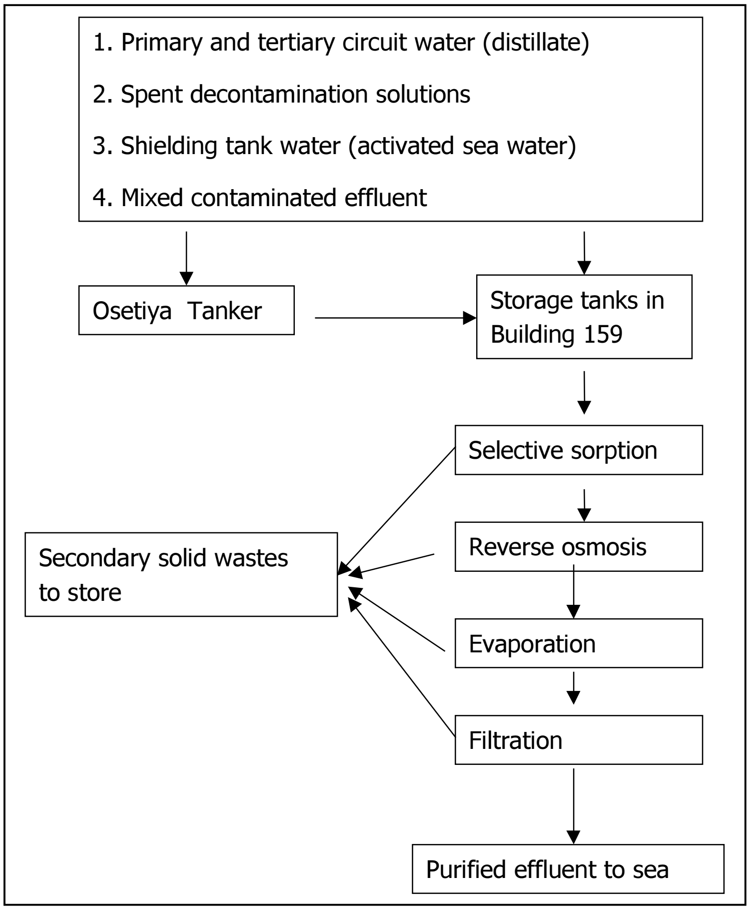
Depending on the place of origin, liquid wastes are initially directed into one of two temporary liquid radioactive waste storage facilities at Zvezdochka:

- The recently refurbished liquid waste storage facility (***Building 159***) via the active effluent pipeline or in liquid waste containers by trucks; or
- The tanker "***Osetiya***" before reaching the liquid waste storage facility (Building 159).

"Osetiya" is a purpose-built tanker with eight 126 m^3 stainless steel tanks for the interim storage of low-level liquid waste and a shielded 33 m^3 tank for the handling of higher activity liquids. "Osetiya" is a Project 1783 ("Zeya" class) commissioned in 1963. It is not self-propelled.

From the storage tanks in Building 159 liquid wastes are transferred for treatment to a new liquid waste treatment plant (***Building 160/161***, commissioned in 2000). This facility treats liquid wastes using consecutively sorption, reverse osmosis, evaporation and filtration (see

Figure 2.1.4-6). Liquid radioactive waste with a low salt content has also been treated at the mobile EKO-3 facility, which is currently being refurbished.



Source: Moffett, Gerchikov et al, 2004

Figure 2.1.4-6: Liquid Radioactive Waste Management Zvezdochka

Following treatment (Figure 2.1.4-6), effluent is directed to holding tanks, where it is sampled. Depending on the results of the analysis, the contents of the holding tanks are discharged to sea via industrial sewage. If the radionuclide concentrations exceed release limits, the liquid is redirected for selective sorption. Tritium, which is not removed by treatment, is either diluted or, if the annual discharge limit has been reached, sent for further storage in Building 159.

Secondary wastes arising from the treatment of liquid waste include filters, contaminated sorbents and evaporation residue ('dry salt'), which are packaged and stored as solid radioactive waste.

Figure 2.1.4-6. Selective sorption and reverse osmosis liquid waste treatment facilities at Zvezdochka shipyard.

Non-Radioactive Waste and Material Management

Zvezdochka shipyard also has extensive processing facilities for managing non-radioactive hazardous materials. Facilities include industrial wastewater plants, a conventional (activated sludge) sewage treatment plant, recycling facilities and dedicated interim storage facilities for substances which cannot currently be processed for sale, re-use or disposal.

Zvezdochka uses the recycling and sale of materials recovered from dismantled vessels as a source of income. Ferrous metals are processed at mechanical and thermal cutting sites, non-ferrous metals are processed at a dedicated site, copper is reclaimed from cables at a specialized site (***Kansk module***) and electrical equipment is disassembled and precious metals recovered at an additional facility. The following paragraphs provide an overview of the classification systems and practices for the recycling and management of these materials.

Zvezdochka uses a hazard classification system to guide the recycling and management of non-radioactive wastes and materials. All materials are classified according to the Russian Federation Ministry of Health hazard classes (four classes with a focus on reducing the risks to human health) and the Ministry of Nature ('MinPrirody') hazard classes (five classes with a focus on environmental protection).

Table 2.1.4–1 provides a summary of the Ministry of Nature's hazard class system. Class Number 1 is the highest hazard category and Class Number 5 is the lowest. The table also identifies some typical materials found in each class. In general, materials in Classes 1-3 are managed through storage at on-site facilities in accordance with authorized procedures. Materials from Classes 4 and 5 may be disposed of off-site, including at municipal landfill sites. Materials are sorted and classified at the point at which they are produced. All materials are recycled as far as possible.

Table 2.1.4-1: Classification System for Materials Recycling and Management

Type	**Hazard Class**				
	1 (High)	**2**	**3**	**4**	**5 (Low)**
Examples of solids related to dismantling	Luminescent lamps containing Mercury	None relevant to dismantling projects	Certain insulation materials, some paints	Rubber, linoleum, ceramic tile; PVC, many insulation materials	Textiles, wood pulp
Examples of liquids related to dismantling	None relevant to dismantling projects	Hydraulic fluid, battery electrolyte, CFCs, diesel fuel	Foaming agents	Lubricants	None relevant to dismantling projects
	Stored On Site			Disposed off site	
	May Be Recycled				

Storage of materials from Classes 1-3 is at a waste storage facility that is currently being upgraded. Current practice is to store these materials in steel containers outside on a concrete pad. Upgrading includes the expansion of the concrete pad and the construction of a roof so that materials may be stored indoors.

Of all the shipyards, Zvezdochka has the most extensive facilities for the management of spent nuclear fuel, radioactive and non-radioactive wastes. There is also significantly more publicly available information with regards to waste management at Zvezdochka. Management of waste at other shipyards is outlined in subsequent sections.

2.1.5 Sevmash Shipyard

The second Severodvinsk shipyard, Sevmash is the largest shipyard in North West Russia. It is also the only one that has facilities to dismantle the largest Russian submarines, the Typhoon class, as well as titanium-hulled submarines, including Alpha-class submarines with lead-bismuth coolant.

Submarines withdrawn from active service arrive at Sevmash following defuelling at Zvezdochka; therefore there is ***no spent nuclear fuel*** management at Sevmash shipyard.

Solid Radioactive Wastes

The total amount of solid waste at Sevmash is over 200 m^3. Facilities for solid radioactive waste management are limited to an open-air interim storage area ***VHTRO***, which is used for the storage of large pieces of contaminated equipment, such as steam generators and coolant pumps (see Figure 2.1.5-1). The facility is in poor condition.

In the past solid wastes were disposed in a near-surface facility '***Mironova Gora'***, which is leaking. It is a matter of concern for the population of Severodvinsk because of its proximity to vegetable gardens. 'Mironova Gora' is outside the scope of the Masterplan [SMP, 2004].

All other solid radioactive wastes are placed within the reactor compartment.

Figure 2.1.5-1. Open-air interim radwaste storage area at Sevmash.

Liquid Radioactive Wastes

Liquid radwaste that is generated at Sevmash is collected and temporarily stored in ***Floating Tanks*** (Figure 2.1.5-2) and then transported to the Zvezdochka plant for treatment.

Four floating tanks, 24m^3 each, are stored within the harbour area adjacent to Sevmash and are moved to Zvezdochka by harbour tugs.

There are no liquid waste processing facilities at Sevmash.

Figure 2.1.5-2. PEK-50 liquid waste storage tanks moored at Sevmash

There is no available information on how non-radioactive wastes are managed at Sevmash.

2.1.6 Nerpa Shipyard

Nerpa shipyard is located to the west of Murmansk near Vyuzhnii town with 30 000 inhabitants.

The following information is available on the management of spent nuclear fuel and radioactive waste at Nerpa:

- Defuelling takes place afloat using Malina-class PM vessels.
- Spent nuclear fuel is then stored within the vessels and shipped to Atomflot, unpackaged, where it is packaged into fuel transport/storage casks, loaded into railcars and transported to Mayak.
- 296 m^3 of containerised solid radioactive wastes are stored in a 500m^3 open-air facility.
- There is a single reactor compartment stored ashore at Nerpa.
- Liquid wastes are stored within two 50te floating PK-15 tanks.
- There are no liquid waste processing facilities at Nerpa. Liquid waste is transferred to Atomflot for processing.
- It is not known how non-radioactive wastes are managed at Nerpa, although, as at Zvezdochka shipyard, there is a US-funded facility for recycling electric cables.

2.1.7 SRZ-10 Shipyard

SRZ-10 shipyard is located to the west of Murmansk near Polyarny town which has a population of about 15000 inhabitants.

The following information is available on the management of spent nuclear fuel and radioactive waste at SRZ-10 shipyard:

- Defuelling takes place afloat using Malina-class PM vessels.
- Spent nuclear fuel is then stored within the vessels and shipped to Atomflot, unpackaged, where it is packaged into fuel transport/storage casks, loaded into railcars and transported to Mayak.
- Some 680 m^3 of containerised solid radioactive wastes are stored in an open-air facility.
- In 2004 a mobile solid waste treatment facility was commissioned at SRZ-10 shipyard. It has facilities for sorting, compacting (into 200 litre drums), monitoring and to some extent temporarily storing the waste.
- Liquid wastes are stored within floating PDKS tanks with a total volume of 150 m^3.
- There are no liquid waste processing facilities at SRZ-10. Liquid waste is transferred to Atomflot for processing.
- It is not known how non-radioactive wastes are managed at SRZ-10.

2.1.8 RTP Atomflot

RTP Atomflot is located 2 km north of the city of Murmansk, with a population of 400 000 people. RTP Atomflot is the main base of the Murmansk Shipping Company, which operates nuclear icebreakers and transport vessls. RTP Atomflot is also involved in the management of spent nuclear fuel and radioactive wastes from submarines which have been withdrawn from service.

Spent nuclear fuel

A number of vessels at Atomflot shipyard are involved in storage and shipping of spent nuclear fuel. Here all SNF originating from the Murmansk region is loaded into transport/storage casks, which are transferred to railcars and transported to Mayak.

Currently a spent-nuclear fuel pad is being constructed at Atomflot. It will be used as buffer storage for TUK-18 and TUK-108 type casks with spent nuclear fuel.

Solid radioactive waste

- In 2004 1137 m^3 of solid radioactive wastes were stored within five facilities:
  - 400 m^3 low level waste store, which houses containerised waste
  - A pad for the storage of packaged high-level waste from the primary circuit
  - A pad for the storage of large waste items (steam generators, pumps)
  - A small area for the storage of containers holding reactor components.

Liquid radioactive waste

- Liquid radioactive waste is stored within two 100 m^3 tanks [Bellona, 2001]
- The liquid waste processing facility has yet to be commissioned. It has a design throughput of 5000 m^3, which is based on sorption and filtration.

2.2 Nuclear Powered Vessels

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 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 1st January 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 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 is also a small number of specialized submarines of other types, which may have to be decommissioned in the near future.

2.2.1 First Generation Submarines

All of the fifty-seven Soviet-built first generation submarines, which were built between 1955 and 1966, have been withdrawn from active service.

They were powered by two pressurized water VM-A reactors with thermal capacity of 70 MWt per reactor. Each reactor core contained approximately 250 fuel assemblies.

The single exception was a modified November-class submarine, which was powered by two VT-1 type liquid metal (lead-bismuth) cooled reactors. This submarine suffered an accident and was scuttled in the Kara Sea.

Naval fuel is stainless steel or zirconium-clad uranium –aluminium or uranium-zirconium alloy [NTI, 2000]. Zirconium-clad fuel cannot be reprocessed at the RT-1 reprocessing plant at Mayak in the Urals at the present time, although it is technically feasible. It is intended that the remaining reprocessable naval fuel will go to Mayak.

Twenty-five first-generation submarines belong to the Pacific Fleet, three have been scuttled or sunk. The remaining submarines have been laid-up in North West Russia and include:

- 7 November-class
- 6 Hotel-class
- 15 Echo-II class
- 1 Papa-class

Table 2.2.1-1 provides a breakdown of these submarines, information on their current status as well as comments relating to their operational history that may have an impact on decommissioning.

Altogether,

- 21 submarines have been defuelled, leaving a further 8 submarines requiring defuelling.
- 8 submarines of this generation have been dismantled, whereby the reactor compartment has been separated and is stored ashore as a single unit or afloat together with two or three adjacent compartments. The remaining 19 submarine hulls have yet to be dismantled.

Several submarines of this generation sank or were deliberately scuttled. It is likely that at least one of these submarines will be retrieved in the near future. November-class K-159, which sank while being towed in 2003 has not been defuelled and once retrieved would also require defuelling and dismantling.

Reactors and primary circuits in first generation submarines typically have higher contamination levels then subsequent generations of naval reactors. This can be attributed to either contamination resulting from microfractures and corrosion in fuel cladding or accidents suffered by some of these submarines.

Of the latter, K-192, which is an Echo-II class submarine represents a special case. It suffered an accident in 1989. As a result of this accident one of the reactors was seriously damaged. It is understood that K-192 is being stored at Sayda Bay. The missile compartment and fuel have been removed [Rosatom, 2005].

It is understood that all other first generation submarines can be safely defuelled using existing methods.

Table 2.2.1-1: First Generation Submarines in North West Russia

Submarine class	Total number/ Laid up	Defuelled/Requiring defuelling	Dismantled/Requiring Dismantling	Comments
November	10/7	6/1	4[2]/3	1. K-3 suffered fire in 1987 2. K-8 sank in the Bay of Biscay in 1960 3. In 1965 K-11 suffered a major accident involving fire 4. K-27, the only November class submarine with liquid metal coolant, was scuttled in the Kara Sea in 1981 5. K-159 sank in the Barents Sea during towing on 30th August 2003
Hotel	6/6	4/2	1/5	K-19 suffered a loss of coolant accident on July 4th, 1961 and a fire in 1972
Echo-1	0	0	0	All 5 Echo-1 class submarines are located in the Far East
Echo-II	15/15	11/4	6/9	1. K-47 suffered fire in 1976 2. K-131 suffered fire in 1984 3. K-192 suffered an accident in 1989. One of the reactors suffered serious damage.
Papa	1/1	0/1	0/1	1. Has a titanium hull 2. Located at Sevmash 3. Suffered an accident in 1980
Juliett	1/1	0/1	0/1	Has 1 reactor, and is currently being dismantled at

[2] In this report submarines are referred to as 'dismantled' if the reactor compartment has been defuelled and separated. As a result of such dismantling either a single reactor compartment unit or units containing the reactor compartment with the adjacent 2 or 3 compartments are stored ashore or afloat.

Submarine class	Total number/ Laid up	Defuelled/Requiring defuelling	Dismantled/Requiring Dismantling	Comments
				Nerpa Shipyard.

2.2.2 Second Generation Submarines

One hundred and forty-two second generation submarines were built between 1964 and 1974 [Bellona, 2001].

Most of them were powered by two pressurized water reactors of OK-300, OK-350, OK-650 or OK-700 modification. These modular reactors had similar characteristics but higher reliability when compared to the reactors used in the first-generation.

Submarines of Charlie-II class were the only examples of this generation to be powered by a single reactor.

Fifty-two second generation submarines belong to the Pacific Fleet, one sank and twenty are still in service. The remaining sixty-nine submarines have been laid –up in North West Russia and include:

- 18 Yankee class
- 9 Delta-I class
- 4 Delta-II class
- 2 Delta III class
- 12 Victor-I class
- 7 Victor-II class
- 11 Victor III class and
- 6 Charlie-II class.

Of these, 18 two-reactor submarines still require defuelling and 25 require dismantling (see Table 2.2.2-1), although in some cases they have undergone partial dismantling by cutting out the missile compartment and welding the remaining sections together.

The last second generation submarine was commissioned over 30 years ago. It can therefore be expected that most, if not all, of the Northern Fleet's second generation submarines that are still operational will be withdrawn from service over the next ten years.

Based on the available information, reactors of all non-dismantled second generation submarines are in good condition, and normal dismantling procedures can be applied in all cases.

Table 2.2.2-1: Second Generation Submarines in North West Russia

Submarine class	Total number/ Laid up	Defuelled/ Requiring defuelling	Dismantled/ Requiring Dismantling	Comments
Yankee	24/19	18/1	12/7	1. K-140 suffered an accident in 1968. This submarine was dismantled at Zvezdochka shipyard 2. K-219 sank in 1986 near the Bermuda Islands
Delta-I	9/9	8/1	8/1	The submarine of this class still requiring dismantling was withdrawn from service in 2003 and is currently at Zvezdochka shipyard
Delta-II	4/4	4/0	4/0	
Delta-III	5/2	2/0	2/0	
Delta-IV	7/0	N/A	N/A	
Victor-I	12/12	5/7	10/2	
Victor-II	7/7	7/0	2/5	
Victor-III	16/11	2/9	1/10	
Charlie-I	0	N/A	N/A	All submarines of this class are based in the Far East
Charlie-II	6/6	6/0	6/0	Powered by a single reactor

2.2.3 Third Generation Submarines

Thirty-six third generation submarines have been built since 1976.

Most of third generation submarines were also powered by two pressurized water reactors, which contained between 180 and 252 fuel assemblies with different enrichment levels [OTA, 1995]. Sierra and Akula class submarines are powered by a single pressurized water reactor.

Ten third generation submarines belong to the Pacific Fleet, two sank and fifteen are still in service. Nine third generation submarines have been laid-up in North West Russia and include:

- 3 Typhoon class
- 2 Oscar-I class
- 2 Oscar-II class
- 1 Sierra class
- 1 Akula class

Of these, 3 two-reactor and both single reactor submarines still require defuelling and 8 require dismantling (see Table 2.2.3-1).

According to Masterplan, a laid-up Typhoon and an Oscar-II class submarine both have high levels of primary circuit contamination. Based on the available information, reactors of all the other third-generation submarines that have not been defuelled are in good condition and normal defuelling and dismantling procedures can be applied.

Table 2.2.3-1: Third Generation Submarines in North West Russia

Submarine class	Total number/ Laid up	Defuelled/Requiring defuelling	Dismantled/Requiring Dismantling	Comments
Typhoon	6/3	1/2	0/3	The largest submarine in the world, 172m long. Requires dismantling facilities which currently only exist at Sevmash shipyard.
Oscar-I	2/2	2/0	0/2	
Oscar-II	6/2	1/1	1/1	Kursk sank on 12th August 2000
Sierra	4/1	0/1	0/1	Single reactor
Akula	7/1	0/1	0/1	Single reactor
Michael	1/0	N/A	N/A	K-278 (Komsomoletz) sank on 7th April 1989

2.2.4 Alpha class Submarines

Seven Alpha class titanium-hulled submarines with lead-bismuth cooled reactors were commissioned between 1960 and 1981. Each of these submarines had a single uniquely designed reactor. The 155 MWt OK-550 or BM-40A reactors had Uranium-beryllium fuel with very high enrichment levels [Bukharin, 1998].

All of them are now out of service. Three Alpha-class submarines still require defuelling and two require dismantling (see Table 2.2.4-1).

Alpha-class submarines present special challenges for defuelling and spent nuclear fuel management. Unlike other submarine reactors, which can be defuelled by removing one assembly at a time, Alpha class submarines are defuelled by removing the whole core, which is then stored as a single unit.

Therefore the reactor cores having been removed from defuelled submarines themselves require a long-term solution. Furthermore, unlike stainless steel clad spent nuclear fuel from other submarine types, Alpha-class fuel cannot be reprocessed at Mayak.

Two laid-up Alpha-class submarines, located near Zaozersk in the Murmansk region, contain spent nuclear fuel encapsulated in the frozen lead-bismuth coolant. These would have to be heated to over 125 degrees Celsius prior to the retrieval of the core. The third non-defuelled Alpha-class submarine is located at Sayda Bay. At one point in its history this submarine was prepared for scuttling, and as a result of this, it is no longer possible to retrieve the core using existing defuelling technology.

Altogether there are 10 cores from Alpha-class submarines in North West Russia. This includes:

- Six cores, which were removed from submarines that have been withdrawn from service.
- Two cores which are still within laid-up Alpha-class submarines. One of these submarines is seriously radioactively contaminated and cannot be defuelled using the normal approach.
- One core which is stored at Sayda Bay within a floating reactor compartment of a dismantled submarine.

Dismantling of titanium-hulled submarines can only be carried out in Severodvinsk at Sevmash shipyard.

Table 2.2.4-1: Alpha-Class Submarines in North West Russia

Submarine class	Total number/ Laid up	Defuelled/Requiring defuelling	Dismantled/Requiring Dismantling	Comments
Alpha	7/7	4/3	5/2	1. Contains a single reactor with liquid metal coolant and highly enriched fuel. 2. Non-defuelled submarines contain frozen coolant. 3. One submarine reactor has been backfilled and cannot be defuelled using standard approaches. 4. K-123 suffered a loss of coolant accident in 1982. 5. The Masterplan states that one of the subs has 'very dangerous radiological conditions in the reactor compartment'. 6. Three of the four defuelled reactor compartments are stored afloat. Depending on the submarine, such storage conditions were designed to only last until 1999-2001 .

2.2.5 Civilian Nuclear-powered Vessels

Eight nuclear-powered icebreakers and one transport ship were commissioned in the Soviet Union between 1959 and 1992. Of these

- Two icebreakers (Lenin and Sibir) have been taken out of service and defuelled.
- Four icebreakers (Arctic, Rossiya, Soviet Union and Yamal) still operate from their Atomflot base near Murmansk on routes in the Barents Sea and elsewhere in the Russian Arctic.
- Two icebreakers (Taimir and Vaigach) mostly operate on the Yenisey River in Siberia.
- Transport ship Sevmorput also operates on Arctic routes and is based at Atomflot.

All of these vessels were equipped with OK-900 reactors. Initially civilian nuclear propelled vessels used low-enrichment (5-6%) Uranium dioxide fuel. Currently these reactors use fuel with higher enrichment. Zirconium fuel has also been used in OK-900 reactors. Such fuel cannot be reprocessed at Mayak.

It is anticipated that all vessels, except for the laid up Lenin and Sibir, will continue to operate for the foreseeable future [SMP, 2004]. A further nuclear icebreaker has been under construction in St Petersburg since 1994.

Civilian nuclear-propelled vessels do not pose immediate decommissioning concerns; however spent nuclear fuel and radioactive waste from the operation of the nuclear civil fleet has to be managed in the same way as wastes resulting from the operation of the military ships. Furthermore all existing icebreakers will be withdrawn from service and will require decommissioning between 2011 and 2020 [SMP, 2004].

2.2.6 Nuclear-powered Battleships

The Soviet Union, and later Russia, commissioned 4 nuclear-powered cruisers and one nuclear-powered communications vessel. The latter has been laid up in the Far East. All four cruisers were based in North West Russia.

Each nuclear cruiser was equipped with two large KN-3 pressurised water reactors of 300 MWt thermal output. Between them the two reactors contain 698 fuel assemblies. There is no information on the fuel type, or enrichment level, which is likely to be high to ensure the required power output.

Cruiser 'Petr Velikiy' is the only one that is definitely operating with the Northern Fleet. Another cruiser, which used to be called 'Admiral Ushakov' had its reactors shut down in 1994. It has been laid up at the Zvezdochka shipyard since September 1999 [SMP, 2004].

There is no definitive information on the status of the other two cruisers ('Admiral Lazarev' and 'Admiral Nakhimov'), although it has been reported that both of them have been taken out of service [Bellona 2001].

All of these vessels have fuel on board and ensuring safety in non-defuelled laid-up nuclear-powered surface ships is difficult. Temperatures of below freezing during the cold winter months could result in damage to the pipes and other structural components of the vessel, which would in turn lead to leaks. Unlike submarines, surface ships have a large number of holes in the hull, which allow heat to escape.

During the SEA consultation scoping meeting which was held in Severodvinsk, in November 2004, it was reported that in the winter months temperatures in the primary circuit of 'Admiral Ushakov' cruiser often drop below postulated levels. It was also stated that a couple of years ago the cruiser suffered a major leak, which nearly resulted in the sinking of the ship [Gerchikov, 2005].

The large dimensions of these ships also pose problems both in sustaining temperatures in winter and in ensuring that the vessels are moored safely when the winds are strong.

There has never been defuelling (or indeed refuelling) conducted on a nuclear battleship. However, the Masterplan states that defuelling can be conducted using existing defuelling and dismantling facilities. Decommissioning project for the cruiser is being developed by NIPTB Onega.

2.3 Technical Support Vessels

Technical support vessels are used for defuelling of submarines and icebreakers afloat, and for the transfer of spent nuclear fuel from bases in the Murmansk region to railheads at RTP Atomflot near Murmansk. They also provide floating facilities for storage of spent nuclear fuel and nuclear waste.

In the last few years the use of such vessels for defuelling has been reduced significantly in Severodvinsk due to the commissioning of the land-based defuelling facility and liquid waste management facilities at Zvezdochka shipyard. In the Murmansk region the use of such vessels represents an essential component of managing spent nuclear fuel and radioactive waste.

There are

- 6 operational PM ships involved in defuelling and storage of spent nuclear fuel from submarines and icebreakers.

- 2 Operational transport ships, Imandra and Lotta, which are used to store and transport spent nuclear fuel and radioactive waste. Imandra is also used to refuel civilian nuclear-powered vessels.
- 1 spent fuel storage ship, Lepse, which has been withdrawn from service and contains a significant quantity of spent nuclear fuel and liquid wastes.
- Other vessels in service and out-of-service, which are not used for the management of spent nuclear fuel, but store and transport radioactive wastes

As specified in Table 2.3-1, a significant number of these vessels require repair or decommissioning.

Table 2.3-1: Technical support vessels

Ship	Purpose	Location	Technical Condition	SNF Assemblies	LRW m^3(Bq)	SRW m^3(Bq)
PM-12 'Malina' 1990	Defuelling, SNF and waste storage and transfer to SV Lotta	Shipyard Nerpa	Requires repairs	749	0	4 (2E11)
PM-63 'Malina' 1984	Defuelling, SNF and waste storage and transfer to railcars	Shipyard Zvezdochka	Requires repairs	294	115	20 (1E9)
PM-78 (Project 326M) 1963	Defuelling, SNF and waste storage and transfer to SV Lotta	Shipyard SRZ-10	Repairs planned to extend operation for 2 years	0	72 (7×10^{11})	3 (2×10^{9})
PM-128 (Project 326M) 1962	Defuelling, SNF and waste storage and transfer to SV Lotta	Shipyard Nerpa	Repairs planned to extend operation for two years	448	24 (2×10^{9})	5 (5×10^{8})
PM-124 (Project 326M) 1960	Defuelling, SNF and waste storage and transfer to PM-63	Shipyard Zvezdochka	Due to be taken out of service in 2005	0	121 (3×10^{11})	0
Imandra 1981	Defuelling, SNF storage and shipping	RTP Atomflot	Good	1446	0	0
Lotta 1961	Transportation and storage of SNF	RTP Atomflot	Good	3856	0	0
Lepse 1936	Out of service	RTP Atomflot	Poor	639	65 (1×10^{10})	0

Table 2.3-1 (cont.)

Ship	**Purpose**	**Location**	**Technical Condition**	**SNF Assemblies**	**LRW m^3(Bq)**	**SRW m^3(Bq)**
TNT-8 1960	Out of service	Shipyard SRZ-10	Partially sunk	0	N/A	0
TNT-12, 1965	Temporary Storage of SRW and LRW	Kola Pennisula	Due to be taken out of service in 2006	0	499 (5×10^7)	0
TNT-19, 1962	Temporary storage of LRW	Kola Pennisula	Out of service	0	903 (2×10^{11})	0
TNT 25	Temporary storage of LRW	Severodvinsk	Due to be taken out of service in 2006	0	Unknown	Unknown
TNT Osetiya 1963	Temporary storage of LRW	Zvezdochka	Good	0	897 (1×10^{11})	0
TNT-29 1968	Out of service,	Gremikha	Stored afloat	0	N/A	0
Volodarksi	Out of service	RTP Atomflot	Out of service	0	0	328 (4×10^{14})
Serebryanka	Temporary storage of LRW	RTP Atomflot	Unknown	0	850 (7×10^9)	0
PEK-50 liquid waste storage vessels	6 have been withdrawn from active service, a number are still operational.	various	Out of service	0	0	0
Small floating liquid waste storage tanks	**Temporary storage of liquid waste**	**Sevmash**	**Uknown**	**0**	**Unknown**	**0**

2.4 Strategic Master Plan Phase 1

Phase 1 of Strategic Master Plan (Masterplan) performed a comprehensive analysis of the current situation, including a preliminary risk assessment of the nuclear legacy in North West Russia. Based on this analysis, strategic goals and priority measures were identified. The major work done in phase I is summarized further in the following subsections.

2.4.1 Summary of the available information

The Masterplan phase I report provides detailed information and analysis regarding the general condition of the nuclear fleet and the associated infrastructure which are subject to decommissioning and environmental rehabilitation, including a review of related Russian regulations. In a number of cases, estimates were made to obtain unavailable data.

The total radiological inventory in North West Russia has been assessed within the Masterplan, along with a brief description of technical conditions of the objects concerned.

2.4.2 Preliminary risk assessment

The Masterplan Phase I report identified the major potential risks under current conditions. The risks are grouped into three categories:

- Category I: Current risks posed by the current level of decommissioning and environmental rehabilitation.
- Category II: Potential risks which are not associated with the decommissioning and environmental rehabilitation technology. Two sub-groups of risks are considered within this category: growing with time (IIa) and constant in time (IIb)
- Category III: Potential risks associated with the technology proposed for the decommissioning and environmental rehabilitation.

The Masterplan also made a comparison between chemical risks and radiation risks related to nuclear submarine decommissioning and concluded that the hazard of chemical pollution is 2 to 3 orders of magnitude higher than the radiation risk in the case of an accident-free nuclear submarine decommissioning process.

2.4.3 Identification of priority tasks

Based on a comprehensive analysis, the strategies of decommissioning and environmental rehabilitation within the scope of the Masterplan are briefly defined and a series of tasks are identified to meet the goals.

The Masterplan also performed an analysis to identify the priorities amongst all of the measures required during the implementation of tasks. Specifically, eight projects have been identified as top priority measures from amongst all the projects considered to address bottleneck issues related to decommissioning and rehabilitation. It is suggested by the Masterplan that these projects should be implemented immediately.

3.0 SCOPE AND ASSESSMENT METHODOLOGY

This section provides information on the SEA scope and on the methodology for conducting the SEA.

3.1 Scope

3.1.1 SEA Purpose

The purpose of SEA is to compliment the Masterplan with a view to ensuring that the environmental consequences of the Masterplanare identified and assessed during its preparation and before its adoption. Taking into account public opinion and those of the environmental authorities in the course of the planning procedure through consultation programs, the SEA report is intended to provide decision-makers with strategic-level information on the environmental impact of the Nuclear Window activities in North West Russia.

The overall objective of the Nuclear Window and therefore of the Masterplan, is to eliminate threats on the personnel, public and environmental level, in North West Russia, by the stabilization and improvement of the environmental situation as it relates to the decommissioning of nuclear submarines and associated support facilities. Accordingly, a prime focus of the SEA is on the radiation environment. The assessment is conducted to determine the effects of radiation on workers, members of the public and the biophysical environment. However, non-radiological considerations are also important and the SEA is carried out taking account of a number of environmental components, including both the biophysical and socio-economic environment.

3.1.2 Scope of the Masterplan

The scope of the plan includes all actions related to the decommissioning of nuclear submarines, nuclear-powered surface ships, maintenance vessels and environmental rehabilitation of coastal maintenance bases. This includes all operations and activities that are required for

- Transportation of the objects of concern from their current locations to the shipyards,
- Dismantling at shipyards,
- Reactor compartment management,
- Spent nuclear fuel management,
- Radwaste management,
- Management of other wastes,
- Restoration & development of waste management facilities,
- Installation of monitoring systems in coastal maintenance bases.

3.1.3 SEA Scope

The scope of the assessment refers to the factors to be considered in the assessment, including:

(a) the environmental effects of the Masterplan, including the environmental effects of malfunctions and accidents that may occur in connection with the plan and any secondary, cumulative and synergistic environmental effects that are likely to result from the implementation of the plan in combination with other projects or activities that have been or will be carried out;

(b) the significance of the effects referred to in paragraph (a);

(c) comments from the public

(d) measures that are technically and environmentally feasible that would mitigate any significant adverse environmental effects resulting from the implementation of the plan; and

(e) any other matters relevant to the assessment, such as alternatives to the strategies described in the Masterplan.

3.2 SEA Methodology

3.2.1 SEA 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 3.2.1-1. 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:

a) ***Logistical arrangements*** for the preparation of the scoping consultations, the distribution of information and the identification of potential stakeholders

b) ***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 will be in accordance with Objective 2 of the Northern Dimension Environmental Partnership: "to address urgent nuclear safety and security issues related to the decommissioning of submarines and associated support facilities in North West Russia".

c) ***Generation of alternatives*** in accordance with 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" [EC, 2001b]. The alternatives will include the projects that are specified in the Masterplan and additional feasible strategies for addressing the main objective. "Business as usual" alternatives will also be specified at this stage so that the implications of not implementing the Masterplan can be assessed and the projects can be prioritised.

d) ***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.

e) ***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, and which can be used to discriminate between the different alternatives. 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.

f) ***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 SEA report.** The objective of this phase is to assess the strategies in accordance with the above by completing the following tasks:

g) ***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 the SEA Directive [EC, 2001a]. They will include secondary, cumulative, synergistic, short, medium and long-term, permanent and temporary, positive and negative effects.

h) ***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.

i) ***Recommend Mitigation.*** The recommendation of mitigation measures and the evaluation of the effectiveness of any mitigation that is proposed is embedded in the process that was discussed previously. The SEA is fundamentally a planning tool, and one of the main purposes of the SEA is to be able to plan feasible mitigation measures, which reduce or eliminate detrimental effects.

j) ***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.

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.

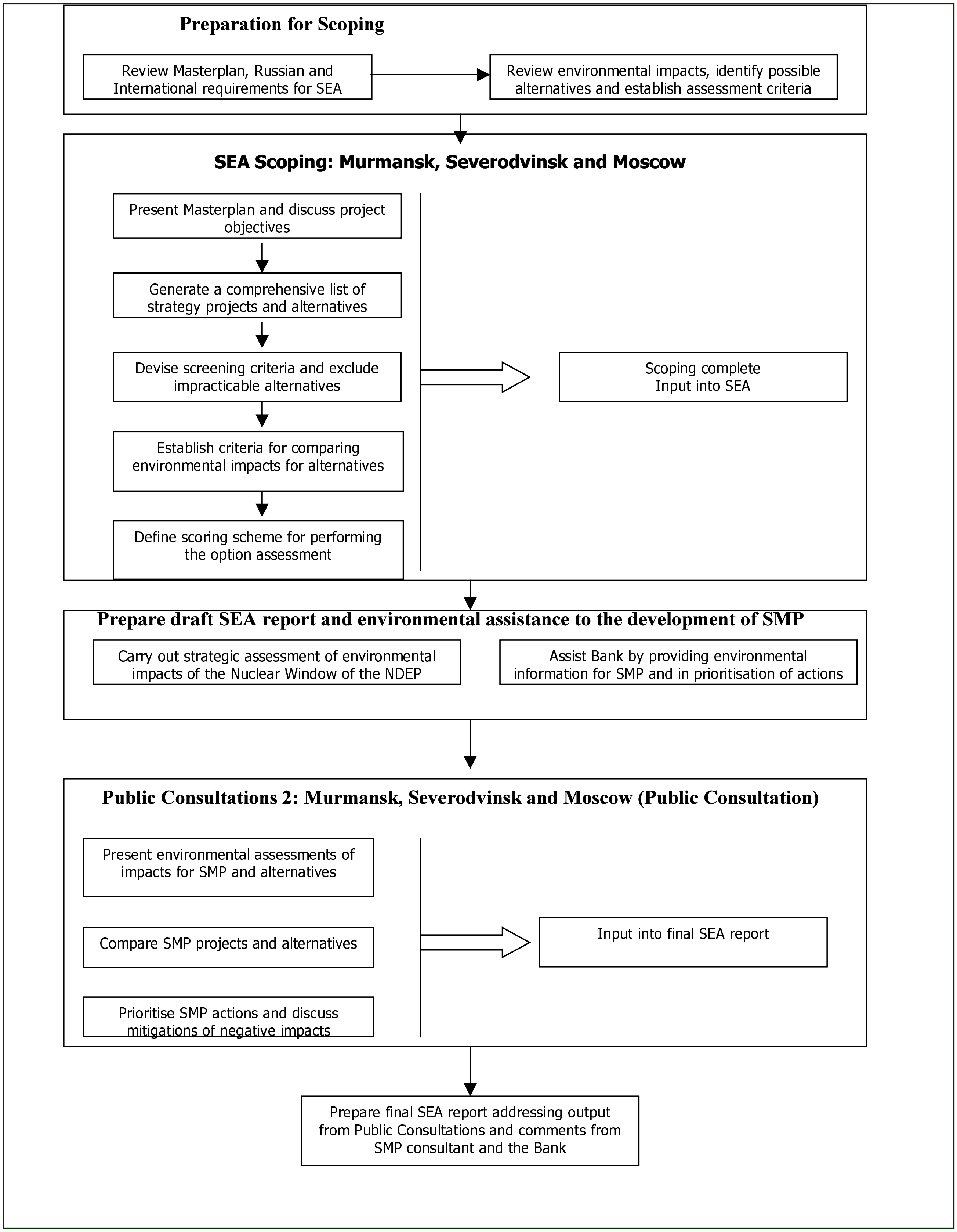


Figure 3.2.1-1. SEA Process

3.2.2 SEA Objectives

For the purpose of the SEA, the environment comprises three **environmental components,** that are the radiological and non-radiological, biophysical and the socio-economic features that are most likely to be affected by the various strategies.

The specific environmental components are identified in later sections along with the SEA objectives and corresponding indicators. The SEA objectives and indicators have been developed following consideration of comments provided during the scoping consultation.

The SEA **objectives** are goals intended to be attained within each environmental component. They represent the yardsticks against which the environmental effects of the various strategies are evaluated. They include worker, public and environmental protection objectives.

The **SEA indicators** are the specific measurable features that can be assessed, either qualitatively or quantitatively. The effects of the strategies in meeting the SEA objectives are evaluated using the SEA indicators by comparison with existing conditions, values reported in scientific literature, and/or international or Russian standards or guidelines.

The assessment methodology is based on the requirements of the EU Directive [EC, 2001a] and on the available guidance [ODPM, 2003]. In this subsection, the SEA objectives are identified first, followed by an introduction of regulatory framework applicable to the SEA. A description of the assessment method is presented, along with the determination of significance and assessment of secondary, cumulative and synergistic effects. Spatial and temporal boundaries are also defined.

3.2.3 Identification of SEA Objectives

"Environment" for the purposes of this assessment was divided into the following three components:

- **Radiological Environment**: radioactivity in the environment, including radionuclide emissions and doses to humans and biota from normal operations and accidents.
- **Non-radiological Environment** includes
  - **Safety of workers –** the non-radiological impacts on workers' health and
  - **Public safety**, which is assessed by evaluating:
    - **Atmospheric Environment -** air quality with respect to non-radiological parameters, including noise, and considers meteorological and climatic conditions.
    - **Surface Water and Terrestrial Resources -** surface water quality and conditions, soil and groundwater quality with respect to non-radioactive parameters.
    - **Aquatic and Terrestrial Ecology -** aquatic and terrestrial biota and habitat.
    - **Physical Protection –** protection from intentional intrusion and theft of radioactive materials
- **Socio-Economic and Cultural Considerations:** the population, the economic base, services, cultural and heritage resources, and the traditional use of land and resources.

Correspondingly, SEA objectives, as shown in the Table 3.2.3-1, are identified for the three environmental components, which might be affected during the implementation of the

Masterplan. The selection was based on the list of important assessment criteria defined by stakeholders during the scoping consultation (see Appendix A) as well as on indicators traditionally used for such assessments. Identified SEA indicators for each SEA objective are listed in the table as well.

Table 3.2.3-1. Environmental Components and Assessment Criteria

Environmental Component	SEA Objective	SEA Indicators	Rationale for Inclusion
Radiological environment	Limit radiation exposure to workers	• Individual doses • Collective doses	Radiation exposure of workers is a key consideration
	Limit radiation doses to members of the public	• Individual doses • Risk of nuclear (criticality) accidents • Risk of other accidents	Radiation exposure of members of the public is a key consideration. Scoping consultation identified nuclear safety as the key assessment criterion
	Minimise quantity of radioactivity potentially accessible to people and the environment	• Total inventory of SNF and waste requiring decommissioning	Clear measure of potential for exposure used in Masterplan Phase I.
	Limit radiation exposure of biota	• Radionuclide concentrations in biota • Radionuclide concentrations in physical environmental	Scoping consultation identified radioactive contamination of marine products as the key assessment criterion

Table 3.2.3-1. (cont.)

Environmental Component	**SEA Objective**	**SEA Indicators**	**Rationale for Inclusion**
Non- radiological environment	Improve worker health and safety	• Accident frequency (number of lost time accidents) • Accident severity (number of fatalities or serious injuries)	Scoping consultation identified that safety of workers is a major concern
	Avoid, remove or reduce sources of air pollution	Emission rates or loadings of non-radiological contaminants to the atmosphere: • Dust • Carcinogens • Non-carcinogens • Greenhouse gases • Ozone depleting substances	Scoping consultation identified consideration of impact of non-radioactive contaminants as an important issue
	Avoid, remove or reduce sources of water pollution	• Releases of non-radiological contaminants to surface water • releases of non-radiological contaminants to groundwater	Scoping consultation identified consideration of impact of non-radioactive contaminants
	Avoid contamination of biota with toxic substances	Concentration of toxic contaminants in biota	Scoping consultation identified consideration of impact of contamination of fish and marine biota
	Maintain or enhance biodiversity	Consideration of potential impact on habitats and species	Important SEA objective
	Maintain or improve natural resources	Consideration of effects on: • Forestry • Fishery • Agriculture • Tourism	Scoping consultation identified consideration of impact of fishery and forestry resources
	Improve physical protection	Risk of theft of nuclear materials and terrorist attacks	Scoping consultation identified physical protection as a major issue

Table 3.2.3-1. (cont.)

Environmental Component	SEA Objective	SEA Indicators	Rationale for Inclusion
Socio-economic considerations	Maintain or improve level of economic growth	• Employment level • Median income	Scoping consultation identified level of life
	Maintain or improve human health	• Life expectancy	Scoping consultation identified life expectancy
	Maintain or improve cultural and heritage resources	• Considerations of impacts on cultural and heritage resources	Important SEA objective

3.2.4 Definition of a scoring scheme

Secondly, the qualitative environmental assessment is performed to analyse the effect of each phase against indicators defined in Section 3.2.3.

As summarised in Table 3.2.4-1, scores of " - ", "0" and "+" will be used to illustrate the assessment results, based on the following criteria.

- **--: Significant adverse effect**, which has the potential to exceed regulatory limit or guidance, either Russian or international.

  If no data are available, and it is believed that the effect is likely to be significant, then a score of '**--**' will be assigned in accordance with the precautionary principle.

- **-: Measurable negative impact**, which is unlikely to exceed regulatory limit or guidance, either Russian or international.

  For the purposes of SEA 'measurable' is understood as potentially exceeding 'normal' or background values by more than 30%.

  If no data are available, but there are reasons to believe that the effect is not likely to be significant, then a score of '**-**' will be assigned in accordance with the precautionary principle.

- **0: No impact or negligible impact**

- **+: Positive effect** improvement to the current situation or mitigation of an existing adverse impact that is unlikely to exceed regulatory limit.

- **++: Significant positive effect**, significant improvement to the current situation or mitigation of an existing adverse impact which could breach regulatory requirements, either Russian or international.

If an assessment cannot be done using quantitative information, then a justified qualitative judgement is used based on the opinion of the authors of SEA report and taking into account Stakeholders' views.

Where an effect is identified as being adverse, possible feasible mitigation measures are identified as necessary to avoid or reduce the effect. All effects where mitigation measures are not possible, or where the effect remains after mitigation, are identified as being "residual adverse " and are advanced for further assessment of significance.

Table 3.2.4-1 : Assessment Criteria

Assessment Score	Assessment Criteria
- -	Potential to breach regulatory limit/guidance either Russian or international
-	Measurable negative impact, unlikely to exceed regulatory limit/guidance either Russian or international
0	No impact
+	Positive effect or mitigation of an existing negative impact
+ +	Mitigation of an existing negative impact which could breach regulatory limit/guidance either Russian or international

3.2.5 Determination of Significance

The significance of all residual adverse effects from all works and activities and from malfunctions and accidents is established within a framework of criteria and effect levels.

Each residual adverse effect is assessed using the following parameters:

- Magnitude **-** the size or degree of the impact compared against baseline conditions;
- Extent **-** the area over, or throughout which, the effects will occur;
- Duration **-** the time period for which the effect will last;
- Frequency **-** the rate of reoccurrence of the effect (or conditions causing the effect);
- Permanence **-** the degree to which the effect can be or will be reversed (typically as measured by the time it will take to restore the environmental feature);
- Probability **-** the likelihood or frequency at which the effect occurs
- Population – the number of people potentially affected during the implementation of the Masterplan.

In this final step of the assessment, each residual adverse effect is evaluated using each assessment criterion shown in Table 3.2.5-1 and assigned a significance level (low, moderate or high) that reflects the degree of impact that could reasonably be expected.

Table 3.2.5-1: Criteria of significance of residual effects

Assessment parameters	**Criteria of Significance of residual effects**		
	Low	**Moderate**	**High**
Magnitude	Effect is evident only at or nominally above baseline conditions	Effect exceeds baseline conditions, however is less than regulation values	Effect exceeds regulation values
Extent	Effect is limited to the site where the work performed	Effect extends beyond the site where the work performed but still within the study area	Effect extends beyond the study area
Duration	Effect is within the short term period defined in section 3 (0-10 years)	Effect is within the medium term period defined in section 3 (10-50 years)	Effect remains long term as defined in section 3 (>50 years)
Frequency /probability	The conditions causing the effect occur very infrequently (every 1000 years).	The conditions causing the effect occur at regular but infrequent intervals (every 10 years)	The conditions causing the effect occur at regular and frequent intervals (more often than once every 10 years)
Permanence/reversibility	Effect is readily reversible right after the occurrence	Effect is reversible during the implementation of the plan	Effect is not reversible and remains permanently
Population	<1 000	>1 000 <100 000	>100 000

Residual adverse effects are categorised as follows:

- Minor Adverse Effect (not significant) **-** The residual effect is minor and/or has been effectively mitigated through the identified mitigation measures; or
- Significant Adverse Effect **-** The residual effect is significant and further or more effective mitigation is not considered feasible.

As a fundamental principle it is established that a residual adverse effect would always be designated as significant if it was of high magnitude, high extent, and high duration. In this case it is necessary to consider how the Strategy can be changed so that the Effect does not arise.

3.2.6 Assessment of Secondary, Cumulative and Synergistic Effects

According to the SEA Directive, secondary, cumulative and synergistic effects should be considered when performing the SEA of a plan or a program.

Secondary effects are those that are not a direct result of the plan, but occur away from the original effect or as a result of a complex pathway. For example construction of a new reactor compartment storage facility may have an impact on groundwater table in the surrounding area, which in turn may affect biodiversity in that location.

Cumulative effects refer to the incremental environmental effects associated with the project added to or combined with effects from other anticipated projects, past, present and future, overlapping in type of effect, area of effect and period of effect. For example combined effect of radioactive releases from submarine dismantling and of radioactive releases from an oil platform being refurbished at the same shipyard is a typical cumulative effect.

Synergistic effects occur where the joint effect of two or more processes is greater than the sum of individual effects. If the total risk resulting from the combined effect of toxic carcinogenic releases and radioactivity were to be larger than the sum of these risks then such effect would be 'synergistic'.

Where there is a likely adverse cumulative, secondary or synergistic effect, mitigation measures are identified and the likely effect reconsidered to determine the residual condition. The significance of the residual adverse effects is assessed using the same significance criteria as specified in Section 3.2.5.

3.2.7 Regulatory framework for the SEA assessment methodology

In developing SEA assessment methodology, consideration was given to the relevant national and international regulations applicable to this SEA, including

- EBRD environmental policy, which is the main driver for the SEA process including consultation
- EU Directive 2001/42/EC of 27 June 2001 (later referred to as the SEA Directive) on the assessment of the effects of certain plans and programs on the environment [EC, 2001a]
- EU Guidance 'Implementation of Directive 2001/42 on the assessment of the effects of certain plans and programs on the environment' [EC, 2001b]
- UK Guidance on SEA implementation [ODPM, 2003]
- UN Convention on environmental impact assessment in a transboundary context, 25 February 1991 (Espoo Convention) [UN, 1991].

Table 3.2.7-1 provides a summary of where the key requirements of the EU Directive have been met in the SEA report.

Table 3.2.7-1. How the requirements of the EU Directive have been met.

SEA Directive or Guidance requirement	Where in the SEA report the requirement is met
Preparation of an environmental report in which the likely significant effects on the environment of implementing the plan or programme, and reasonable alternatives taking into account the objectives and geographical scope of the plan or programme, are identified, described and evaluated.	Current SEA report
An outline of the contents, main objectives of the plan or programme, and relationship with other relevant plans and programmes	Sections 1, 2 and 4
The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme;	Section 5
The environmental characteristics of areas likely to be significantly affected;	Section 5
Any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance	Section 5
The environmental protection objectives, established at international, Community or national level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation;	Section 3.2
The likely significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors. (Footnote: These effects should include secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative effects);	Section 7
The measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme;	Sections 6 and 7
An outline of the reasons for selecting the alternatives dealt with,	Section 4
Description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information;	Sections 5 and 7
A description of measures envisaged concerning monitoring in accordance with Art. 10 (c) (e)	Section 7

Table 3.2.7-1. (cont.)

SEA Directive or Guidance requirement	Where in the SEA report the requirement is met
A non-technical summary of the information provided under the above headings	Executive Summary
The report must include the information that may reasonably be required taking into account current knowledge and methods of assessment, the contents and level of detail in the plan or programme, its stage in the decision-making process and the extent to which certain matters are more appropriately assessed at different levels in that process to avoid duplication of the assessment	SEA Report
Monitoring of the significant environmental effects of the plan's or programme's implementation (Art. 10)	Requirements are identified in Section 7. Monitoring will be implemented after completion of the current SEA project

Application of Espoo Convention

Under this convention, Contracting Parties to the convention are required to undertake environmental impact assessments prior to authorizing activities that are listed in Appendix I of the Convention, which are likely to cause a significant adverse transboundary impact. The convention also outlines consultation requirements in potentially affected areas. Russia became a signatory to the Convention on the 6th June 1991, but has not yet ratified it. All the neighbouring countries have ratified the Convention.

Of the 17 activities that are listed in Appendix I of the Convention, only one 'Waste-disposal installations for the incineration, chemical treatment or landfill of toxic and dangerous wastes' is likely to be part of any SMP project. However, under Article 2(5), other activities not listed in Appendix I may be treated as if they were if is so agreed amongst the Concerned Parties. The criteria to assist in the determination of the environmental significance of activities not listed in Appendix I are given in Appendix III:

(a) Size: proposed activities which are large for the type of the activity;

(b) Location: proposed activities which are located in or close to an area of special environmental sensitivity or importance (such as wetlands designated under the Ramsar Convention, national parks, nature reserves, sites of special scientific interest, or sites of archaeological, cultural or historical importance); also, proposed activities in locations where the characteristics of proposed development would be likely to have significant effects on the population;

(c) Effects: proposed activities with particularly complex and potentially adverse effects, including those giving rise to serious effects on humans or on valued species or organisms, those which threaten the existing or potential use of an affected area and those causing additional loading which cannot be sustained by the carrying capacity of the environment.

Within the SEA (a) and (c) of Appendix III of the Espoo convention have been considered in terms of the impacts, see Table 3.2.5.1. Proposed location of activities is considered in Section 5.

As Russia has not ratified the convention, it is unlikely that an official letter will be issued by the Russian Government. However, representatives of the countries that may be affected by the Masterplan will be identified as stakeholders in the SEA and will be invited to participate in the public consultation.

3.2.8 Spatial and Temporal Boundaries

3.2.8.1 Spatial boundaries

Spatial boundaries define the geographical area within which environmental effects are considered. As such, these boundaries become the study areas adopted for the assessment. Study areas are defined as either regional or local. When environmental impacts are assessed, they are always assessed in relation to either the regional or one of the local study areas depending on the scale of the territory that may be affected. Information is therefore collated for each environmental component in relation to the study area that is affected. For the purposes of this assessment it is assumed that if a significant effect can be expected beyond the Regional Study area, then it would also be detected within the area.

The **Regional Study area** encompasses

- Murmansk and Arkhangelsk regions, including adjacent areas of the Barents and White Seas, which are used for spent fuel and radwaste shipping and storage and submarine towing (Figure 2.1-1).

- The Rail link from Murmansk and Severodvinsk to Mayak, which is used for transporting spent nuclear fuel.

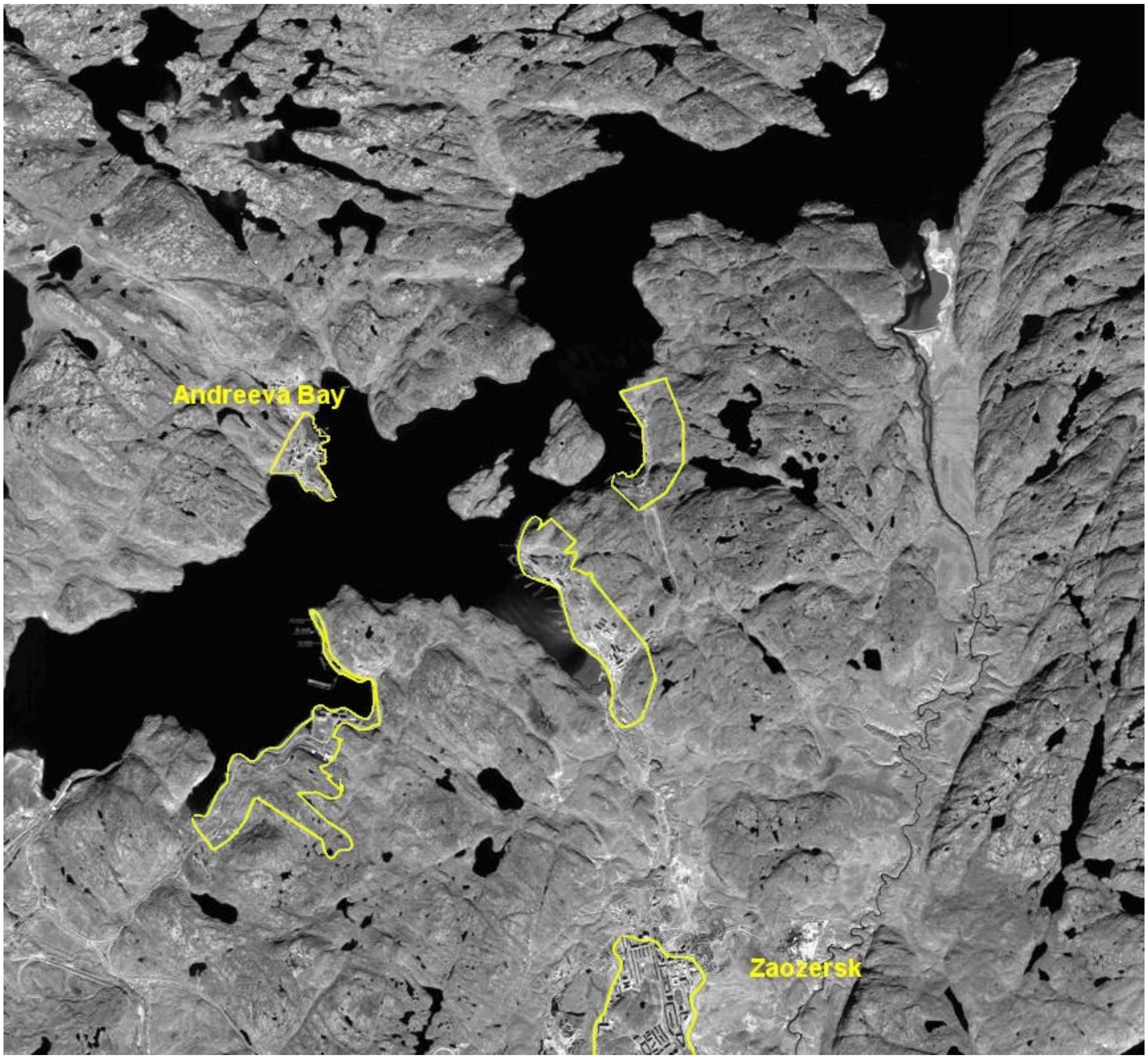
Local Study areas include

Murmansk Region

- Coastal maintenance bases at Andreeva bay (Figure 3.2.8.1-1) and Gremikha (Figure 3.2.8.1-2) in the Murmansk region, which store radioactive waste and spent nuclear fuel in poor conditions.
- Sayda Bay in the Murmansk region, where reactor compartments are stored after submarine dismantling (Figure 3.2.8.1-3).
- Other naval bases and waste management facilities in the Murmansk region where submarines which have been withdrawn from active service are currently stored.
- Nerpa and Polyarny shipyards in Murmansk region where the submarines are defuelled and dismantled (Figures 3.2.8.1-4 and 3.2.8.1-5).
- RTP Atomflot facility near Murmansk where nuclear powered icebreakers are serviced and which provides a transport link for transferring spent nuclear fuel to Mayak.

Arkhanglesk Region

- Areas surrounding Zvezdochka and Sevmash shipyards in Severodvinsk, Arkhangelsk region, where the submarines are defuelled and dismantled, and where the nuclear-powered cruiser Ushakov which has been withdrawn from service is stored (see Figure 3.2.8.1-6).



Source: http://www.globalsecurity.org/military/world/russia/images/ikonos_browse_andreeva_100-1.jpg

Figure 3.2.8.1-1 Local Study Area, Andreeva Bay

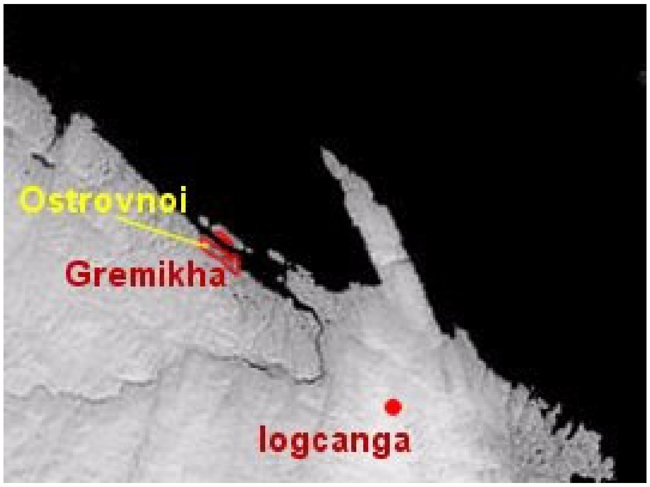


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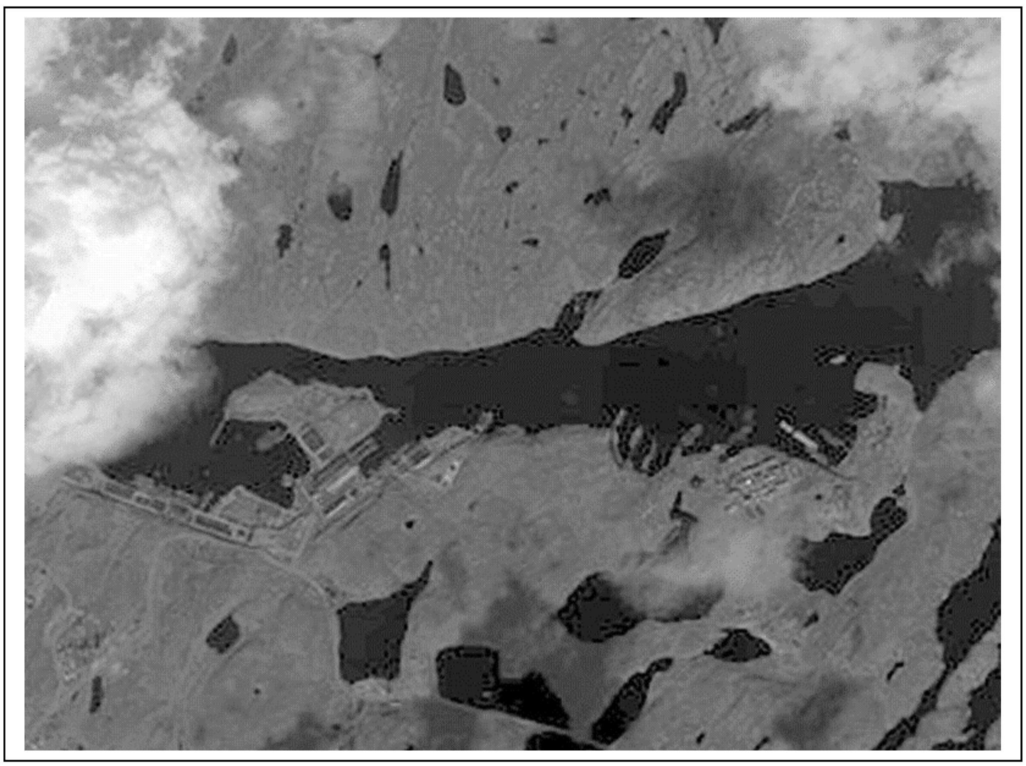
Figure 3.2.8.1-2 Local Study Area, Gremikha

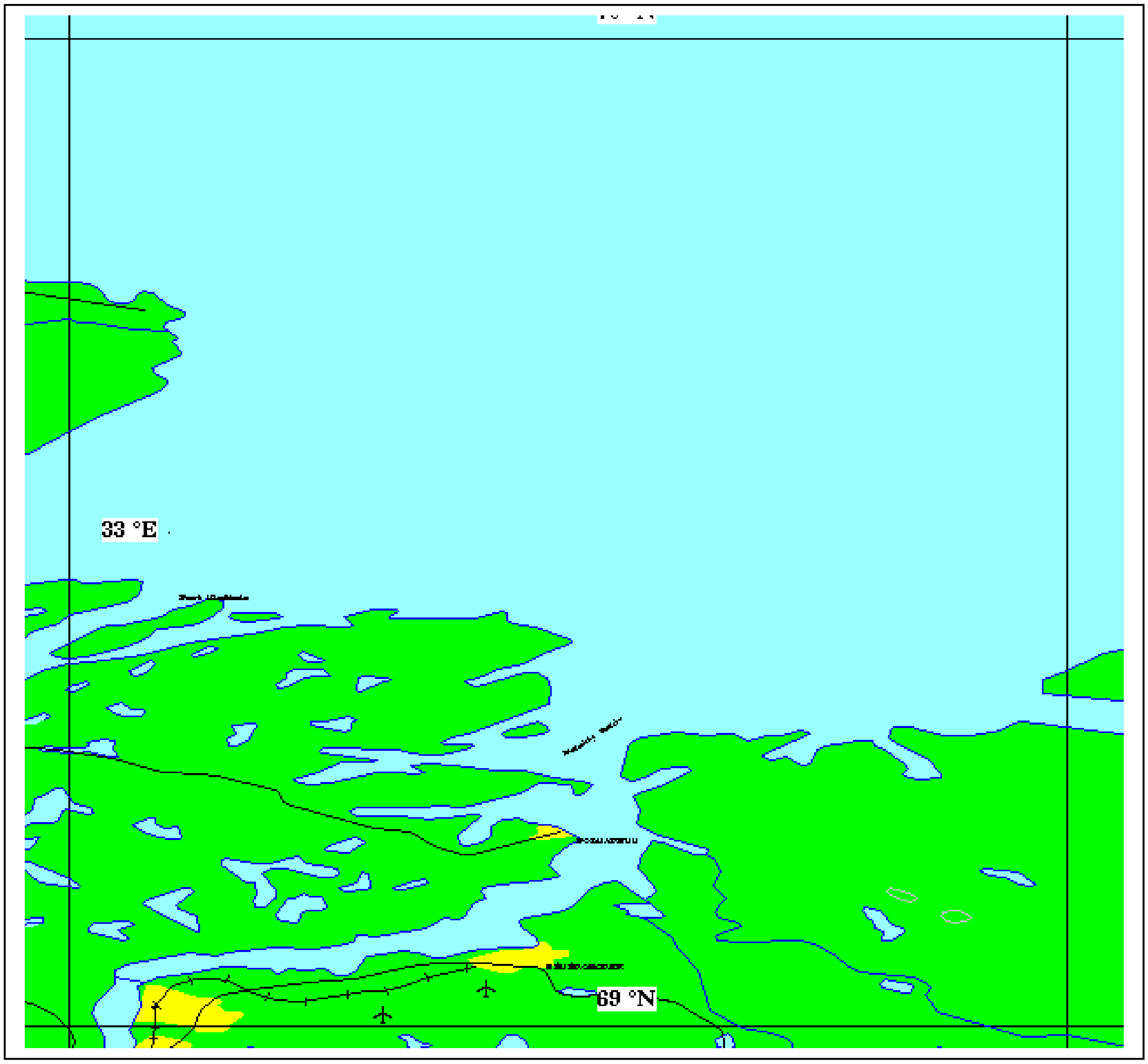


Source: http://www.globalsecurity.org/military/world/russia/images/ikonos_browse_olenya_050-1.jpg

Figure 3.2.8.1-3 Local Study Area, Sayda Bay

Source: http://www.globalsecurity.org/military/world/russia/snezhnogorsk.htm

Figure 3.2.8.1-4 Nerpa - Local Study Area



Source: http://www.globalsecurity.org/military/world/russia/polyarny.htm

Figure 3.2.8.1-5 SRZ-10 - Local Study Area

Figure 3.2.8.1 -6 Local study area Andreeva Bay– Zvezdochka and Sevmash shipyards.

3.2.8.2 Temporal Boundaries

The environmental effect of each strategy will be assessed over the whole period of potential impact. The significance of each effect will be assessed depending on potential duration:

- Short term impact: up to 10-20 years from now. This is the period of time over which, it is assumed, most of the Masterplan projects will be completed.
- Medium term: up to 60-80 years from now (human lifetime).
- Long term: beyond 60-80 years from now.

4.0 DEFINITION OF STRATEGIES AND ALTERNATIVES

4.1 Strategies

Four strategies have been identified from 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 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 (b)]. 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.

The Scoping consultation 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].

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.

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

In addition, the scoping consultation 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.

4.2 Decommissioning of Nuclear Powered Submarines

The work and activities involved in nuclear submarine decommissioning project could be grouped into six principal phases:

1. **Submarine transportation**. This phase involves towing to the shipyard for dismantling.

2. **Submarine dismantling.** This phase involves removal of wastes and spent nuclear fuel from the submarine and cutting out the fore and aft compartments.

3. **Management of reactor compartments.** This stage involves preparation for long-term storage and the storage itself.

4. **SNF management.** Storage, processing and disposal of spent nuclear fuel.

5. **Radwaste management.** Storage, processing and disposal of radioactive waste.

6. **Management of other wastes**. Storage, processing, recycling and disposal of non-radioactive waste.

In the following subsection, the major activities in each phase will be briefly reviewed.

Figure 4.1.1 -1 presents a schematic overview of the nuclear submarine decommissioning process.

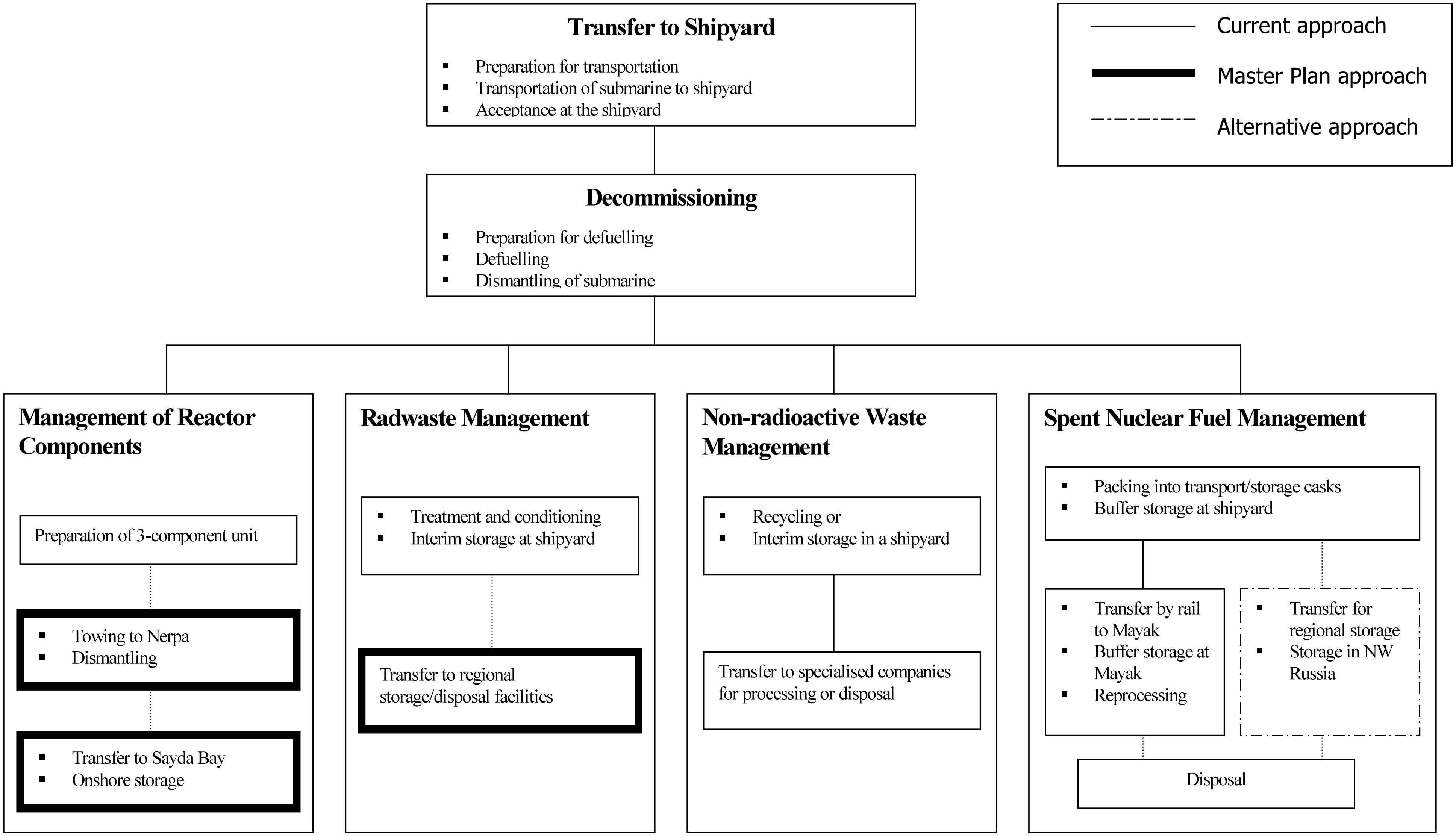


Figure 4.1.1–1 Nuclear Submarine Decommissioning Strategy

4.2.1 Transportation Phase

The decommissioning process begins with the transfer of the vessel to a civilian crew and preparation for transit, which takes approximately two months. After thorough inspection and repair, including vacuum and positive pressure testing of compartments and ballast tanks, removal of flammable materials and a radiological survey, a towing plan is finalized based on the assessment of the vessel.

At this stage the submarine's reactors will have been shutdown for at least 3 years following their withdrawal from active service. Control rods will have been fully inserted within the core with the electric removal mechanism disabled.

Towing of a submarine is typically performed by two tugs, comprising a main and an "auxiliary" vessel. Since the sinking of the K-159 submarine during towing, towed submarines have had no personnel onboard during this operation.

Prior to the sinking of the K-159, submarines with badly damaged hulls were towed with the assistance of additional air-tight tanks, which were used as floatation aids – see Figure 4.1.1.1-1. According to the Masterplan such towing is now believed unsafe. According to Masterplan, ***there is a plan to rent floating docks for towing out-of-service submarines from naval bases to dismantling shipyards***.

At 'Arrival and Acceptance' the submarine is moored at the designated shipyard, and the shipyard assumes all responsibility for the vessel.

Figure 4.2.1-1 Towing of K-159 with Floatation Assistance

4.2.2 Dismantling Phase

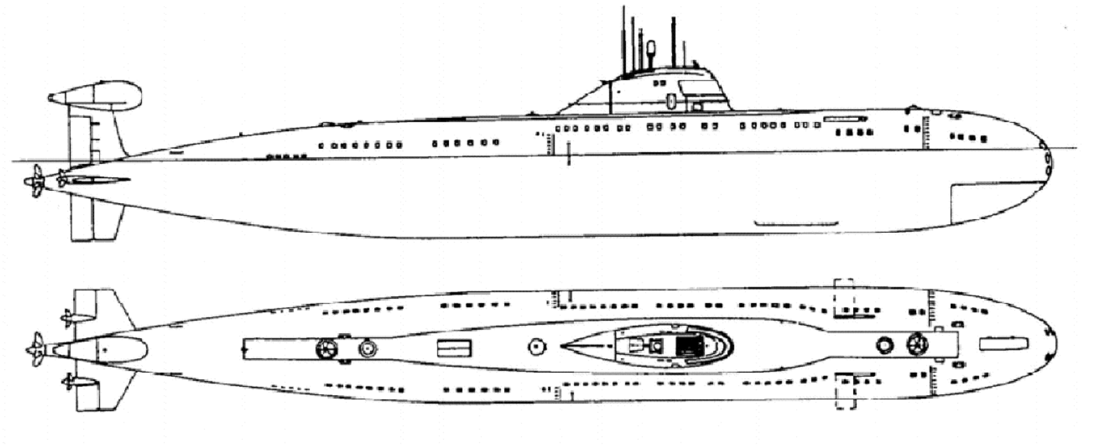
Preparations for Reactor Defuelling follows acceptance of each submarine. All equipment, supplies, infrastructure and required permits are put in place. ***Solid and liquid radioactive waste are removed from the submarine***. If processing facilities are available then the wastes are processed at the shipyard. At Zvezdochka and RTP Atomflot, wastes are directed to special radioactive waste management facilities. Elsewhere the wastes are stored with liquid wastes being shipped to RTP Atomflot or Zvezdochka shipyard.

The submarine is prepared for the actual process of removing SNF. In all, this typically takes 2 - 3 months. Zvezdochka is the only shipyard which has a land-based defuelling facility, other dismantling shipyards use PM 'Malina' vessels for defuelling afloat.

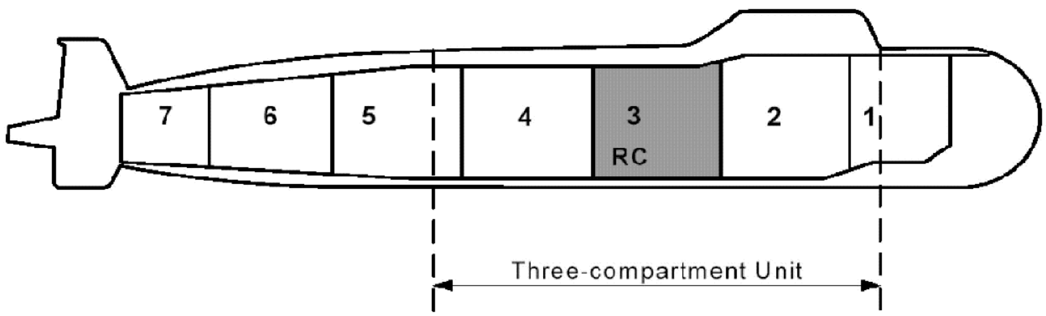
A guiding device and transfer casks are used to retrieve fuel assemblies from submarine reactors one a time. Assemblies are placed into canisters. At Zvezdochka canisters are then placed either into special shielded transport and storage containers (also called "casks"). Elsewhere defuelling canisters are placed into specialised transport/storage vessels. This process can take 2 months.

The defuelled submarine is then subject to 'Preparation for Submarine Dismantling'. The reactor compartment, which contains some radioactivity because of trace contamination and activation, is segregated from the non-radioactive parts of the submarine through the construction of the 'Three-Compartment Unit', which typically takes 3 - 6 months. Zvezdochka for example, can form four to five three-compartment units per year. Essentially, the reactor compartment and its two neighbouring compartments are cut out and reconfigured into a water-tight unit. The sections are illustrated schematically in Figure 4.1.1.2-1.

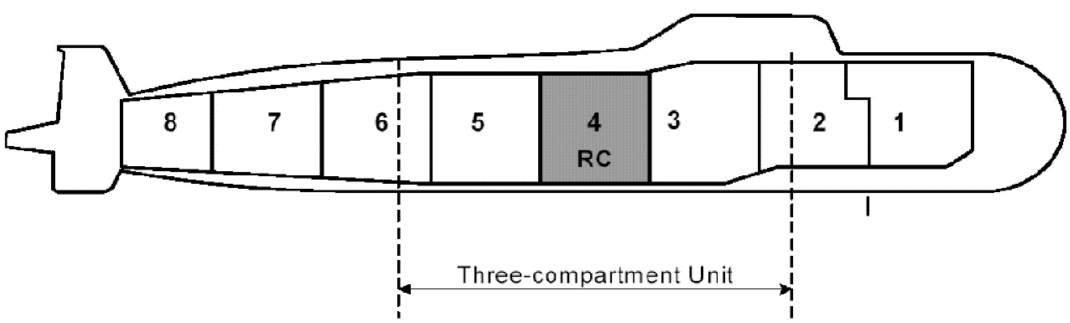
While the three-compartment unit is being finished, the dismantling of the fore and aft compartments proceeds. Materials are recycled as far as possible.



General view of «Viktor-class» submarine



NPS (Victor I Class) Separation into Units According to the Three-compartment Variant.



NPS (Victor III Class) Separation into Units According to the Three-compartment Variant.

Source: Sverodvinsk, 2004

Figure 4.1.1.2-1 Schematic of the submarine three-compartment unit

4.2.3 Reactor Compartment Management Phase

The three-compartment unit, which includes the reactor compartment, is subject to 'Preparation of Reactor Compartment for Transportation' which takes 4-9 months. In accordance with the Masterplan strategy it is envisaged that ***Nerpa shipyard*** will provide facilities for ***interim storage afloat*** for up to 15 years, after which the ***reactor compartment will be separated from the adjacent buoyancy compartments*** of the three-compartment unit. It will then be transported by barge to a ***storage pad at Sayda Bay***, where it will be stored for 70 years.

4.2.4 Spent Nuclear Fuel Management Phase

From the SEA perspective, work and activities associated with spent nuclear fuel management will be divided into two stages.

The first stage is the temporary storage of spent nuclear fuel after defuelling and the transportation of SNF within the region. This can be done using:

- ***a land-based fuel storage facility*** which stores licensed storage/transport casks TK-18 or TK-108 containing spent fuel at Zvezdochka shipyard. From this facility casks can be loaded directly into special trains for subsequent transportation to Mayak.

- **a new land-based fuel storage facility** which will be commissioned at RTP Atomflot in 2005.

- ***defuelling, transportation and storage vessels,*** which store and ultimately transport canisters of fuel to RTP Atomflot for subsequent packaging into casks and transportation to Mayak (Nerpa, SRZ-10). As identified in the Masterplan a number of the vessels involved in defuelling, SNF storage and transportation require repair and maintenance, these have been planned by the Russian Federation.

The second stage will include the transportation of spent nuclear fuel from Zvezdochka or Atomflot to either

- ***SNF reprocessing facility at Mayak*** in the Southern Urals and subsequent storage of vitrified high-level waste (Masterplan). Masterplan also proposes construction of a new buffer spent fuel storage facility at Mayak, where fuel will be stored prior to reprocessing.

- ***Long-term spent fuel storage at a regional storage facility*** (an alternative strategy).

It should be noted that neither Zirconium-clad fuel nor damaged fuel can be reprocessed at Mayak at the present time, though there are plans to develop new facilities, which would allow reprocessing of the damaged fuel at Mayak. In any case Zirconium-clad fuel would have to be stored in North-West Russia.

Ultimately Russian policy envisages ***geological disposal***, possibly in North West Russia; however currently there are no specific plans.

4.2.5 Radwaste Management Phase

Shipyards are responsible for the management of radioactive wastes. This entails processing solid and liquid wastes generated during dismantling, releasing treated liquids and storing residual solids. Liquid waste treatment facilities are only available at Zvezdochka and RTP Atomflot.

At present all conditioned and packaged solid wastes from submarine dismantling are either temporarily stored at the shipyards or placed within reactor compartments. The latter practice is constrained by the weight of the waste that can be safely placed within the three-compartment unit without affecting its buoyancy.

The Masterplan identifies transfer to a ***future regional radwaste disposal facility*** as the long-term strategy. In the interim the intention is to ***build a facility for processing and storage of solid radioactive waste on the Kola Peninsula.*** It is proposed that this is at Andreeva Bay, however, no decision has been made on which wastes it will accept and from where.

4.2.6 Non-radioactive Waste Management

At Zvezdochka a significant proportion of such wastes is recycled (e.g. cabling, rubber); other wastes are either stored on site or transferred to plants in Severodvinsk or St Petersburg for processing and disposal. There is no information on the management of toxic wastes at Nerpa or SRZ-10.

The Masterplan states the objective is to ***develop technology for safe processing of toxic wastes*** as opposed to long-term storage in the region.

At the same time there is an ***existing Russian project to commission a new regional facility for processing and storage of toxic wastes***. Information suggests no decision has been made on the location or capabilities of this facility.

4.2.7 Decommissioning of Alpha-class submarines and submarines in poor condition

The above submarine decommissioning strategy applies to submarines with pressurized water reactors that are in good condition radiologically. Currently there is ***no strategy for decommissioning Alpha-class submarines or submarines that cannot be decommissioned using standard technologies due to heavy contamination***.

It is intended that the defuelling of Alpha-class submarines will take place in the dry dock facility in Gremikha, once the facility has been refurbished.

Once reactor cores from Alpha-class submarines are placed into storage at Gremikha, they, according to Masterplan, present a significant potential nuclear explosion risk. The Masterplan proposes to repair the storage buildings. This would provide a temporary solution until new technologies can be developed.

The Masterplan also states that there is an existing Russian project to develop infrastructure for the transportation and processing of spent fuel cores from Alpha-class submarines. There is no information on the scope or approach to be used in this project.

Alpha-class submarine No 910 has serious radioactive contamination and the Masterplan identified the need to ***develop a special approach for defuelling of Alpha-class submarine No 910***.

Based on the available information, there is only one submarine with a pressurized water reactor that has suffered a serious accident in North West Russia. It is understood that K-192 is being stored at Sayda Bay [Rosatom, 2005]. Although the Masterplan says that this submarine has not been defuelled more recent information [Rosatom, 2005] suggests that the missile compartment and fuel have been removed. ***The Masterplan does not identify***

any management issues for the dismantling of K-192 submarine with the damaged PWR reactor.

4.3 Decommissioning Nuclear-powered Surface Ship

Nuclear Powered surface cruisers have never been decommissioned or defuelled. It is not clear whether additional infrastructure will be required; it may be feasible to use the same technology as is used for defuelling icebreakers. The current phase of the Masterplan does not provide a decommissioning strategy for these vessels.

Nuclear ice-breakers are regularly defuelled. However, there is no decommissioning experience for these vessels. The Masterplan states that there is no requirement to decommission these vessels in the foreseeable future.

The Masterplan proposes to construct an ***interim fuel storage facility at RTP Atomflot***, which will be used for non-reprocessable fuel, including Zirconium-clad fuel from ice-breaker reactors.

4.4 Decommissioning of Maintenance Vessels

As discussed above, ultimately the strategy is to decommission maintenance vessels, as in the case of nuclear submarines. However, only decommissioning of Lepse has been identified as a priority.

According to the Masterplan, maintenance vessel decommissioning will be carried out in two stages.

During the first stage, all spent nuclear fuel, liquid and solid radioactive wastes will be removed from the vessels. Then the maintenance vessels will be sealed for safe storage afloat.

The ultimate decommissioning of maintenance vessels will be carried out after the creation of the regional storage facility for radwaste reprocessing and storage. Please refer to Figure 4.1.1-1 for the phased work and activities during this stage.

If any part of the maintenance vessel is radioactively contaminated, up to levels which prevent their safe dismantling and transfer for reprocessing, these parts of maintenance vessel should be converted, along with the hull structures, into special units for long- term storage.

The Masterplan identified the decommissioning of Lepse as one of the high priority tasks.

4.5 Rehabilitation of Coastal Maintenance Bases

The work and activities involved in rehabilitation of coastal maintenance bases can be grouped into four principal phases: preparation for rehabilitation, spent nuclear fuel management, radwaste management, and rehabilitation of contaminated objects. In the following subsection, the major activities in each phase will be briefly reviewed. Representative malfunctions and accidents are described separately.

Figure 4.5-1 outlines the strategy for environmental rehabilitation of coastal maintenance bases.

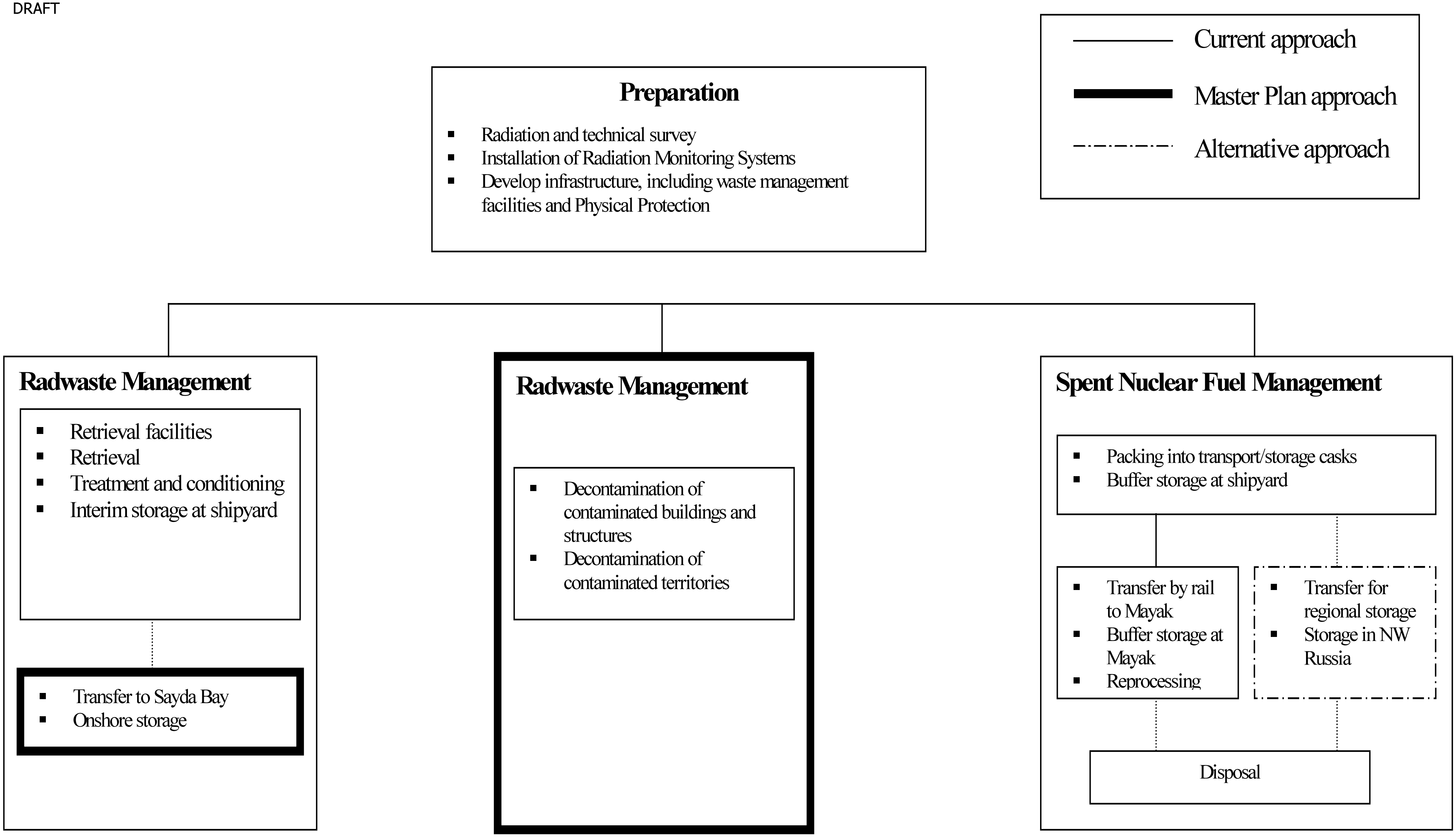


Figure 4.5-1 Environmental rehabilitation of coastal maintenance bases

4.5.1 Preparation for rehabilitation

An integrated engineering and radiation survey will be performed to investigate the technical conditions and radiation levels of buildings, structures, land and water in and around the Coastal maintenance bases. The radiation survey will also seek to clarify the quantities, types and conditions of spent nuclear fuel and radwaste.

Infrastructure development will include installation of monitoring systems, construction of a waste management facility to store waste generated during the rehabilitation, reconstruction of a 'Spent Removable Core' storage facility and restoration of infrastructure for spent nuclear fuel management in coastal maintenance bases storage facilities. Measures for physical protection of nuclear materials should be in place.

4.5.2 Spent nuclear fuel management

Planned management of spent nuclear fuel at coastal maintenance bases comprises

- Removal of spent nuclear fuel from the current storage facilities.
- Transfer of SNF into suitable transport containers. The Masterplan does not specify whether or not damaged fuel will be retrieved from the existing containers prior to shipment to Mayak. This issue will be addressed at a future stage.
- Shipping of spent nuclear fuel to Atomflot. This will require upgrades to the existing infrastructure at Andreeva Bay and Gremikha.
- Transport of spent nuclear fuel by rail to the reprocessing facility at Mayak, in the Southern Urals.
- Reprocessing of spent nuclear fuel
- Long-term storage and subsequent disposal of the resulting waste, possibly in North West Russia.

4.5.3 Radwaste management

Radwaste management involves

- Retrieval of radioactive waste from damaged stores
- Conditioning, treatment and encapsulation
- Packaging
- Long-term storage and disposal

It is planned to build a number of radwaste management facilities, including long-term storage facility at Andreeva Bay. At Gremikha it is planned to package the waste for shipment to Andreeva Bay.

4.5.4 Rehabilitation of contaminated objects

This phase involves

- decontamination and dismantling of contaminated buildings, structures and territories.

- Radioactive wastes will be managed in accordance with the approach specified in Section 4.5.3.

4.6 Alternatives

According to the Masterplan, all spent nuclear fuel, after short-term storage in the shipyard, will be transferred to Mayak for reprocessing and subsequent storage and/or disposal. Alternatively, the spent nuclear fuel could be transported to a regional storage facility established in North West Russia for long-term storage or disposal without further reprocessing. From the SEA perspective, this option has been identified as the alternative to the Masterplan and will be compared and assessed in this report.

"Business as usual" will be considered as another alternative and taken through the assessment.

4.7 Masterplan Phases Common to All Strategies

A number of measures have been identified within the Masterplan which are not specific to any of the four strategies. These include measures to:

- ***Ensure the safe storage afloat of submarines, which have been withdrawn from service, surface vessels and reactor compartments***. This is an existing project which has been ongoing in Russia since 2003. It is not known what measures have been implemented within the project, however, it may involve a combination of measures such as

    a) regular inspections,

    b) regular in-dock servicing, such as repainting to prevent corrosion.

    c) developing of infrastructure to ensure that in-dock servicing can be implemented.

- ***Provide physical protection at all sites***. This may involve a combination of automatic intruder detection systems and CCTV, provision of physical barriers, locks, fences and guards, provision of radioactivity detection systems and provision of rapid reaction forces.

- ***Remove bottlenecks and improve safety*** examples of such projects envisaged within the Masterplan include

    - construction of a new bridge over Nikolskoye Ustiye to increase the rate and safety of spent nuclear fuel transfer from Zvezdochka shipyard.

    - Provision of regional and site emergency monitoring and management systems in Murmansk and Arkhangelsk regions.

5.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 Introduction

This section provides an assessment of existing environmental conditions for the regional and local study areas.

For the purposes of this SEA, "existing environmental conditions" are defined as those of the last decade (1990 to 2000), supplemented by more up-to-date information where available. The assessment focuses on areas known or likely to be effected by the Masterplan.

With respect to the criteria of Appendix III of the Espoo Convention (see Section 3.2.7) there are no sites of special interest.

The existing environment is assessed according to the Environmental Components presented in Table 3.2.3-1:

- Radiological Environment,
- Non- Radiological Environment, and
- Socio-Economic Considerations.

5.2 Radiological environment

The SEA objectives associated with the radiological environment are:

- To Limit radiation exposure to workers
- To Limit radiation doses to members of the public
- To Minimise the quantity of radioactivity potentially accessible to people and the environment, and
- To Limit radiation exposure of biota.

The current exposure levels of the workers, public and biota are all influenced by the levels of radioactivity in the environment: the air, water and soil. Potential exposure is dependent on the quantity of radioactivity that could be released to the environment. Available data on the current radioactivity levels in the three environmental media are presented in this section along with information on doses to workers, public and biota. Summary of the information collated for the local study areas is presented in Table 5.2-1 with more detailed information provided in subsequent sections.

Radioactivity levels are compared to the Russian permissible levels, where available, to give an indication of the acceptability of the existing situation. Some marine radioactivity data are also benchmarked against environmental radioactivity levels in European seas.

Information on risks of accidents at nuclear facilities for the 'business as usual' strategy is provided in Section 5.2.8.

Table 5.2-1. Current situation – Impacts of Radioactivity on the environment

Facility			Radioactivity in Water	Radioactivity in Soil and Sediments	Radioactivity in Biota
	Aerosol	Gamma Dose Rate			
Zvezdochka	0 24-52x10^{-5} Bq/m^3 [SMP 2004]*	0 On site measurements of 9x10^{-5} – 1.4 x 10^{-4} mSv/h [Kennett, Gerchikov, et al 2001]	0 Data – well below MAL** [Nikitin, V.S. 2004]	- Data – well below MAL but above background. Waste store 162 is a potential source of contamination [Nikitin, V.S. 2004; Sarkissov, Edson, et al 2003]	- There are no site-specific data. However AMAP and Russian data in the coastal areas of the Murmansk and Arkhangelsk region show that Sr-90, Cs-137 concentrations in commercial marine products are consistent with or below the levels measured elsewhere in the Arctic region [AMAP, 2004].
Sevmash	0 11-28x10^{-5} Bq/m^3 [SMP, 2004]	-- No data	0 2.6Bq/l – well below MAL[Kennett, Gerchikov, et al 2001]	0 5-48Bq/kg – well below MAL[Sarkissov, Edson, et al 2003]	- As for Zvezdochka

Legend

+	Positive effect
++	Significant positive effect
-	Measurable negative impact
--	Significant adverse effect
0	No impact or negligible impact

* No MPC value provided in the reference.

Masterplan states: "Many years of observations of the man-made radionuclide content in the FSUE Zvezdochka, SUE PO Sevmash and the town of Yagra territories (the northeast section of the city of Severodvinsk) have shown concentrations that are not large and correspond to 10^{-5}–10^{-7} of the maximum permissible concentrations (MPC)"

** Maximum Allowable Levels (Russian Standards)

Table 5.2-1. (cont.)

Facility	Aerosol	Gamma Dose Rate	Radioactivity in Water	Radioactivity in Soil and Sediments	Radioactivity in Biota
Nerpa	- Masteplan states that these data are typical for all areas close to nuclear facilities. Supported by one set of data for Nerpa shipyard which give Sr-90 values which are of the same order of magnitude as those measured for Arkhangelsk region [SMP 2004]	0 no substantial contamination [SMP 2004[4]]	0 no substantial contamination [EBRD 2004]	0 Cs-137 2-14Bq/kg; Co-60 1-12Bq/kg – well below MAL [SMP 2004]	- As for Zvezdochka
SRZ-10		-- No data	-- No data	-- Values below MAL – but values for the 3 year period from 1995 – 1997 showed an 8 fold increase.	- As for Zvezdochka
Andreeva Bay		-- (Worker Dose) On site measurements up to 500 µSv/h [SMP 2004]	-- No data	-- Significant increases in radioactivity levels – indicating loss of containment at several facilities. Cs-137 concentration in sediments of 100-1000 Bq/kg dry weight [SMP 2004].	- As for Zvezdochka

Legend

- \+ Positive effect
- ++ Significant positive effect
- \- Measurable negative impact
- -- Significant adverse effect
- 0 No impact or negligible impact

[4] Masterplan Chapter 2, p 67 but no accompanying figures are given.

Table 5.2-1. (cont.)

Facility	Aerosol	Gamma Dose Rate	Radioactivity in Water	Radioactivity in Soil and Sediments	Radioactivity in Biota
Gremikha		-- (Worker Dose) On site measurements up to 500 µSv/h [SMP 2004]	-- No data	-- Hot spots of extremely high concentrations in sediments. Cs-137 values greater than MAL (up to 4000 Bq/kg dw). [SMP 2004]	- As for Zvezdochka
Atomflot		-- according to the Masterplan, such data should be available but could not be located	-- No data	- Data above background but below MAL [SMP 2004]	- Cs^{137} concentration of 0.3-1.0 Bq/kg in Kola Bay [Matishov, 1997] No information on more recent measurements
Sayda Bay		-- No data	-- No data	0 Cs-137 3-34Bq/kg; Co- 60 0.7-12 Bq/kg- Well below MAL [SMP 2004]	- As for Zvezdochka

Legend

+	Positive effect
++	Significant positive effect
-	Measurable negative impact
--	Significant adverse effect
0	No impact or negligible impact

5.2.1 Radioactivity in Air

5.2.1.1 Aerosol Activity

Data on the radionuclide content of air local to the sites in the Arkhangelsk region are provided in the Masterplan. The radioactive substance content of the atmospheric air in the enterprises' locations does not differ, in practice, from the background (Table 5.2.1.1-1). Many years of observations of the man-made radionuclide content at Zvezdochka, Sevmash and the territories of Yagra town (the northeast section of the city of Severodvinsk) have shown that levels of activity in the air are average for the region and correspond to 10^{-5}–10^{-7} of the maximum permissible concentrations (MPC).

Table 5.2.1.1-1: Total specific beta-activity of aerosols and atmospheric fall-outs in the territories of enterprises involved in NS decommissioning, neighbouring cities and background [SMP, 2004]

Facility	Indicator	Average	Range
Zvezdochka	Aerosol activity, 10^{-5} Bq/m^3	34	24-52
	Fall-out density, Bq/m^2·month	9	5-17
Sevmash	Aerosol activity, 10^{-5} Bq/m^3	20	11-28
	Fall-out density, Bq/m^2·month	10	8-14
Severodvinsk	Aerosol activity, 10^{-5} Bq/m^3	24	10-34
	Fall-out density, Bq/m^2·month	9	7-11
Average in the Murmansk region (including sampling points in Murmansk, Ostrovnoi and Polyarny [Gidrometeoizdat, 2004]	Aerosol activity, 10^{-5} Bq/m^3	6.7 10	3-15 N/A
Polyarny [Gidrometeoizdat, 2004]	Fall-out density, Bq/m^2·month	1	N/A
Murmansk [Gidrometeoizdat, 2004]	Fall-out density, Bq/m^2·month	0.4	N/A
Region background (over 100 km from shipyards)	Aerosol activity, 10^{-5} Bq/m^3 Fall-out density, Bq/m^2·month	22 10	14-45 6-16
Background in the territory of Russia	Aerosol activity, 10^{-5} Bq/m^3 Fall-out density, Bq/m^2·month	19 44	10-36 36-48

In the Murmansk region there are nine locations where radionuclide fallout density and aerosol activity is monitored on a regular basis [Gidrometeoizdat, 2004]: Murmansk, Kandalaksha, Monchegorsk, Ostrovnoi, Zasheek, Pechenega, Polyarny, Teriberka, Barentzburg. In addition there are three air sampling monitoring points in Murmansk, Kandalaksha and Zasheek.

In these locations the average monthly concentration of beta-emitters in air in 2003 ranged between 3×10^{-5} Bq/m^3 to 15×10^{-5} Bq/m^3. Average annual concentration of beta-emitters was consistent with the data for the previous years and at 6.7×10^{-5} Bq/m^3 was less than half of the average value for the whole of Russia in 2003 (15.9E-5 Bq/m^3).

Average annual concentration of ^{137}Cs and ^{90}Sr in aerosols near ground level in Murmansk in 2003 was 1.5×10^{-7} and 0.45×10^{-7} Bq/m^3 respectively.

Available data indicate that concentrations of man-made radionuclides in air do not exceed 10^{-5}–10^{-7} MPC and are consistently below the Russian average at the facilities in Severodvinsk and at the monitoring locations in the Murmansk region. Therefore it seems extremely unlikely that in ambient conditions airborne contamination in the Murmansk or Arkhangelsk region will have a significant impact on dose to workers, the public or biota.

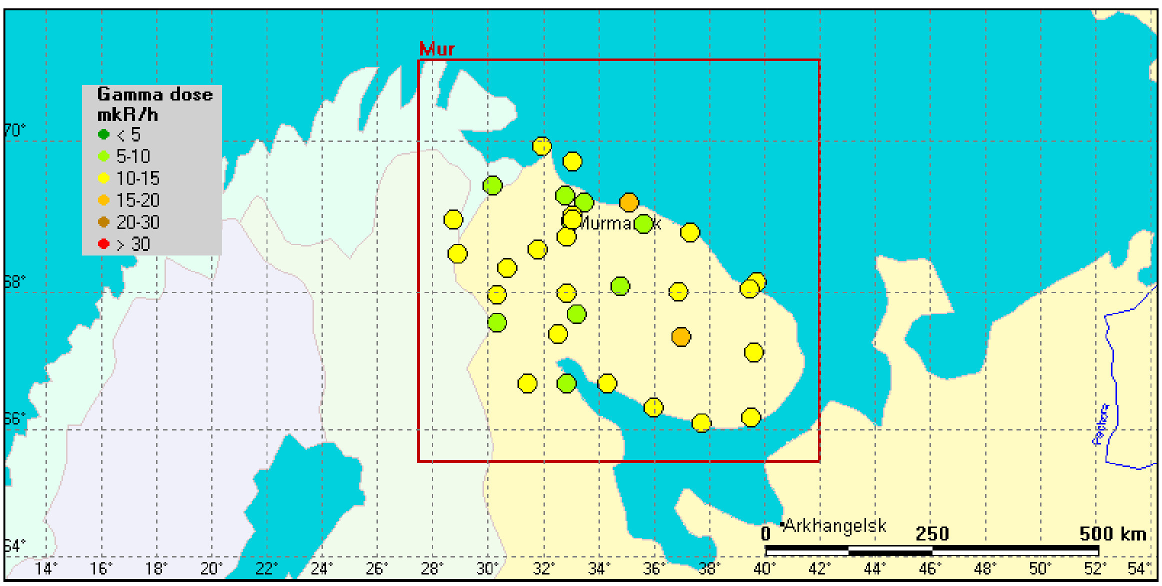
5.2.1.2 Gamma radiation

Murmansk region

In 2003 the gamma dose rate was continuously monitored in 35 locations in the Murmansk region [Gidrometeozidat, 2004]. Average annual dose rates in settlements adjacent to the shipyards and naval bases indicated radiation levels consistent with background (less than 0.2 µSv/h).

Figure 5.2.1.2-1 shows radiation level (gamma dose rate) on December 1, 2004 in monitoring points located in various settlements in Murmansk region. The dose rates shown do not exceed 2 µSv/h and are consistent with average background radiation levels typical throughout the region and worldwide.

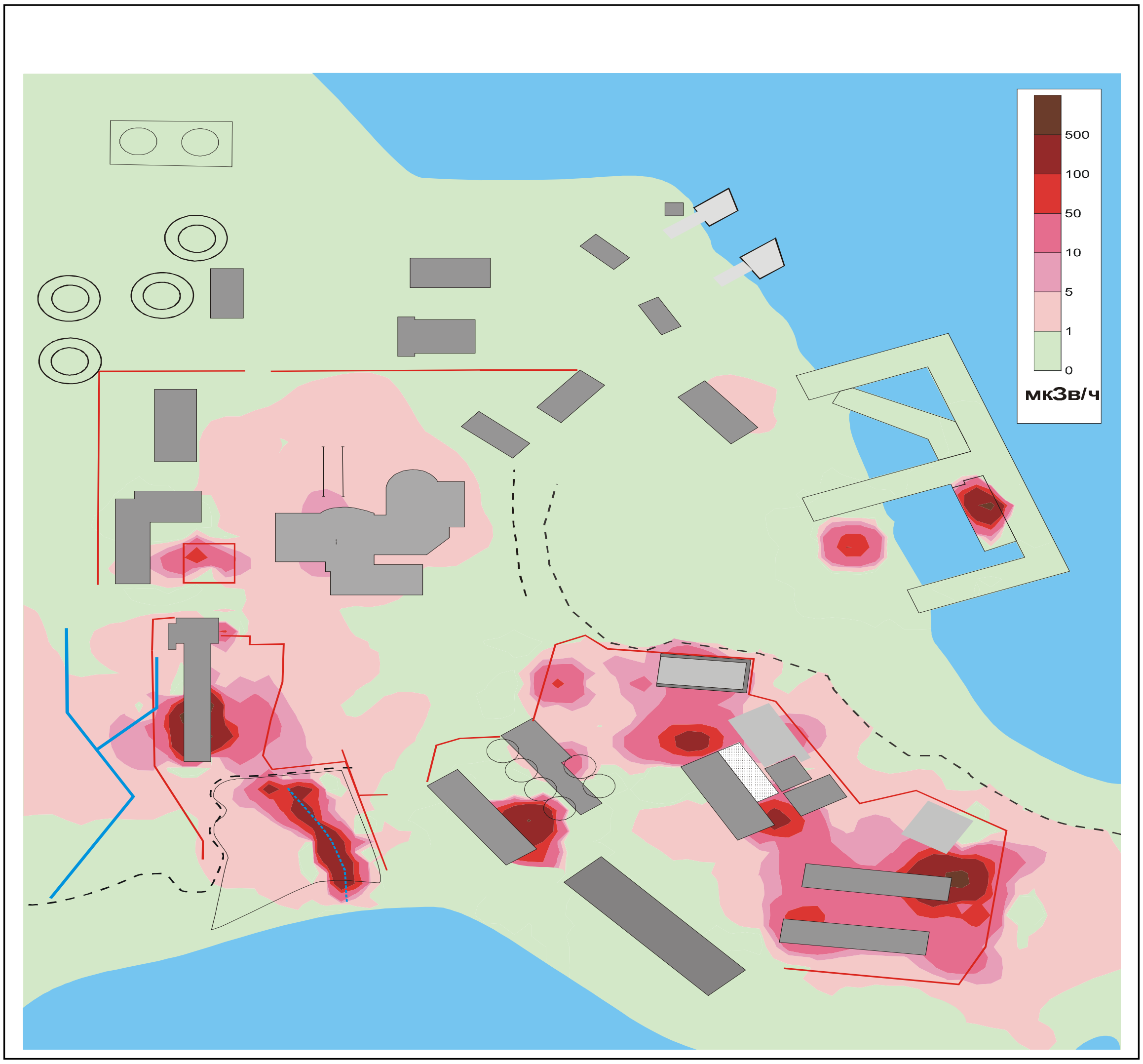
However, although the averaged contamination levels over the region are acceptable, at nuclear sites there are locations which are heavily contaminated. In particular at the Coastal Maintenance Bases in Andreeva Bay and Gremikha in the areas surrounding spent nuclear fuel and radwaste stores, there is contaminated soil with radiation levels of over 500 µSv/h (Figure 5.2.1.2-2 and Figure 5.2.1.2-3). These levels are over three orders of magnitude higher than normal background radiation levels.



Source: Radiation dose map: http://mtrs.ecoinfo.ru/mtaskro/htmls_eng/Frame1.htm

Units: 10 mkR/h = 0.1 µSv/h

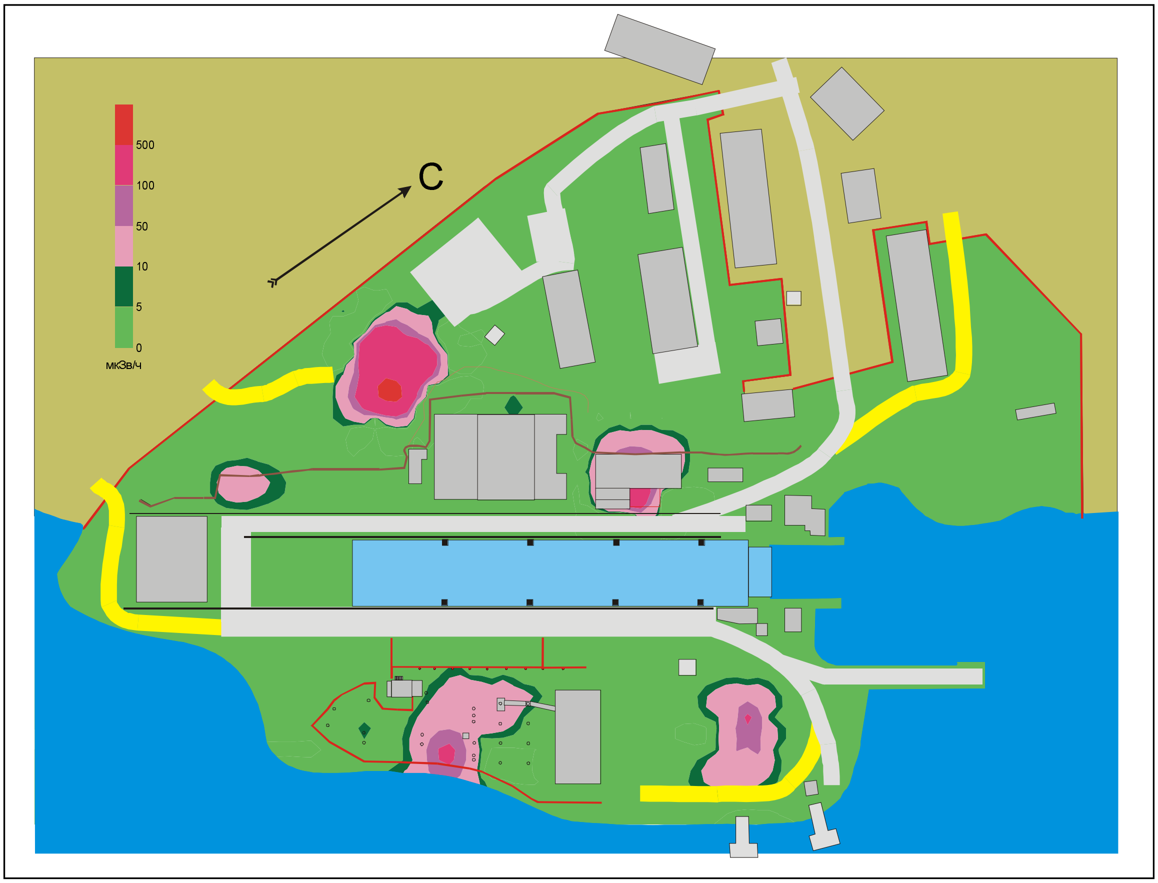
Figure 5.2.1.2-1: Maximum daily gamma dose rate in Murmansk region, December 1, 2004



Source: SMP, 2004

Note: Measurements were made in 2002 and since then two of the hot spots were removed [Vasiliev, 2005]

Figure 5.2.1.2-2: Gamma dose-rate at Andreeva Bay, µSv/h



Source: SMP, 2004

Figure 5.2.1.2-3: Gamma dose-rate at Gremikha, μSv/h

Arkhangelsk Region

In Severodvinsk, the radiation dose in 1999 in the Yagry Island residential area adjacent to Zvezdochka shipyard was measured at 0.09 to 1.4μSv/h, which is consistent with background levels. Data on the other facilities in the region are missing so no further conclusions can be drawn.

A ‘silt valley’ waste disposal site adjacent to the Zvezdochka shipyard was contaminated in the 1990s, but remedial measures removed the majority of contamination.

At Zvezdochka and Sevmash shipyards there are certain historic waste storage facilities that do not comply with current regulations. In particular, radwaste storage facility 162 at Zvezdochka (Figure 2.1.4-5) contains waste with surface dose rates up to 3 Sv/h. Some of this waste is exposed to the elements and may be a source for groundwater contamination. [Zvezdochka, Onega, 2004].

It is known that there is leakage of radiation into the groundwater at the Mironova Gora waste disposal site; however this site is not included within the scope of the Masterplan.

In summary, elevated radiation levels due to human activities are observed at the coastal maintenance bases of Andreeva Bay and Gremikha in Murmansk region and in the old radwaste store in Building 162 at Zvezdochka shipyard. No data are available for other naval sites in Murmansk region or for Sevmash shipyard in Severodvinsk.

Where measurements have been taken outside the boundaries of nuclear facilities the gamma dose rates have been found to be close to background levels.

5.2.2 Radioactivity in water

As illustrated in Figures 5.2.2-1 and 5.2.2-2, generally Cs-137 and Pu concentrations in the Arctic region are consistent with global Cs-137 fallout levels from nuclear weapons testing.

Source: Dutton et al, 2003

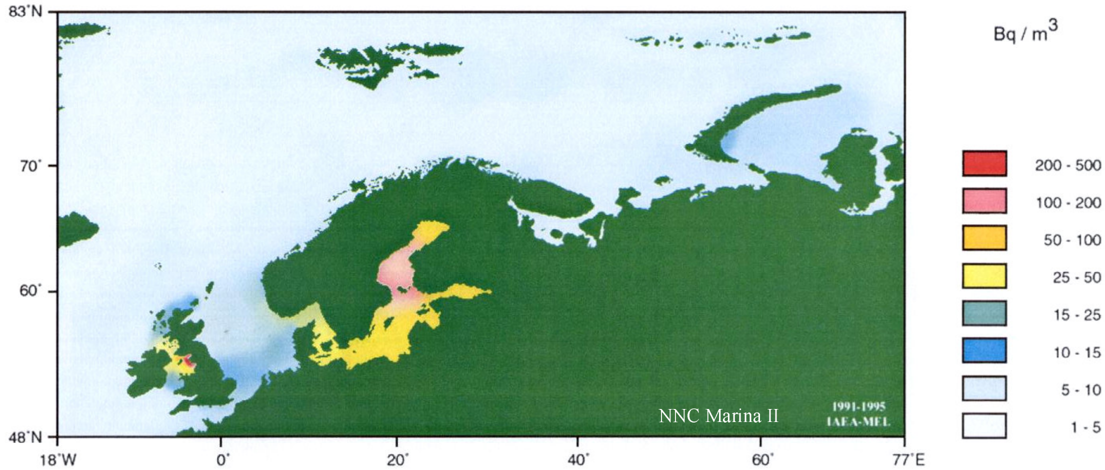
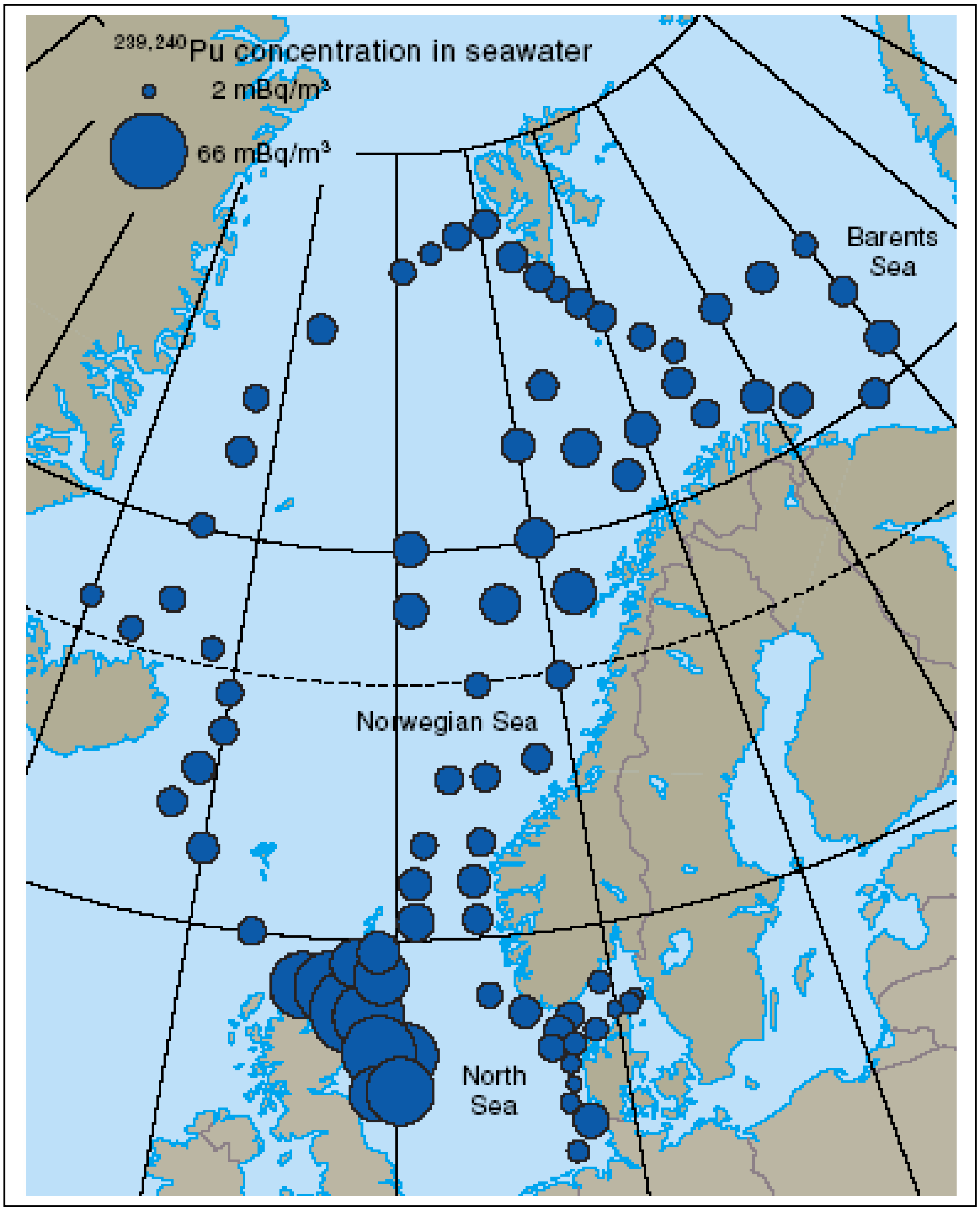


Figure 5.2.1.2-1 Caesium-137 water concentration levels in 1990s



Source: AMAP, 2004

Figure 5.2.1.2-2: ^{239,240}Pu in seawater in the northern seas in 1995 (surface level)

Barents Sea and White Sea

Concentrations for selected artificial radionuclides (Sr-90 and Cs-137) were measured in the surface waters of the Barents Sea and White Sea between 1991 and 1998 [Sarkissov et al, 2003]. The results of the monitoring are presented below.

Measurements were made of Sr-90 and Cs-137 concentrations in seawater from the Barents Sea and White Sea between 1991 and 1998 (Sarkissov et al 2003), the samples were taken from the surface. The results are presented in Table 5.2.2-1.

Table 5.2.2-1 Artificial Radionuclide Concentrations in the seawater of the Regional Study Area (1991-1998)

Sea	Water (Bq/m^3)	
	Sr-90	Cs-137
Barents Sea	4.0 ± 1.0	5.8 ± 1.5
White Sea	6.8 ± 2.5	10.0 ± 2.0
MAL	1800	800

MAL: Maximum Allowable Level

In general, marine concentrations of artificial nuclides Cs-137 and Sr-90 are lower in the Russian Arctic than in the adjacent areas of the North East Atlantic due to the impact of reprocessing facilities on those areas [Dutton et al, 2003].

The Cs-137 and Sr-90 concentrations in water recorded in the White Sea slightly exceed the corresponding concentrations in the North Sea, Norwegian Sea, Greenland Sea and Kara Sea. The Cs-137 and Sr-90 concentrations in water recorded in the Barents Sea were less than the corresponding concentrations in the North Sea and Kara Sea. The Cs-137 and Sr-90 measurements in the Barents and White Seas are well below the Russian MALs in marine water [Sarkissov et al, 2003].

Ara Bay and Kola Bay

The Cs-137 concentration in Ara Bay is below the MAL [Namyatov et al, 2001].

In the water of Kola Bay within 100m from RTP Atomflot the concentration of Cs-137 is 5-8 Bq/m^3 which corresponds to the background levels. Low concentrations of Cs-134 – 0.2-0.4 Bq/m^3 as well as presence of Co-60 and Eu-152 in the bottom sediments observed in the 1990s, is evidence of its man-made origin [SMP, 2004].

Additional data on the Cs-137, Sr-90, Pu-239,240 and Tritium concentrations in sea water in Kola Bay next to RTP "Atomflot" are shown in Table 5.2.2-2. It can be seen that some of the levels are above background levels; however it should be noted that the samples were taken in immediate proximity to RTP Atomflot effluent discharge pipe.

Table 5.2.2-2 Radionuclide Concentrations in sea water in the Kola Bay near RTP Atomflot (August, - September 1998)

	Cs-137, Bq/m^3	Sr-90 (solution), Bq/ m^3	Pu-239,240 (solution), mBq/ m^3	H-3, Bq/ m^3
Surface horizon	3.0 - 7.1- solution <0.05 – 3.5- suspension 3.0 – 8.9-total	2.4 – 4.9	17.9 – 70*	5.6 – 12.7
Bottom horizon	4.1- 4.7- solution <0.05 – 0.8- suspension	2.0 – 3.3	15.7 – 40	1.4 – 5.6

*) unfiltered water.

Source: Vasiliev et al (2005)

Dvinskaya Bay and Nikolsky Mouth

Table 5.2.2-3 summarises measurements from the Dvinskaya Bay area of the White Sea, and the Nikolsky Mouth which borders the Zvezdochka shipyard. The concentrations of Co-60, Sr-90 and Cs-137 in the Nikolsky Mouth are two to eight times those measured in the open waters of the White Sea. Currently, the concentrations of Sr-90 and Cs-137 are 1.5 to 2 times above background measurements within a radius of 100 km from Zvezdochka and Sevmash [Sarkissov et al, 2003].

Table 5.2.2-3 Artificial Radionuclide Concentrations in Surface Waters of the Local Study Area (2000)

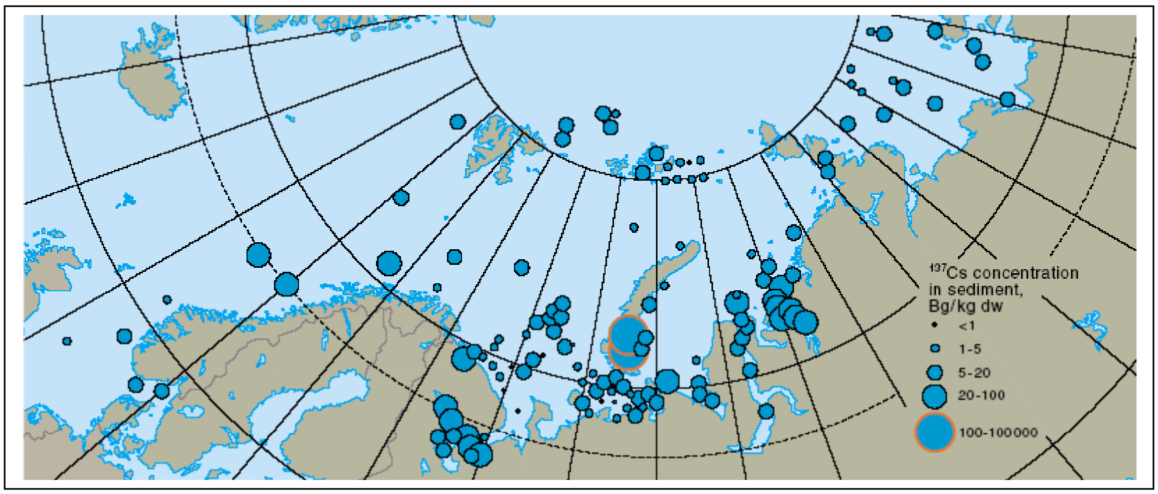
Sea	Water (Bq/m³)		
	Co-60	Sr-90	Cs-137
Nikolsky Mouth inlet	< 0.8	7.7 ± 2.6	-
Nikolsky Mouth outlet	< 0.9	6.5 ± 2.1	9.4 ± 3.2
Dvinskaya Bay	< 1.0	8.7 ± 2.9	-
MAL	1000	1800	800

The Co-60, Sr-90 and Cs-137 measurements in the Nikolsky Mouth are well below the Russian MALs for seawater.

5.2.3 Radioactivity in soil and sediments

5.2.3.1 Radioactivity in sediments

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 5.2.3.1-1.



Source: AMAP, 2004

Figure 5.2.3.1-1. Distribution of ^{137}Cs in surface sediments from 1993 to 1998

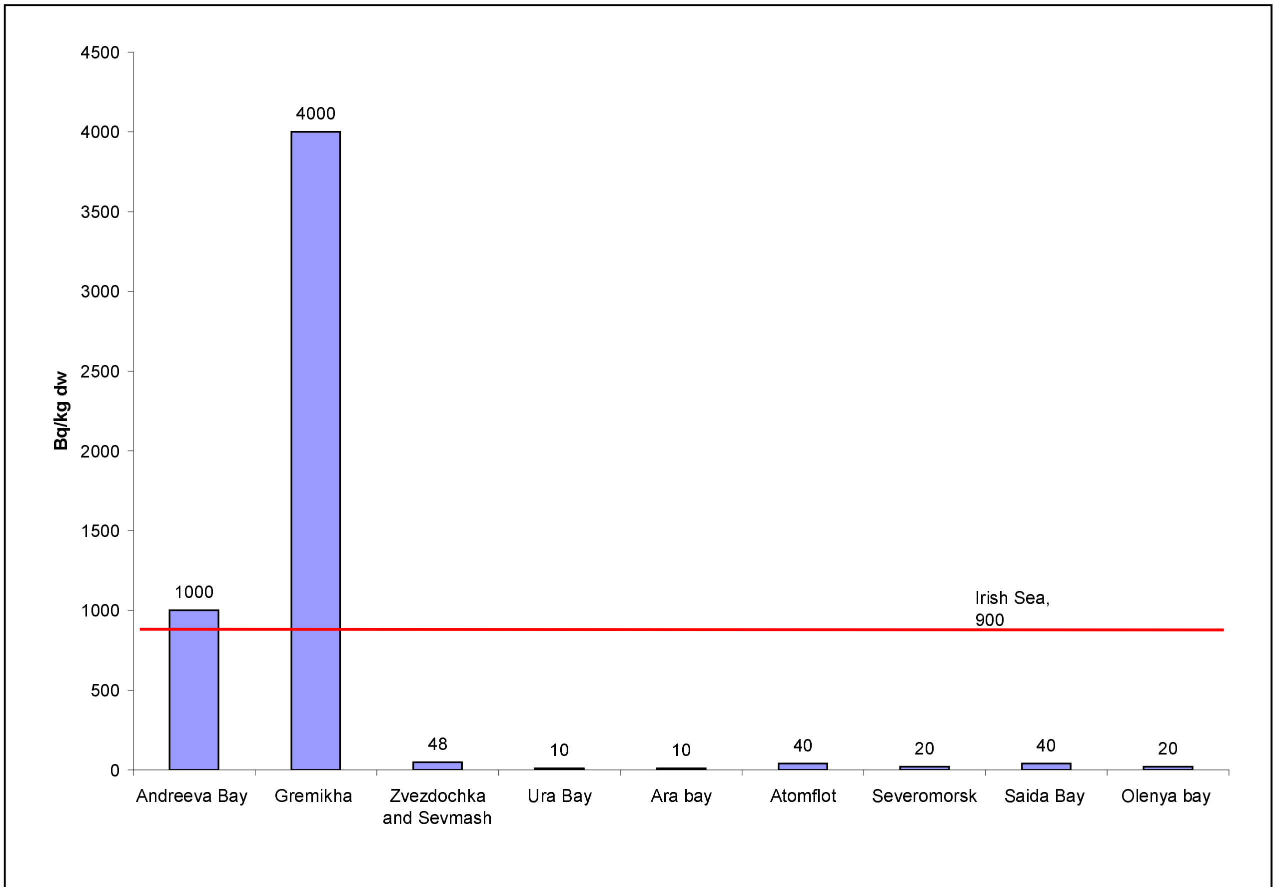


Figure 5.2.3.1-2. Maximum Cs-137 concentrations in sediments (Bq/kg dry weight) Data from the Masterplan for Local Study areas in North West Russia compared to averaged Irish Sea concentrations for 1989-1999 [Dutton et al, 2003]

From Figure 5.2.3.1-2 it can be seen that concentrations of Cs-137 in sediments in the bays adjacent to the coastal maintenance bases significantly exceed concentrations in other locations in the region. Concentrations in Zapadnaya Litza are comparable to, and in Gremikha are significantly higher than, concentrations in the Irish Sea (the latter are affected by discharges from the Sellafield reprocessing plant in the UK).

Barents Sea and White Sea

Measurements of Sr-90 and Cs-137 in bottom sediment were taken in the Barents Sea and White Sea (the Dvinskaya Bay area) between 1991 and 1998 [Sarkissov et al, 2003]. The results of the monitoring are presented in Table 5.2.3.1-1.

Table 5.2.3.1-1 Radionuclide Concentrations in Bottom Sediments (1991-1998)

Sea	Bottom Sediments (Bq/kg)	
	Sr-90	Cs-137
Barents Sea	0.3 ± 0.2	8.0 ± 3.0
White Sea	-	10.0 ± 2.0
MAL	1800	4500

MAL: Maximum Allowable Level

The bottom sediments of the Barents Sea show an average Cs-137 concentration of 8.0 Bq/kg, with a maximum of 11.0 Bq/kg. In comparison, the open part of Kola Gulf/Bay, on the outlet of the Murmansk Fjord, measures an average of 13.0 Bq/kg with a maximum of 24 Bq/kg. Both locations record a maximum Co-60 concentration in bottom sediments of less than 1.0 Bq/kg.

The concentrations of Cs-137 in bottom sediments recorded in the White Sea are less than the corresponding concentrations in the Norwegian Sea, Greenland Sea and Kara Sea and are slightly greater than those in the Barents Sea [Sarkissov et al, 2003]. Arctic Sea sediments typically have Cs-137 concentration measurements of up to 30 Bq/kg [Matishov et al, 1999].

Ara Bay

Measurements of Cs-137 in bottom sediments from Ara Bay showed average levels of 4.2 Bq/kg [Namyatov et al, 2001]. All measurements were well below the MAL of radionuclides in sediments of 11,000 Bq/kg for Co-60, 1,800 Bq/kg for Sr-90 and 4,500 Bq/kg for Cs-137 [Sarkissov et al, 2003].

Atomflot

In 1990s the Murmansk Marine Biology Institute carried out an assessment of radionuclide concentrations in the environment of Kola Bay in the vicinity of RTP Atomflot [Matishov et al 1997].

Within 100 m from RTP Atomflot, the following radionuclide concentrations were reported in sediments:

- ^{60}Co: 2 - 27 Bq/kg
- ^{137}Cs – 2 - 40 Bq/kg
- ^{152}Eu – up to 55 Bq.

In 8 out of 65 sampling points concentrations of Pu isotopes were above detection limits (0.5-1.0 Bq/kg).

Such levels are dozens of times higher than background but still within permitted values [SMP, 2004].

Andreeva bay

Most of the measurements of Co-60 are below detection limits. However, the sediment samples taken at a depth of between 2 and 2.1 inches deep showed Co-60 levels of

5.8Bq/kg. This could have resulted from leakage from a former wet SNF storage facility in Andreeva Bay.

Figure 5.2.3.1-3 shows the Cs-137 and Co-60 content in bottom sediments at the sites where nuclear ships and their supporting infrastructure reside in the Murmansk region. It can be seen that concentration in sediments at Andreeva Bay is 30-70 Bq/kg for Co-60 for Cs-137 (100-1000 Bq/kg dry weight, SMP, 2004). These values significantly exceed background levels.

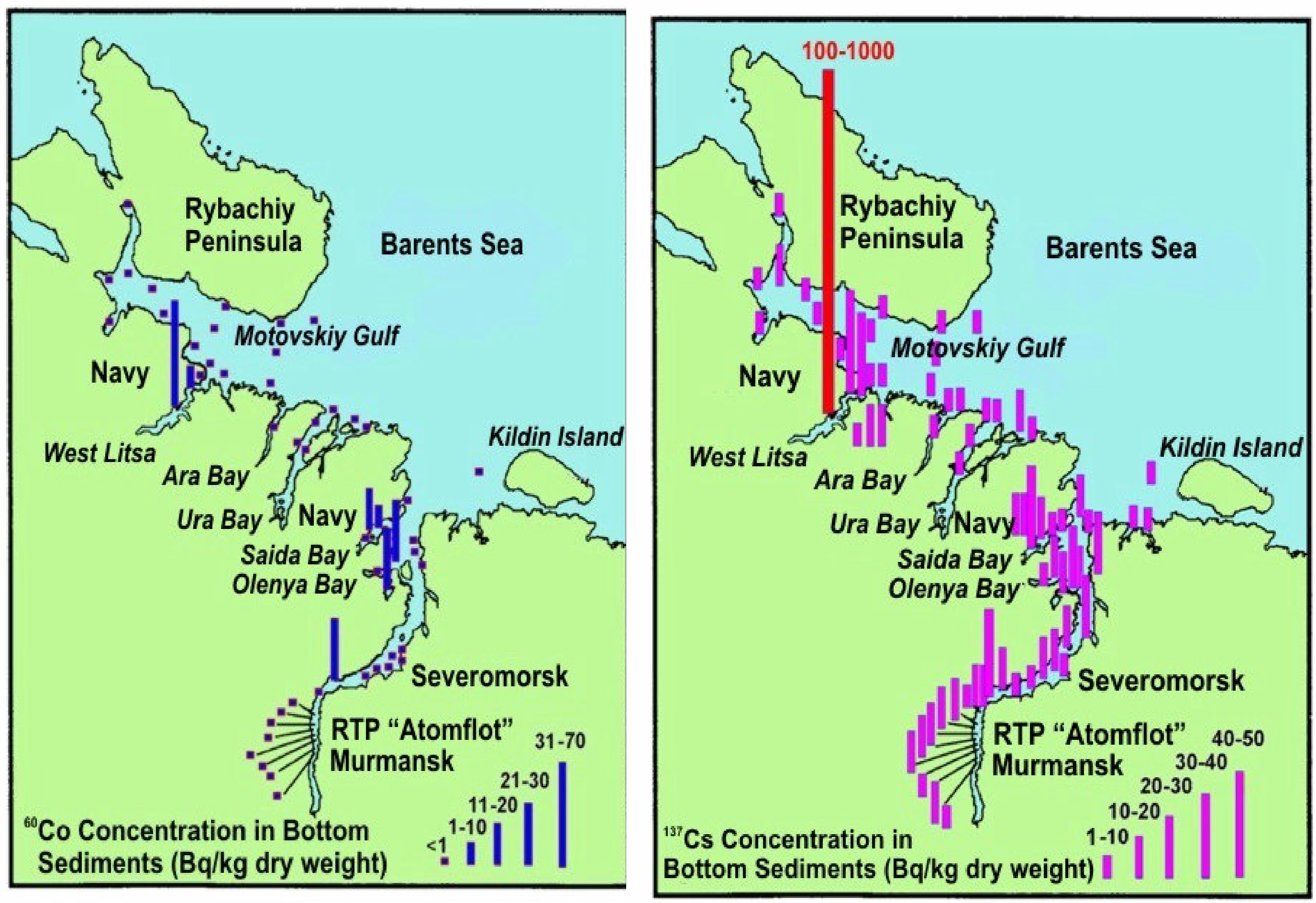


Figure 5.2.3.1-3 Man-made radionuclide content in bottom sediments in locations of retired nuclear ships and their supporting infrastructure.

Gremikha

In August 2003, a radiation survey of the natural environmental in the coastal and marine area adjacent to the CMB was carried out.

In the course of the survey, the following were undertaken:

- direct measurement of radioactivity of seawater and bottom sediments using submerged gamma-spectrometers;
- sampling of bottom sediments;

- determination of Cs-137 content in seawater by concentration using a selective sorbent;
- sampling of soil and bottom sediments in the coastal area and along the tide line;
- dosimetry survey in the coastal area and along the perimeter of the facility.

The map of Cs-137 contamination on the surface of the bottom sediment in the coastal area (see Figure 5.2.3.1-4) shows hot spots of high Caesium-137 concentrations - in excess of 4000Bq/kg (dry weight).

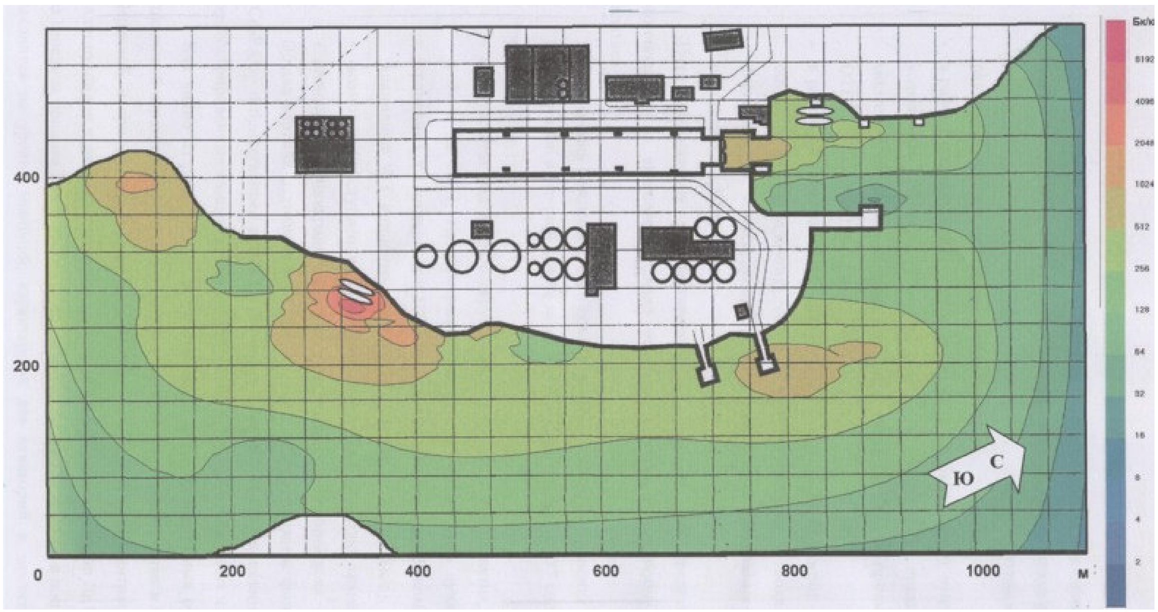


Figure 5.2.3.1-4 Distribution of Cs-137 specific activity in the bottom sediment surface layer in the coastal area adjacent to CMB Gremikha

Polyarny

There is a trend towards increasing concentrations of Co-60 in the sediments outside the naval shipyard SRZ-10 in Polyarny. Measurements of sediments taken in the period between 1995 and 1997 show an increase from below 10 Bq/kg to over 80 Bq/kg in this 3-year period.

Nikolsky Mouth and near-shore Dvinskaya Bay

Since 1975, North Hydrometeorology and Environment Monitoring Board carries out annual sampling of superficial sediments in Dvinskaya Bay of the White Sea in the area adjacent to Zvezdochka and Sevmash shipyards [Vasiliev et al, 2005]. NPO "Typhoon" carries out radionuclide analysis of these samples. The sampling locations for the Severodvinsk area are shown in Figure 5.2.3.1-5.

The average of Cs^{137} concentration measurements for all sampling points is provided in Table 5.2.3.1-2. It can be seen that there has been no increase in ^{137}Cs concentrations in sediments in Dvinskaya Bay since 1970s. The measurements are consistent with background levels.

Table 5.2.3.1-2: Average Cs^{137} concentration in suprerficial bottom sediments in Dvinskaya Bay (1975-2000)

Year	Sampling Date	^{137}Cs concentration, Bq/kg dry weight
1975	24.09	9.3
1976	10.11	7.4
1977	20.08	10.4
1978	26.08	12.2
1994	25.07	12.3
1995	22.10	11.2
1996	15.07	9.2
1998	13.10	10.9
1999	16.10	8.0
2000	22.08	8.6

Source: Vasiliev et al, 2005

Figure 5.2.3.1-5 Sediment sampling locations in Dvinskaya Bay

More detailed data on the concentrations of radionuclides present closer to the shipyards in bottom sediments in the Nikolsky Mouth and near-shore Dvinskaya Bay areas are available for the year 2000 [Sarkissov et al, 2003]. These measurements are presented in Table 5.2.3.1-2.

Table 5.2.3.1-3: Radionuclide Concentrations in Bottom Sediments (2000)

Sampling Location	**Bottom Sediments (Bq/kg)**		
	Co-60	**Sr-90**	**Cs-137**
Nikolsky Mouth (Zvezdochka) – quay for spent fuel unloading and liquid and solid radioactive waste receipt and transport	– <LOD	-	12 - 42 avg 22
Nikolsky Mouth (Zvezdochka) – deep water quay for radioactive waste handling operations	< <LOD 1	-	30 - 37 avg 33.5
Nikolsky Mouth (Zvezdochka) – nuclear submarine storage (on water) after decommissioning	<LOD - 4	-	5 - 38 avg 23.5
Nikolsky Mouth inlet (east of Zvezdochka)	<LOD	-	10
Nikolsky Mouth outlet (west of Zvezdochka, border of Dvinskaya Bay)	<LOD	-	6
Dvinskaya Bay in White Sea, 15 km from Severodvinsk	<LOD	-	9
Nikolsky Mouth (Sevmash)	-	<LOD - 3	5 - 48 avg 17.1
Background - Dvinskaya Bay town beach (Yagry Island shore)	<LOD	-	2
MAL	11,000	1,800	4,500

LOD : Limit Of Detection
MAL: Maximum Allowable Level

The concentration of Cs-137 in bottom sediments in the Nikolsky Mouth was above background levels at all measurement locations, but were well below the MALs. Bottom sediments in the area of the Zvezdochka shipyard are sampled using a winch and dredger [Nikitin, 2004].

5.2.3.2 Radioactivity in soil and groundwater

There is little data available that quantifies the levels of activity in soil and groundwater. Only two datasets are available; these are presented below.

Yagry Island and Zvezdochka shipyard

Soil surface contamination was measured to be 1.6×10^4 Bq/m^2 in the Yagry Island residential area in 1999 [Kennett et al, 2001]. Radioactivity in the soil of the Zvezdochka shipyard in 2003 ranged between 1.4×10^4 and 2.6×10^4 Bq/m^2 [Nikitin, 2004].

Coastal Maintenance Bases

According to the Masterplan the concentration of man-made radionuclides in the soil inside the CMBs is $10^4 – 10^7$ Bq/kg, which is considerably higher than background and a hundred – thousand times higher than the maximum permissible concentrations for basic radionuclides established by the Russian Navy. Given the potential for high levels of soil contamination at the facilities there is the added potential for contamination of offsite areas (e.g. coastal areas close to the CMBs). Some of these contaminated areas are already the source of the radioactive contamination of the coastline (see Figure 5.2.3.1-4). It is necessary to obtain soil contamination data for all areas included in the study.

5.2.4 Radiation exposure of workers

No information is available on average and maximum annual dose rates received by workers at the facilities. It is understood that individual doses are within postulated Russian limits, which are consistent with the ICRP guidance and EU Directives. It should be noted that there are deficiencies in the individual dose monitoring and collation methods. For example extremity dosimeters are not used. In operations involving manual handling of active components or exposure of other extremities (e.g. during loading of canisters with spent fuel into fuel casks) this may lead to some doses being undetected.

The adequacy of the equipment used to measure individual doses should be reviewed and information should be collated on worker doses by operation and facility.

5.2.5 Radiation exposure to members of the public

In Russia, the average annual human exposure due to natural ionizing radiation sources is estimated at 2.2 mSv. This value typically includes 1.0 mSv from indoor radon, 0.5 mSv from gamma radiation from naturally occurring radioactivity in the ground and from building materials, 0.4 mSv from natural background radiation via ingestion, and 0.3 mSv due to cosmic irradiation.

The relative contribution of different sources of ionizing radiation to the exposure of the population in North-West Russia is presented in Table 5.2.5-1.

There is no information on doses to critical groups. This information should be collated.

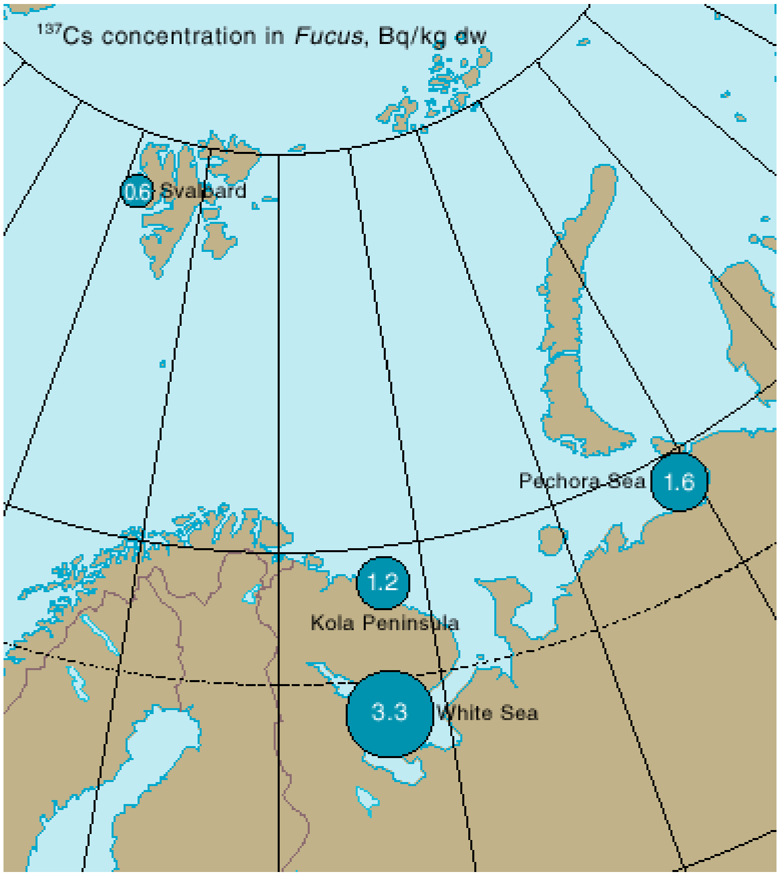
Table 5.2.5-1 Relative Contribution of Radiation Sources to Exposure

Population Exposure Sources	% of average total
Natural sources	> 70
Medical exposure	~ 29
Global fallout	≤ 0.63
From units and facilities involved in nuclear submarine, spent nuclear fuel and radioactive waste management	≤ 0.14

Source: [Sarkisov, A. (No Date)]

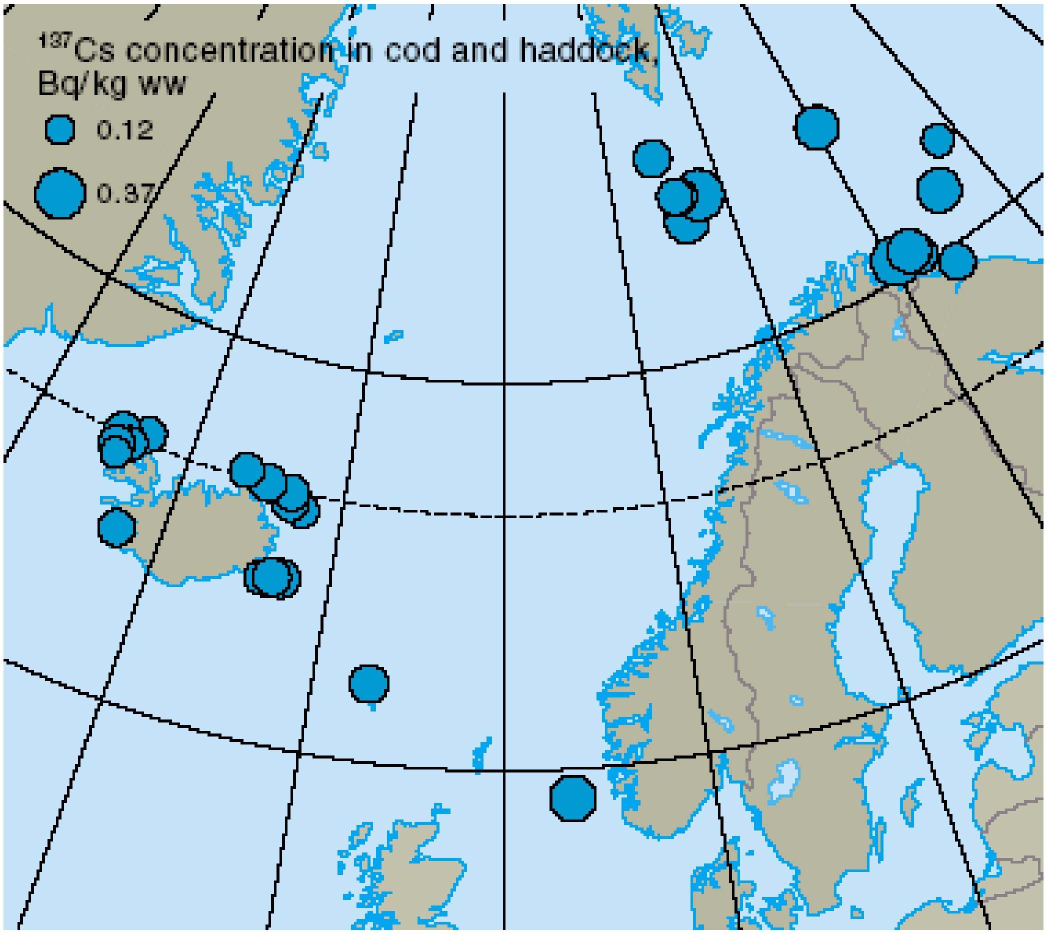
5.2.6 Radioactivity in biota

Brown Algae (Genus Fucus)



Source: AMAP, 2004

Figure 5.2.6-1 Activity concentrations of Cs-137 in *Fucus*



Source AMAP, 2004

Figure 5.2.6-2 . Average Cs-137 activity concentrations in cod and haddock from 1995 to 2000

Cs-137 activity concentrations in *Fucus* in the Barents, Pechora, and White Seas are shown in Figure 5.2.6-1. The highest values of 3.3 Bq/kg dw were detected in the White Sea with the lower value of 1.2 Bq/kg dw at Kola Peninsula.

Cs-137 concentrations in cod and haddock are shown in Figure 5.2.6-2. It can be seen that concentrations of caesium in fish in locations adjacent to the Kola Peninsula are consistent with concentrations in other areas in the Arctic and Northern Atlantic.

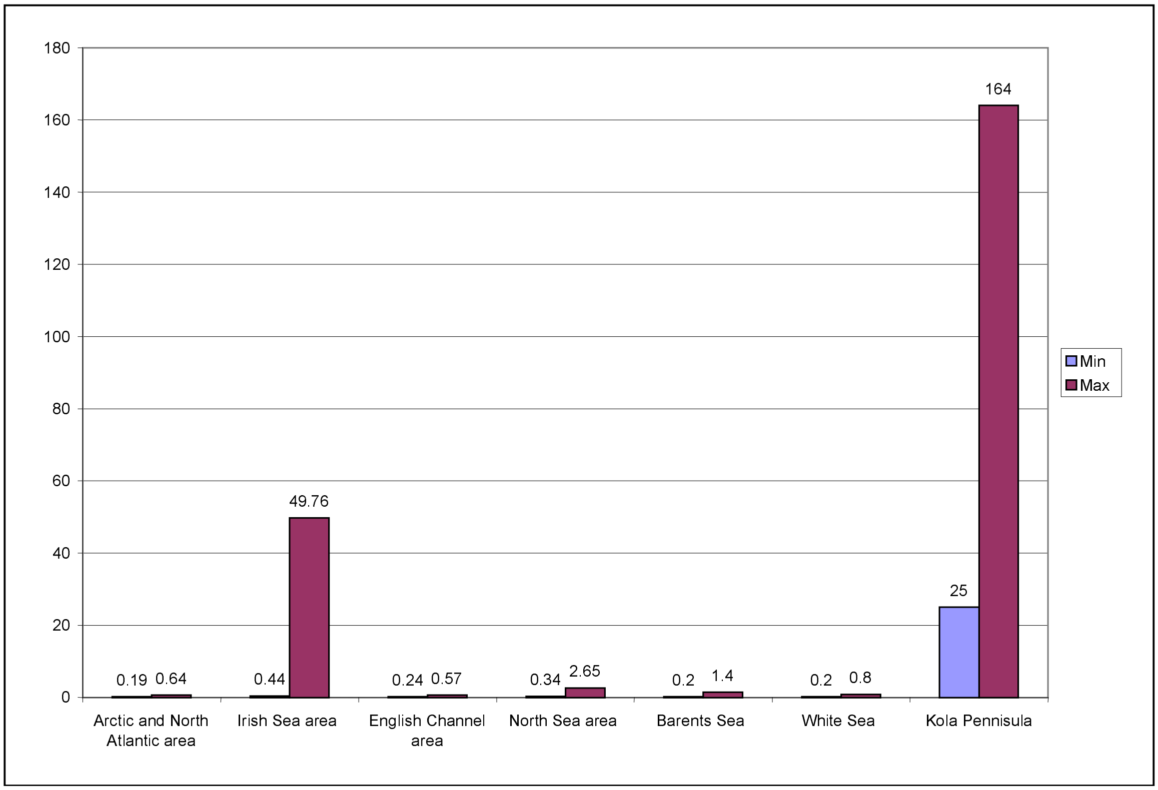
There are a number of sources of data on radionuclide concentrations in marine biota in the Barents Sea. These data are summarised in Table 5.2.6-1. The following specific activities were measured in fish caught commercially: ^{90}Sr 0.01-0.03 Bq/kg; ^{137}Cs 0.2-1.5 Bq/kg; ^{239,240}Pu 0.0006-0.002 Bq/kg wet weight.

Table 5.2.6-1. Radionuclide concentrations in Biota in the Barents Sea, Bq/kg. [AMAP 2004; Sazykina, Kryshev, 1999].

Fish	^{90}Sr	^{137}Cs	^{239,240}Pu
Cod	0.03	0.9±0.4	
Haddock	0.004	0.5±0.2	
Crab		4.2±0.3	
Zoobenthos		3.0±2.8	0.02
Seaweed		1.7±0.7	

Note: All concentrations are for wet weight, except seaweed.

Similar levels of ^{137}Cs in fish were measured in the vicinity of RTP Atomflot (0.3-1.0 Bq/kg, [Matishov et al, 1997].



(Note: Kola Peninsula data are for freshwater fish)

Source: Dutton et al, 2003 and Moffett, Gerchikov 2004

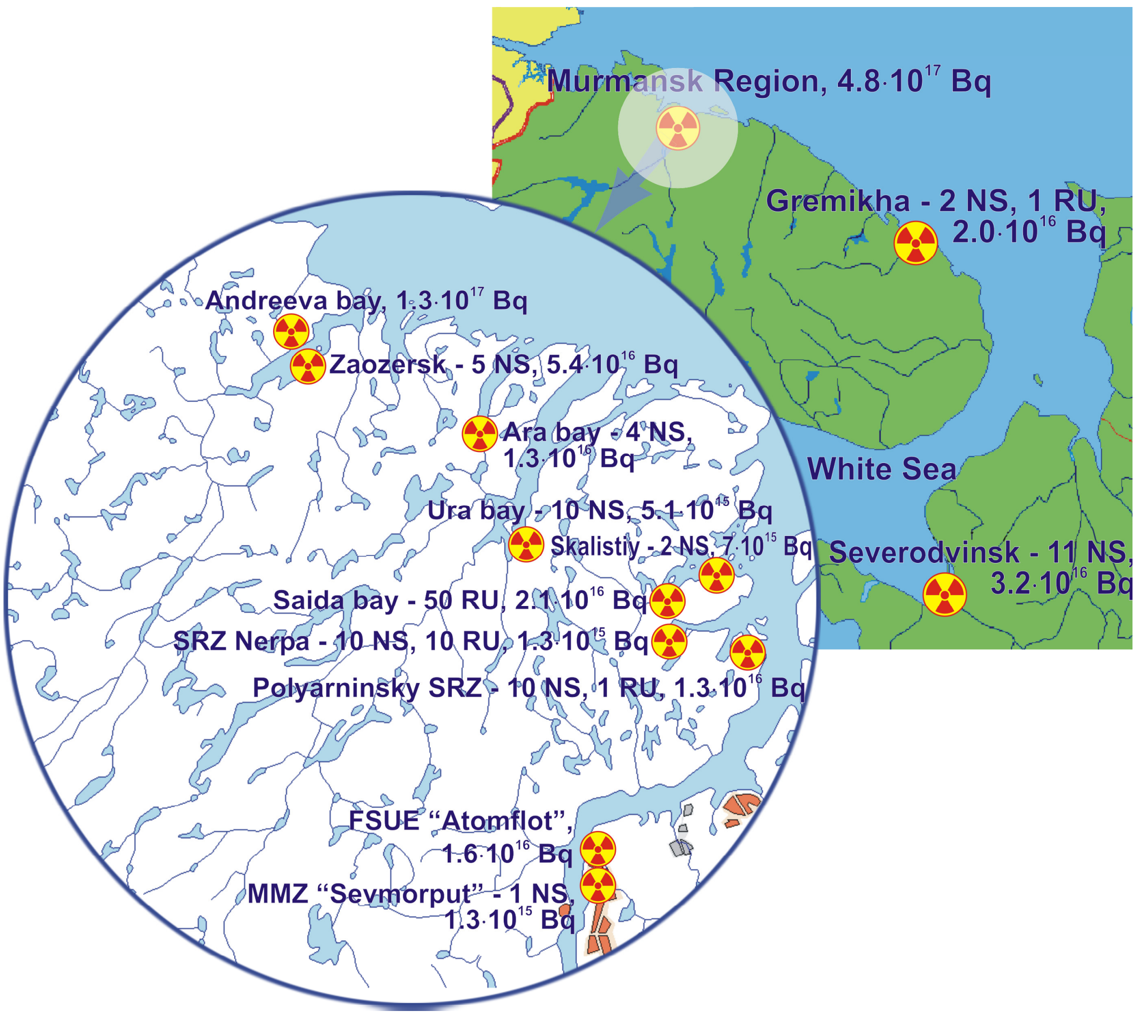
Figure 5.2.6-3 Activity concentrations of Cs-137 in Fish, Bq/kg ww

Figure 5.2.6-3 shows that the concentrations of Cs-137 in the Barents and White Seas are comparable or lower than concentrations in fish elsewhere in North-East Atlantic. In the Kola Peninsula there are relatively high concentrations of Cs-137 in freshwater fish, probably due to fallout from Chernobyl.

5.2.7 Radioactivity potentially accessible to people and the environment

The significant amount of SNF in NS, at the coastal maintenance bases and in other facilities represents a considerable potential danger. The accumulated activity at these facilities is nearly 40 times higher than that of fallout resulting from nuclear weapon tests. The situation is aggravated by the high concentration of potential radiation sources accumulated in the North-West region.

Figure 5.2.7-1 shows the locations of decommissioning facilities and their distribution along the Murmansk coast of the Barents Sea.



Source: SMP, 2004

Figure 5.2.7-1 Distribution of the inventory of radioactivity from decommissioning facilities in the North-West Region of Russia

Currently, the total residual radioactivity of SNF in North-West Russia is 5.1×10^{17} Bq, more than 90 % of which is ^{137}Cs and ^{90}Sr. In addition, the total radioactivity of solid radwaste and liquid radwaste in the region is about 2.75×10^{16} Bq and 9.4×10^{12} Bq, respectively [SMP, 2004].

There are great concerns in Russia and internationally about both the security of the radioactive material and the potential release of activity into the environment. This is due to insufficient physical protection measures and the poor conditions of coastal maintenance bases and nuclear- powered vessels.

5.2.8 Accidents involving radioactivity

The authors of the Masterplan developed a qualitative system for evaluating the probability of an accident and the radiological and non-radiological consequences. The scale of consequences was loosely defined as being 'high, medium or low' and took into account both radiological and other consequences. The latter included ecological, economic, socio-political and psychological consequences, however, it is not clear what weight was assigned to these considerations.

The results of this expert assessment are presented in Table 5.2.8-1. Most of the impacts were considered as potentially significant and the potential impact of an accident at the SNF storage facilities at Coastal Maintenance Bases, the floating fuel storage facilities, including Lepse and in relation to the nuclear icebreakers were considered high. The Masterplan stated of the considered scenarios an unspecified 'criticality accident' would have the highest consequences. It was separately stated that there is a reasonable probability of such accidents occurring at land-based Alpha-class reactor core storage facilities and at Andreeva Bay and Gremikha facilities containing badly damaged fuel.

There is no information on quantitative safety assessments for any of the facilities and operations considered within the Masterplan, except for submarine dismantling operations.

Quantitative safety assessments for the facilities considered within the Masterplan project should be undertaken. 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.

Table 5.2.8-1: Accidents involving radioactivity [SMP, 2004]

Facility	Location	Activity, BQ	Probability*	Impact
Storage of NS with SNF storage afloat: - 1-10 years; - 10-15 years; - over 15 years.	Naval bases and Shipyards	 $(6\text{-}14)\times10^{15}$ $(1\text{-}4)\times10^{15}$ $(3\text{-}7)\times10^{15}$	 Low Medium High	 Medium Medium Medium
Storage of NS RU	Sayda Bay and Nerpa	$(2\text{-}60)\times10^{13}$	Low	Low
Storage of Surface nuclear-powered cruisers	Zvezdochka	$> 20\times10^{15}$	High**	Medium
Maintanance Vessels	shipyards	$(1\text{-}100)\times10^{15}$	Medium	High
Storage of FMB *Lepse* with defective SNF	Atomflot	$\sim 20\times10^{15}$	Medium	High
Nuclear icebreakers	Atomflot		Low	High
SNF long-term storage at CMB	Andreeva Bay and Gremikha	$\sim 130\times10^{15}$ $\sim18\times10^{15}$ (including cores ashore)	Medium	High
Criticality	Gremikha/ Andreeva Bay	$10^{17}\text{-}10^{19}$	Low	High
RW storage and transportation	CMBs and shipyards	$10^{9}\text{-}10^{12}$	Medium	Medium
Storage of Alpha-class submarines – SCR	Sayda Bay, Gremikha	15E15	Medium	High
Storage of cores from Alpha class submarines	Gremikha	13E15	High	High

5.3 Non-radiological environment

In this section the effect of non-radiological factors on the safety of the public and workers is considered along with effects on biota. The information is summarized in Table 5.3-1. As in the previous section considering radiological impacts, the potential effects of non-radiological pollutants are identified by studying air quality, water quality and ground pollution.

* Based upon expert qualitative assessment.

** Probability changed to high due to the fact that a major leak nearly led to the sinking of Ushakov cruiser in 2002.

Table 5.3-1. Summary of Non Radioactive impacts on the environment

Facility	Air Quality	Water Quality	Soil	Groundwater	Biota
Zvezdochka, Sevmash	0 Data on air quality – all discharges below permitted levels.	- Organic Carbon Concentration – most data are well above (up to 20 times) the average for world rivers Data on discharges to water breach permitted levels on several occasions. Monitoring data from two points along shore adjacent to shipyard, shows all substances to be within allowable concentrations, apart from suspended matter which exceed allowable values at both monitoring locations.	-- Samples analysed for Fe, Cu, Ni, Cr, Zn, Mn, Pb showed greater than MAL in nearly all cases. Believed to result from previous activities at the shipyard.	-- No data	-- No data
Nerpa	- Data on Suspended solids, SO2, CO2 and NO2 – all below allowed level, but above background	-- No data	-- No data	-- No data	-- No data
SRZ-10	-- No data	-- No data	-- No data	-- No data	-- No data
Andreeva Bay	-- No data	- Levels of toxic contaminants exceeding background, but similar to levels at neighbouring Norwegian ports	-- No data	-- No data	-- No data

Table 5.3-1 (cont.)

Facility	Air Quality	Water Quality	Soil	Groundwater	Biota
Gremikha	-- No data	-- No data	-- No data	-- No data	-- No data
Atomflot	-- No data	- Levels of toxic contaminants exceeding background, but similar to levels at neighbouring Norwegian ports	-- No data	-- No data	-- No data
Sayda Bay	-- No data	-- No data	-- No data	-- No data	-- No data

5.3.1 Atmospheric Environment

The release of pollutants into the environment can result in a number of significant effects both locally and on a global scale including:

- Global warming
- Ozone Depletion
- Photochemical ozone creation
- Health effects on the local population
- Damage to local ecosystem e.g. disturbance of sediments, changes to water temperature or pH, which could have an adverse effect on one or more species in the vicinity.

Air Quality

The Murmansk Region is one of the most industrialized areas in northern Russia. Sources and emissions of air pollutants in the Kola Peninsula in the Murmansk region are presented in Table 5.3.1-1.

Table 5.3.1-1 Sources and Emissions of Air Pollutants (T/yr)

Region and Source	As	Cd	Cr	Mn	Ni	Pb	Sb	Se	V	Zn
Cu-Ni production	154	15	2	2	535	412	14.0	16.0	-	61
Fossil fuel combustion	2	1	34	30	40	54	2.0	4.0	-	10
Steel and iron	3	1	47	37	44	13	2.3	1.5	-	19
Phosphate fertilizer		10			21	3		2.4	-	80
Wood processing	6	2	39	37	5	26	4.8	1.7	-	10
Gasoline combustion	-	-	-	-	-	237	-	-	-	-
Total	165	29	122	106	645	745	23.1	25.6	122	180

Source: [Pacyna, 1995]

Air quality in Andreeva bay and Gremikha

No information has been identified in relation to air quality these areas. This information should be collected.

Nerpa shipyard and Zvezdochka shipyard

Air quality has been measured at the Nerpa shipyard in the Murmansk Region and Zvezdochka shipyard in the Arkhangelsk Region. Levels of total suspended solids (TSS), SO_2, CO_2 and NO_2 were monitored. A summary of the results is presented in Table 5.3.1-2 below.

Table 5.3.1-2 Air Monitoring at Nerpa Shipyard and Zvezdochka shipyard, 2003 (mg/m^3)

Contaminant	Air quality at Nerpa Shipyard	Air quality (Average Levels at Sampling Point) at Zvezdochka shipyard at 2003						Maximum allowed level
		1	2	3	4	5	6	
Dust	0.1	0.219	0.2775	0.276	0.32	0.323	0.302	0.5 at Point 1, 1.8 at Points 2-6
CrO_3	n/a	$1.6x10^{-5}$	n/a	$1.6x10^{-5}$	n/a	n/a	n/a	0.0015 at Point 1, 0.003 at Points 2-6
MnO_2	n/a	n/a	n/a	N/a	n/a	0.00107	0.00027	0.01 at Point 1, 0.06 at Points 2-6
SO_2	0.05	0.0469	0.0378	0.5895	0.0364	0.0217	0.0396	0.5 at Point 1, 3.0 at Points 2-6
CO2	0.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NO_2	0.015	0.0101	0.0222	0.0123	0.0166	0.0209	0.0107	0.085 at Point 1, 1.5 at Points 2-6

The release of pollutants at the Zvezdochka shipyard is monitored and compared to permitted release limits such as the admissible release limit (ARL) set by the Norms, and/or the temporary agreed release limit (TAR). In 2002, the overall release of pollutants measured 1,143.9 tons, which did not exceed the permitted release limit of 1,891.8 tons. The actual releases of the 63 monitored pollutants measured 139 tons, which did not exceed the permitted release limits (ARL and TAR) of 611.7 tons [Severodvinsk, 2004].

5.3.2 Surface Water and Terrestrial Resources

The quality of surface water, ground water and soils are considered.

Surface Water Quality

Barents Sea and White Sea

Cadmium concentrations measured at 43 sites in the Barents Sea averaged 0.08 ± 0.08 mg/kg dw. Surface sediments taken from the Barents Sea had lead levels of 5 to 32 mg/kg dw.

Generally, levels of polycyclic aromatic hydrocarbons (PAHs) in the open ocean are in the low ng/l range. The concentrations of total PAHs in the Russian Arctic marine environment range from below the detection limit to 88 ng/l.

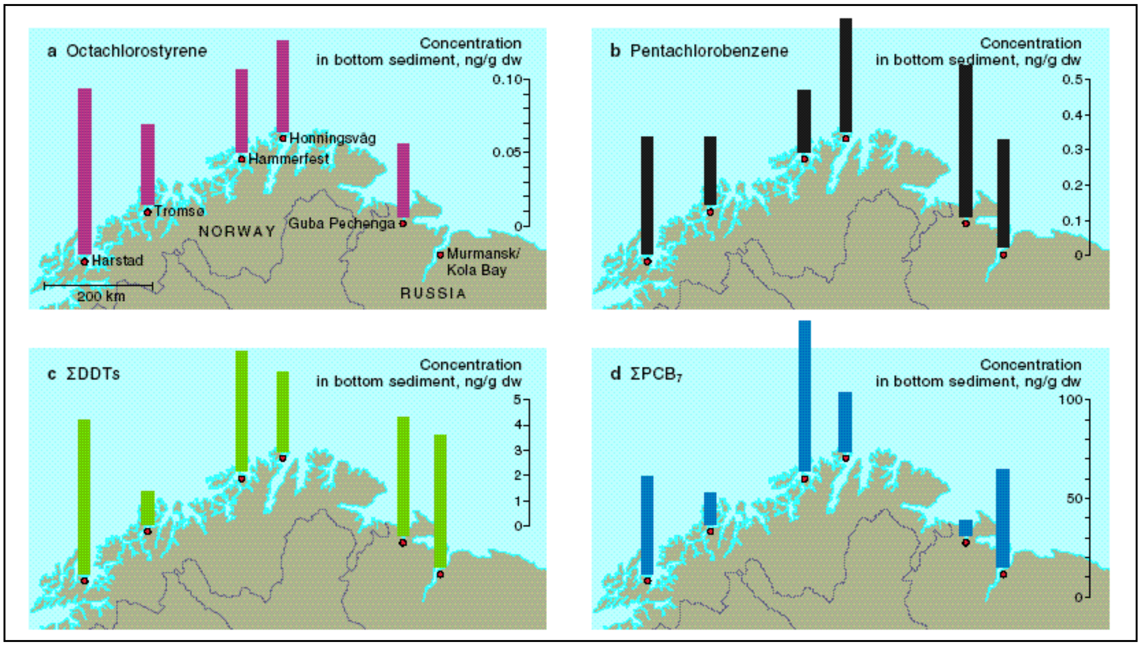
Phenanthrene and naphthalene are the most abundant PAH compounds in the White Sea. PAH concentrations in surface sediments from the Russian marine environment are generally lower than 500 µg/kg dry weight (dw) (range of 4 to 3400 µg/kg dw). Background values for sediments fall in the range 500±20 µg/kg dw.

Polychlorodibenzo-dioxins and -furans (PCDD/Fs) in sediments in the Barents Sea were low and fell within the range of 12 to 32 ng/kg dw for PCDDs and 16 to 102 ng/kg dw for PCDFs. The total petroleum hydrocarbon concentrations in marine sediments from open parts of the Barents Sea range from 5 to 60 mg/kg dw [OSPAR, 2000].

The Murmansk area of Kola Bay near Atomflot had elevated concentrations of PCBs, DDTs and OCs (see Figure 5.3.2-1), however the levels were consistent with those at Norwegian ports.

Kola Bay concentrations of toxaphene are also high (up to 681 ng/g dw) [Savinov et al, 2003].

Elevated concentrations of up to 100 ng/g were also found in Zapadnaya Litsa near the Andreeva Bay area.



ΣDDT = *p,p'*-DDE + *p,p'*-DDD + *p,p'*-DDT; ΣPCB7 = CB28 + CB52 + CB101 + CB118 + CB138 + CB153 + CB180.

Source: AMAP, 2002

Figure 5.3.2-1. Geometric mean concentrations of octachlorostyrene, pentachlorobenzene, ΣDDT, and ΣPCB_7 in bottom sediments of some harbours of northern Norway and the Kola Peninsula

Waste water in Murmansk region

The impact of anthropogenic contamination on Arctic water can be illustrated by the condition of the waste water which is discharged into water bodies in the Murmansk Region of the Kola Peninsula. The Murmansk Region is the most industrialized area of northern Russia. In 1994, only 4.7% of the waste water in the Murmansk Region was treated to specified standards. Approximately 6.1% of the waste water (103.5 x 10^6 m^3) was discharged into water bodies without any treatment and 13.6% (229.1 x 10^6 m^3) was considered to be insufficiently treated. The remaining 75.6% (1,269.8 x 10^6 m^3) was classified as 'conditionally clean' and allowed to be discharged without treatment [AMAP, 1998].

North Dvina River

Dissolved and particulate organic carbon concentrations in the North Dvina River, which flows into Dvinskaya Bay of the White Sea are presented in Table 5.3.2-1 [AMAP, 1998].

Table 5.3.2-1 Organic Carbon Concentrations (North Dvina River)

River	Dissolved Organic Carbon (mg/l)	Particulate Organic Carbon (mg/l)	POC, % in Total Suspended Sediment	Total Organic Carbon (mg/l)	DOC/TOC %
North Dvina	20.1	3.2	23.4	23.3	86
Average of world rivers	5.3	4.6	1	9.9	55

Nikolsky Mouth

The amounts of polluting substances discharged from the Zvezdochka shipyard into the surrounding waters were monitored against a specified maximum allowable discharge limit (ADL) for each substance. The results of the 2002 monitoring [Severodvinsk, 2004] are presented in Table 5.3.2-2. Where permitted levels are exceeded these are marked in bold.

Table 5.3.2-2 Contaminants Discharged to Water from Zvezdochka Shipyard in 2002 (kg/yr)

Substance	Discharge from Releases 1-8		Discharge from Release 9 (SPW)		Summary of discharges	
	Real	ADL*	Real	ADL*	Real	ADL*
Ammonia nitrogen	**2,251.3**	1,432.0	24,391.0	42,768.0	26,642.3	44,200.0
Nitrate nitrogen	128.5	366.0	**48,699.0**	40,040.0	**48,827.5**	40,406.0
Nitrite nitrogen	3.8	24.8	1,864.0	2,330.0	1,867.8	2,354.8
BOD, complete	**8,250.9**	1,863.0	37,208.0	66,000.0	45,458.9	67,863.0
Suspended matter	**7,660.4**	6,558.0	41,931.0	66,000.0	49,591.4	72,558.0
Iron	**802.7**	249.4	842.0	1,760.0	1,644.7	2,009.4
Cadmium	0	6.2	0	44.0	0	50.2
Manganese	**88.5**	74.9	126.0	440.0	214.5	514.9
Copper	**15.3**	12.4	15.2	88.0	30.5	100.4
Petroleum products	**200.5**	135.9	330.0	616.0	530.5	751.9
Nickel	0.558	6.2	0	44.0	0.558	50.2
Mercury	0	n/a	0	n/a	0	n/a
Lead	3.11	5.95	4.5	35.0	7.61	41.0
Phosphates (by P)	**182.4**	122.5	8,444.0	9,240.0	8,626.4	9,362.5

Substance	Discharge from Releases 1-8		Discharge from Release 9 (SPW)		Summary of discharges	
	Real	ADL*	Real	ADL*	Real	ADL*
Chromium (III)	0.152	3.0	0	31.0	0.152	34.0
Zinc	21.6	30.7	0	220.0	21.6	250.7

ADL of sewage waters after purification is approved by the "Permit for the Discharge of Pollutants into the Water Objects", registration number 04-08 from 01.07.2002, issued by the Committee on Nature Resources of the Arkhangelsk Oblast'.

In 2002, the discharges from release points 1 – 8 exceeded the allowable discharge limits for the following substances: ammonia nitrogen, suspended matter, iron, manganese, copper, petroleum products and phosphates. For release point 9, from the sewage purification works (SPW), the allowable discharge limit was exceeded for nitrate nitrogen. The increase in the nitrogen nitrate in the SPW discharge is due to improved operation of the SPW, which reduce the output of copper, iron, lead and zinc in the discharge. Water samples were taken at two points (upstream and downstream from the sewer discharges) in the Nikolsky Mouth along the shore from the Zvezdochka shipyard. These were analyzed for their chemical content. Point 1 is near the bridge on the east side of the shipyard, and Point 2 is located where the Nikolsky Mouth meets Dvinskaya Bay. The results of the 2003 monitoring [Nikitin, 2004] are presented in Table 5.3.2-3 along with the allowable concentration limits (ACL).

Table 5.3.2-3: Chemical Analysis of Water from Nikolsky Mouth (2003)

Substance	Point 1 (mg/L)	Point 2 (mg/L)	ACL (mg/L)
Suspended matter	**16.14**	13.96	13.76
Biochemical Oxygen Consumption	1.36	1.82	6.0
Ammonium nitrite	0.65	0.64	2.0
Nitrite nitrogen	0.016	0.007	3.3
Nitrate nitrogen	0.09	0.11	45.0
Copper	0.003	0.003	1.0
Chromium (III)	n/a	n/a	0.5
Iron	0.22	0.18	0.3
Cadmium	n/a	n/a	0.001
Zinc	0.03	0.08	1.0
Lead	n/a	n/a	0.03
Petroleum products	0.008	0.008	0.3
Nickel	n/a	n/a	0.1
Mercury	n/a	n/a	0.0005

Suspended matter levels exceed the ADL at both monitoring points which is consistent with the monitoring completed since 1999 [Severodvinsk, 2004].

<u>Soil quality</u>

Murmansk region

No information available.

Severodvinsk

Soils in the Severodvinsk area were measured for concentrations of mercury and lead. The results of the 2002 [Severodvinsk, 2004] monitoring are presented in Table 5.3.2-4.

Table 5.3.2-4 Soil Quality in Severodvinsk (2002)

Sampling Point	Mercury (mg/kg)	Lead (mg/kg)
Municipal dumping ground	0.002	82.89
Roadbed on the road to “PO “Sevmash” accumulator	0.02	23.06
Sevmash accumulator	0.01	68.75
Zone of kitchen-gardens	0.002	1.15
Spent sludge of the SPW in the town	0.05	284.17
Spent sludge of the Yagry SPW	0.06	122.85

The MAL for lead is 32 mg/kg, and the majority of the soil samples exceed this value (up to 25-32% of that for standard soil samples during previous years). At present, issues concerning the disposal and neutralization of different types of consumption and production wastes are not adequately addressed, which leads to an increasing burden on the habitat and creates a threat to public health [Severodvinsk, 2004]. The highest lead levels were found in SPW storage areas and areas where wastes have historically been dumped, leading to the assumption that the levels are primarily due to historic contamination.

Zvezdochka shipyard

Soil at the submarine dismantling sites at the Zvezdochka shipyard has been monitored for concentrations of heavy metals. The results of the 2003 monitoring [Nikitin, 2004] are presented in Table 5.3.2-5. Results exceeding the MAL are marked in bold.

Table 5.3.2-5 Soil Quality at Zvezdochka Shipyard (2003)

Contaminant	Sampling Location						MAL
	4-1	4-2	5-5	5-6	6-3	6-4	(mg/g)
Iron	3.14	**6.30**	2.36	**6.81**	**6.33**	**8.12**	5.0
Copper	**0.019**	**0.094**	**0.005**	**0.060**	**0.190**	**0.070**	0.003
Nickel	**0.080** (2002)	**0.040**	**0.030** (2002)	**0.130** (2002)	**0.310** (2002)	n/a	0.004
Chromium	**0.023** (2002)	**0.190**	0.005 (2002)	**0.009** (2002)	0.006	**0.022** (2002)	0.006
Zinc	0.013	**0.110**	0.022 (2001)	**0.040**	**0.160**	**0.100**	0.023
Manganese	0.090	0.350	0.030	0.150	0.260	0.060	0.400
Lead	**0.100**	**0.040**	**0.080**	**0.040**	**0.180**	**0.070**	0.032

MAL: Maximum Allowable Level

Where iron, copper, nickel, chromium, zinc and lead in the soils at the dismantling sites exceed the MAL this is assumed to be caused by previous shipyard activities. Levels above the MAL were also noted in previous years [Severodvinsk, 2004].

Groundwater quality

Murmansk region

No information available.

Arkhangelsk Region

Groundwater quality in the Arkhangelsk Region generally meets Russian standards. MALs were exceeded for iron and manganese, which may be caused by geological structure and hydrogeological conditions. The increased concentration of these elements in the groundwater affects the colour and turbidity. Pollution of groundwater by petroleum products has also been noted [Ministry of Nature of the Russian Federation 2002]. The top of the saturated zone is at a depth of 0.2 to 1.5m and is from 8 t0 18m thick in the area of the Zvezdochka shipyard. The underground stream inclines toward the Nikolsky Mouth and Dvinskaya Bay. The groundwater is weakly mineralized fresh water [Severodvinsk, 2004].

5.3.3 Aquatic and Terrestrial Ecology

5.3.3.1 Contamination of biota with toxic substances

Contamination of biota in Barents and White Seas

The concentration of mercury in the bottom sediments of the Barents Sea was < 0.06 mg/kg dw, and the concentration of copper was in the range of 2 to 36 mg/kg dw [Sarkisov and LeSage, 2003, page 147].

The concentrations of contaminants in a number of aquatic biota in the Barents Sea are presented in Table 5.3.3.1-1.

Table 5.3.3.1-1: Contaminants in Aquatic Biota in the Barents Sea

Contaminant	**Biota**	**Concentration (mg/kg ww)**
Mercury	Fish	0.01 – 0.1
	Seabirds (liver)	0.1 – 3.0
	Seabirds (eggs)	0.06 - .34
Lead	Fish	0.03 – 0.06
	Seabirds (muscle)	< 0.4
Copper	Fish (muscle)	0.1 – 4.0
	Fish (liver)	2.0 - 9.0
PCBs	Fish (liver)	0.047 – 0.082
	Fish (muscle)	0.015 – 0.057
PAH	All	Global background levels

ww: wet weight

Copper is not considered a matter of concern for the marine environment in the Barents Sea region.

The range in concentrations for selected organochlorine compounds in biota (µg/kg ww) is shown in Table 5.3.3.1-2.

Table 5.3.3.1-2 Concentrations of Organochorides in Biota (µg/kg ww)

Biota	**Dates**	**Tissue**	**HCHs**	**DDTs**	**PCBs**
Fish					
Polar Cod	1991-4	liver	7-15	21-54	36-114
Atlantic Cod	1991-4	liver	3-17	67-344	115-685

Biota	Dates	Tissue	HCHs	DDTs	PCBs
Long rough dab	1991-4	liver	1-5	6-43	-
Seabirds					
Kittiwake	1991-2	liver	0.2-25	3-279	12-2,378
Common eider	1991	liver	0.2-1.3	0.5-18	0.8-54
Glaucous gull	1991	liver	0.9-14	65-432	116-2,989
Marine mammals					
Harp seal	1990	blubber	50-190	55-7,870	750-9810
Harbour seal	1989-90	blubber	-	-	5,200
Grey seal	1989	blubber	-	-	5,700
Ringed seal	1990	blubber	-	1,070	1,130
Walrus	1991-2	blubber	-	4,340	11,500
Harbour porpoise	1988-9	blubber	473	15,400	24,500
Minke whale	1992	blubber	-	1,400	2,000
Polar bear	1990-4	fat	Nd – 1,150	-	200-90,000

Nd: Not detected.
HCH: hexachlorocyclohexane
PCB: polychlorinatedbiphenyl
DDT: 4,4'-dichlorodiphenyl-1,1,1-trichloroethane

Levels of the three organochorides in polar cod were similar to those found in the Norwegian and Greenland Seas, while Atlantic cod was found to be higher in DDTs and PCBs. Levels of organochorides in the harp seal were higher than those found in the Greenland Sea. Most other results were comparable to those from other seas [OSPAR, 2000].

5.3.3.2 Biodiversity and natural resources

The biodiversity and natural resources in the concerned area are described in terms of the following two sub-components: aquatic habitat and biota and terrestrial habitat and biota.

Aquatic Habitat and Biota

The Barents Sea is a high-latitude, shallow-water ecosystem and is one of the world's most biologically productive oceans, with an area of 1.4 million km^2. The high level of biological production is due to the sea's shallow waters (5 to 400 m with a mean depth of 230 m), a high level of vertical mixing, and the confluence of warm North Atlantic current and cold Arctic waters. Living resources include fish, marine mammals and seabirds. The sea serves as a nursery area for commercially important herring, cod and haddock, while it is a breeding area for capelin and polar cod. Several species of cetaceans (i.e. mink and humpback whales, white-sided dolphin and white-beaked dolphin) visit the area during feeding migrations. The sea supports some of the world's largest seabird populations [Eglington et al, 1998].

The White Sea is a relatively small sea with a surface area of only 90,000 km^2. The ice in the White Sea is one of the three major breeding (and hunting) grounds of Harp Seal world-wide.

There are six species of fish that support major fisheries in the Barents Sea: cod, saithe, haddock, blue whiting, herring and capelin [OSPAR, 2000]. Haddock and blue whiting are not located near northern Russia in the Barents Sea.

Cod is a common and economically important species in the region. The north-east arctic cod in the Barents Sea is potentially the largest cod stock in the world. The Barents Sea is also considered to support the largest Capelin stock in the world. The region is therefore important both ecologically as it supports a number of rare and endangered species (particularly the whale populations) and economically with major fish stocks and seal products.

The data presented in the previous sections suggest that the environmental impacts, in terms of spread of pollutants, from the facilities are limited to their immediate vicinity. Zooplankton, is by far the most important contributor to biomass of the Barents Sea, and is the main food source for herring, capelin, mackerel, etc. Zooplankton are abundant in near shore areas and are therefore vulnerable to pollution of the area from onshore facilities.

It is not believed that fish spawn in the vicinity of Zvezdochka due to the adverse environment created by the hydrological and hydrochemical conditions in Nikolsky Mouth. There are no marine mammals, rare animals or birds reported in the area of Severodvinsk [Severodvinsk, 2004].

There is no information specific to locations adjacent to Murmansk shipyards and coastal maintenance bases. It is recommended that steps are taken to address this omission.

<u>Terrestrial Habitat and Biota</u>

Arkhangelsk Region

The Arkhangelsk Region is covered by 29.6 million hectares of forests. The forests are made up of 82.6% coniferous trees and 17.4% deciduous trees. There are no forests in the territories adjacent to Severodvinsk [Severodvinsk, 2004]. Nearly 400 species of terrestrial vertebrates and several thousand species of invertebrates live in the Arkhangelsk Region.

The rare species of terrestrial vertebrates at the Arkhangelsk Region are recorded in the RF Red Book and the Arkhangelsk Region Red Book. In accordance with current legislation these rare species of animals are protected by the State. There are no rare animals and birds reported in the vicinity of Severodvinsk [Severodvinsk, 2004].

Murmansk region

The territory of Murmansk region is located in the limits of three botanical and geographical zones: tundra, forest-tundra transition area and taiga. The tundra predominates on coasts. Away from the coast the basic plants here are moss and lichen, which cover from 25 to 50% of the surface, voronika, bearberry, mountain cranberry and yernik. Grassy plants are rare. Forest-tundra vegetation is sparse birch growth. Underbrush is juniper and yernik, sometimes rowan and willow. The mosses, lichen and the kustarnichki dominate the open landscape. The Forest zone, together with the forest-tundra transition area, occupies approximately 80% of the territory. However, the forests only covers about 30% (remaining part is occupied with sparse birch growth, swamps and lakes). Basic forest species are the fir tree, pine tree and birch. The Bushy tier is expressed weakly. Juniper and dwarfish birch are rare species. In the mountain regions of this zone, the high-altitude sequence is expressed: to 400-450 m above sea level - coniferous forests, to 550 m - birch krivoles'ya, to 800-900 m - mountain tundra, are above the belt of Arctic desert.

5.4 Physical Protection

According to the "Rules of Physical Protection of Nuclear Materials, Nuclear Installation and Nuclear Material Storage Facilities" [Russian Federation, 1997], the physical protection of nuclear facilities involves organizational measures, engineered and technical features and a protective force to prevent sabotage or theft of nuclear materials. In the following paragraphs, the existing physical protection systems at shipyards and naval bases will be discussed. Physical protection measures are summarized in Table 5.4-1.

Table 5.4-1. Summary of Physical Protection Measures

Item	Protection Measure	Comment
Mooring Locations	Procedures to protect NPI and SNF are in place and are implemented.	Dependant on adequacy of procedures and implementation
During dismantling	Physical protection systems are well established and functioning	Given increased requirement for security, the engineered features of the protection system should be reviewed and further developed where necessary.
Three compartment reactor units – kept afloat at Sayda Bay	Guarded area, some protection features	Given increased requirement for security, the engineered features of the protection system should be reviewed and further developed where necessary.
Coastal Maintenance Bases	Passive fencing, guard patrol	Work is ongoing at these facilities to provide adequate protection.
Maintenance vessels pending decommissioning	Access control and accounting for radwaste on board is sufficient for vessels with no spent nuclear fuels	Decision must be made regarding protection system for all coastal maintenance vessels.

<u>Physical protection of nuclear facilities and nuclear materials in nuclear submarines (and nuclear-powered surface ships) in mooring locations (pending decommissioning)</u>

At present, 8 NS and the HNMC *Admiral Ushakov* with SNF are located at shipyards (Zvezdochka, Nerpa, Sevmash and Shipyard-10). In addition, these shipyards house 23 defueled NS. 23 NS are located in the territories of Navy Northern Fleet (Ura Bay, Ara Bay, Gremikha, Belomoskaya, Yagelnaya Bay, Lopatka Bay, and Nerpichiya Bay).

Physical protection of mooring NPI and SNF in NS (and SS with NPI) includes:

- security of the facility as a whole;
- recording of all events related to NS, NPI and SNF;
- control and accounting of access of individuals to NS, reactor compartment, NPI control room, reactor enclosure;
- communication with the checkpoint and necessary on-shore force, NF commandment or shipyard management.

Currently, all duties and functions of mooring NS maintenance personnel as regards physical protection of NPI and SNF are set forth in procedures and are being implemented.

<u>Physical protection of three-compartment reactor units kept afloat at Sayda Bay</u>

The goal of physical protection of the three-compartment reactor units kept afloat at Sayda Bay is to prevent access by outsiders and the unauthorized retrieval of radioactive materials from the units.

<u>Physical protection measures at coastal maintenance bases in Andreeva bay and Gremikha</u>

It is planned that the spent fuel assemblies and radwaste in coastal maintenance bases in Andreeva bay and Gremikha will undergo large-scale management operations. These will include examination, re-packing into modern shrouds or containers, handling of radwaste or defective spent fuel assemblies, temporary storage and transport preparations. All the listed operations are subject to physical protection. So far, the following work, as shown in Table 5.4-2, has been done in both coastal maintenance bases.

Table 5.4-2: Physical protection measures in coastal maintenance basesys in Gremikha and Andreeva Bay

CMB in Gremikha	CMB in Andreeva Bay
Preparation of construction site	Preparation of construction site
Passive fencing of outer perimeter	Passive fencing of outer perimeter
Earth works, construction of artificial structures along the outer perimeter fencing	Earth works, construction of artificial structures along the outer perimeter fencing
Patrol route	Patrol route
Guardhouse. Building structures	Guardhouse
Checkpoint	Checkpoint-1 Checkpoint-2 – phase one
Guard towers	Shoreline enforcements

Physical protection of maintenance vessels pending decommissioning

There are various physical protection system designs for coastal maintenance vessels. For vessels without spent nuclear fuel onboard, it would be sufficient to have access control and accounting of radwaste kept on board of those vessels.

The decision has not yet been made regarding the physical protection of maintenance vessels taken out of operation and pending decommissioning.

5.5 Worker Health and Safety

No information was available for the occupational health of workers in the concerned facilities in the Murmansk region.

Provided in Table 5.5-1 is the worker safety statistics at Zvezdochka shipyard for the first six months of 2004. The information in the table is approximate and assumes a typical worker at Zvezdochka works 1,800 hours per year (40 hours per week for 45 weeks). The results for 2004 continue the improvement shown in recent years [Rosatom, 2005].

Table 5.5-1 Shipyard Safety Performance (January – June, 2004)

	Rate	**Total**
Fatalities	0	0
Lost Time Accidents		
Frequency	10 events per 200,000 hours	40 accidents
Severity	200 hours lost per 200,000 hours worked	8,000 hours lost time

It is noted that the accident frequency is higher than for comparable facilities in the West.

5.6 Socio-Economic and Cultural Considerations.

5.6.1 Economic growth

Historically, the Murmansk Region has been of importance to the Russian Federation both politically and economically. The region provided the country with its only all-weather port and served as home to the Northern Fleet of the Russian Navy and the Murmansk Shipping Company, which was the main shipping agent for commercial cargo along the Russian Northern Sea Route. The main economic activities of the Murmansk Region are mining and metallurgy of non-ferrous metals, fishing, shipping and forestry [OSPAR, 2000]. An estimated 100,000 people in the north-west of the Russian Federation work directly in the fishing industry [OSPAR, 2000]. Approximately 65% of the people are of working age, 25% are under and 10% older than working age in the Murmansk Region. In recent years, there has been increasing interest in the potential for oil and gas development in the Barents Sea which provides economic opportunities as well as environmental challenges for the Murmansk Region [Eglington et al, 1998]. However, in the Murmansk Region, one of the most industrialized, urbanized and relatively well-off regions of the Russian north, 21% of the population had incomes below the poverty line in 1997 [Ribova, 2000].

There is no employment rate and income information that is more specific to the locality of the facilities in the Murmansk or for the area of Severodvinsk.

5.6.2 Human health and life expectancy

Murmansk Region

Life expectancy in the Murmansk Region remains below the Russian average [Ribova, 2000]. In the Murmansk Region, the average life expectancy was 70.3 years in 1990 and by 1994 it had fallen to 63.1 years, which was under the Russian average at that time of 64 years. Alcoholism and unhealthy diet are some of the main reasons for the deterioration in health and decreased life expectancy for the residents of the Russian north in the last decade. Among the main causes of death are trauma, infectious disease (especially tuberculosis), and cardiovascular, parasitic, and respiratory diseases. Diseases related to alcohol are especially common. Some of this stems from social factors leading to high rates of alcoholism and suicide [AMAP, 1998].

Birth rates declined in the 1990s and mortality rates increased reflecting, in part, an aging population. Although health care in north-west Russia is still of a relatively high standard, a negative indicator of the economic and social problems experienced in the 1990s is the infant mortality rate, which was as high as 17.2 in the Russian Federation in 1997, as shown in Table 5.6.2-1.

Table 5.6.2-1: Natural Population Growth and Child Death Rate in Russia in 1996-98 [Arctic Centre, 2005 and Severodvinsk, 2004]

Region	Per 1 000 inhabitants						Infant death	
	Births		Deaths		Nat. Pop. Growth		<1 year per 1 000 Births	
	1997	1998	1997	1998	1997	1998	1997	1998
Severodvinsk	N/A	7.7	N/A	8.9	N/A	-1.2	N/A	12.2
Arkhangelsk Oblast	8.4	8.7	13.0	12.6	-4.6	-3.9	13.0	13.3
Murmansk Oblast	7.8	8.1	9.0	8.7	-1.2	-0.6	13.9	11.8
Republic of Karelia	8.0	8.2	13.2	13.3	-5.2	-5.1	13.3	15.2
Republic of Komi	8.9	9.3	10.5	9.9	-1.6	-0.6	16.7	17.2
Total (average)	8.3	8.6	11.4	11.1	-3.2	-2.6	14.2	14.4
Russian Federation	8.6	8.8	13.8	13.6	-5.2	-4.8	17.2	16.7

Severodvinsk

More up to date information is available for Severodvinsk [Severodvinsk, 2004]. Data shows an upward trend in both birth (8.83 in 2002) and death rates (11.87 in 2002). Infant death in Severodvinsk has fluctuated between a low of 6.02 in 2001 and a high of 12.2 in 1998. In 2002 the Severodvinsk population decreased by 0.3%.

The population decrease in Severodvinsk is due to population migration as well as relatively high death and low birth rates.

There are serious concerns with regards to the health of 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.

There is no available information that is specific to the following areas Zaozersk, Gremikha, Skalisti, Vidyaevo, Polyarny.

5.6.2.1 Cultural and heritage resources

No important cultural and heritage resources in the study areas, as defined in Section 3.1.4.1, have been identified.

It is reasonable to assume that the "business as usual" work has no adverse impact on cultural and heritage resources because most of the work will be carried out at existing shipyards and some naval bases.

5.7 Emergency Systems

Some aspects of the emergency preparedness systems in the Murmansk and Arkhangelsk region are described in the Masterplan and are known from personal communications with the shipyards.

Detailed emergency plans exist at the shipyards, but it is not known whether appropriate arrangements are in place at the Coastal Maintenance and Naval bases. It is understood that the majority of these sites have trained staff with specific responsibilities in the case of an emergency. There are also off-site emergency management structures at all significant population centres in the Murmansk and Arkhangelsk regions.

An emergency exercise takes place in Severodvinsk every year. Depending on the scale of the exercise, it involves either one of the two shipyards or both as well as off-site emergency services and the general public in Severodvinsk.

An emergency exercise took place in Murmansk in 2004, but it is not known how frequent or widespread such exercises are in the Murmansk region. The extent of emergency preparedness training and the availability of qualified staff at sites is also not known, particularly at the coastal maintenance bases.

The Atomflot and Zvezdochka shipyards, as well as the towns of Murmansk and Severodvinsk, are known to have at least some elements of an automatic system for monitoring radiation levels. Atomflot appears to be the best-equipped facility with a centrally controlled automatic radiation monitoring and alarm system. The Murmansk region also has an extensive automated system that collates radiation data from 31 meteorological stations.

5.8 Summary

5.8.1 Radioactivity in the environment

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 certain locations 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.

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 western nuclear facilities.

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 shipyards.

5.8.2 Accidents involving radioactive releases

There is no quantitative information on the risk or probability for most of the accident scenarios that are identified within the Masterplan. Based on the available information, the qualitative safety concerns raised in the Masterplan and the potential to affect neighbouring countries the following key conclusions can be drawn with regards to the principle potential sources of serious accidents involving releases of radionuclides into the environment. The current SEA recognises the requirements of the Espoo Convention, which require environmental impact assessments to be carried out prior to the authorisation of activities likely to cause significant transboundary impacts.

- Alpha cores stored ashore at Gremikha

This is one of the main potential sources of a serious nuclear criticality accident. The cores are stored within a solid lead-bismuth eutectic solution, which apparently was not designed for long-term storage and may contain large defects. The stores themselves are in a poor state and require repair to prevent the ingress of water. The Masterplan states that “20 kg of water (~ 10 % of the amount of coolant in the core) can lead to a criticality”.

- PWR SNF stored at Andreeva Bay and Gremikha

This is the other principle potential source of a serious nuclear criticality accident. According to the Masterplan, fuel that is in a powder form from three canisters (i.e. 27 assemblies) can initiate a criticality incident when mixed with water. The damaged state of fuel within some of the stores at the Coastal Maintenance Bases and the poor integrity of the storage facilities is causing serious concern. In addition, Andreeva Bay is the largest single store of radioactivity in North West Russia.

The stores are already a source of environmental contamination. Across the Andreeva Bay and Gremikha sites, soil and sediment contamination have been observed, as have high dose rates.

- Lepse

Again, only qualitative risk information is available. However, the Masterplan states "The floating maintenance base 'Lepse' has for many years posed the biggest hazard from the Murmansk Shipping Company fleet. The vessel presents a major hazard as a result of its large total inventory ($\sim 20\times10^{15}$Bq), the high proportion of damaged fuel and the poor condition of the vessel.

It is not clear whether nuclear safety is an issue, but there is a definite risk of leakage into the environment or atmospheric dispersion under accident conditions.

- Other maintenance vessels with SNF

A number of these vessels are in a poor state of repair. The casks in which the fuel is being stored have not been certified in accordance with IAEA transport regulations. Accidents involving the sinking of such vessels are more likely to lead to leakage from SNF than is the case of submarines that sink. In submarines, the fuel matrix is protected not only by the fuel cladding, but also by the hull and the reactor pressure vessel.

- The 'Adminal Ushakov' cruiser

The main risk is that the vessel will sink as a result of damage to the hull. The vessel is moored at Severodvinsk and there are considerable problems in maintaining a suitable temperature inside the vessel to prevent the coolant and other liquids from freezing, which would lead to structural damage. The vessel nearly sank two years ago.

- Radwaste stores at AB, Gremikha, Zvezdochka, Sevmash, and other shipyards

These sites contain radwaste stores that are in a state of disrepair and are likely to result in radionuclides leaching into the soil and groundwater.

- Submarines stored for over 15 years

The risk of these vessels sinking is higher than for those submarines which have been withdrawn from service in the last 5-10 years. As a result of corrosion, the hulls are in a poor state of repair and sinking could result in discharges of coolant and non-radioactive contaminants into the sea.

- Other submarines

The risk of sinking is likely to be lower than for the older submarines.

5.8.3 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 when 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 organochorides in the Kola and Zapadnaya Litsa bays indicate levels that they are significantly above background levels, but they are comparable to contamination levels at Norwegian ports.

5.8.4 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.

5.8.5 Health

There are serious concerns with regards to 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.

6.0 PRIORITY ISSUES

6.1 Environmental Priorities

The previous sections have shown that 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 exposure of workers to radiation and conventional hazards during dismantling activities and the release of both radioactive and non-radioactive material to the environment.

In this section the Strategies which should be given priority in the Masterplan are evaluated based on the consequences and likelihood of nuclear accidents for situation as it is today, if the Masterplan strategies are not implemented. Mitigation measures in relation to implementing the Masterplan strategies are addressed in Section 7.

The basis for deciding the priority that should be given to the projects in the Masterplan was by identifying which address accidents with the highest probability and significant impact in accordance with criteria specified in Table 3.2.5-1. Accidents which are judged to have very low probability of occurrence or can be mitigated if certain measures are implemented are assigned a lower level of priority. This is to ensure that the programme is focused on the immediate hazards as opposed to events which take place only once per million years.

Table 5.2.8-1 summarises the range of potential consequences of accidents, which are used in Table 6.1-1 to allocate the potential impact of an accident at each type of facility in North West Russia. These are the basis for the expert assessment of the radiological consequences in the Masterplan from the potential accidents.

It will be seen from Table 6-1 that the accident that is judged to have a both a high frequency and a high impact for all significant 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 stated 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)**[5]. It will then be necessary to ensure that long-term safety is provided 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.

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**

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

The fuel stores at Andreeva Bay and Gremikha contain the largest amounts of radioactivity and are known to be causing an environmental impact (see Section 5).

The sinking of a vessel that contains damaged fuel will allow sea water to reach 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 SNF 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 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 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 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 involving 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**.

Table 6.1-1 Expert assessment of radiological impact significance for accidents considered within the Masterplan

Accident	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	 Low Low Low	 Low Low* Moderate**	 Low Low Low	 Low Low Low	 6 6 5
Sinking of reactor compartments	Sayda Bay	Low	Low	Low	Low	Low	Low	7
Sinking of nuclear-powered cruisers	***Zvezdochka***	***Moderate***	***Moderate***	***Moderate***	***High***	***High***	***High***	***4***
Sinking of Maintenance Vessels, including Lepse	***shipyards***	***High***	***Unknown***	***Unknown***	***High***	***Unknown***	***High***	***2***
Leakage of radioactivity from spent nuclear fuel stored at Andreeva Bay and Gremikha	***Andreeva Bay and Gremikha***	***High***	***Moderate***	***High***	***High***	***High***	***Low***	***2***
Land-based storage of cores from Alpha-class submarines (SCR accident)	***Gremikha***	***High***	***High***	***High***	***High***	***High***	***High***	***1***
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 in Severodvinsk and Murmansk	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.

** 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.

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 6.2-1. 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 6.2-1 is purely for ease of reference.

Table 6.2-1 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 (irrespectively of the ultimate option of SNF management in North-West Region).
4.	Development of FS, required design and engineering documentation. Creation of the regional center 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 SRC management 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 (irrespectively 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 Lepse.
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.
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-reprocessible SNF at MV of MSC.
45.	Creation of the temporary container storage facility for non-reprocessible 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 is 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.

Based on the priorities that have been identified in this SEA, the associated Masterplan measures are listed in Table 6.2-2 below.

Table 6.2-2 The Master Plan Measures that are Associated with each SEA Priority

SEA Priorities	Related Masterplan Measures
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.	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).
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.	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)
2(b) The removal of spent nuclear fuel from the Lepse 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	The principle measures are the decommissioning of the Lepse 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)
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.	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)
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.	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)

Table 6.2-2 (Cont.)

SEA Priorities	Related Masterplan Measures
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: • Fuel cladding; • Reactor pressure vessel and primary circuit; and • Reactor compartment and submarine pressure hull 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.	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).
6. Dismantling submarines that have been out of service less than 15 years.	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).
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.	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).

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.

7.0 ASSESSMENT OF ENVIRONMENTAL EFFECTS

In this section each of the four strategies will be assessed against the environmental indicators identified in Section 4.

The level of assessment depends on the level of information available on each strategy. There is a large amount of information on the dismantling of submarines, with PWR reactors, as there are a large number of on-going or completed dismantling projects. Phase 1 of the Masterplan proposed a number of enhancements to the existing strategy.

In contrast, the three other strategies are formulated only in very general terms with no clear technical approach. For these strategies, the Masterplan proposes key priority measures, which involve surveying to gain information on the current situation and the development of conceptual approaches.

Of the four strategies, only the dismantling of submarines with PWR reactors can be assessed in detail. This is addressed in Section 7.1.1 – 7.1.5 for the different dismantling phases under normal conditions and in Section 7.1.6 for accidents.

In addition, a generic review with recommendations can be provided for the proposals contained within the Masterplan for the decommissioning of coastal maintenance bases, submarines with lead-bismuth cooled reactors, surface nuclear-powered ships and technical support vessels. This review is provided in Sections 7.2-7.4.

7.1 Environmental assessment of nuclear submarine decommissioning

This section presents an assessment of the environmental effects of nuclear submarine decommissioning in accordance with the strategy envisaged in the Masterplan. The potential environmental effects of normal operations and representative accidents are analysed. Site-specific data are used for quantitative assessments where appropriate. Meanwhile, mitigation measures are identified to eliminate, reduce or control any adverse effects. The residual adverse effects that remain after mitigation are also identified.

7.1.1 Transportation phase

Table 7.1.1-1 summarises the assessment results for this phase during normal operating conditions.

Table 7.1.1-1 Potential environmental effects of nuclear submarine decommissioning - Transportation phase

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Radiological environment	Limit radiation exposure to workers	- / 0	Small doses to workers, far below the regulatory limit	Investigate use of PPE at naval bases during preparation of submarines for transfer to shipyard Ensure doses to workers from all operations at naval bases are ALARA
	Limit radiation doses to members of the public	0/0	Members of the public are not exposed	None required
	Minimise quantity of radioactivity potentially accessible to people and the environment	++	As a result of the dismantling strategy approximately 1×10^{17} Bq per submarine is transferred from floating deteriorating out-of-service submarines to controlled management within the Russian Fuel cycle system ashore	None required
	Limit radiation exposure of biota	0/0	Biota is not exposed	None required
Non- radiological environment	Improve worker health and safety	0/0	Procedures in place, trained staff	None required
	Avoid, remove or reduce sources of surface water pollution	-/0	No information on managing oils/lubricants/ and other wastes resulting from preparation of submarines for transfer at naval yards	It is necessary to verify that adequate facilities for managing conventional wastes resulting from submarine preparation are in place at naval bases.
	Avoid, remove or reduce sources of air pollution	-/0	Emissions are within the regulatory limits. Negligible if mitigated	Tug or barge engines should be inspected, maintained and operated to approach MARPOL standards as closely as possible. High quality, low-sulphur fuel is recommended whenever feasible. Emissions control measures, such as water injection, are available if follow-up were to indicate adverse effects on air quality.

Table 7.1.1-1 (cont.)

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
(Non- radiological environment)	Avoid contamination of biota with toxic substances	-/0	No information on managing wastes resulting from preparation of submarines for transfer at naval yards	It is necessary to verify that adequate facilities for managing conventional wastes resulting from submarine preparation are in place at naval bases.
	Maintain or enhance biodiversity	0/0	No impact	None required
	Maintain or improve natural resources	0/0	No impact	None required
	Improve physical protection	-/0	No information on physical protection against marine attacks during transfer	Verify that adequate measures are in place to protect against marine attacks during transfer
Socio-economic considerations	Maintain or improve level of economic growth	+/+	Small positive effect on a small number of jobs at naval yards and in the shipping industry (800 person-days of effort). In the longer term removal of laid-up submarines from the naval bases will result in potential loss of employment at naval bases.	Consider introduction of alternative sources of employment for naval staff who are presently involved in servicing out-of-service nuclear submarines.
	Maintain or improve human health	0/0	No impact	None required
	Maintain or improve cultural and heritage resources	0/0	No impact	None required

7.1.1.1 Radiological environment

Radiation exposure to workers

During the transportation of nuclear submarines to shipyards, no personnel will be present onboard the submarine and, therefore, the radiological exposure of workers is negligible.

However, some radiological exposure of workers will be incurred during the preparation for transit activities. This consists of external exposure to gamma radiation from the contaminated components within the reactor compartment and the inhalation of contaminated particulate and gaseous emissions.

It was estimated that for a typical Victor class submarine, the total individual dose for a worker received during preparations for towing was below 0.07 mSv [Moffett, Gerchikov et al, 2004]. This is less than 0.5% of the annual dose limit of 20mSv for workers set up by the Russian Standard NRB-99. The collective dose received by 20 workers, the approximate workforce required for the preparatory work, will not exceed 1.5 person-mSv.

It is unlikely that the same worker will be involved in more than 4 preparatory operations per year. Therefore, the total annual dose from dismantling activities will stay within the 20 mSv limit. However, it is necessary to ensure that the cumulative impact from all other activities taking place at naval bases is small compared to the regulatory limits.

It is anticipated that the radiation exposure of workers during this phase is similar for all submarines with pressurized water reactors, which have not suffered accidents.

However, a detailed assessment should be performed during the environmental assessment process for each individual project.

The reduction of worker exposure could be achieved by a reduction in the time spent on a submarine. However, surveying, testing and other work implemented in the process of preparing a submarine for towing is essential to ensure safety during towing.

There is no information on personal protection equipment used during the preparation of a submarine for towing.

The following mitigation measures are proposed to ensure that doses are As Low As Reasonably Achievable (ALARA):

1. ***It is important to make realistic predictions to be used as dose budgets for the dose uptake for each phase of the preparatory work and then monitor the actual accrued doses throughout the phase against these dose predictions. If at any stage of the work, doses are accrued faster than anticipated, then the work should be suspended and the approach reassessed to demonstrate that the work is still ALARA.***

2. ***It is necessary to evaluate whether further reductions of doses to workers can be achieved by the use of respiratory protection equipment, reduction of time or the provision of extra shielding during such operations as preparation of the hull for towing, radiological surveys and testing of the integrity of the reactor compartment.***

Upon the arrival of the submarine at the shipyard, personnel will spend a minimal amount of time in its immediate vicinity, which will be only as long as it takes to connect supplies of power and air. These operations are not carried out in high-radiation areas and it has been estimated that the individual doses incurred during these operations will not exceed 0.01 mSv [Moffett, Gerchikov et al 2004], which is far less than the annual dose limit of 20 mSv.

Based on the available information, it can be concluded radiological impacts on workers can be mitigated if the ALARA principle is implemented in full.

Radiation exposure of members of the public

Under normal conditions it is unlikely that there will be measurable doses to the public during the transportation phase. The results of a radiation survey of three Victor-class submarines conducted in May of 2004 indicates that inside compartments other than the reactor compartment, the gamma radiation dose rate ranged from 0.09 to 0.13 μSv/hr [Moffett, Gerchikov et al, 2004]. Outside the submarine, this dose is reduced through shielding by the pressure hull and by the external hull. Within a few meters of the submarine, external dose-rates are at normal background level.

No transportation-related activities, including preparation for transit, transportation of the nuclear submarine and its arrival and acceptance at the shipyard will result in any measurable release of radioactivity to environment, including to water, atmosphere or the soil and groundwater.

The lack of emissions, the low level of radiation outside the submarine and the restricted access to submarines during the transportation phase mean that there is ***no radiation exposure to the public during submarine transportation*** to the shipyard under normal conditions.

Radiation exposure of biota

No transportation-related activities, including the preparation for transit, transportation of the nuclear submarine and its arrival and acceptance at the shipyard will result in any measurable release of radioactivity to the environment, including to the surface water resource, the atmospheric environment, soil and groundwater. Therefore, there is ***no radiological contamination of the physical environment and no measurable radiation doses to biota.***

Radioactivity potentially accessible to people and the environment

Transportation to the shipyards is the first step of submarine decommissioning. Prior to decommissioning, a typical nuclear submarine with two pressurized water reactors contains between 1×10^{15} and 1×10^{17} Bq in fuel and between 1×10^{13} and 1×10^{14} Bq in the reactor compartment as well as solid and liquid radioactive waste, depending on its operational history and when the reactor was shut down. Altogether there are roughly 30 non-defuelled submarines stored afloat.

Implementation of the decommissioning project will ensure that both the fuel and the radioactive waste are stored within the controlled conditions of the Russian fuel cycle and waste management system. It will remove the risk of the radioactivity being released to the marine environment.

Therefore, this and all subsequent phases of the project have a significant positive effect in removing large quantities of radioactivity from a situation where they are potentially accessible to people and the environment.

7.1.1.2 Non-radiological environment

Worker health and safety

During the transportation phase, all activities entail some worker exposure to potential hazards, both physical and chemical. In particular, this involves handling hazardous materials, such as lamps containing mercury or cabling containing asbestos during preparation of submarines for towing.

The transfer operation will involve either towing or using barges and floating docks. The risks involved are typical of shipyard and maritime work and are limited i.e. small numbers of persons involved for short periods. To minimise the risks to workers, health and safety procedures and practices are in place. These include monitoring and engineered controls. Crews are specifically trained and equipped to conduct their work safely.

In the light of the existing mitigation measures, no residual adverse effects are anticipated.

Surface water resource

Preparations for the transport of the nuclear submarine can result in the release of liquid effluents to surface water, and thus affect water quality. It is for example expected to generate about 900 kg of liquid wastes (oils and lubricants) per submarine [Moffett, Gerchikov et al, 2004]. It is understood that waste management facilities exist at least at some naval bases. However, the information is limited and it is not clear that these are being used to process conventional waste.

If waste management procedures and practices are in place to minimize or avoid liquid effluent discharges while a submarine is at a naval base, any discharges will be limited and the resulting changes to surface water quality are likely to be highly localized, of limited duration and indistinguishable from background.

It is necessary to verify that adequate facilities for managing conventional wastes resulting from submarine preparation are in place at naval bases.

During transportation, arrival and acceptance at the shipyard, small amounts of sewage and oily water could be released to the sea. Since the towing vessels operate under strict safety controls related to submarine towing, and are expected to comply with the relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL), these releases would be very small in volume. Because of the movement of the source and the nature of the receiving bodies, any changes to surface water quality are likely to be highly localized, of limited duration and indistinguishable from background.

In summary, surface water contamination during the transportation phase is anticipated to be negligible, if it can be verified that adequate waste management facilities exist at the naval bases.

Atmospheric environment

The transportation phase will involve the operation of large marine diesel engines and it will result in releases to the atmosphere of combustion products, including carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), other oxides of nitrogen (NO_x), hydrocarbons (HC) and particulate matter (PM).

Table 7.1.1.2-1 show the calculated emissions of a nuclear submarine towed from Vidyaevo to Zvezdochka, with the assumption of 6.7 MW tugs, 80% average load and 72 hours of operation [Moffett, Gerchikov et al, 2004]. These calculations are believed to be representative of tug emissions.

Table 7.1.1.2-1: Estimate of emissions from typical towing vessels

Pollutant	Emission Factor (g/kW-hr)	Emission Rate (g/s)	Total Emissions for a Three-day Trip (Kg per 72 hrs)
PM	0	0	125
NO_X	11	20	5084
NO_2	16	29	7554
SO_2	24	44	11509
CO	1	1	323
HC	0	0	23
CO_2	684	1273	329904

PM: particulate matter, HC: hydrocarbons

According to this calculation, the total magnitude of emissions from towing (less than 2000 nautical miles per tug, including two return trips to Vidyaevo) is minor compared to overall emissions from general shipping and coastal traffic (approximately 2,000,000 nautical miles in 2002 [Arctic Centre, 2005].

International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI standards, effective after May 2005 for vessels constructed or overhauled after 2000, specifies NO_x emission limits based on engine rpm. Assuming the tug engines have a maximum operating speed of approximately 2000 rpm, the relevant MARPOL criteria is 9.8 g/kW-hr. The emissions factor used to estimate emissions exceeds this limit by about 60%.

MARPOL limits on sulphur dioxide come in the form of restrictions on the sulphur content of fuel, to 4.5% on a mass basis in general with a cap of 1.5% for "SO_x Emission Control Areas". The Barents Sea is not one of these areas; however, calculations indicate that requiring the use of low-sulphur fuel for the tow could cut SO_2 emissions by two-thirds, i.e. 7.6 tonnes.

MARPOL Annex VI criteria are not expected to be legally binding for the decommissioning of the nuclear submarine concerned (tugs are expected to be more than four years old), but provide an indication of prudent environmental management practices. Given that the work includes a limited number of submarine transfer operations, non-compliance to the degree estimated is not expected to lead to adverse effects on the atmospheric environment.

To control and reduce the source of air pollution, engines of vessels used for the transfer of submarines to shipyards should be inspected, maintained and operated to approach MARPOL standards as closely as possible. High quality, low-sulphur fuel is recommended whenever feasible. If subsequent assessments were to indicate any adverse effects on air quality, emissions control measures, such as water injection, are available.

Considering the proposed mitigation measures, residual adverse effects are unlikely.

Soil and groundwater

During the phase of nuclear submarine transportation, there are no activities influencing soil and groundwater quality, except for accidental spills of oil or other contaminants removed from submarines prior to towing. Therefore, non-radiological contamination of the soil and groundwater is unlikely during the transportation phase.

Contamination of biota with toxic substances

Any possible impact on fish or other representatives of biota, which may be affected by toxic substances, will be due to contamination of surface waters, soil or air.

As stated above, if waste management procedures and practices are in place to minimize or avoid liquid effluent discharges while a submarine is prepared for transportation at a naval base, any discharges will be of limited scope and highly localized, of limited duration and indistinguishable from background.

It is necessary to verify that adequate facilities for managing conventional wastes resulting from submarine preparation are in place at naval bases.

Biodiversity and natural resources

Physical environmental parameters, such as air quality, water quality or habitat, are the key factors in maintaining the level of biodiversity and natural resources. Previous sections have established that the effects of this phase on air and water quality are either negligible or can be mitigated.

According to Masterplan it is not envisaged that large facilities will have to be constructed to transport submarines which have been withdrawn from active service, to dismantling shipyards; therefore significant impact on the habitat is unlikely.

Therefore, the changes in biodiversity including habitat, species and natural resources such as forestry and fishery, from this phase, are negligible and the current level of biodiversity and natural resources will be maintained.

Physical protection of radioactive materials

It is extremely difficult to access nuclear materials in a non-defuelled submarine. Therefore the main risk is of a terrorist attack as opposed to theft of nuclear materials.

Normal security arrangements will be in place at naval bases during the preparation of submarines which have been withdrawn from active service for the transfer to dismantling shipyards (see Section 5).

During transportation the submarine will present a moving, and therefore more difficult target for aerial attacks than during its storage phase.

It will be necessary to ensure that measures are in place to protect against attacks at sea.

On arrival to a dismantling shipyard, normal security arrangements will be in place.

7.1.1.3 Socio-economic considerations

Economic growth

In the short-term, all work and activities associated with this phase contribute to an increase in employment level and the average income, which is one of the foundations of economic growth in the study area. For example, preparations for transporting a single nuclear submarine is expected to involve approximately 800 person-days of employment. Transportation of a nuclear submarine provides approximately 300 person-days of employment.

In the longer term removal of laid-up submarines from the naval bases where they are currently stored will result in the potential loss of employment from these naval bases. It is necessary to consider the introduction of alternative sources of employment for naval staff who are presently involved in servicing these nuclear submarines.

Human health

Previous sections have established that the effects of this phase on the physical environmental are either negligible or can be mitigated. Therefore, human health will not be affected in the study area due to the work or activity from this phase. Accordingly, measurable negative changes in human health from this phase are unlikely.

Cultural and heritage resources

Measurable changes in cultural and heritage resources are unlikely.

7.1.2 Submarine dismantling phase

This phase involves ***removal of spent nuclear fuel and radioactive waste from nuclear submarines, dismantling of the fore and aft compartments and formation of a three-compartment unit at the shipyards involved in dismantling***. ***In addition spent fuel management and temporary storage at the shipyard*** is considered within this sub-section. Management of spent nuclear fuel once it has been transferred from dismantling shipyards is considered in Section 7.6. Table 7.1.2-1 provides a summary of the assessment for the submarine dismantling phase.

Table 7.1.2-1 Potential environmental effects of nuclear submarine decommissioning -Dismantling phase

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Radiological environment	Limit radiation exposure to workers	-/0	Work takes place in areas with high dose rates of over 1mSv/h. Worker dose limits are not exceeded, however compliance with 20 mSv/y is achieved using dose sharing, which is against IAEA guidance. Worker dose data is limited and the ALARA principle is not followed. It is therefore believed that worker doses can be reduced further.	Necessary to ensure that worker dose data are collated at dismantling shipyards. Need to introduce the ALARA principle
	Limit radiation doses to members of the public	0/0	No impact	None required
	Minimise quantity of radioactivity potentially accessible to people and the environment	++/++	As a result of the dismantling strategy approximately 1×10^{17} Bq per submarine is transferred from floating deteriorating out-of-service submarines to controlled management within the Russian Fuel cycle system ashore	None required
	Limit radiation exposure of biota	0/0	Biota is not exposed	None required
Non- radiological environment	Improve worker health and safety	--/0	Workers lose a year of life over 10 years' of employment in submarine dismantling due to toxic emissions from cutting.	Replace thermal cutting with mechanical cutting whenever possible Ensure PPE is used without exceptions Verify the effectiveness of forced-air ventilation and filtration in work areas; Introduce regular health check-ups for shipyard personnel

Table 7.1.2-1 (cont.)

Environmental Component	**SEA Objective**	**Potential effects before/after mitigation**	**Comments/explanation**	**Mitigation measures**
(Non- radiological environment)	Avoid, remove or reduce sources of air pollution	-/0	Emissions at Zvezdochka are within the regulatory limits. No information on Nerpa and SRZ-10 shipyards.	Obtain information on Nerpa and SRZ-10 shipyards Maximise mechanical cutting
	Avoid, remove or reduce sources of surface water pollution	--/0	Discharges to surface waters are known to exceed regulatory limits in Russia.	Improved surface covering and drainage of metal cutting sites Commissioning of storm-water treatment facilities at dismantling shipyards
	Avoid contamination of biota with toxic substances	--/0	No information on concentration of chemicals in biota; assumed to be affected as a result of surface water contamination	As for reduction of surface water pollution
	Maintain or enhance biodiversity	0/0	No impact	None required
	Maintain or improve natural resources	0/0	No impact	None required
	Improve physical protection			
	Land-based facilities	0/0	Good level of SNF protection at land-based facilities.	Install radiation monitoring equipment at shipyard exits. Review physical protection at sites storing sealed radioactive sources.
	Storage of SNF and waste afloat	--/Not clear	-	Assess physical protection for off-shore storage of SNF and wastes

Table 7.1.2-1 (cont.)

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Socio-economic considerations	Maintain or improve level of economic growth	++/++	Significant positive effect on sustaining employment at the shipyards	None required
	Maintain or improve human health	--/0	Potential impact from non-radioactive discharges exceeding limits	As for 'Avoid, remove or reduce sources of surface water pollution'
	Maintain or improve cultural and heritage resources	0/0	No impact	None required

Legend

- \+ Positive effect
- ++ Significant positive effect
- \- Measurable negative impact
- -- Significant adverse effect
- 0 No impact or negligible impact

7.1.2.1 Radiological environment

Radiation exposure of workers

Because of the radiation levels associated with spent nuclear fuelled, irradiated reactor components, radioactive waste and the possibility of airborne releases, there will be measurable radiation exposure of workers during submarine defuelling and radioactive waste management.

There are no data on actual individual worker doses. Table 7.1.2.1-1 presents estimated worker doses for the external exposure pathway during this phase during defuelling at Zvezdochka shipyard, which is believed to be representative [Moffett, Gerchikov et al, 2004]. Individual doses, which are several orders of magnitude below the annual worker dose limit of 20 mSv, are based on average dose-rates reported at Zvezdochka shipyard.

However, ***maximum reported dose-rates of 1 mSv/h during the removal of the reactor lid and 1.7mSv/h during the management of solid radioactive wastes*** indicate that workers are present in a high-radiation environment and that actual doses are likely to be significantly higher than those based on ‘average’ dose rates.

In Russia defuelling takes place after the reactor is drained; therefore no shielding is provided by the water. The impact is mitigated by the significant time periods, of at least 3 years, which typically pass between the shut down of the submarine reactors and subsequent defuelling at dismantling shipyards.

Table 7.1.2.1-1 Radiation dose to workers (Dismantling single Victor Class submarine at Zvezdochka)

	Time (person-hours per submarine)	**Number of workers**	**Average dose rate, mSv/h**	**Collective dose, person-Sv**	**Average individual dose, mSv**
1. Unloading of shells from resistance thermometers	20	3	1.0E-03	2.0E-05	6.7E-03
2. Thermocouple removal	20	3	1.0E-03	2.0E-05	6.7E-03
3. Cutting of shells and A3 rods	40	3	1.0E-03	4.0E-05	1.3E-02
4. Reactor lid dismantling, set up of the guiding device	60	3	1.0E-03	6.0E-05	2.0E-02
5. Operation of defuelling guiding device	44	6	1.0E-03	4.4E-05	7.3E-03
6. Defuelling	44	6	1.0E-03	4.4E-05	7.3E-03
7. Collection of liquid wastes	10	5	1.0E-03	1.0E-05	2.0E-03
8. Liquid waste transportation	4	3	1.0E-02	4.0E-05	1.3E-02
9. Liquid waste storage	3	1	1.0E-02	3.0E-05	3.0E-02
10. Conditioning of liquid wastes	352	20	2.00E-03	7.0E-04	3.5E-02

Table 7.1.2.1-1 (cont.)

	Time (person-hours per submarine)	**Number of workers**	**Average dose rate, mSv/h**	**Collective dose, person-Sv**	**Average individual dose, mSv**
11. Collection and transportation of radioactive waste	10	3	1.0E-02	1.0E-04	3.3E-02
12. Solid waste storage	Limited to inspections	1	1.0E-03	N/A	N/A
13. Preparation of three-compartment unit	80 000	100	background	N/A	N/A
14. Transportation of three-compartment unit	35	35	background	N/A	N/A
15. Fuel transportation and storage	10	5	background	N/A	N/A
16. Loading of fuel casks into special train	20	8	2.0E-01	4.0E-03	5.0E-01
Total	80 317	183		4.4E-03	

Inhalation of radioactive dust and gaseous radionuclides is prevented by the use of PPE when required (i.e. gas masks).

Annual collective dose for workers at shipyards can be illustrated using Zvezdochka data, which are provided in Table 7.1.2.1-2. There is a clear inconsistency between estimated collective dose per dismantled submarine of 4×10^{-3} person-Sv (Table 7.1.2.1-1) and the actual annual collective dose of 4.7 person-Sv (Table 7.1.2.1-2).

This must be partially due to the definition of 'average' dose as explained previously or due to other shipyard activities in addition to submarine dismantling. In particular there is no data on the doses resulting from radiography involving the use of sealed sources at the phase of preparing the three-compartment unit.

Individual doses are within the Russian NRB-99 and international annual limits of 20mSv/yr, which were established to ensure that the risk to workers is acceptable. However compliance is sometimes achieved by removing workers from active duties once annual dose limit has been reached.

The number of Category A radiation workers appears to be unnecessarily high, and includes top management and engineers. This may be due to the benefits that are awarded to such workers in the Russian nuclear industry. ***Any link between radiation exposure and benefits should be removed,*** on the contrary minimisation of doses should be encouraged.

Table 7.1.2.1-2: Collective Worker Dose Data for Zvezdochka

Year	2000	2001	2002	2003
Collective dose, man-Sv	4.6	4.6	5.6	4.7
Number of category A personnel	2424	1843	2660	2660
Average individual dose, mSv/y	1.9	2.5	2.1	1.8

The overall exposure of the work force could be reduced by introduction of the ALARA principle and dose targets for each operation.

Accurate worker dose data should be collected and analysed by shipyards where the decommissioning work will be carried out.

Reducing the exposure of workers to radiation and obtaining reliable data on the exposure that workers do receive can be achieved by implementing IAEA guidelines such as those contained in Safety Guide DS 313 [IAEA, 2004]. The measures include:

a) A clear role and line of accountability for the health physics staff within the overall organisation,

b) Comprehensive health physics procedures,

c) Regular training,

d) Regular auditing to ensure that the procedures are followed

e) Comprehensive dose monitoring by both individual and task and the reporting of accurate statistics

f) ALARA planning using past dose data for each dismantling operation with a comprehensive review of alternative techniques for performing tasks in high radiation areas

g) The setting of dose budgets based on the above and the regular monitoring of performance against those budgets

h) The provision of adequate dosimeters and personal protection equipment

i) Incentivisation schemes for achieving low levels of exposure.

The success of such measures is demonstrated by the levels of exposure that are achieved in the decommissioning of civil reactors in several countries.

<u>Radiation exposure of members of the public</u>

Under normal conditions public exposure may result from authorised effluent releases to sea or air.

There are no routine or planned radioactive releases or discharges to surface water from any activities during this phase. Radioactive liquid waste is collected and sent for treatment to either Zvezdochka or Atomflot liquid waste treatment plants.

The interaction between the work in this phase and soil and groundwater is also very limited. Accordingly, radiological contamination of the surface water, the soil, and groundwater is unlikely.

However, direct and/or indirect releases of radioactivity to the air are anticipated during normal operations in this phase. Discharge will take place during the following operations:

- Discharge of gases from the high pressure system;
- Removal of liquids from the reactor prior to defuelling;
- Opening of reactor lid; and
- Defuelling.

All inert gases contained within the reactor compartment will be discharged. Discharges of Cs-137 to the atmosphere will not exceed 2% of the inventory contained within the primary coolant [Moffett, Gerchikov et al, 2004]. Atmospheric discharge of other radionuclides will be limited to 1% of the coolant inventory.

The total estimated discharge to the atmosphere, using the data from defuelling a typical Victor class submarine as an example, are as follows:

Table 7.1.2.1-3 Discharge to Atmosphere during Defuelling of a Victor Class Submarine [Moffett, Gerchikov et al, 2004]

Radionuclide	**Activity, Bq**
Kr-85	1.1×10^{10}
Sr-90 + Y-90	7.3×10^{1}
Ru-106 + Rh-106	7.5×10^{2}
Cs-134	3.6×10^{6}
Cs-137 + Ba-137m	1.7×10^{7}
Ce-144 + Pr-144	4.1×10^{3}
Fe-55	2.0×10^{6}
Ni-59	6.3×10^{3}
Co-60	2.2×10^{5}
Ni-63	6.7×10^{5}

In the short term, these discharges will result in increased radionuclide concentrations in the atmosphere. However, within hours, these atmospheric radionuclide concentrations will revert to background levels.

Such releases will result in exposure of members of the public via the following pathways:

- External exposure from the plume ‘cloudshine’;
- External exposure from contaminated soil;
- Internal exposure due to inhalation;
- Re-suspension; and
- Internal exposure from ingestion.

The general public is not allowed to settle within the 'Sanitary Protection Areas', which surrounds all shipyards involved in dismantling. For Zvezdochka Shipyard the dose beyond this zone from authorized releases was estimated to be below 10 μSv, which represents 1% of the annual dose limit of 1 mSv to the general public [Moffet, Gerchikov et al, 2004]. Therefore during normal dismantling operations there will be no radiological impact on the general public.

Radiation exposure of biota

As detailed above normal releases of radioactivity to atmospheric environment during dismantling are very small and there are no discharges of radioactivity to water planned. Therefore under normal circumstances there will be no measurable changes in radiation exposure of biota resulting from dismantling.

Radioactivity potentially accessible to people and the environment

As described above the dismantling strategy has a significant positive effect of removing large quantities of radioactivity potentially accessible to people and the environment.

7.1.2.2 Non-radiological environment

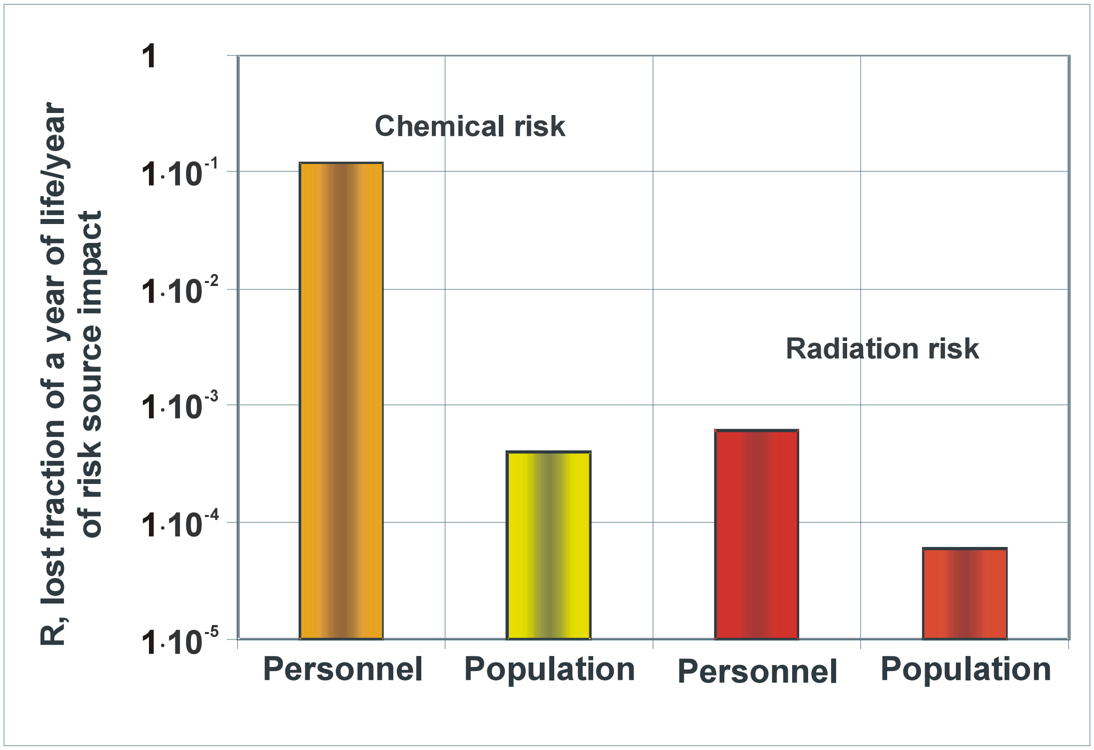
At Zvezdochka and Nerpa shipyards there is a clear health and safety and environmental protection management structure with a developed set of procedures. Zvezdochka shipyard is working towards compliance and certification in accordance with ISO 14001.

Worker health and safety

Preparation for reactor defuelling, preparation for nuclear submarine dismantling, construction of a three-compartment unit and dismantling of fore and aft compartments and a number of other activities within this phase will result in workers being exposed to routine shipyard risks. Metal cutting work is the main potential source of adverse occupational health effects.

Several reports [Severodvinsk, 2004, Smith et al, 2004, Sarkissov et al, 2003, Nikitin, 2004] have identified high concentrations i.e. above the threshold for 'measurable effect' of gases and suspended solids in the immediate area of various cutting and grinding operations. For instance, gouging and cutting of surfaces coated with lead paint or containing a high lead content, such as cables, leads to local concentrations of airborne lead at up to 114 times maximum permissible levels [Moffett, Gerchikov et al, 2004]. Titanium, zinc, copper, lead, nickel, manganese, chrome, "dust", dibutyl phthalate and epylchlorhydrite have been identified at levels of concern [Sarkissov et al, 2003] in the workplace.

The Masterplan estimated that, due to toxic emissions, an average worker involved in dismantling loses, on average, a year of life over 10 years of employment (Figure 7.1.2.2-1). This represents a significant negative effect.



Source: SMP, 2004

Figure 7.1.2.2-1. Comparative assessment of chemical and radiation risks from submarine dismantling

Potential falls are another area of concern due to work undertaken at significant heights.

Workers involved in dismantling at Zvezdochka, Nerpa and SRZ-10 shipyards have a range of protective equipment, including hard hats, protective masks, steel-toe cap boots and respirators, but it has been observed that due to uncomfortable working conditions personal protection equipment is not always used.

To mitigate the adverse effect on worker health and safety it is necessary to:

1. ***Introduce Engineering Measures.*** This may involve alternative methods of metal work, such as replacement of thermal cutting with mechanical cutting.

2. Ensure that ***personal protective equipment is ALWAYS used.***

3. ***Verify the effectiveness of forced-air ventilation and filtration in work areas***.

4. Implement periodic ***reviews of medical monitoring data*** (e.g., hair, urine and lung capacity data) to help ensure that protective measures are properly implemented.

Implementation of the proposed mitigation measures will minimize the impact on workers to acceptable levels.

<u>Surface water resource</u>

Shipyards involved in dismantling generate significant quantities of contaminated water as a result of run-off from metal cutting sites, processing oils and other hazardous materials.

Contaminants discharged from Zvezdochka shipyard are presented in Table 7.1.2.2-1. It can be seen that in a number of instances Russian regulatory limits were exceeded (these cases are marked in bold). This is known to have resulted in enhanced concentrations of chemical contaminants in Nikolskoye Ustije. Although there is no information on comparable discharges at Nerpa and SRZ-10 shipyards, it is highly likely that they face similar problems.

It can therefore be concluded that currently dismantling has a significant negative effect on surface water resources.

Mitigation measures should be implemented, including

- **Improved surface covering** and drainage of metal cutting sites (at Zvezdochka shipyard this measure is being implemented).
- Commissioning of **storm-water treatment facilities** at dismantling shipyards.

Table 7.1.2.2-1 Contaminants Discharged to Water from Zvezdochka Shipyard in 2002 (kg/yr)

Substance	Discharge from Releases 1-8		Discharge from Release 9 (SPW)		Summary of discharges	
	Real	ADL*	Real	ADL*	Real	ADL*
Ammonia nitrogen	**2,251.3**	1,432.0	24,391.0	42,768.0	26,642.3	44,200.0
Nitrate nitrogen	128.5	366.0	**48,699.0**	40,040.0	**48,827.5**	40,406.0
Nitrite nitrogen	3.8	24.8	1,864.0	2,330.0	1,867.8	2,354.8
BOD, complete	**8,250.9**	1,863.0	37,208.0	66,000.0	45,458.9	67,863.0
Suspended matter	**7,660.4**	6,558.0	41,931.0	66,000.0	49,591.4	72,558.0
Iron	**802.7**	249.4	842.0	1,760.0	1,644.7	2,009.4
Cadmium	0	6.2	0	44.0	0	50.2
Manganese	**88.5**	74.9	126.0	440.0	214.5	514.9
Copper	**15.3**	12.4	15.2	88.0	30.5	100.4
Petroleum products	**200.5**	135.9	330.0	616.0	530.5	751.9
Nickel	0.558	6.2	0	44.0	0.558	50.2
Mercury	0	n/a	0	n/a	0	n/a
Lead	3.11	5.95	4.5	35.0	7.61	41.0
Phosphates (by P)	**182.4**	122.5	8,444.0	9,240.0	8,626.4	9,362.5
Chromium (III)	0.152	3.0	0	31.0	0.152	34.0
Zinc	21.6	30.7	0	220.0	21.6	250.7

* ADL of sewage waters after purification is approved by the "Permit for the Discharge of Pollutants into the Water Objects", registration number 04-08 from 01.07.2002, issued by the Committee on Nature Resources of the Arkhangelsk Oblast'.

Significant adverse effects can be mitigated if the proposed measures are implemented.

<u>Atmospheric environment</u>

A large amount of work during this phase including handling volatile, metal work such as surface preparation, grinding, gas cutting and air-arc gouging will create locally hazardous concentrations of metal dust, carbon monoxide and nitrogen dioxide. In addition, heavy equipment used at the dismantling sites will result in emissions of combustion products.

Handling volatiles: Preparations for reactor defuelling include the handling of volatile materials, particularly fuel. However, the quantities handled are small (in the order of six tonnes of fuel) and volatile substances will be transported and held in closed containers. Opportunities for volatilization are therefore limited.

Effects on the atmospheric environment will be mitigated by compliance with relevant procedures for handling volatiles such as fuel and, by the use of high-efficiency organic compounds filter systems.

Depressurization of submarine systems: During preparations for reactor defuelling, pressurized systems are depressurized. This includes bleeding high pressure gas from the reactor's pressure compensation system. There are few conventional air pollutants associated with this operation. Compressed air, nitrogen and other harmless gases will be vented to the atmosphere, and will not lead to adverse effects.

Metal work: Preparations for reactor defuelling, preparation for submarine dismantling, construction of three-compartment unit and dismantling of fore & aft compartments all extensively entail these kinds of metal work.

Aerosols are produced containing gases (e.g. carbon monoxide, nitrogen dioxide, fluorine) and suspended solids (paint, nickel, copper, aluminium, iron, manganese, chrome, etc.). Table 7.1.2.2-2 presents an estimate of total atmospheric emissions for metal work during dismantling a second-generation nuclear submarine.

Table 7.1.2.2-2: Estimate of Atmospheric Emissions from Dismantling a Second-Generation Nuclear Submarine [Sarkissov et al, 2003]

Total (kg)	Suspended Solids (kg)							Gases (kg)		
	Manganese	Chrome Oxide	Chrome Anhydride	Nickel Oxide	Aluminium	Copper	Lead	Carbon Monoxide	Nitrogen Dioxide	Fluorine
1948.48	66.33	1.125	2.72	3.525	0.24	4.655	1.3	389.2	315.8	1.788

Up to 1000 kg of paint dust may also be suspended as a result of surface preparation.

In the immediate work area, Russian maximum permissible concentrations for airborne contaminants can be exceeded by up to a factor of 114 (airborne lead during arc-air gouging) [Nikitin, 2004].

Studies to investigate the environmental condition at the Zvezdochka site have modelled the dispersion of hazardous substances using "Ecolog" software and concluded that dismantling will not result in the degradation of environmental conditions at the site boundary [Nikitin, 2004]. This is in accordance with the results of the existing air monitoring program, which do not indicate breach of maximum permissible concentrations for harmful substances at the site boundary [Nikitin, 2004].

It is not known whether the same information is available for other dismantling shipyards.

Operation of heavy equipment: Preparation for submarine dismantling, construction of three-compartment unit and dismantling of fore & aft compartments involves continuous operations of heavy equipment using diesel engines at various locations across the shipyard. Emissions from diesel engines are likely to lead to changes in air quality.

A study was carried out to assess the effects of likely changes in air quality at Zvezdochka shipyard, which is believed to be representative. Vehicle emission scenarios were created for various areas at the shipyard and were modelled to ascertain likely concentrations of air pollutants at the boundary of the Sanitary Protective Area (SPA).

Five emission scenarios were created for five key areas of the shipyard as follows:

- Cable cutting area – One 160 horsepower (hp) mobile crane;
- Mechanical cutting area – Two Caterpillar 375 excavator rated each at 428 hp;
- On-road trucks – One 350 hp and one 206 hp (154 kW) truck;
- Rail line at Dry Dock – One 737 hp (550 kW) diesel locomotive; and
- Thermal cutting area – One Caterpillar 375 excavator rated at 428 hp.

In addition, all of the above sources were modelled as a single source at the average distance to the SPA outer boundary for the five specific locations noted.

Emission rates for each source (i.e. each piece of equipment) were calculated using methods from USEPA Report No. NR-009A, [Beardsley M & Lindhjem, 1998], to provide an indication of the range of pollutant concentrations likely at the SPA outer boundary. The results are summarized in Table 7.1.2.2-3.

Table 7.1.2.2-3: Estimate of Emissions from Heavy Equipment

Scenario	Active Equipment	Approximate Distance from SPA boundary (m)	Contaminants	Emission Rate (g/s)	Conc. at impingement point (µg/m3)
Cable cutting area	One 160 hp mobile crane	400	HC	0.03	3.1
			CO	0.12	12.3
			NO_X	0.37	38.2
			PM	0.02	1.8
			SO_2	0.05	4.9
Mechanical cutting area	Two 428 hp Caterpillar 375 excavator chassis	400	HC	0.16	16.4
			CO	0.64	65.6
			NO_X	2.00	204.9
			PM	0.10	10.2
			SO_2	0.26	26.6
On-road trucks	One 350 hp truck, one 206 hp truck	300	HC	0.11	18.4
			CO	0.42	73.1
			NO_X	1.30	226.8
			PM	0.06	10.8
			SO_2	0.17	29.0
Rail complex at Dry Docks	One 737 hp diesel locomotive	580	HC	0.14	7.6
			CO	0.55	30.3
			NO_X	1.72	93.9
			PM	0.08	4.5
			SO_2	0.22	12.0
Thermal cutting area	One 428 hp Caterpillar 375 excavator	425	HC	0.08	7.7
			CO	0.32	30.4
			NO_X	1.00	94.4
			PM	0.05	4.5
			SO_2	0.13	12.1
All sources grouped together	One 160 hp mobile crane, three 428 hp Caterpillar 375 excavators, one 350 hp truck, one 206 hp truck, one 737 hp diesel locomotive	425	HC	0.52	46.0
			CO	2.05	182.5
			NO_X	6.37	566.4
			PM	0.30	27.0
			SO_2	0.81	72.3

Possible air pollutant concentrations were compared with standards protective of human health and the environment [Moffett, Gerchikov et al, 2004]. The results show that ***no actual adverse effects are likely for the atmospheric environment under normal conditions***.

Effects on the atmospheric environment can be mitigated by inspection, maintenance and operation of heavy equipment. Emission control measures for existing diesel engines and the newer cleaner diesel engines are available if follow-up monitoring were to indicate adverse effects on air quality.

For metal work, mitigation includes the following:

- Maximizing the amount of mechanical cutting;
- Monitoring air quality at the sites and using the data to focus any required corrective actions; and

If atmospheric emissions were to prove unacceptable, further reductions could be made by changing building ventilation systems to improve treatment, by increasing the capacity for mechanical cutting and by introducing the capacity for hydraulic and laser cutting.

In consideration of proposed mitigation measures, no residual effects are anticipated.

Soil and groundwater

During normal operation there will be no discharges of contaminated substances to soil or groundwater.

The only work activity which may result in measurable changes in soil quality are cutting operations not undertaken on concrete pads with proper drainage. To mitigate potential effects on soil quality, the measures include ***provision of good concrete coverage and drainage in cutting locations.***

In consideration of proposed mitigation measures, no residual adverse effects are anticipated.

Contamination of biota with toxic substances

Quality of air, water and soil define the impact on biota in the study area. Previous sections have demonstrated that there are potential impacts from dismantling on air pollution and contamination of the water resource, but they can be mitigated.

Biodiversity and natural resources

Previous sections have established that the effects of this phase on air and water can be mitigated. All dismantling facilities are already in place; therefore no changes in habitats are likely to occur and the impacts on species and natural resources such as forestry and fishery from this phase are negligible.

It can be concluded that there will be no impact on the current level of biodiversity and natural resources will be maintained.

Physical protection of radioactive materials

Prior to retrieval of nuclear materials from a submarine, they are very difficult to access and realistic threats are limited to terrorist attacks on vessels moored at the shipyard. The fact that submarines have been transferred to dismantling shipyards from their original storage location at naval bases makes no difference to the nature of this threat.

Additional risk of theft comes into force once radioactive materials, crucially, spent nuclear fuel, have been retrieved from submarines in the course of dismantling.

There are existing physical protection measures at the shipyards aimed at preventing both theft of radioactive materials and terrorist attacks. These measures include:

- restriction of access to foreigners to the regions where dismantling shipyards are located;

- all dismantling shipyards have a perimeter fence and are guarded.

Ensuring security of spent nuclear fuel presents the main concern in relation to physical protection. After defuelling, the fuel is handled by one of two methods:

1. Placed into fuel casks for temporary storage ashore or

2. Transferred for storage or shipping in surface vessels

Storage of SNF and radioactive waste ashore

Being heavy and large in size, fuel casks themselves provide an excellent protection. Once the casks are placed into storage at the recently constructed land-based buffer storage sites at Zvezdochka and Atomflot, then they are secured by additional barriers, automatic intruder detection systems, CCTV and radiation monitors.

There are several known cases of theft from Russian shipyards, mainly involving the theft of titanium. Although theft of radioactive materials has taken place at Russian naval bases, there have been no such incidents at dismantling shipyards.

Further improvement to physical protection measures for materials stored at the shipyards would be provided if automatic radiation were to be installed at exits from dismantling shipyards.

Storage of SNF and radioactive waste off-shore

Storage of fuel and radioactive waste in surface vessels leaves it potentially exposed to air- and sea-borne attacks. The containment and protection provided to fuel assemblies stored in PM vessels, without casks within such vessels is unlikely to be as good as that provided by the hull and reactor pressure vessel of a submarine.

It is not clear that the current off-shore storage/shipping approach provides adequate protection and it is proposed that security of off-shore fuel and waste storage at dismantling shipyards should be reviewed.

7.1.2.3 Socio-economic considerations

Economic growth

All work and activities associated with this phase contribute to an increase in employment and average income, which is one of the foundations of the economic growth in the study areas.

Shipyard activities are the dominant industries in all dismantling locations, including Severodvinsk, Polyarny and Snezhnogorsk. Therefore the effects of work and activities associated with the dismantling phase on economic growth are positive.

As discussed in the previous sections, impacts on surface waters can be mitigated. Therefore, the fishing industry will not be adversely affected by this phase.

Human health

As detailed in Section 5, the population in areas adjacent to dismantling shipyards have serious concerns about the impacts of dismantling on health, particularly in children.

Statistical evidence has been quoted during the scoping consultation [Gerchikov 2005] stating that there is a higher occurrence of certain diseases in Severodvinsk than in other towns in Arkhangelsk region.

The precise source of this increase is unclear; it may result from other activities undertaken at shipyards, including:

- refurbishment of oil platforms at Zvezdochka and Sevmash
- operation of a thermal power plant in Severodvinsk or
- contamination of Dvinskaya Bay waters

It may also be a result of better detection of diseases in Severodvinsk compared to the surrounding areas.

However, with discharges of some chemical pollutants due to dismantling operations being in excess of the current Russian limits, this is also a possible contributor to the cumulative impact on health in population adjacent to dismantling shipyards.

Therefore the ***measures recommended for reduction of non-radioactive discharges will mitigate potential impacts on human health.***

It is also recommended that ***monitoring of population health in the local study areas should be further improved.***

Cultural and heritage resources

All activities are carried out at existing shipyards. Therefore there will be no measurable changes in cultural or heritage resources.

7.1.3 Reactor compartment management phase

Assessment results of this phase are summarised in Table 7.1.3-1.

Table 7.1.3-1 Potential environmental effects of reactor compartment management phase

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Radiological environment	Limit radiation exposure to workers	-/0	No data. Assumed that worker dose limits are not exceeded, however the ALARA principle is not followed. It is therefore believed that worker doses can be reduced further.	Necessary to ensure that worker dose data are collated at dismantling shipyards, during compartment transfer and compartment management sites. Need to introduce the ALARA principle
	Limit radiation doses to members of the public	-/0	No impact in the short or medium terms.	Assess long-term impacts and develop long-term strategy for the disposal of reactor compartments
	Minimise quantity of radioactivity potentially accessible to people and the environment	-/++	As a result of the Masterplan strategy approximately 10×10^{14} Bq per reactor compartment will be transferred to secure storage ashore. No clear strategy for the period until Sayda Bay facility becomes available.	Need to define approach for storage of reactor compartments from submarines that are being dismantled over the next four years.
	Limit radiation exposure of biota	0/0	No impact in the short or medium term.	Assess long-term impacts and develop long-term strategy for the disposal of reactor compartments
Non- radiological environment	Improve worker health and safety	--/0	Conventional risks related the preparation of 3-compartment units for towing and to cutting of 3-compartment units at Nerpa. Other risks relate to normal shipyard activities or monitoring and are trivial.	As for submarine dismantling phase
	Avoid, remove or reduce sources of air pollution	-/0	Potential emissions related to planned cutting of 3-compartment units at Nerpa.	As for submarine dismantling phase
	Avoid, remove or reduce sources of surface water pollution	--/0	Cutting operations at Nerpa will have a potential impact, as for dismantling	Improved surface covering and drainage of metal cutting sites Commissioning of storm-water treatment facilities at Nerpa

Table 7.1.3-1 (cont.)

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
(Non- radiological environment)	Avoid contamination of biota with toxic substances	--/0	No information on concentration of chemicals in biota; assumed to be affected as a result of surface water contamination	As for reduction of surface water pollution
	Maintain or enhance biodiversity	-/0	Potential impact from loss of habitat. No information on the assessment / measures implemented at Sayda Bay storage facility	Identify whether there are potential impacts on populations of species at Sayda Bay construction sites
	Maintain or improve natural resources	0/0	No impact	None required
	Improve physical protection	+/0	Positive impact from measures proposed in the Masterplan	None required
Socio-economic considerations	Maintain or improve level of economic growth	++/++	Significant positive effect on sustaining employment at the shipyards and Sayda Bay	None required
	Maintain or improve human health	-/0	Potential impact from long term storage of reactor compartments.	Assess impact for long-term storage and develop disposal strategy.
	Maintain or improve cultural and heritage resources	0/0	No impact	None required

Legend

+	Positive effect	-	Measurable negative impact	0	No impact or negligible impact
++	Significant positive effect	--	Significant adverse impact		

7.1.3.1 Radiological environment

Radiation exposure to workers

Measurable changes in radiation dose to workers may occur at each of the following stages:

- the construction of three-compartment units
- interim storage at shipyards
- transfer to Nerpa
- separation of reactor compartments at Nerpa
- transfer of reactor units to Sayda Bay
- storage at Sayda Bay.

Annual doses to workers during these phases are significantly below 20 mSv [Rosatom, 2005]. However based on the current understanding of the practices accepted in Russia it can be assumed that as for submarine dismantling

1. There will be strict compliance with worker dose limits
2. Improvement will be required to minimize worker doses in accordance with the ALARA principle.

Radiation exposure to members of the public and biota

No releases of radioactivity to the environment are anticipated during this phase in the medium term (tens of years). Therefore there will be no measurable changes in doses to members of the public or biota from this phase in the short or medium term.

It is proposed that the compartments will be stored for 70 years.

Radioactivity potentially accessible to people and the environment

Masterplan strategy is to construct a land-based facility for storage of reactor compartments. This approach is currently being implemented at Sayda Bay.

As a result of this strategy, reactor compartments, each containing approximately 10^{14} Bq will be transferred from storage afloat to a more environmentally secure engineered facility ashore.

Therefore, there will be a positive impact on this objective.

A short-term issue is that at present the pontoon storage facility at Sayda Bay is full. ***It is not clear what the Masterplan strategy for the interim storage of reactor compartments from submarines dismantled between 2004 and 2008 is, 2008 being when the new Sayda Bay facility is expected to become available.***

7.1.3.2 Non-radiological environment

Workers health and safety

Activities during reactor compartment management phase entail worker exposure to potential hazards, both physical (e.g. fall, burns, drowning) and chemical (e.g., exposure to chemicals, welding fumes).

The risks associated with cutting of 3-compartment units into separate compartments at Nerpa are similar to those identified in Section 7.1.2.2 and therefore, similar mitigation measures will be required.

It should be noted that no personnel will be present on reactor-compartment units during towing operations.

Health and safety procedures and practices will be in place to minimise or avoid risks to workers

Surface water resource

During the compartment transfer phase, a small amount of sewage and oily water could be released to the sea by towing vessels. However, the changes to surface water quality are likely to be highly localized, of limited duration and indistinguishable from background, while towing vessels are expected to be operated in accordance with MARPOL regulations and related Russian guidelines.

Emissions to water during the planned cutting of a 3-comparment unit at Nerpa will be consistent with the metal cutting during dismantling phase and can be mitigated in a similar manner.

Atmospheric environment

Transportation of the reactor compartment during this phase includes operation of marine diesel engines and the emissions are similar to those from the initial transportation of the nuclear submarine to shipyard. Just like the analysis for the transportation of the nuclear submarine, no measurable changes are expected to the atmospheric environment.

Air pollution could be further mitigated by inspection, maintenance and operation of tug engines so that MARPOL standards are achieved as far as possible. High quality, low-sulphur fuel is recommended whenever feasible. Emissions control measures, such as water injection, are available if follow-up were to indicate adverse effects on air quality.

Soil and groundwater

No work and activities during this phase will get the soil and groundwater contaminated under normal conditions.

There will be a potential for soil and groundwater contamination at the Nerpa site where the reactor compartment will be separated from the adjacent compartments. The same measures should be applied as for cutting pads at submarine dismantling sites.

In the short and interim period non-radiological contamination of soil and groundwater during the reactor compartment storage phase is unlikely.

In the longer term, the surface and drainage of the compartment storage pad at Sayda Bay may deteriorate, then there will be a limited potential for soil contamination. Potential for this impact must be assessed.

Contamination of biota with toxic substances

No impact.

Biodiversity and natural resources

Loss of habitats as a result of construction of a land-based facility for storage of three-compartment units may affect biodiversity both during construction and during storage (see Figure 7.1.3.2-1).

(a) *(b)*

Source: http://www.a-submarine.ru/News/Main/view?id=6474&idChannel=105

Figure 7.1.3.2-1. Sayda-Bay construction site in July 2004 (a) and in September 2004 (b)

There is no information on the presence of protected species in the area. Crucially ***there is no information on whether these impacts have been assessed prior to construction of the facility, and whether the appropriate mitigation measures have been implemented.***

Physical protection of radioactive materials

According to the Masterplan, a number of additional physical protection facilities will be installed at Sayda Bay. This will include provision of equipment for the guarded area and provision of a new checkpoint site.

There will be a positive impact on this objective.

7.1.3.3 Socio-economic considerations

Economic growth

All work and activities associated with this phase contribute to an increase in employment and average income, which is one of the foundations of the economic growth in the study areas. Consequently, effects of work and activities associated with this phase on economic growth are positive.

Human health

Previous sections have established that the effects of this phase on the physical environment are either negligible or can be mitigated. Therefore, there will be no impact on human health and life expectancy will not be affected in the study area due to activities undertaken at this phase.

Cultural and heritage resources

No measurable changes in cultural and heritage resources have been identified.

7.1.4 Radwaste management phase

Table 7.1.4-1 summarises assessment results for radwaste management phase.

Table 7.1.4-1 Potential environmental effects of radioactive waste management phase

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Radiological environment	Limit radiation exposure to workers	-/0	Based on the available information it can be concluded that worker dose limits are not exceeded. However the ALARA principle is not followed. It is therefore believed that worker doses can be reduced further.	Necessary to ensure that worker dose data are collated at dismantling shipyards, during compartment transfer and compartment management sites. Need to introduce the ALARA principle
	Limit radiation doses to members of the public	-/0	No impact in the short or medium terms from the current activities. However old stores at Zvezdochka and Sevmash require remediation.	Assess long-term impacts and develop long-term strategy for the management of radioactive wastes from dismantling Decommission unsafe and leaking storage facilities at Zvezdochka and Sevmash
	Minimise quantity of radioactivity potentially accessible to people and the environment	-/++	Positive impact in the short and medium terms resulting from the processing transfer of radioactive waste from laid-up submarines to the controlled storage. In the longer term it will be necessary to establish facilities for the disposal of radioactive wastes, which will then ensure that all radioactive waste is inaccessible to the people and environment.	Establish regional long-term storage or disposal facilities
	Limit radiation exposure of biota	0/0	No impact.	No impact
Non- radiological environment	Improve worker health and safety	-/0	As for submarine dismantling phase	As for submarine dismantling phase
	Avoid, remove or reduce sources of air pollution	0/0	No impact	No impact

Table 7.1.4-1 (cont.)

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
(Non- radiological environment)	Avoid, remove or reduce sources of air pollution	0/0	No impact	No impact
	Avoid, remove or reduce sources of surface water pollution	-/0	Potential impacts from conventional contaminants associated with radioactive waste in leaking storage facilities.	Decommission old storage facilities
	Avoid contamination of biota with toxic substances	--/0	No information on concentration of chemicals in biota; assumed to be affected as a result of surface water contamination	As for reduction of surface water pollution
	Maintain or enhance biodiversity	-/0	Potential impact from loss of habitat. No information on the assessment / measures implemented at Sayda Bay storage facility	Identify whether there are potential impacts on populations of species at Sayda Bay construction sites
	Maintain or improve natural resources	0/0	No impact	None required
	Improve physical protection	+/0	Positive impact from measures proposed in the Masterplan	None required
Socio-economic considerations	Maintain or improve level of economic growth	++/++	Significant positive effect on sustaining employment at the shipyards and Sayda Bay	None required
	Maintain or improve human health	-/0	Potential impact from long term storage of reactor compartments.	Assess impact for long-term storage and develop disposal strategy.
	Maintain or improve cultural and heritage resources	0/0	No impact	None required

Legend

+	Positive effect	-	Measurable negative impact	0	No impact or negligible impact
++	Significant positive effect	--	Significant adverse impact		

7.1.4.1 Radiological environment

Radiation exposure to workers

It is necessary that the ALARA principle is implemented (see Section 7.1.2).

Radiation exposure to workers

Mitigation measures for radiation exposure to workers during the management of radioactive wastes will involve implementation of the ALARA principle in accordance with the requirements identified in Section 7.1.2.

Radiation exposure to members of the public

Radioactive exposure to members of the public will result from effluent releases to the environment during the key phases of processing radioactive waste detailed in Section 4. The majority of radioactive effluent discharges result from the processing of radioactive liquid wastes.

Liquid wastes from submarine dismantling are processed either at Zvezdochka or at Atomflot.

Atmospheric releases will result in exposure of members of the public via the following pathways:

- External exposure from the plume ‘cloudshine’;
- External exposure from contaminated soil;
- Internal exposure due to inhalation;
- Re-suspension; and
- Internal exposure from ingestion.

Releases to sea will result in exposure of the public via

- ingestion of fish and crustaceans and via
- external exposure.

It has been estimated that doses to general public, arising from atmospheric emissions of radionuclide inventory equal to annual discharge limit at Zvezdochka shipyard will be below 10 µSv, which represents 1% of the annual dose limit to general public [Moffett, Gerchikov et al, 2004].

Furthermore, the actual monitoring data at the Zvezdochka and Sevmash and Nerpa shipyards indicate that no elevated levels of radioactivity have been measured in the area surrounding the shipyard in over 10 years of submarine dismantling.

There is no information on radioactive releases resulting from processing radioactive wastes at Atomflot, although it is likely that the discharges from recently built facilities have been minimized and are negligible compared to the annual dose limit of 1 mSv.

In summary, it is concluded that there is no radiological impact on members of the public from radioactive waste management during submarine dismantling.

Radiation exposure of biota

As described in Section 5, there is no radiological contamination of the areas surrounding dismantling shipyards and Atomflot. Dismantling and radioactive waste have taken place for a number of years and no increase in discharges will result from Masterplan proposals relating to dismantling.

It can therefore be concluded that there will be no measurable radiological impact on populations of biota.

Radioactivity potentially accessible to people and the environment

During this phase, depending on the submarine class, over 100 m^3 of liquid and solid wastes will be conditioned, packaged and placed into interim storage at shipyards or within reactor compartments.

The volume of solid radwaste will be reduced via compaction for soft wastes. Large metallic wastes will be size reduced by cutting. Some metallic waste will be decontaminated and then cleared for recycling.

Liquid radwaste will be collected and treated. Filters, resins evaporation and reverse osmosis residue resulting from the processing of liquid wastes will be packaged and stored at shipyards.

Therefore, the total volume of radwaste will be significantly reduced and the radioactivity potentially accessible to people and the environment is minimized.

However the shipyard storage facilities are only designed for short-term storage and the capacity is limited.

The Masterplan already identifies the need for long-term disposal plans for wastes that will be generated as a result of decommissioning the facilities at coastal maintenance bases. ***It is necessary to confirm that these facilities will also accept radioactive waste from submarine dismantling or that additional facilities will be commissioned for long-term storage or disposal of such radioactive wastes.***

Taking into account of the proposed mitigation measures, the strategy will have a positive impact on minimizing the amount of radioactivity potentially accessible to people and the environment.

7.1.4.2 Non-radiological environment

Worker health and safety

Non-radiological aspects worker health and safety at dismantling shipyards have been addressed in Section 7.1.2.

Surface water resource, atmospheric environment

As described in Section 5, there is no radiological contamination of the areas surrounding dismantling shipyards and Atomflot. Dismantling and radioactive waste have taken place for a number of years and no increase in discharges will result from Masterplan proposals relating to dismantling.

Therefore it is concluded that under normal operation there will be no impact on these objectives.

Geology and hydrogeology

No release of non-radioactive contaminants to soil or groundwater will occur during radioactive waste processing and storage in controlled conditions.

Potential impact may result from the storage of conventional heavy metal or backfill materials, associated with radioactive waste storage, in degraded storage facilities at the shipyards.

The impact on soil and groundwater of any future radioactive waste storage and disposal sites will have to be assessed.

Contamination of biota with toxic substances

The impact on the quality of air and water is either non-existent or can be mitigated. Therefore, contamination of biota with toxic substances from this phase is negligible.

Biodiversity and natural resources

The impact on biodiversity and natural resources of any future radioactive waste storage and disposal sites will have to be assessed.

Physical protection of radioactive materials

Mitigation measures related to the improvement of physical protection at dismantling shipyards identified in Section 7.1.2 are also applicable to this phase.

7.1.4.3 Socio-economic considerations

Economic growth

All work and activities associated with this phase contribute to the maintainence of employment and average income, which is one of the foundations of the economic prosperity in the study area. Consequently, effects of work and activities associated with this phase on the local economy are positive.

Human health

It has been noted in 7.1.2.3 that there are serious concerns about the impact of activities at Severodvinsk dockyards on the health of the local population. However, in contrast to the discharges of chemical substances the discharges of radioactivity from the site are very low. Environmental concentrations of radionuclides in the area of the shipyards are known to be low compared to the limits or general background (see Section 5); however there are cases when concentrations of conventional pollutants exceed the Russian regulatory limits.

Therefore, life expectancy in the study areas will not be affected due to the work or activity from this phase due to discharges of non-radioactive contaminants being very small compared to metal cutting activities. Accordingly, measurable negative changes in human health from this phase are unlikely.

Cultural and heritage resources

All work and activities will be carried out at the existing shipyards which are already involved in dismantling. Therefore there will be no impact on cultural and heritage resources.

7.1.5 Non-radioactive waste management phase

Table 7.1.5-1 gives a summary of the assessment results.

This phase will impact on geology or hydrogeology, contamination of biota with toxic substances and on human health. Impacts on other objectives will either be the same as for submarine dismantling as described in Section 7.1.2 or non-existent (see Table 7.1.5-1).

Table 7.1.5-1 Potential environmental effects of nuclear submarine decommissioning -Non-radiological waste management phase

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Radiological environment	No Impact			
Non- radiological environment	Improve worker health and safety	--/0	As detailed in Section 7.1.2	As detailed in Section 7.1.2
	Avoid, remove or reduce sources of air pollution		As detailed in Section 7.1.2	As detailed in Section 7.1.2
	Avoid, remove or reduce sources of surface water pollution		As detailed in Section 7.1.2	As detailed in Section 7.1.2
	Avoid contamination of biota with toxic substances	+/+	Potential positive effect of plans to implement 'projects for management of toxic wastes' due to removal of potential contamination sources	None required
	Maintain or enhance biodiversity	0/0	No impact	None required
	Maintain or improve natural resources	0/0	No impact	None required
	Soil and groundwater	++/++	There is potential for contamination of groundwater due to poor storage practices. The strategy involves 'implementation of projects for management of toxic waste and for creation of their storage pads'	None required
	Improve physical protection	+/+	As detailed in Section 7.1.2	As detailed in Section 7.1.2

Table 7.1.5-1 (cont.)

Environmental Component	SEA Objective	Potential effects before/after mitigation	Comments/explanation	Mitigation measures
Socio-economic considerations	Maintain or improve level of economic growth	+/+	As detailed in Section 7.1.2	As detailed in Section 7.1.2
	Maintain or improve human health	+/+	As detailed in Section 7.1.2	As detailed in Section 7.1.2
	Maintain or improve cultural and heritage resources	0/0	No impact	None required

Legend

+	Positive effect	-	Measurable negative impact	0	No impact or negligible impact
++	Significant positive effect	--	Significant adverse impact		

Soil and groundwater, contamination of biota with toxic substances and human health

This phase involves the handling, storage, processing and disposal of toxic liquids and solids. In particular the use of various pipelines, storage tanks, drums and open-air storage facilities create opportunities for leaks to occur which may affect soil and groundwater quality.

Substantial quantities of toxic and other wastes are generated during submarine dismantling (see Table 7.1.5-2).

At present some of the highly toxic wastes are stored at shipyards in inadequate conditions without proper protection from precipitation or leakage. This creates ample opportunity for contamination of storage sites with toxic chemicals. It is feasible that such spills will exceed regulatory requirements. They may in turn impact on soil quality, groundwater, biota and on human health.

It is known that some of these materials are recycled or sent for disposal at specialized facilities away from the shipyards. However, at least in some cases, there is no present disposal route.

Masterplan identified the need to implement projects for the management of toxic waste and for creation of suitable storage facilities.

Table 7.1.5-2 Materials Associated with Dismantling a Single Victor Class Submarine at Zvezdochka [Moffett, Gerchikov et al, 2004]

Material/Item	Russian Ministry of Nature hazard category	Quantity (tonnes)	Management route and disposal destination
1. Luminescent lamps	1	1200 units	Mercury recycled at Vtorresursy
2. Hydraulic liquids, containing glycerine	2	5.6	Temporary storage on site, recycling
3. Electrolyte (potassium hydroxide)	2	0.24	Neutralized and treated
4. Electrolyte (37% sulfuric acid, 73% water)	2	5.0	Neutralized and treated
5. Khladon 114B_2, Khladon 12 (Russian cooling agent; CFC)	2	1.92	Temporary storage on site, transfer to external companies.
6. Thermal insulation (FS-7), ‘poroplast’	3	28.8 (288 m^3)	Temporary storage on site. Transferred to St Petersburg for special disposal
7. Swipe from the cutting site	3	14.4	Temporary storage on site. Transferred to St Petersburg for special disposal
8. Foam materials from submarine fire suppression system	3	0.052	Treatment at Zvezdochka

Table 7.1.5-2 (cont.)

Material/Item	Russian Ministry of Nature hazard category	Quantity (tonnes)	Management route and disposal destination
9. Rubber waste	4	481.6	Temporary storage on site, sold for recycling
10. Linoleum with remains of varnish	4	5.6	Severodvinsk waste disposal site
11. Ceramic tiles	4	2.4	Severodvinsk waste disposal site
12. Thermal insulation (not containing asbestos)	4	192.56	Severodvinsk waste disposal site
13. Flexible PVC	4	0.48	Severodvinsk waste disposal site
14. Fibreglass	4	4.4	Severodvinsk waste disposal site
15. Thermal insulation, containing asbestos	4	22.4	Severodvinsk waste disposal site
16. Layered plastics	4	0.8	Severodvinsk waste disposal site
17. Organic glass	4	0.24	Severodvinsk waste disposal site
18. Paronite (rubberized asbestos fabric)	4	0.32	Severodvinsk waste disposal site
19. Plastics, urethane foam, polyurethane foam	4	5.6	Severodvinsk waste disposal site
20. Cardboard (electric insulation)	4	0.4	Severodvinsk waste disposal site
21. Cable waste (except recyclable materials)	4	82.0	Severodvinsk waste disposal site
22. Sealant for cable boxes.	4	2.64	Severodvinsk waste disposal site
23. Lubricants	4	8.87	Temporary storage on site, recycling
24. Textile materials	5	1.04	Severodvinsk waste disposal site
25. Wood pulp waste	5	4.8	Severodvinsk waste disposal site

7.1.6 Assessment of Accidents.

The Masterplan provided an assessment of bounding accidents for submarine dismantling. The results are summarized in Table 7.1.6-1.

Table 7.1.6-1. Individual dose burden, radiation risks and ecological consequences which can occur in the event of possible accidents during NS decommissioning [SMP, 2004]

Accident scenario	Probability* of the event, year^{-1}	Dose, mSv		Risk, 10^{-6} in case of accident/potential		Ecological consequences
		Personnel	Population	Personnel	Population	External environment
NS sinks near the pier (with fuel on board; Sv per year)	~ 10^{-3} - 10^{-4}	0.1 – 1**	0.01-0.001	56 / < 1	< 1 / < 1	Local contamination
NS sinks at the passage to the land-based defuelling facility (Sv per year)	~10^{-3}	0.1 – 1**	0.01-0.001	56 / < 1	< 1 / < 1	Local contamination
Liquid radioactive waste spillage	~ 10^{-3}-10^{-4}	0.01-0.1**	≤ 0.001	6 / < 1	< 1 / < 1	Limited contamination
Release of gas from the high pressure gas system	~ 10^{-2}	0.001-0.01	≤ 0.001	< 1 / < 1	< 1 / < 1	No consequences
SFA damage during unloading	~ 10^{-2}	0.1 - 1	≤ 0.001	56 / < 1	< 1 / < 1	No consequences
Fall of transportation package TK-18 (TUK-108/1)	~ 10^{-2}	0.001-0.01	≤ 0.001	< 1 / < 1	< 1 / < 1	No consequences
Fall of heavy objects onto open transportation packages	~ 10^{-6}	0.1-1	≤ 0.001	56 / < 1	< 1 / < 1	No consequences
Fire at NS in the reactor compartment	~ 10^{-2}	0.1 - 1	≤ 0.001	56 / < 1	< 1 / < 1	Limited contamination
Inadvertent SCA (self-sustaining criticality accident)	~ 10^{-7}	1000-10000	1 - 10	10^{6} / < 1	730 / < 1	Large-scale contamination; transboundary migration is possible
Aircraft crash onto NS during SNF removal	~ 10^{-8}	10-1000	0.1 - 1	10^{5} / < 1	73 / < 1	Large-scale contamination; transboundary migration is possible
Collision of FMB with other vessel, fire, sinking	~ 10^{-8}	1-100	1-10***	5600 / < 1	730 / < 1	Large-scale contamination
Aircraft crash onto the FMB with failure of SFA storage, fire	~ 10^{-9}	fatalities	1-100***	- / < 1	7300 / < 1	Large-scale contamination; transboundary migration is possible

Table 7.1.6-1. (cont.)

Accident scenario	Probability* of the event, $year^{-1}$	Dose, mSv		Risk, 10^{-6} in case of accident/potential		Ecological consequences
		Personnel	Population	Personnel	Population	External environment
RU sinks without loss of leaktightness of the primary circuit during transportation	$\sim 10^{-3}$	≤ 0.001	≤ 0.001	< 1 / < 1	< 1 / < 1	No consequences
RU sinks with loss of leaktightness of the primary circuit during transportation	$\sim 10^{-4}$	0.01-0.001**	0.01-0.001	< 1 / < 1	< 1 / < 1	Limited contamination
Aircraft crash onto the RU in TSF on Saida Bay	$\sim 10^{-6}$	0.1 – 1	0.001-0.01	56 / < 1	< 1 / < 1	Limited contamination
Aircraft crash onto the coastal LSF for RU	$\sim 10^{-6}$	0.1 – 1	0.001-0.01	56 / < 1	< 1 / < 1	Limited contamination
Aircraft crash onto the SRW open storage pad at CMB in Andreeva Bay, fire	$\sim 10^{-8}$	10 - 100	0.1–1****	5600 / < 1	73 / < 1	Limited contamination
Explosive rupture of SNF dry storage units at CMB in Andreeva Bay, fire	$\sim 10^{-8}$	100 - 1000	1–100****	10^5 / < 1	7300 / < 1	Large-scale contamination; transboundary migration is possible
Explosion, failure of dried storages of SNF at CMB in Gremikha, fire	$\sim 10^{-7}$	100 - 1000	1–100****	10^5 / < 1	7300 / < 1	Large-scale contamination; transboundary migration is possible

Notes:

* - Probability of an event assessed for decommissioning of 10 NS a year;

** - For unauthorised fishing and eating seafood from contaminated bay;

*** - An accident occurs near a settlement 2-3 km away from the shore;

**** - For radioactive cloud passing through a settlement. In accordance with NRB-99, the unconditionally acceptable risk is $\leq 1 \cdot 10^{-6}$.

Accidents with a probability of over one in a million per year

It can be seen that, for all accidents with probabilities higher than one in a million, the estimated doses to workers are at least 20 times below the annual dose limit of 20 mSv/yr. For such accidents, doses to members of the public are at least two orders of magnitude below the annual dose limit of 1 mSv/yr.

It can be concluded that, based on this assessment, potential accidents that are related to submarine dismantling will not the affect conclusions that were reached in the previous sections with regard to the impacts on the radiological objectives. Individual projects will require safety cases to demonstrate that the Masterplan assessments are valid in each specific situation.

However accidents involving nuclear submarines and radioactive materials may impact on the socio-economic situation in the adjacent population centres. This is a particularly sensitive issue for large cities with significant fishing industries, such as Severodvinsk and Murmansk.

Three accidents with probabilities above one in a million are judged to have a particularly high potential for a psychological and economic impact:

1. Sinking of submarines, either in towing or when moored at the shipyard

2. Dropping of fuel assemblies, fuel casks or accidents involving fuel transport.

3. Fires at nuclear facilities

The Masterplan proposed a number of measures that are aimed at reducing the probability of such accidents, including:

- Use of floating docks/barges for transporting submarines to the dismantling shipyards

- Construction of a new bridge in Severodvinsk to replace the damaged structure that is currently used by trains transporting fuel.

The Masterplan also identified the need for upgraded emergency and monitoring centres in Murmansk and Severodvinsk.

In addition to measures that are already identified within the Masterplan Phase 1 report, it is proposed that the following mitigation measures should be considered:

- ***Regular maintenance of the hulls of submarines that are stored at Naval Bases***. From the state of some hulls, it is clear that, at least in some cases, the current measures are ineffective (see Figure 4.1.1.1-1).

- It is not clear why the Masterplan estimated the probability of fire to be relatively high. A high proportion of flammable materials, such as oil, are removed from submarines prior to transfer to the shipyard. There is no electric power on a submarine and there are strict fire safety procedures throughout the process. ***It is necessary to understand why the probability of fires is believed to be high and to ensure that adequate mitigation measures are in place.***

- ***A commitment to monitor the state of the environment in the vicinity of submarines, which have been sunk, and to retrieve submarines if warranted by monitoring data is required.***

Storage of spent nuclear fuel in ships and defuelling afloat

It is not clear why the Masterplan estimated the likelihood of accidents involving PM 'Malina' and other FMB (Floating Maintenance Vessels) to be lower than similar accidents involving submarines during defuelling. In particular, it is not clear why the probability of collisions with other vessels was estimated on the basis the periods of time when the floating maintenance vessels are mobile. It would also appear that accidents involving sinking due to storms and poor hull conditions have not been taken into account.

According to the Masterplan, most of these vessels are in a state of disrepair and a number of them continuously store spent nuclear fuel, which is not packaged into licensed fuel casks. The latter, technically, contravenes the IAEA requirement to store spent nuclear fuel in containers, which have undergone certain tests [IAEA, 2000].

Accidents relating to defuelling afloat, where both the defuelling ship and submarine are relatively unstable, have not been assessed.

These safety concerns have to be weighed against the need to ensure the speedy defuelling of submarines that have been withdrawn from active service, because such facilities provide a major contribution to the defuelling capacity in the region.

It is therefore recommended that ***safety cases should be prepared*** to analyse the safety of

1. ***The continued storage and shipping of spent nuclear fuel on board PM vessels*** and
2. ***The continued defuelling of submarines afloat***.

7.1.7 Decommissioning of Alpha-class submarines

Decommissioning of submarines with lead-bismuth cooled reactors represents a special case. The Masterplan states that 'there is no infrastructure to carry out the work'.

As specified in Section 4, the Masterplan envisages that the required infrastructure will be installed at Gremikha and, in addition, states that a new approach should be developed to defuel the Alpha-class submarine No 910, which has suffered an accident.

At the same time, it is clear that storage conditions for the removed cores of Alpha-class submarines are unsatisfactory. It is stated that ***"The situation with regard to the unloaded LMC reactors is very dangerous.*** ... Thus, the situation where precipitation or any other moisture gets into the core space cannot be completely ruled out in the current conditions of SRC (reactor core) storage... An ingress of 20 kg of water can lead to SRC criticality ($K_{eff} = 1$). The analysis of the technical conditions of nuclear and radiation hazardous objects has shown that their degradation is sufficient grounds for concern, in relation to accidents involving release of radioactive substances into the environment".

In summary, the combination of poor storage conditions for reactor cores that have been removed from submarines and high fuel enrichment result in a relatively high probability of a criticality accident. Although the consequences of such an accident have not been assessed, it is likely that it would result in a significant radiological impact on workers, the population and the environment (see Table 7.1.7-1).

However, the Masterplan states that ***non-defuelled Alpha-class submarines that have been withdrawn from active service are stored in satisfactory conditions***.

Therefore, ***the technology and facilities for dismantling the reactor cores and placing spent fuel in storage conditions that prevent criticality should be developed, PRIOR to removing cores from Alpha-class submarines.***

While this approach is developed, it is necessary to ensure that the hulls of stored submarines remain in good condition.

Table 7.1.7-1 Assessment of radiological impact for decommissioning strategy in relation to Alpha-class submarines

Environmental Component	SEA Objective	Comments/explanation	Mitigation measures
Radiological environment	Limit radiation exposure to workers	High likelihood of criticality accident in case of water ingress into reactor cores of Alpha-calls submarines which are stored ashore	Technology and facilities for dismantling reactor core and placing spent fuel in storage conditions that prevent criticality should be developed prior to removing cores from Alpha-class submarines. Ensure that the hulls of out-of-service submarines with fuel are in good condition
	Limit radiation doses to members of the public	as above	as above
	Minimise quantity of radioactivity potentially accessible to people and the environment	as above	as above
	Limit radiation exposure of biota	as above	as above

7.1.8 Determination of residual adverse effects and significance

The adverse effects from the proposed strategy can be mitigated and there are no residual adverse effects.

Taking into account the proposed mitigation measures, the proposed dismantling strategy will address the negative effects identified in Section 5 for the 'Business as usual' approach.

Three key measures, which impact on the Masterplan strategy, are:

1. ***Ensuring that a safe fuel management approach is available prior to retrieving reactor cores from Alpha-class submarines.***

2. ***Demonstrating that the current approach of storage of spent nuclear fuel afloat is safe.***

3. ***Carrying out a separate environmental impact assessment for the dismantling of such vessels and if required, for the construction of new facilities.***

Separate environmental impact assessments will be required for projects that involve:

- the defuelling of boats afloat and
- the transport and defuelling of boats that have suffered an accident.

7.2 Decommissioning nuclear powered surface ships

No nuclear-powered surface ship has ever been defuelled or decommissioned and the strategy has been formulated only in terms of general objectives. It is not clear whether new facilities will have to be constructed to enable the defuelling, spent fuel management and dismantling of such vessels. Therefore, only a generic assessment can be applied at this stage (Table 7.2-1).

However it should be noted that,

- As demonstrated in Section 5, there is an urgent ***need to ensure that a dismantling project is developed and implemented, as soon as possible, due to the safety concerns associated with the continued mooring of the nuclear cruiser Ushakov at Zvezdochka shipyard***.
- If the project can be implemented using the existing facilities, the assessment described in Section 7.1 will also apply to the decommissioning of nuclear powered surface ships.

Therefore, the proposed Masterplan strategy, which identifies the decommissioning of nuclear powered surface ships as a high priority measure, is addressing the risks associated with the 'Business as usual' strategy. The project-definition phase should commence as soon as possible, which would enable a more detailed assessment to be implemented.

Table 7.2-1 Generic environmental effects of the Masterplan decommissioning strategies

Environmental Component	SEA Objective	Potential effects before /after mitigation	Comments/explanation	Mitigation measures
Radiological environment	Limit radiation exposure to workers	-/0	Typically worker dose limits are not exceeded however the ALARA principle is not followed. Shortage of qualified personnel in some remote locations in the Murmansk region has been identified as a problem at stakeholder meetings. In Gremikha the removal of 'ZATO' status has been identified as a potential threat to SevRAO's and Navy's ability to keep the qualified staff at the site.	Need to introduce the ALARA principle across the industry. Ensure that the qualified staff is available by providing training taking into account availability of qualified resources when planning ensuring sufficient funding
	Limit radiation doses to members of the public	-/0	There are serious risks associated with some aspects of the decommissioning. In particular this relates to all handling of damaged fuel in Andreeva Bay and Gremikha and Lepse. Powderized fuel from just three canisters (27 assemblies) can initiate criticality when mixed with water (no reference available)	Design engineering measures which exclude criticality during fuel-handling operations Ensure that SNF and radwaste shipping and transportation by rail is carried out in strict compliance with the Russian and regulatory guidance
	Minimise quantity of radioactivity potentially accessible to people and the environment	++/++	Major benefits result from all Masterplan strategies	None required
	Limit radiation exposure of biota	+/+	Implementation of the Masterplan strategies at Gremikha, Andreeva Bay and other sites where spent nuclear fuel and radioactive waste are stored in contact with water will lead to the reduction of environmental concentration of radionuclides which will in turn result in the reduction of impact on biota	None required

Table 7.2-1 (cont.)

Environmental Component	SEA Objective	Potential effects before /after mitigation	Comments/explanation	Mitigation measures
Non- radiological environment	Improve worker health and safety	--/0	There will be significant conventional risks to workers' health from all decommissioning operations.	Introduction of safety procedures and safety culture engineered protection means and personal protection equipment
	Avoid, remove or reduce sources of air pollution	--/0	Conventional emissions to air will be significant from metal cutting operations for surface vessel dismantling. There will also be impacts to air resulting from transportation and from construction of new facilities	Project-specific mitigation measures will have to be considered. Use of mechanical cutting for ship dismantling must be maximized
	Avoid, remove or reduce sources of surface water pollution	-/0	There will be potential discharges to surface waters from ship dismantling, construction and decommissioning operations. Likely to be consistent with normal shipyard or naval base activity	Project-specific mitigation measures will have to be considered.
	Avoid contamination of biota with toxic substances	-/0	Potential effluent discharges may have an impact on the contamination of biota. Likely to be consistent with normal shipyard or naval base activity	As for reduction of surface water pollution
	Maintain or enhance biodiversity	-/0	Potential impact from the construction of new facilities or discharges	Necessary to consider on a project-specific basis
	Maintain or improve natural resources	-/0	Water, energy and materials will be required to implement the strategy. The use of resources is likely to be limited.	Necessary to take into account when considering alternative options.

Table 7.2-1 (cont.)

Environmental Component	SEA Objective	Potential effects before /after mitigation	Comments/explanation	Mitigation measures
(Non- radiological environment)	Improve physical protection	++/++	Masterplan provides a comprehensive list of measures to improve physical protection	None required
Socio-economic considerations	Maintain or improve level of economic growth	++/++	Significant positive effect on sustaining employment across the regional study area	None required
	Maintain or improve human health	--/0	Potential impact toxic emissions	As above
	Maintain or improve cultural and heritage resources	0/0	There may be an impact if new construction projects displace or have a serious negative impact on local communities. In recent history this took place at Sayda Bay, where naval facility replaced a fishing village in 1980s. In some cases the vessels and objects that are being decommissioned may represent cultural and historic interest. Potential use of these resources should be considered	Consider on a project-specific basis. In particular consider establishing museums within the vessels which have been made safe by removing spent nuclear fuel, waste and contamination. If feasible, these approaches create potential socio-economic benefits as well as reduces pollution and waste resulting from dismantling.

2

Legend

+	Positive effect	-	Measurable negative impact	0	No impact or negligible impact
++	Significant positive effect	--	Significant adverse effect		

7.3 Decommissioning of Maintenance Vessels

As is the case for the nuclear-powered surface ships, the strategy has been formulated only in general terms. Therefore, only a generic assessment can be applied at this stage (Table 7.2-1).

As discussed in Section 4.1.3, the Masterplan proposes to implement decommissioning of these vessels in three stages:

1. At first, all radwaste and spent nuclear fuel will be removed from the vessels.

2. Then maintenance vessels will be sealed and transferred to SevRAO for safe storage afloat.

3. The ultimate decommissioning of maintenance vessels will be carried out after the creation of the regional storage facility for radwaste processing and storage.

Although there is no information on the proposed location of any of these phases, it is likely that the similar mitigation measures will apply to decommissioning of technical support vessels as those identified for submarine decommissioning in Section 7.1.

As stated in Section 5, there is an clear ***need to ensure that a dismantling project is developed and implemented, as soon as possible, due to safety concerns resulting from storage of these vessels, particularly those with spent nuclear fuel on board***.

Therefore the proposed Masterplan strategy, which identifies the decommissioning of the Maintenance vessel ‘Lepse’ as a high priority measure due to the high inventory and bad condition of the fuel on board of this vessel, is addressing the key risks associated with the ‘Business as usual’ strategy.

7.4 Environmental rehabilitation of Coastal Maintenance Bases

The priority measures identified within the Masterplan (see Appendix B) in relation to the rehabilitation of Coastal Maintenance Bases of Andreeva Bay and Gremikha are aimed at

1. Surveying of the sites

2. Improvement of the physical protection

3. Improvement of the infrastructure

4. Identification of the best options for the management of spent nuclear fuel and radioactive waste.

In addition to these four measures, several elements of the rehabilitation are already identified within Phase 1 of the Masterplan. These include construction of radwaste and spent nuclear fuel conditioning and packaging facilities at both sites and construction of a radioactive waste storage site at the Andreeva Bay site.

At this stage it is not clear what decommissioning technologies and what types of decommissioning facilities will be required and how the waste and spent nuclear fuel will be conditioned and packaged.

The same generic mitigation measures have been identified for this strategy as for the other Masterplan strategies (see Table 7.2-1).

As stated in Section 5, the spent nuclear fuel, and to a lesser extent, radioactive waste storage facilities at Andreeva Bay and Gremikha present the highest risk to the public and environment.

Therefore the proposed Masterplan strategy, which identifies measures related to the decommissioning of Andreeva Bay and Gremikha spent nuclear fuel and radioactive waste storage facilities as a high priority is addressing the key risks associated with the 'Business as usual' strategy.

7.5 Determination of secondary, cumulative and synergistic effects

7.5.1 Effects overlapping in type, time and space

Other works and activities with the potential to create similar effects as the implementation of the Masterplan in the same effective area and timeframe have been identified. These works and activities include:

- Paper plants
- Coal-fired power plant
- Off-shore oil production
- Decommissioning oil platforms
- Nuclear power plant
- Repairs to and servicing of military and civilian nuclear vessels in the study area

However, no residual adverse effects have been identified from the project. It has been determined that it is feasible to meet the Masterplan objectives and, at the same time, ensure that discharges resulting from the environmental concentrations represent only a small fraction of regulatory limits. Therefore, based on the available information no synergistic or cumulative effects are expected from the Masterplan.

It is necessary for the monitoring of environmental impacts from Masterplan strategies to continue to ensure that cumulative and synergistic effects can be detected through the monitoring program, allowing the modification of the plan and or remediation.

7.6 Comparison of 'Regional Storage' and 'Transfer to Mayak' options

As discussed in Section 4, the regional storage of spent nuclear fuel has been identified as an alternative to transporting the spent fuel to Mayak for reprocessing. These will be referred to as the Storage and Mayak options.

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 the only option that is considered in the Masterplan.

In the absence of a regional store, transport to Mayak is the only option, in the short term, for removing spent fuel from the interim stores at Atomflot and Zvezdochka and providing space for the ongoing defuelling of the submarines that have been taken out of service. In the past, donors have provided funds to enhance the transport of spent fuel to Mayak and for the reprocessing of some submarine fuel.

Neither the Mayak nor Storage Options constitute a long-term management strategy. It is necessary to process the high and intermediate level waste from reprocessing so that it is suitable for geological disposal and to eventually place it in a repository. It has to be stored in the interim period. Spent nuclear fuel in a regional store would eventually have to be placed in a repository.

A significant proportion of the spent fuel currently stored in North West Russia is non-reprocessible. At present non-reprocessible fuel includes:

- all Zirconium-clad fuel from nuclear icebreakers.
- Fuel from liquid-metal cooled submarines.
- Damaged fuel in Andreeva Bay, Gremikha, Lepse and elsewhere.

In accordance with the Masterplan an interim fuel storage facility will be constructed at Atomflot to store some of this fuel.

There is no clear long-term strategy for the management of spent fuel from liquid-metal cooled submarines.

For the damaged fuel the current strategy is to construct new facilities that would be capable of separating damaged fuel from cladding and making it suitable for subsequent reprocessing.

Furthermore, at the present time there is very limited buffer storage capacity at Mayak and it is planned to construct a new dry storage facility.

Therefore, ***in any case, an interim spent fuel store will have to be constructed in the north west region for the storage of the currently unknown, but a significant, proportion of unreprocessible spent nuclear fuel from the region***.

Reprocessing of naval fuel represents only a small fraction of the current reprocessing at Mayak. If it were to be assumed that some 30 000 naval assemblies, each containing roughly 2 kg of fuel can be reprocessed at Mayak, then the total quantity of reprocessible fuel that would be made available for shipping to Mayak from North West Russia over the next 10-20 years amounts to 60 te. This should be compared against Mayak's nominal capacity to annually reprocess 400 te every year. If all fuel from the North West were to be reprocessed over 10 years, it would contribute only 1.5% to Mayak's capacity throughput.

Therefore,

1. ***In the short term transfer of spent nuclear fuel to Mayak from the North West is an essential component of the submarine dismantling strategy.***
2. ***Naval fuel from North West Russia represents a very small proportion of the overall reprocessing at Mayak***

The key issue is whether a storage facility should be designed and built in North West Russia, which can be used for storage of reprocessible as well as for storage of non-reprocessible fuel.

7.6.1 Transportation phase

7.6.1.1 Radiological environment

Radiation exposure to workers

There is no actual data on doses to workers from loading, unloading and transporting spent nuclear fuel. Based on the known practices and the design of the licensed fuel casks TUK-18 and TUK-108, which are licensed in accordance with the Russian and international regulations, and TK-VG-18 and TK-VG-18A carriages it is likely that annual doses to workers are very small compared to the annual dose limit of 20 mSv/year.

Transportation to regional storage will have a slight advantage over the current option in terms of dose minimization due to shorter distances involved.

Radiation exposure to members of the public

Under normal conditions there will be no radioactive emissions to the environment and both options will have no effect on radiation exposure to members of the public. Fuel transport casks have met stringent IAEA and Russian requirements for Type B containers [IAEA, 2000], including fire, impact and immersion tests. The US Department of Energy has recently concluded a study which demonstrated that the fuel casks are capable of withstanding the most severe accidents feasible during rail transportation [US Department of Energy, 2003].

There is the potential for a small exposure if someone comes into proximity with a cask during transport. This potential is greater for the Mayak Option because the train has to travel a greater distance.

Radiation exposure of biota

As described above there will be no releases to the environment resulting from either option.

Radioactivity potentially accessible to people and the environment

Both options can be designed to ensure that spent nuclear fuel and/or waste resulting from reprocessing are stored in safe conditions. Project-specific environmental and safety assessments will have to be conducted to demonstrate that this objective has been met.

7.6.1.2 Non-radiological environment

Worker health and safety

Due to the greater transportation distance, the risk of an occurrence of a transportation related accident is higher for the Mayak option. Therefore the regional storage option performs better than the current option of spent fuel transfer to Mayak.

Russia has a comparatively good rail transport safety record with 0.2 accidents per million train-km [Guriev S, 2002]. Shipping of 30 000 assemblies at 500 assemblies per train will require 60 train journeys over the distance of some 3 000 km (to Mayak). This is equivalent to 180 000 km of train travel with the probability of conventional accidents being relatively small.

The loading and unloading operations will be required for both options. Based on the safety assessment results provided for such operations within the Masterplan it can be concluded that such operations are safe.

Surface water resource

There will be no discharges to water in either transport option.

Atmospheric environment

Transportation will have some impact on atmosphere due to release of greenhouse gases and other contaminants from train engines.

It is necessary to verify that the train engines comply with the Russian and international regulations.

Transportation to Mayak will have a greater impact due to the greater distance. If a future radwaste disposal facility were to be located in North West Russia, as appears likely, then long-lived waste resulting from reprocessing of spent nuclear fuel will have to be transported back to North West Russia. This will further increase the emissions to the atmosphere.

Soil and groundwater

There will be no discharges to soil or groundwater in either transport option.

Contamination of biota with toxic substances

There will be no releases of toxic substances.

Biodiversity and natural resources

There will be no impact on biodiversity or natural resources in the Mayak Option because the existing rail infrastructure will be used.

The impact of the Regional Storage will have to be addressed when the location has been selected. There is an existing railhead leading to the current location selected for storage of non-reprocessible fuel (Atomflot).

Physical protection of radioactive materials

Based on the available information and considerable difficulties facing any possible attackers who may attempt to target spent nuclear fuel which has been placed in a TUK-108 or TUK-18 transport casks, it can be concluded that both options will perform equally well.

7.6.1.3 Socio-economic considerations

Economic growth

The impact from either option will be small, short-term and limited to personnel involved in loading/unloading and transport operations.

Human health

Neither option will impact on this objective due to the high reliability of the railway transport in Russia.

Cultural and heritage resources

Neither option will impact on this objective.

7.6.2 Spent Nuclear Fuel Management.

Full environmental assessments for reprocessing at Mayak and for the regional storage of spent nuclear fuel options are beyond the scope of the current project. The comparison of the two options provided below is aimed at reviewing the key aspects of these strategies, which are relevant to the decision-making process.

7.6.2.1 Regional Storage

Adverse environmental impacts from the interim storage of reprocessible spent nuclear fuel in a dry storage facility in North West Russia are likely to be small because:

- In any case such a facility will have to be constructed for non-reprocessible fuel and
- Several countries, including Russia, are already successfully operating or planning to construct dry fuel storage facilities which have undergone rigorous environmental assessments.

7.6.2.2 Reprocessing

The key issue that needs to be addressed is that of radioactive discharges to the environment, which will result from reprocessing of spent nuclear fuel from North West Russia.

Historic discharges and accidents

Serious accidents involving atmospheric releases to the environment took place at Mayak in 1957 and 1967. They resulted in radioactive contamination of 23000 km^2 'Eastern Ural Radioactive Trace' –approximately 124 000 people were exposed to radiation [Degteva, M. O.; Kozheurov, V. P.; Vorobiova, M. I.; Burmistrov, D. S., 1997].

A number of reservoirs, as well as Mishelyak and Techa Rivers, were contaminated as a result of routine discharges between 1947 and 1951. Since 1951 an estimated 5 500 PBq (150 MCi) has been released into the environment, of which 4,400 PBq (120 MCi) went into Lake Karachay [Gerchikov et al, 2000].

These problems resulted from the nuclear arms race and were characteristic for the period.

Current discharges

Discharges of liquid radioactive waste to the reservoirs and to the Karachay lake are still taking place at Mayak at a rate of approximately 1 million Ci per year. The latter resulted in a contaminated groundwater plume that stretches over 3 km from the Karachay Lake.

Doses to the critical group of the population in the settlements of Muslumovo and Novogorny resulting from the on-going reprocessing discharges are below the annual dose limit of 1 mSv.

Discharges of radioactivity into the environment at Mayak have already resulted in impacts on biota whereby all living organisms have been eliminated from the Karachay lake.

There has also been a visual impact on the forests in the area surrounding the Karachay lake, which may have resulted from the nitrates discharged into the lake.

Impact from reprocessing submarine fuel

The amount of fuel originating from North West Russia and the associated impact is small compared to the total reprocessing throughput at Mayak. However the impact from its reprocessing will contribute to the cumulative adverse impacts on environment in the vicinity of discharge locations unless measures can be implemented to mitigate discharges.

7.6.3 Summary

From the comparative review of the possible environmental impacts from transportation of spent nuclear fuel to Mayak for reprocessing and construction of a regional storage facility in North West Russia, it can be concluded that

1. An interim spent fuel store will have to be constructed in the north west region for the storage of an unknown, but a significant proportion of unreprocessible spent nuclear fuel from the region.

2. In the short term, the transfer of spent nuclear fuel to Mayak from the North West is an essential component of the submarine dismantling strategy.

3. There are no significant environmental impacts from transportation by rail to either Mayak or regional storage facility, but the latter has a slight advantage due to shorter transportation distance.

4. Impacts associated with the reprocessing of Naval fuel from North West Russia represent a very small proportion of the overall reprocessing at Mayak. However, reprocessing at Mayak already resulted in adverse impacts on local environment. Therefore, in order to proceed with the strategy of reprocessing spent nuclear fuel from naval reactors at Mayak it is necessary to demonstrate that both radioactive and conventional discharges resulting from the reprocessing can be mitigated.

Based on this preliminary analysis, regional storage of spent nuclear fuel in North West Russia is the best environmental option, unless discharges from reprocessing at Mayak can be mitigated.

Transfer of spent nuclear fuel to Mayak should continue until such facility can be constructed.

8.0 PUBLIC CONSULTATION

8.1 Consultation Strategy

The consultation strategy is described in the "Public Consultation and Disclosure Plan (PCDP) for Strategic Environmental Assessment of the Northern Dimension Environmental Partnership Nuclear Window" [Collier and Gerchikov, 2005].

It provides for an early and meaningful engagement with stakeholders during the scoping of the SEA and for the sharing of information and consultation during the SEA implementation phase with key stakeholders who may be affected by or interested in the project. It is consistent with the EBRD's requirements as set out in its guidelines for PCDP preparation [EBRD, 2003] and comprises 6 main activities:

Activity	Duration	Target start date
Preliminary engagement		Complete
Scoping notification & scoping consultation	30 days	Complete
Announcement of consultation and Issue of draft SEA		April 2005
Release of the draft SEA and consultation thereon	120 days	April-July 2005
Analysis of comments and reporting	Within consultation period	July 2005
Release of final SEA		September 2005

8.2 Scoping Consultation

The scoping consultations took place between 15th November and 15th December 2004 and involved

1. Provision of the Scoping Information Pack to key stakeholders.
2. Collection of questions and suggestions from the public.
3. Three public meetings and three 'open evenings' in Murmansk, Severodvinsk and Moscow.
4. Analysis of the suggestions that were made and incorporating them into the methodology for the SEA.

A broad range of organizations were identified by local members of the SEA organizing committee in Murmansk, Severodvinsk and Moscow and invited to the meetings. They included:

1. Representatives of organizations that are responsible for the clean-up and dismantling in Northwest Russia (Rosatom, SevRao, Zvezdochka, Sevmash).

2. Representatives of NGOs (Bellona, Greenpeace, Zeleny Krest, Green Party, Nature and Youth).

3. Representatives of the local authorities and regulators (local government Sanepidnadzor and Medbioextrim representatives, members of the local environmental committees, local and regional Gosatomnadzor and naval regulators).

4. Masterplan authors.

5. International stakeholders including government and regulatory organizations from neighbouring and donor countries.

6. Local public.

A summary of the key proposals that were received from the public during the scoping consultation and the ways in which these proposals are addressed in the SEA report are summarized in Appendix A. Further details on the scoping consultation are summarised in "Masterplan Strategic Environmental Assessment Scoping Consultation Summary" [Gerchikov, 2005]

8.3 Main Consultation Phase

8.3.1 Announcement of Consultation

An announcement letter will be sent to registered stakeholders, including the contact points for the potentially affected States, announcing the commencement of the SEA consultation and inviting their participation. The announcement will be no later than two weeks before the commencement of the main consultation period.

An updated overview of the SEA project, including an outline programme with key dates and the PCDP (which also includes information on the project and EBRD's complaints procedures) will be attached. Instructions will be provided for obtaining and making comments on the draft SEA and details will be given of Russian and international contact points.

A series of press releases will be sent to the editors of potentially interested media in Moscow, Murmansk and Severodvinsk announcing the SEA project and associated public consultations. Copies will also be sent to the editors of NGO and other on-line newsletters. If it proves necessary, press releases will be supplemented by paid advertisements.

Additional stakeholders will continue to be added to the register as they are identified or identify themselves.

8.3.2 Consultation Documents

The Draft SEA will be made publicly available for inspection and comment for a period of 120 days and there will be a minimum of 120 days between the release of the Draft SEA and consideration of the final version by the SEA by the Assembly of Contributors to the NDEP Support Fund.

The Consultation Information Pack (CIP) will be prepared in English and Russian. It will include the Draft SEA, plus a copy of the announcement letter and its supporting and contact information. Hard copies will also be available for the 120 days duration of the main consultation phase in suitable locations, including Murmansk, Severodvinsk and Moscow.

Copies will also be sent to the authorities of the main settlements within the potentially affected area.

Copies of the CIP will also be sent free of charge in electronic form (CD-ROM) to all the stakeholders on the register and anyone else requesting one. Hard copy versions will be sent on request, but payment may be requested to cover the cost of printing and posting..

8.3.3 Public Meetings

Public consultation meetings will be held to review the Draft SEA report in Murmansk, Severodvinsk and Moscow. The meetings will be open but, if more people wish to participate than can be accommodated, priority will be given to stakeholders who have informed the project sponsor of their intention to attend. Details of venues etc. will be confirmed when the extent of public interest in each area is clearer.

It is likely that each meeting will start with a brief presentation by the project sponsor summarising the programme and the main conclusions of the draft SEA, and identifying issues on which stakeholder input is particularly needed. The usual plenary question and answer session will be followed, if it seems appropriate, by an 'experts fair' where participants can talk informally to the various specialists present. Each meeting is expected to last for no more than four hours. Each meeting will be chaired or moderated by two experts: NNC's Project Manager or his representative and an independent local expert.

Notes will be made of the main points that arise, but it is not the intention to prepare detailed transcripts. A summary of the comments made at public meetings or received in writing and the consultants' response will be compiled and included in the revised Chapter 8 or an annex. It will also be posted on the EBRD website (below).

The formal meetings will be supplemented by informal opportunities to meet the team during the evening.

8.3.4 Use of the Web Site

It is important that members of the public have the opportunity to provide comments and/or request additional information online. The CIP will therefore be available for downloading via the internet and stakeholders will be able to comment via email. The intent is that an updated list of Q&As will also be available online.

8.3.5 Legal Issues of Consultation

Russia is not a signatory to the Aarhus Convention, which defines the right of the public to access environmental information and the right to participate from an early stage in environmental decision-making.

Russia has not ratified the Espoo Convention on EIA in a Transboundary Context which places a requirement on the Government of the host nation to inform Governments of the countries which may be affected by the project.

Notwithstanding the above, the principles and requirements of the Espoo convention will be followed and the governments of potentially affected states will be notified by the project team of the commencement of the main consultation phase at the same time as other national and international stakeholders and invited to participate.

The objective will be to provide participants in other countries with broadly equivalent information and ability to comment. Information dissemination and comment routes will therefore not discriminate unreasonably between Russian and international participants. It will not however be practical to provide translation into languages other than English and Russian and comments can only be accepted in these languages. If the government of a neighbouring country wishes to have a meeting, they may contact EBRD, which will consider requests in discussion with the host country. In any event, the countries, which are members of the NDEP, will be kept fully informed. **Final SEA**

The SEA will be updated as necessary in the light of comments received and the section covering the results of consultation will be extended to summarise the results from the full set of PCDP activities. Copies of the final SEA will be placed in the same locations as the draft SEA for public inspection and electronic copies will be made available on request.

8.4 Ongoing Stakeholder Involvement

The SEA will result in some broad recommendations for stakeholder involvement during the implementation phase of the SMP, which resulted from the discussions in the scoping meetings. The public in the vicinity of the shipyards (Severodvinsk and Murmansk regions) made requests that a brochure with a non-technical summary of the overall SMP programme be developed for the understanding of the general public. In addition, they require regular information on the implementation of the SMP, such as a newsletter regarding activities in their specific location (Severodvinsk or Murmansk regions) on a routine basis (3-4 times per year). The following objectives should be considered in planning the on-going communication:

- To help ensure that citizens and stakeholders have access to information about the Strategic Master Plan and implementation progress.

- To help ensure that citizens and stakeholders have a means of asking questions and raise concerns with both those responsible for implementation and the supervising authorities.

- To help ensure citizens and stakeholders have access to authoritative and timely environmental and safety information, under both normal and post-accident conditions.

- The detailed implementation will depend on the structure of the implementation plans for the SMP and the resources and facilities allocated. However, the following are suggested as one of the possible approaches that might be adopted in such circumstances. Contact points: Each shipyard should have a contact point or information officer to act as a focal point for public/stakeholder/media interest, to produce regular updates on progress, and to feed this information back to the NDEP Communications Liaison manager (below) and website. The contact point should look for opportunities to maintain contact with stakeholders and public groups, informing them of progress etc. and acting as administrator for any meetings and events

- Outreach: The SMP should identify and train a Communications Liaison manager to work with the Contact Points identified at the shipyards, and to advise them on community interaction, information preparation and distribution, and updating the website.

- Environmental information: provision of environmental and safety information, and information on any events of safety significance (or rumours of such events); general status report on progress in each location (typically through a local newsletter produced 3-4 times per year and distributed locally. The project website will also need to be kept up to date for donors and neighbouring countries.

- Six-monthly public forum: In Murmansk and Severodvinsk, public meetings should be held twice per year to update stakeholders, the public and the media on the progress with the SMP. This is an important part of accountability and transparency, and will allow people the chance to get information and have questions answered.

- General Information Brochure on the SMP goals, objectives, and general programme should be developed and distributed to local communities, donors, authorities and environmental groups. It should also be posted on the website. This information, in non-technical language was strongly requested during scoping. A good example provided was the US brochure providing an overview of land-based defuelling facility which was constructed at Zvezdochka shipyard and used diagrams and easy-to-understand text to explain their project.

- Media: A media strategy for the SMP, including liaison with local community media, national and international media needs to be thought through, both to inform people, and to recognise the countries that are contributing to the SMP programme.

- Additional Initiatives, such as developing Local Liaison Groups would be a natural feature for such a large project. This would have a higher cost associated with the management of the intiative, but would result in a more informed local community.

- The advisability of using existing or planned information centres, such as in Murmansk should be considered. While opportunities to maximise use of existing facilities is encouraged, the communications plan should not rely on facilities not under its control. (It should be seen as extra.)

9.0 CONCLUSION AND RECOMMENDATIONS

The analysis in Section 6 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 measures that are proposed in the Masterplan will result in major improvements that will achieve the objectives that are defined in Section 3.

Based on the analysis of Section 6, the main elements of the strategies in the Masterplan are listed in order of priority in Section 9.1 below. These can now be 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 Sections 5 - 7.

9.1 Prioritisation

The main threat to the environment from the current situation is the accidental release of radioactivity. Based on an analysis of the potential accidents and their consequences, a priority has been assigned to each of the major elements of the four strategies that are described in the Masterplan. These are summarised in Table 9.4-1 below.

These priorities have implications for the priorities that are assigned to the 45 measures that are identified in the Masterplan and listed in Table 6.2-1. The priority that is recommended for the Masterplan measures is also shown in the table.

Table 9.1-1 The SEA Priorities and the Associated Master Plan Measures

SEA Priorities	Related Masterplan Measures
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.	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).
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.	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)

Table 9.1-1 (Cont.)

SEA Priorities	Related Masterplan Measures
2(b) The removal of spent nuclear fuel from the Lepse 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	The principle measures are the decommissioning of the Lepse 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)
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.	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)
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..	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)
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: • Fuel cladding; • Reactor pressure vessel and primary circuit; and • Reactor compartment and submarine pressure hull 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.	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).
6. Dismantling submarines that have been out of service less than 15 years.	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).
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.	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).

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.

9.2 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 the best environmental option, unless the discharges from reprocessing at Mayak can be significantly reduced. The storage option also minimises the need the need to transport spent nuclear fuel with its associated concerns on preserving the security of the fuel during transport. 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.

9.3 Summary of the Environmental Impact of the Masterplan.

This section summarises the environmental impact of the Materplan in terms of the SEA objectives that are presented in Table 3.2.3-1.

1. Exposure of Workers to Radiation

As shown in Appendix A, 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 confirm or update the priorities identified within the SEA report. Detailed safety cases should be completed for all implementation projects.

The evidence from Zvezdochka in Section 7.1.2.1 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 and there is no direct evidence that the necessary management structures and procedures are in place to control doses in accordance with the ALARA principle. 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 review the equipment used to measure individual doses to ensure their adequacy. This should include the need to use extremety 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.

Sections 7.1.2.1 and 7.1.4.1 have shown 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 the of natural background. Furthermore, monitoring at the Zvezdochka, SevmarshSevmash 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 (Table 7.2-1), 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. Thus, the protection of human health and 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:

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 critical group near any of the shipyards including Zvezdochka, Sevmash, Nerpa, Atomflot and SRZ-10 or the coastal maintenance bases and 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.

4. Exposure of Biota to Radiation

As shown in Appendix A, 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 was 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 (Figures 5.2.6-1 to –3).

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 (Table 7.2-1). 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 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 presented in Sections 5.5 and 7.1.2.2 show 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' 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, as shown in Table 5.3-1, 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 12 above.

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

7. Contamination of Biota

As shown in Appendix A, 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 was 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.

Section 5.3.3 shows that 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 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 also 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

Section 5.3.3.2 identifies the Barents Sea as containing rare and endangered species of whale and zooplankton as being 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 reported mammals or rare animals or birds in the area of Severodvinsk. 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 11 above.

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

The measures to protect these species are the same as discussed in the sections above.

9. Physical protection

Section 5.4 has identified that 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, the same section has identified the 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 for the maintenance vessels that have been taken out of service when projects are implemented at these facilities.

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

Appendix A shows that 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 Section 5.6.2 identifies important 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 in both the Murmansk and Severodvinsk regions 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.

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 he 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.

9.4 Recommendations Common to all Masterplan Strategies

The above recommendations are listed below:

1. 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.

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 review the equipment used to measure individual doses to ensure their adequacy. This should include the need to use extremety 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.

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 an 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 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.

    Furthermore it is necessary to inform the population on the progress. This is in the basis of Recommendation 20:

20. There 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 of 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 Severdvinsk.

The majority of the above recommendations are relevant to all the SEA priorities. The relevance of each of them to individual measures in the Masterplan is shown in Appendix C.

9.5 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 removal of the cores from the out-of-service Alpha-class submarines should be delayed until such time as the technology and facilities that are required to ensure the safe storage or disposal of the fuel become available.

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.

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.

9.6 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 unlikelihood 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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11.0 ACRONYMS

Acronyms	Description
ACL	Allowable Concentration Limit
ADL	Maximum Allowable Discharge Limit
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
EDOD	Engineering Documentation
EBRD	European Bank of Reconstruction and Development
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)
MARPOL	International Convention for the Prevention of Pollution from Ships

Acronyms	Description
MPC	Maximum Permissible Concentrations (Russian Standards)
MSC	Murmansk Shipping Company
MT	Maintenance Tanker
MV	Maintenance Vessels
NF	Nuclear Fuel
NDEP	Northern Dimension Environmental Partnership
NNC	National Nuclear Corporation Limited (UK and Canada)
NPI	Nuclear Power Installation
NS	Nuclear Submarines
OC	Organochorides
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
SNF	Spent Nuclear Fuel
SPA	Sanitary Protection Area
SPW	Sewage Purification Works
SRC	Spent Removable Core

Acronyms	**Description**
SRW	Solid Radioactive Waste
SS	Surface Ship
TAR	Temporary Agreed Release Limit
TUK (TP)	Transportation Package (transportation and packaging set)
ZATO	Closed Administrative Zone

Appendix A: Issues raised during the scoping consultation

Issue	Source[6]	SEA approach
Assessment Criteria		
Impact on the contamination of fish. Seafood is a priority	Murmansk, Severodvinsk	The baseline data will contain information on this issue and the SEA will evaluate the potential impact of the SMP on the contamination of fish.
Must ensure that loss of forestation due to new projects is assessed	Murmansk	Possible impact of plans on land use will be considered in SEA
Important to address impact from non-radiological contaminants	Murmansk, Severodvinsk, Moscow	The baseline data will contain information on this issue and the SEA will evaluate the potential impact of the SMP due to non-radiological contaminants.
Safety of workers should be given a priority. Poor current record of protecting workers	Murmansk	Possible impact of plans on the health and safety of workers will be considered in the SEA. Mitigation measures will be proposed if problems are identified
Need to consider socio-economic impacts on local populations	Severodvinsk, Moscow	Will be addressed in SEA in the review of the baseline data and included in assessment criteria
Requirement to use Russian Laws in defining assessment criteria	Severodvinsk	The assessment methodology will take Russian and international standards into account. Russian requirements will also be addressed subsequently to the SEA project, including implementation project-specific EIAs (OVOS) in line with the Russian legal and regulatory requirements.
Nuclear Safety should be the main criteria in evaluating strategies	Moscow	Will be included among SEA criteria. The relative importance of this aspect relative to others will be addressed as part of the overall assessment of alternative strategies.
Need to ensure compliance with western as well as Russian regulations, particularly for transport of radioactive materials	Murmansk, Moscow	International guidelines will be taken into account when evaluating strategies against safety assessment criteria
Loss of resources and activities in the shipyards involved in dismantling activities at the end of the implementation of the SMP (are reconversion plans considered?)	Submitted in writing	The issue of employment will be addressed in the SEA report
Is the intention to adjust the criteria to the EU Directive and the Espoo Convention? For instance would points be added like Are all foreseeable inherent risks of the implementation of the SMP considered and how are they going to be managed and minimised How is the monitoring going to be made	Submitted in writing	SEA will address criteria set out in Annex II of the EU Directive and in Appendix III of the Espoo Convention.
Impact on marine hydrobionts should be assessed	Submitted in writing	SEA will assess impacts on all aspects of the marine environment. The level of depth of this assessment will be limited by the lack of detail on specific projects envisaged within the Masterplan at this stage.

[6] Location of scoping meeting where it was raised, alternatively where the submission was made in writing to the SEA team.

Issue	Source	SEA approach
Assessment Criteria (cont.)		
It is necessary to create a regional laboratory in Murmansk to monitor radiological contamination	Submitted in writing	Monitoring requirements will be considered within the SEA
It is necessary to survey radiological contamination of marine environment in the areas adjacent to naval bases	Submitted in writing	Monitoring requirements will be considered within the SEA
It is necessary to create a disposal route for solid radioactive wastes	Submitted in writing	This issue has been identified within the Masterplan
Identification of priorities		
Need to monitor health conditions of workers and surrounding population	Severodvinsk, Moscow	If SEA baseline data indicate inadequate health monitoring for workers then a mitigation measure will be proposed to address the problem
Need to ensure that all bottlenecks and safety problems are properly identified and prioritised. Specific issues raised during consultation in Severodvinsk include Poor state of Nikolskoye Ustye Bridge, which is used to transport spent fuel in Severodvinsk Leaking Radwaste Store 162 at Zvezdochka Laid up nuclear cruiser Ushakov, which is stored in unsatisfactory conditions and has already suffered an accident 2 years ago Lack of repository for Severodvinsk radwaste arisings Lack of adequate storage and disposal facilities for hazardous wastes Leaking disposal facility at Mironova Gora in Severodvinsk Need to improve interface between the monitoring points and emergency centre.	Severodvinsk	Specific issues raised during scoping consultations will be considered within the strategies evaluated in the SEA
Shortage of trained staff in Murmansk. Need to provide training	Murmansk, Severodvinsk, Moscow	If confirmed, this will be identified as an issue requiring mitigation
Necessary to identify emergency preparedness measures	Submitted in writing	If lack of existing procedures is confirmed, this will be identified as an issue requiring mitigation
Necessary to consider an alternative to transporting spent fuel to Mayak. This could be a regional spent fuel store	Moscow	Will be considered as an alternative strategy

Issue	**Source**	**SEA approach**
Identification of priorities (cont.)		
No alternatives are proposed in the SMP and the main principle "closed fuel cycle", fixed by the Russian Federation Policy, determines the measures in the field of SNF management. One question which could be raised is: "What is your opinion concerning the option of "No retreatment for the SNF unloaded from NS and NPSS"? I think that some donors countries do not agree to pay for the retreatment.	Submitted in writing	Masterplan addresses clean-up and dismantling in Northwest Russia. It does not address Russian policies on reprocessing of spent nuclear fuel. However, the long-term storage of fuel in Northwest Russia will be considered in the SEA as an alternative to reprocessing – also see next comment.
I refer to the SMP Summary for scoping consultation pages 22 –24. The presentation of the risks (and the table) explains and justifies the identification of the priority tasks, ultimate goals, measures and priority of measures. I consider that this presentation is a little bit fallacious because it does not take in consideration the probability of the events (a terrorist action or an aircraft crash in Gremikha are certainly less probable than in Murmansk or Severodvinsk and the consequences are different due to the geographical situation and to the density of population).	Submitted in writing	The SMP risk assessment will be reviewed within the SEA study
The temporary concentration of SNF and RW in some locations of the NW region (Shipyards involved in unloading and dismantling activities of NS, in preparation of RC for long term storage, buffer storages for SNF before transportation to Mayak, centres for RW management); it means the increase of the risk in such places. What will be the position of the local populations? Is this temporary situation better than the existing one?	Submitted in writing	No specific concerns were raised by the local population during the scoping consultation. There was broad support for the Masterplan as a programme which will address legacy problems in Northwest Russia. However, there may be greater concerns if long-term interim storage of spent nuclear fuel in NW Russia were implemented as an alternative to reprocessing at Mayak. This issue will be considered by the SEA and the outcome will form part of the consultation on the overall SEA.
For the long term, the implementation of the SMP means a final storage of defective SNF and of RW in the NW region (creation of a final disposal regional centre). What will be the reaction of the local population?	Submitted in writing	This is not the current strategy identified in the Masterplan. It is proposed to transport all spent fuel, including damaged fuel to an interim store at Mayak
Consultation and Communication Process		
Early notice must be given of consultation meetings	Murmansk	A 30-day minimum notice will be given prior to the consultation meetings
Need to communicate progress on Masterplan implementation (regular meetings with the public, brochures, web-site in Russian)	Murmansk, Moscow, Severodvinsk	Will be included as proposals in SEA for communication during project implementation phase

Issue	**Source**	**SEA approach**
Consultation and Communication Process (cont.)		
What is the significance of "consultation" in the overall decision process? Does it require consensus	Submitted in writing	The IAPP describes the aim of consultation as follows - The sponsor promises to keep stakeholders informed, listen to and acknowledge concerns and provide feedback on how their input influenced the decision. This seems to fit the current context; consensus amongst all participants is not a requirement and would be unachievable. Having said this, we acknowledge the reality of the situation, that there have been and will continue to be discussions with key stakeholders in addition to the formal consultation programme.
What are the real possibilities of stakeholders to give their opinion while SEA is going on and influence the result before decision is taken?	Submitted in writing	Stakeholders are requested to provide oral or written comments and suggestions in two stages: prior to commencement of the assessment (scoping consultation) and during a 120 day consultation on draft SEA
What would be the consequences, as regards the application of the EU Directive 2001/42/EC, of the fact that Russia has not ratified the Aarhus Convention and the Espoo Convention?	Submitted in writing	The principles and requirements of the Espoo convention will be followed as far as possible and potentially affected parties will be invited to participate in scoping and notified before the main consultation phase
What are in your opinion the implications of "consultation" as compared with "information" in the contacts with the stakeholders?	Submitted in writing	The EBRD's procedures set out the Bank's requirements. There are no universally agreed definitions of the terms 'information' and 'consultation', but as a general principle we usually look first to those proposed by the International Association for Public Participation (IAPP). (http://iap2.org/practitionertools/index.shtml)
It is necessary to set up a regional public information centre in Murmansk	Submitted in writing	The SEA will include a discussion of future needs.
What is the relationship between PCDP of SMP and that of SEA?	Submitted in writing	The SEA will comment on this issue

Issue	Source	SEA approach
Other		
Definition of the objectives of the SEA study: what kind of basis is assumed to set out the primary boundary conditions to allow the definition of the "best" environmental strategy?	Submitted in writing	In accordance with the Terms of References, the SEA objectives are as follows: To improve the environmental dimension of the SMP and thus contribute to the overall decision-making process which will shape the Nuclear Window of the NDEP. To be the key part of the EBRD's environmental due diligence of the NDEP as required under the Bank's Environmental Policy. To be the key part of public disclosure and consultation process as required under the Bank's Public Information Policy. To provide the information that is expected by the Contributors to the Nuclear Window of the NDEP Support Fund and the Russian Authorities in their assessment and due diligence of individual projects (should this be required). The best environmental strategy will be defined by assessing the Masterplan strategies and feasible alternatives.
Need to ensure that the report can be understood by non-expert readers	Murmansk, Moscow	Executive Summary will be written clearly and will ensure that all terms are explained. Comparisons with easily understood concepts or western facilities will be made whenever possible
What would be the information data on conditions of submarines and associated support facilities in NW Russia that will be the basis for a SEA to be done in a complete and reliable way?	Submitted in writing	Information will be based on the Masterplan report. Additional technical information from the public domain may be used to fill in the gaps.
What would be the rationale for choosing various scenarios for accidents and incidents in subsequent environmental impact assessments?	Submitted in writing	Scenarios will be based on the Masterplan report. Additional accident scenarios may be identified by SEA consultants if necessary to ensure compliance with western assessments of this nature
What would be the assumptions in the judgement of chosen, expected problems with occupational exposures as regards organisation, planning, radiation control, education, training etc.?	Submitted in writing	SEA report will specify mitigation measures. These will have to be taken into account when specifying future projects in accordance with the Masterplan
Are any problems foreseen to undertake a SEA considering the Russian regulations on EIA in connection with projects to be started?	Submitted in writing	No. Russian EIA requirements will be followed in full in accordance with Bank's policy when implementation projects commence following completion of SEA

Issue	**Source**	**SEA approach**
Other (cont.)		
Evaluation of the effects of each strategy alternative: what is in your opinion or definition of "significant" and "as fully as possible" as given in the SEA Directive Annex 1(g)?	Submitted in writing	This must be a matter for professional judgement. Annex II of the Directive provides a list of criteria that can be used to judge whether an environmental effect is significant. Further advice on interpretation of the criteria set out in Annex II is provided in the European Commission guidance on the SEA Directive. Significant adverse effects will have to be mitigated as fully as possible. In the context of Masterplan this means that positive environmental impact will be expected from implementing Masterplan Strategies compared to the 'Status Quo' and that best practicable means should be followed during implementation. Specific measures will be proposed to mitigate adverse effects.
How could the results of the SEA influence the results of the SMP in terms of priority and measures?	Submitted in writing	SEA conclusions and proposed mitigation measures will be taken into account when identifying and specifying future implementation projects
Is it sure that the SMP selects the best environmental strategy? In my opinion (I refer to the SMP Summary for scoping consultation pages 26 -27) the restoration of the infrastructure for SNF management in CMB storage facilities (irrespectively of the ultimate option of SNF management in North-West region) has to be discussed: if the option of retreatment is considered (it means retrieval of the SNF actually stored or unloading of SNF from NS and conditioning for transport to Mayak), the restoration could be different from the one necessary for the option "no retreatment" (it means "conditioning for final disposal" and transportation to final or interim storage).	Submitted in writing	Long-term fuel storage in Northwest Russia will be considered as an alternative to reprocessing

Issue	Source	SEA approach
Other (cont.)		
The actual activities in the field of sorting and conditioning of RW are conducted without clear criteria for sorting according to the activity level, the future destination of the waste (burnable or not, compactable or not, to be reprocessed (melting of metal), final disposal), and without acceptance criteria of packages in interim or final storage. The establishment of such criteria could be one priority task in order to avoid double exposure or the personnel (implementation of the ALARA principle). The result of these sorting activities is good for the short term (RW are conditioned and stored in conditions which avoid further release of radioactive substances in the environment in isolated regions) but it requests further work (and radiological exposure of personnel) in regional centres for the final and safe disposal of waste (result to be obtained for the long term).	Submitted in writing	The SEA will focus on the main strategic issues of the SMP and the alternatives. However if in the course of the assessment any specific problems were to be identified with regards to acceptance criteria or implementation of the ALARA principle, they would be considered.
Closure of the CMBs (What will be the future resources (activities) of the local population taking in consideration the "brown field" status of the CMB territories at the end of the SMP?)	Submitted in writing	The SMP does not address the future use of the sites after the plan has been implemented. However, the SEA will address the environmental impact of implementing the plan and the mitigation measures that are required to ensure that any future contamination is minimised.
End of the status of "closed cities" in the near future (are alternative measures planned in order to maintain a sufficient working craft for dismantling and rehabilitation activities of the CMB?)	Submitted in writing	The availability of a skilled workforce is clearly an essential element of implementing the SMP and this will be identified in the SEA. Any additional details that SevRAO can make available will be included.
The implementation of the SMP means a lot of transport of radioactive material during the coming years (transfer of NS to SY, transfer of RU from Sayda bay to NERPA and of RC from NERPA to Sayda Bay, transport of radioactive waste from CMB to conditioning centres, transport of SNF to Mayak....). Is the risk analysis of these activities sufficient for population acceptance?	Submitted in writing	The issue will be addressed in the SEA report
Are all foreseeable inherent risks of the implementation of the SMP considered and how are they going to be managed and minimised?	Submitted in writing	The implementation risks will be considered to the extent possible at the early strategy planning phase. Specific project risks will be evaluated after completion of the SEA
How is the monitoring going to be made?	Submitted in writing	The SEA will propose monitoring arrangements, including the list of effects which need to be monitored.

Issue	Source	SEA approach
Other (cont.)		
What is the timetable of decision of Strategic Master Plan (SMP) and SEA respectively?	Submitted in writing	The SEA will be completed in August 2005. The timetable for the implementation of the SMP will depend on policy decisions made within Russia and the availability of the required funding.
A number of specific proposals identifying companies capable of performing the work	Various sources	Not relevant to the SEA
A number of issues concerning specifics of the Russian regulatory system	Various sources	Not relevant to the SEA
A number of environmental issues which were not linked to nuclear legacy issues in North West Russia	Various sources	Not relevant to the SEA

Appendix B: List of priority and high priority measures

The high priority and priority measures as set out in the Masterplan [SMP, 2004] are reproduced below.

High priority measures:

- Development of FS to justify optimum and safe options of SNF management in CMB in Andreeva Bay.
- Integrated Engineering and Radiation Survey (IERS) of buildings, structures, territory and water area of CMB in Andreeva Bay. Inventory taking of SNF and SRW.
- Restoration of infrastructure for SNF management in CMB storage facilities in Andreeva Bay (irrespectively of the ultimate option of SNF management in North-West Region).
- Development of FS, required design and engineering documentation. Creation of the regional center for reprocessing, conditioning and storage of SRW in North-West Region.
- Development and implementation of projects to ensure physical protection at CMB in Andreeva Bay.
- Implementation of measures to support radiation safety of the personnel in the territory of CMB in Andreeva Bay.
- IERS of buildings, structures, territory and water area of CMB in Gremikha. Inventory taking of SNF and SRW.
- Development of FS to select optimum and safe options of SNF management in CMB storage facilities in Gremikha.
- Development of FS to select optimum and safe options of SRC management in CMB storage facilities in Gremikha.
- Development of FS and implementation of project to eliminate the open-air pad for SNF and RW storage at CMB in Gremikha.
- Implementation of measures to support radiation safety of the personnel in the CMB territory in Gremikha.
- Development and implementation of projects to ensure physical protection of CMB in Gremikha.
- Restoration of infrastructure of the facility in Gremikha for unloading SRC from reactors of Alpha class NS.
- Development and implementation of project for reconstruction of SRC storage facility at CMB in Gremikha.
- Restoration of infrastructure for management of SNF located in storage facilities at CMB in Gremikha (irrespectively of the ultimate option of SNF management in North-West Region).
- Development of FS and design, engineering and process documentation for decommissioning of FMB Lepse.

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

Priority measures

- Development of FS for RW management in Andreeva Bay. Creation of necessary technical capabilities.
- Removal of SRW from open-air pads in Andreeva Bay.
- Development of FS for rehabilitation of buildings, structures, territories and water areas in Andreeva Bay.
- Development of FS for RW management in Gremikha. Creation of necessary technical capabilities.
- Development of FS for rehabilitation of buildings, structures, territories and water areas in Gremikha.
- 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.
- Design and fabrication of specialized pontoons or lease of transportation vessel.
- Continuous maintenance and recovery repairs at FMB and reloading equipment.
- Creation of special mobile reprocessing installations for LRW of complex chemical composition;
- Manufacturing and supply of installations for filling NS DBT with polystyrene as well as modular diesel compressor installations.
- Scheduled decommissioning of NS.
- Radiation survey of MV. Development of EDOD for sealing, preparing and waterborne storage. MV sealing.
- Inventory taking and removal of RW from MV.
- Development of equipment and infrastructure at PA Mayak for handling TUK-108/1 containers.
- Repair of existing and building of new piers in Saida Bay.
- Development of projects for forming units for storage of SFA at FMB and their long-term storage in LSF.

- Development of EDOD for decommissioning of NPSS and forming a reactor hall unit (RHU). Execution of the work. Transfer of RHU to LSF.
- Development of the concept and technology for management reactor unit № 900 of *Alpha* class NS.
- Development of FS and implementation of projects for management of toxic waste and for creation of their storage pads.
- Development of the concept and technologies, selection of location and drafting of design documentation on facilities for ultimate elimination and disposal of toxic waste.
- Development of the concept, selection of location and drafting of design documentation for creation of the regional RW repository.
- Creation of the buffer container storage facility at PA Mayak.
- Conditioning of non-reprocessible SNF at MV of MSC.
- Creation of the temporary container storage facility for non-reprocessible SNF at Atomflot.

Appendix C: List of Masterplan priority measures and the related SEA recommendations

Priority Measure	**Impact of SEA Recommendations**
	SMP High Priority Measures
Development of a FS to justify the optimum and safe options for SNF management at the CMB of Andreeva Bay.	It is necessary to ensure that : 1. ALARA planning with a comprehensive review of alternative options for performing tasks in high radiation areas is carried out in the process of identifying a safe SNF management option. The objective of this review will be to minimize doses to workers. 2. The resulting projects have provisions for data on worker doses to be properly collated and analysed. 3. Staff and workers involved in the resulting projects are appropriately qualified. 4. 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. In particular it is necessary to ensure that SNF is shipped in casks which comply with the IAEA regulations. 5. There is adequate provision in place to ensure conventional safety for workers during decommissioning buildings, management of the resulting wastes and movement of loads. 6. Necessary to ensure that high priority measures relating to the emergency systems at Coastal Maintenance Bases are completed prior to commencement of the implementation project. 7. Necessary to ensure that information on the progress is available to the public and is communicated on a regular basis to the population in ZATOs Zaozersk and Ostrovnoi and in the city of Murmansk. 8. Environmental impact assessments and independent expertise are conducted for the implementation projects.
Integrated Engineering and Radiation Survey (IERS) of buildings, structures, territory and water area of CMB in Andreeva Bay. Inventory taking of SNF and SRW.	Recommendations 1-3, 5 and 7 above.
Restoration of infrastructure for SNF management in CMB storage facilities in Andreeva Bay (irrespectively of the ultimate option of SNF management in North-West Region).	Recommendations 1-8.
Development of FS, required design and engineering documentation. Creation of the regional center for reprocessing, conditioning and storage of SRW in North-West Region.	Recommendations 1-8. Furthermore 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.
Development and implementation of projects to ensure physical protection at CMB in Andreeva Bay.	Recommendations 1-3, 5, 7. The installation of automatic radiation monitoring equipment at the exits from the shipyards and coastal maintenance bases should be considered as an

Priority Measure	**Impact of SEA Recommendations**
	SMP High Priority Measures
	additional physical protection measure.
Implementation of measures to support radiation safety of the personnel in the territory of CMB in Andreeva Bay.	Ensure that recommendations 1 and 2 are addressed.
IERS of buildings, structures, territory and water area of CMB in Gremikha. Inventory taking of SNF and SRW.	Recommendations 1-3, 5 and 7 above.
Development of FS to select optimum and safe options of SNF management in CMB storage facilities in Gremikha.	Recommendations 1-3 and 5-8.
Development of FS to select optimum and safe options of SRC management in CMB storage facilities in Gremikha.	Recommendations 1-3 and 5-8. This measure has been identified within the SEA as the top priority measure along with a measure to repair the existing facilities for storage of cores from Alpha-class submarines.
Development of FS and implementation of project to eliminate the open-air pad for SNF and RW storage at CMB in Gremikha.	Recommendations 1-8.
Implementation of measures to support radiation safety of the personnel in the CMB territory in Gremikha.	Ensure that recommendations 1 and 2 are addressed.
Development and implementation of projects to ensure physical protection of CMB in Gremikha.	Recommendations 1-3, 5, 7. 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.
Restoration of infrastructure of the facility in Gremikha for unloading SRC from reactors of Alpha class NS.	Recommendations 1-3 and 5-8. Prior to defuelling Alpha-class submarines, it is necessary to ensure that the removed cores can be converted into a safe state which would exclude any possibility of an uncontrolled chain reaction. Until the time when such technology becomes available, the state of hulls of Alpha-class submarines with fuel on board should be regularly monitored and the hulls should be repaired if necessary.
Development and implementation of project for reconstruction of SRC storage facility at CMB in Gremikha.	Recommendations 1-3 and 5-8. This measure has been identified within the SEA as the top priority measure along with a measure to develop technology for converted the cores from Alpha-class submarines into a safe state which would exclude any possibility of an uncontrolled chain reaction
Restoration of infrastructure for management of SNF located in storage facilities at CMB in Gremikha (irrespectively of the ultimate option of SNF management in North-West Region).	Recommendations 1-3 and 5-8.
Development of FS and design, engineering and process documentation for decommissioning of FMB Lepse.	Recommendations 1-8.
Development of the project and implementation of work to reconstruct the railway bridge over Nikolskoije Ustie in	Recommendations 3-8.

Priority Measure	Impact of SEA Recommendations
	SMP High Priority Measures
Severodvinsk.	
Drafting of the working documentation of forming RC and their long-term storage.	Recommendations 1-3 and 5-8
Completion of works to create a surface RC long-term storage facility.	Recommendations 1-3 and 5-8.
Creation of site-wide, regional monitoring and emergency systems in Murmansk Region.	Should be completed prior to the commencement of the implementation decommissioning projects.
Creation of site-wide, regional monitoring and emergency systems in Arkhangelsk Region.	Should be completed as soon as possible.
	SMP Priority Measures
Development of FS for RW management in Andreeva Bay. Creation of necessary technical capabilities.	Recommendations 1-8
Removal of SRW from open-air pads in Andreeva Bay.	Recommendations 1-8
Development of FS for rehabilitation of buildings, structures, territories and water areas in Andreeva Bay.	Recommendations 1-8
Development of FS for RW management in Gremikha. Creation of necessary technical capabilities.	Recommendations 1-8
Development of FS for rehabilitation of buildings, structures, territories and water areas in Gremikha.	Recommendations 1-8
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.	Recommendations 1-8. Prior to defuelling submarine No 901, it is necessary to ensure that the removed core can be converted into a safe state which would exclude any possibility of an uncontrolled chain reaction. Until the time when such technology becomes available, the state of hulls of Alpha-class submarines with fuel on board should be regularly monitored and the hulls should be repaired if necessary.
Design and fabrication of specialized pontoons or lease of transportation vessel.	Recommendations 3 and 5.
Continuous maintenance and recovery repairs at FMB and reloading equipment	Recommendations 1-3; 5-8
Creation of special mobile reprocessing installations for LRW of complex chemical composition	Recommendations 1-3, 5-8

Priority Measure	**Impact of SEA Recommendations**
	SMP High Priority Measures
Manufacturing and supply of installations for filling NS DBT with polystyrene as well as modular diesel compressor installations.	Recommendations 1-3, 5-8
Scheduled decommissioning of NS.	Recommendations 1-8
Radiation survey of MV. Development of EDOD for sealing, preparing and waterborne storage. MV sealing.	Recommendations 1-3, 5-8
Inventory taking and removal of RW from MV.	Recommendations 1-8
Repair of existing and building of new piers in Saida Bay.	Recommendations 1-3, 5-8
Development of projects for forming units for storage of SFA at FMB and their long-term storage in LSF.	This measure appears to involve long-term storage of spent nuclear fuel afloat (at floating maintenance bases). As such it contradicts SEA recommendation that it is necessary to demonstrate the safety of storage and shipping of spent nuclear fuel on board of PM vessels prior to selecting this approach as a viable strategy.
Development of EDOD for decommissioning of NPSS and forming a reactor hall unit (RHU). Execution of the work. Transfer of RHU to LSF	Recommendations 1-8
Development of the concept and technology for management reactor unit № 900 of Alpha class NS.	Recommendations 1-8. Prior to defuelling submarine No 900, it is necessary to ensure that the removed core can be converted into a safe state which would exclude any possibility of an uncontrolled chain reaction. Until the time when such technology becomes available, the state of hulls of Alpha-class submarines with fuel on board should be regularly monitored and the hulls should be repaired if necessary.
Development of FS and implementation of projects for management of toxic waste and for creation of their storage pads.	Recommendations 3, 5-8
Development of the concept and technologies, selection of location and drafting of design documentation on facilities for ultimate elimination and disposal of toxic waste.	Recommendations 3, 5-8
Development of the concept, selection of location and drafting of design documentation for creation of the regional RW repository.	Recommendations 1-8. This is one of the two strategic recommendations of the SEA
Creation of the buffer container storage facility at PA Mayak.	SEA recommends to construct an interim SNF storage facility in North West Russia.
Conditioning of non-reprocessible SNF at MV (Maintenance Vessels of MSC (Murmansk Shipping Company)	See the following recommendation
Creation of the temporary container storage	This measure appears to involve construction of an interim SNF storage

Priority Measure	Impact of SEA Recommendations
	SMP High Priority Measures
facility for non-reprocessible SNF at Atomflot.	facility at Atomflot. If understood correctly, recommendations 1-8 would apply. Furthermore SEA recommends to construct an interim storage facility for all naval fuel rather than just for non-reprocessable SNF. Benefits of alternative locations should be considered.