THE NORDIC ENVIRONMENT FINANCE CORPORATION (NEFCO)

# BARENTS REGION ENVIRONMENTAL PROGRAMME

## PROPOSALS FOR ENVIRONMENTALLY SOUND INVESTMENT PROJECTS IN THE RUSSIAN PART OF THE BARENTS REGION.

**Volume one: Non-radioactive contamination**

Prepared by the AMAP Expert Group
December 1995

Volume One:
Non-radioactive contamination
Report of Phase I

Presentation of 17 recommended investment projects to amend non-radioactive disturbance to the environment and human health

Prepared by the AMAP Expert Group
December 1995

This report is dedicated to the memory of the Finnish environmental expert Lauri Haverinen, who tragically passed away during the field mission to Nenets Autonomous Area.

## Foreword

The first phase of the NEFCO[1] Barents Region Environmental Programme ('NEFCO-Programme') has been carried out by Russian-Nordic Expert Groups and headed by the Secretariat of the Arctic Monitoring and Assessment Programme (AMAP). This first phase has thus become known as the 'NEFCO-AMAP project'. The results of the project have been supervised by a Steering Committee comprising members of the Ministry for Protection of the Environmental and Natural Resources of the Russian Federation, the Ministry of Defence of the Russian Federation, the regional environmental authorities of the Republic of Karelia, Murmansk and Archangel Provinces, the Nordic countries, NEFCO and the AMAP secretariat.

The first phase, which consists of a selection of environmentally sound investment projects in the Russian part of the Barents Region, based on a screening process of the environmental conditions, has been carried out by two AMAP Expert Groups. One Expert Group has worked with radioactive contamination, while the second has dealt with the remaining environmental issues. The findings concerning the latter issues are presented in this volume: 'Non-radioactive contamination', while issues on radioactive contamination are presented separately in Volume Two: 'Radioactive contamination'.

During meetings and field missions, the AMAP Expert Group collected and analysed the available information on environmental and health problems together with their possible solutions. Based on this information, the Expert Groups have selected the most urgent areas of concern and outlined a series of projects aimed at tackling the various problems. These suggestions are all presented in this report, and will be evaluated along with other possible options in the second phase of the NEFCO-Programme; the feasibility study.

Further background information concerning the NEFCO-Programme and the screening phase is given in Chapter 1. Chapter 2 contains a general description of the environment in the Russian part of the Barents Region. All the projects discussed during Phase I are presented in Chapter 3, while those projects which the AMAP Expert Group recommend for further feasibility studies are described in more detail in Chapter 4.

NEFCO has supplied the finances to carry out this study. The AMAP Secretariat has been responsible for the organisation of Phase I of the NEFCO-Programme, including the field missions. The AMAP deputy secretary has headed the missions and acted as the link between the Russian and Nordic experts. The AMAP Secretariat, the Russian experts from the regional environmental authorities of the Barents Region and the Nordic experts from Lapland Regional Environmental Centre (Finland) and Akvaplan-niva (Norway) have analysed the environmental information and drafted this report. The medical aspects of the projects have been summarised by experts from the Institute for Community Medicine (ISM), University of Tromsø. Finally, Akvaplan-niva has acted as secretary for the project.

The report is prepared and presented in English, using the Collins English dictionary, third edition 1991, as the language authority. The report is further translated into Russian.

[1] Nordic Environment Finance Corporation

**Acknowledgements**

The contributions from the experts of the Environmental Committees of the Provinces of Murmansk and Archangel (including the Environmental Committee of Nenets Autonomous Area) and the Ministry of Ecology of the Republic of Karelia, have been of great importance.

I also wish to thank their chairmen, I. Vishnyakov, M. Fetchenko and A. Minyaev as well as the responsible representatives within the Ministry of Protection of the Environment and Natural Resources of the Russian Federation and the Ministry of Defence of the Russian Federation.

Oslo, December 6th, 1995.

Lars Otto Reiersen
Executive Secretary of AMAP

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# SUMMARY WITH RECOMMENDATIONS

## Background and scope of work

The initiative for the NEFCO Barents Region Environmental Programme ('NEFCO-Programme') came in 1994 from the Governments of the Nordic Countries, which are the founders of NEFCO (Nordic Environment Finance Corporation). The goal of the NEFCO-Programme is to assist the Russian authorities in their efforts to improve the environmental situation and decrease pollution problems, as well as to support the economic development in the Russian part of the Barents Region.

The NEFCO-Programme consists of three phases:

- During Phase I, a number of potential environmental investment projects have been identified and documented. Some of these projects are recommended for further studies.
- During a feasibility study of the recommended projects from Phase I, some projects will be given priority as pilot projects (Phase II). The feasibility study is scheduled to be carried out during the first half of 1996.
- Finally, during Phase III, in co-operation with other financial bodies, NEFCO will implement selected pilot projects. This phase is scheduled to begin in the autumn of 1996.

## Organisation

NEFCO is in charge of the Programme and also supplies the necessary funding. The Arctic Monitoring and Assessment Programme (AMAP) is the international environmental programme, established in 1991 by the ministers of the eight Arctic countries. The AMAP Secretariat has been engaged by NEFCO to organise, prepare and carry out the first phase of the NEFCO-Programme.

The organisational structure of the NEFCO-Programme has entailed one Steering Group appointed by NEFCO and two Expert Groups headed by the AMAP Secretariat. One Expert Group has dealt with issues on radioactive contamination, while the other has handled those on non-radioactive contamination.

The Steering Group consists of members from Russian regional environmental authorities, the Ministry of Defence and the Ministry of the Environment of the Russian Federation, Norway, Finland, NEFCO and AMAP Secretariat.

The AMAP Expert Groups have been responsible for the collection and compilation of information, preparation of project proposals and report writing for Phase I. The Expert Groups include members from the Nordic countries and the three Russian administrative units of the Barents Region; the Province of Murmansk, the Republic of Karelia and the Province of Archangel.

The findings of Phase I of the NEFCO-Programme are presented in two separate volumes. Volume One is entitled 'Non-radioactive contamination', while the title of Volume Two is 'Radioactive contamination'.

## Phase I Identification of environmentally sound investment projects concerning environmental and health problems.

The Steering Group has identified 10 environmental issues of concern

1. Environmentally safe operation of nuclear installations
2. Handling and storage of radioactive wastes
3. Reduction of industrial gas emissions
4. Preservation of freshwater resources, including improvement of drinking water supply
5. Solid wastes
6. Prevention of marine pollution of the White Sea and the Kola Fjord
7. Preservation of forest resources
8. State of the environment and lifestyle of the indigenous and traditional population in the Region
9. Development of integrated environmental and human health monitoring system
10. Environmental issues concerning energy consumption and energy saving

The AMAP Expert Group on issues on radioactive contamination has visited Murmansk and Archangel during the first half of 1995, while the AMAP Expert Group working on non-radioactive contamination has carried out missions to Murmansk, Petrozavodsk, Archangel and Narjan-Mar during the same period. During these missions, the Expert Groups gathered information on the state of the environment and sources of anthropogenic impact, located in the respective areas. Particular attention was paid to the project proposals presented by the regional environmental authorities. Based on the available information, a total of 71 (5 projects on radioactive contamination and 66 projects on non-radioactive contamination) projects were identified. The Nordic part of the AMAP Expert Group was appointed responsibility for compiling the project report of Phase I.

## The recommended projects

The AMAP Expert Groups have evaluated the available information, and recommend that a feasibility study should be carried out for 5 projects concerning radioactive contamination and 17 projects concerning non-radioactive contamination during Phase II of the NEFCO-Programme. The projects selected all deal with urgent environmental or health problems and may be divided into two groups:

- projects of particular environmental importance for specific areas.
- pilot projects of importance in the entire Barents Region, which can later be duplicated in other areas of the Region, after the appropriate adjustments.

In the evaluation process, the priorities of the regional environmental authorities have been taken into account, as well as the fact that the projects should be investment projects aiming to tackle a definite environmental or health problem, rather than being purely for research or educational purposes. In the selection procedure, particular attention was paid to those projects where the environmental improvement scheme is based not merely on improved treatment of production wastes (industrial gases, waste waters, hazardous solid wastes etc.), but rather on the installation of new, environmentally clean and energy saving technology. The recommended projects are fairly distributed within the region and between the 10 given issues of concern. Projects which are the subject of bilateral or multilateral environmental and technical co-operation, and for which significant steps have already been taken towards their implementation, were not selected as priority projects for the NEFCO-Programme.

A number of possible actions are listed for most of the recommended projects. It should be emphasised that this is not an authorised list, but rather a presentation of possible actions which have been presented to the AMAP Expert Group. The Expert Group has not carried out any specific research in this field, since the evaluation of actions, including technical and economical analyses, belongs to the feasibility study in Phase II of the NEFCO-Programme. Also, for some projects, the regional environmental authorities presented cost estimates for a given action. These estimates have not been evaluated by the Expert Group, and will be handed over to the feasibility study.

The Expert Group further wish to emphasise that the projects which have not been included in the list of recommended projects for the NEFCO-Programme, also have significant environmental importance and can be recommended for future implementation, with technical and financial participation of international partners and investors.

## Overview of the recommended projects.

**Radioactive contamination (Volume Two)**

| | |
|---|---|
| 1 | **Handling and transport of radioactive waste and spent nuclear fuel**<br>Transporting vessel for spent nulear fuel<br>Transport ship for transport to Novaya Zemlya.<br>Emptying and removal of full waste storage.<br>Treatment of liquid radioactive waste with stationary and mobile equipment.<br>Facility for reduction of solid radioactive waste before transport and storage. |
| 2 | **Regional storage for radioactive waste and spent nuclear fuel (especially if not suited for reprocessing)**<br>Storage site at Matochkin Shar<br>Storage site at South Novaya Zemlya |
| 3 | **Development of alternative techniques for decommissioning of nuclear submarines** |
| 4 | **Nuclear Safety at the Kola Nuclear Power Plang**<br>Safety culture, pre project |
| 5 | **Risk and impact assessment including monitoring systems**<br>Risk and impact assessment for man and the environment from military and civilian sources.<br>Monitoring-system for environmental releases of radioactivity from civilians and military sources.<br>Emergency system in the Arkhangelsk region<br>Monitoring system in Arkhangelsk region<br>Regional Laboratory |

## Non-radioactive contamination (Volume One)

The project proposals have been assigned a unique reference number. A letter identifies to which part of the Barents Region the project belongs, i.e. M for Murmansk Province, K for the Republic of Karelia and A for Archangel Province including Nenets AA. The projects concerning the Barents Region in general is assigned the letter G. The first numeral denotes which of the 10 issues of concern the project is classified under, and the second numeral refers to the assigned project number.

### Projects in the Province of Murmansk

| | |
|---|---|
| M41 | Construction of communal waste water treatment system in the town of Kildinstroy |
| M44 | Improvement of Monchegorsk City water supply system |
| M51 | Establishment of a system for treatment of non-radioactive hazardous waste in Murmansk Province |
| M52 | Treatment of faeces and effluents from the Murmanskaya (or Snezhnaya) poultry farm (Kola River water shed) |
| M61 | Improve the treatment of municipal waste-water discharged into the Kola fjord from Murmansk City, the Northern sewage treatment plant |
| M101 | Energy saving and reduction of the air-borne emissions from the Southern heating and power plant in Murmansk City |

### Projects in the Republic of Karelia

| | |
|---|---|
| K31 | Segezha pulp and paper mill, reduction of gas and dust emission and waste-water discharges |
| K32 | Nadvoitsy aluminium plant, reduction of gas and dust emission and waste-water discharges |
| K41 | Kostomuksha iron pellet plant "Karelsky Okatysh", reduction of waste-water discharges and industrial gas emissions |
| K61 | Artificial rearing of Atlantic salmon (*Salmo salar*) in the Karelian part of the White Sea, in order to increase the stock of salmon in the Karelian rivers. |

### Projects in the Province of Archangel, including Nenets AA

| | |
|---|---|
| A42/A43 | Drinking water supply in the cities of Archangel and Novodvinsk |
| A46 | Archangel pulp and paper mill in Novodvinsk, reduction of waste-water discharges and gas and dust emission |
| A71 | Preservation of virgin north taiga forests in Mezen County |

### Projects concerning indigenous and traditional people

| | |
|---|---|
| M81 | Water supply in Lovozero village |
| A81 | Improvement of environmental aspects of human health in the settlement of Nelmin Nos |
| A82 | Drinking water and sewage treatment in small villages of Kenozero National Park |

### Projects concerning the entire Barents Region

| | |
|---|---|
| G91 | Integrated environmental and human health monitoring systems |

# CHAPTER 1 INTRODUCTION

## 1.1 RATIONALE

In the Russian part of the Barents Region, there are significant aggregations of heavy industries, human settlements and activities such as power plants, mining and metal smelting activities and a large-scale fishing industry. There is also a strong military presence in the Region. These activities lead to heavy emissions and discharges of contaminants to air, land and water bodies (Hydromet yearbooks of 1992, 1993 and 1994). There is also a need to 'clean up' waste and sewage dumps, which are themselves sources of continuous further contamination of soil, watersheds and marine areas.

In some areas, the natural vegetation has severely been affected, the water bodies have become polluted and very poor air and drinking water quality has been recorded (Ministry of Environment Protection and natural resources of the Russian Federation 1994; Igamberdiev *et al.* 1995; Castberg & Stokke 1992). As a result, high incident rates of several respiratory and intestinal, dermal diseases have been reported in the most heavily polluted areas.

The environmental effects of the large emissions of pollutants in the Russian part of the Barents Region are not restricted to Russia. In particular, the emissions of sulphur dioxide from the smelters on the Kola Peninsula have negative impacts on terrestrial and freshwater ecosystems in the northernmost part of Finland and parts of Finnmark, the northernmost province in Norway.

The Russian authorities of to-day are aware of the problems and are taking steps to amend the situation and to reduce the discharges of contaminants. However, in Russia many profound changes within the economical and political structure are taking place in this period. These changes deeply affect all parts of Russian society and must be taken into consideration in the continuation of the NEFCO-Programme. There is also a decline in the economy, with a 40 % reduction in industrial production in 1994 as compared to the situation in 1991 (Barents Euro-Arctic Council 1995).

Until now, the lack of funding and in some cases the lack of political will to give priority to environmentally sound investments, both for industries and municipalities, has effectively halted or slowed down the process of transition to 'environmentally friendly' technology and methods, as well as necessary repair and replacement of damaged and outdated equipment (Castberg & Stokke, 1992; Bjorvatn & Castberg 1994; Ries 1994).

Commercially profitable investments, which at the same time also have environmental benefits ('win-win projects'), so far appears to have been most successful (Holtedahl 1994).

## 1.2 OBJECTIVES

The initiative for the NEFCO Barents Region Environmental Programme (NEFCO-Programme) came in 1994 from the governments of the Nordic Countries, who are the founders of NEFCO. Through the NEFCO-Programme, the Nordic countries wish to assist the authorities of Russia in their efforts to improve the environment and decrease pollution problems in the Russian part of the Barents Region; Murmansk Province, the Republic of Karelia and Archangel Province (including the Nenets Autonomous Area). The programme shall be viewed as a part of the bilateral and multilateral co-operation between the Nordic Countries and Russia.

It is envisaged that funds will be made available by NEFCO and other investors or international financing programmes to support implementation of the priority pilot investment projects. However, the funding may also be of different kind, such as direct investments, loans or grants. In brief, there are two main types of potential additional financing:

- Bilateral financing between the Nordic countries and Russia;
- International financing through banks and agencies such as the World Bank (WB) and the European Bank for Reconstruction and Development (EBRD).

However, it should be noted that NEFCO considers local contribution and support to be an essential input for the success of the NEFCO-Programme. The programme is carried out in three phases, as described below.

**Phase I: the screening exercise.**

The aim of the screening exercise is to document the environmental problems in the Russian part of the Barents Region and, based on evaluation of this information, identify a number of potential investment projects for improvement of the environmental and health situation. A brief project description of these problems has been compiled, containing information on the type of environmental or human health problem the project aims to tackle.

Based on the available information, some of these projects should be recommended for a further feasibility study. The recommended projects should then be documented in some more detail, describing the problem and giving the quantities and qualities of gas and dust emissions, water discharges, observed levels of contaminants as well as their effects on human health or the countryside.

During Phase I of the project, the deputy secretary of AMAP visited each of the environmental authorities in Murmansk, Karelia and Archangel during January 1995, and presented the NEFCO-Programme. The environmental authorities appointed their participants in the AMAP Expert Groups.

During the period March to June 1995, the AMAP Expert Group on non-radioactive contamination met in the cities of Murmansk, Petrozavodsk, Archangel and Narjan-Mar. During these missions, the environmental authorities presented the environmental problems to the Expert Group, and a number of projects aimed at improving the environmental situation and/or human health conditions were identified. This identification was based on assessment of information gathered on the environmental situation in the Region. The Nordic component of the Expert Group was given responsibility for further documentation of the project proposals and composition of the first draft of the report.

**Phase II: the feasibility study**

A feasibility study of the projects recommended in Phase I will be carried out by consultants, in close co-operation with NEFCO. This phase includes technical and financial evaluation of the project implementation and assessment of the possibility for financing, as well as cost-benefit analyses and the compilation of a realistic time schedule. The feasibility study should generate sufficient information to decide which of the recommended projects from Phase I will be given priority as pilot projects. The feasibility study will be initiated once the report from Phase I is available.

**Phase III: implementation of the selected pilot projects**

This phase of the project deals with implementation of the priority projects. It is the intention that ideally, a number of the priority projects will be implemented within a period of 2-4 years. The selected pilot projects will differ in both character and complexity and the financial framework for each of them could vary from few million up to some hundred million US dollars.

## 1.3 ORGANISATION

In order to link the NEFCO-Programme to the Rovaniemi Process and other international initiatives to assess and improve the environmental situation in the Arctic, NEFCO engaged the Arctic Monitoring and Assessment Programme (AMAP) to be responsible for Phase I, and also to assist NEFCO in Phase II of the project. AMAP is the international environmental programme established in 1991 by the ministers of the eight Arctic countries.

The Steering Group consists of members of the Russian regional environmental authorities, the Ministry of Defence, the Ministry of the Environment, together with representatives from Finland, Norway, NEFCO and the AMAP Secretariat. The Steering Group has acted as a common consultative and reference body on behalf of the National Governments and the other parties involved in the work. To implement Phase I; the AMAP Secretariat established two Expert Groups to be responsible for the collection and compilation of information on the environmental problems, preparation of project proposals as well as report writing. One Expert Group dealt with radioactive contamination while the other was concerned with the remaining environmental issues.

This volume of the report from Phase I deals with the issues of concern around non-radioactive contamination. In co-operation with the AMAP Secretariat, Lapland Regional Environmental Centre and Akvaplan-niva, experts from the environmental authorities of Murmansk, Karelia and Archangel have prepared the information and composed this report. The medical aspects of the projects have been summarised by experts from Institute for community medicine (ISM), University of Tromsø. Akvaplan-niva has been engaged to act as secretary to the Expert Group on non-radioactive contamination and the Steering Group. The composition of the organisational bodies is detailed in Appendix 2.

## 1.4 SCOPE OF WORK AND TIME SCHEDULE

The Steering Group has adopted ten main environmental issues of concern to be dealt with by the NEFCO-AMAP project. This report addresses issues on non-radioactive contamination (issues 3-10).

1. Environmentally safe operation of nuclear installations
2. Handling and storage of radioactive wastes
3. Reduction of industrial gas emissions
4. Preservation of freshwater resources, including improvement of drinking water supply
5. Solid wastes
6. Prevention of marine pollution of the White Sea and the Kola Fjord
7. Preservation of forest resources
8. State of the environment and lifestyle of the indigenous and traditional population in the Region
9. Development of integrated environmental and human health monitoring system
10. Environmental issues concerning energy consumption and energy saving

The Steering Group has also adopted the following guidelines for identification of projects:

- The projects should be investment projects, not research
- The projects should be pilot projects which in the future may be copied elsewhere in the Region with appropriate modifications
- Projects should be selected in such a way that all the environmental issues listed above are addressed
- There should be a fair spatial distribution of the projects, emphasising particular problems of each area
- The selected pilot projects should in practical terms be implementable within 2-4 years from initiation of Phase II

**Overall time-schedule**

| Phase | Duration | Activity |
|---|---|---|
| I | February 1994 - February 1995. | Organisational issues, negotiations between NEFCO, AMAP and Russian authorities. |
| | March 1995 - December 1995. | Field missions, translation, analyses and preparation of the report |
| II | Planned January 1996 - June 1996. | Feasibility study. Detailed technical and financial evaluation of the recommended projects. |
| III | Planned Autumn 1996 and onwards. | Implementation of pilot projects |

## 1.5. RELATED ACTIVITIES

At the meeting of the Barents Council of Ministers of the Environment, Bodø, 14-15th June 1994, it was agreed that a joint Task Force of experts should be established, to develop further selected projects within the five areas of the Barents Region Environment Action Programme dealing with the following themes:

- Preparedness against nuclear accidents and prevention of radioactive contamination
- Environmental management and regional harmonisation of environmental standards and guidelines
- Reduction of pollution from industrial activities
- Protection of natural habitats and management of flora and fauna
- Co-operation between regional authorities

The Task Force was given the following mandate by the Barents Council:
" On the basis of the environmental objectives for the Barents Euro-Arctic Region and the principles and priorities established in the AEPS, The Task Force shall further develop selected projects under the five areas of the Action Programme. This work should take into due account on-going and planned activities of The Barents Regional Council and its Environmental Committee. With a view to achieving overall co-ordination of efforts and avoiding duplication of work, the Programme shall take into account appropriate existing supplementary national, bilateral and multilateral environmental projects and programmes, including AEPS.

Furthermore, the Task Force shall seek to identify projects of importance for the achievement of the objectives of the Arctic Programme, in areas not at present covered by co-operative activities within the Barents Region. The Task Force is requested to present appropriate proposals to the second Meeting of Environment Ministers of the Barents Council."

In parallel with the work of the Steering Group of NEFCO/AMAP project, the Task Force has elaborated a Report to the Barents Council where it has undertaken the following:

- on the basis of a reporting procedure, to enlist on-going bilateral and multilateral projects and activities within the five areas of the Action Programme.
- to identify closely related or duplicating projects among those reported to the Task Force.
- to identify existing project areas particularly suitable for bilateral or multilateral co-operation where a higher degree of co-ordination and co-operation could be obtained, with the aim of seeking a cost effective achievement of Programme objectives.
- on the basis of an assessment of on-going projects and activities, to identify new projects or project areas, not at present covered by on-going bilateral or multilateral activities, where multilateral undertaking and financing should be recommended.

The conclusion and recommendations of the Task Force have been summarised in the report presented to the second meeting of environment ministers of the Barents Council in Rovaniemi, 14-15th December 1995

*The Task Force recommends, inter alia, the relevant members of the Barents Council to commence the implementation of selected priority projects in accordance with the Barents Region Environment Action Programme, including projects proposed by AMAP/NEFCO.*

# CHAPTER 2 GENERAL DESCRIPTION OF THE ENVIRONMENTAL SITUATION IN THE RUSSIAN PART OF THE BARENTS REGION AND THE EFFECTS OF HUMAN ACTIVITIES

**Structure of Chapter 2.**

This chapter presents background information on the state of the environment in each of the administrative sectors in the Russian part of the Barents Region: Murmansk Province, the Republic of Karelia and Archangel Province, including Nenets Autonomous Area. The information is thematically presented according to the appointed environmental issues of concern (Section 1.4). Since the information on issues 'Indigenous and traditional populations' and 'Integrated environmental and human health monitoring system' concern the entire Barents Region, these are presented in separate sections (2.4 and 2.5).

Some basic facts on demography and geography, economic structure, natural resources and infrastructure are also included as background information. This presentation is restricted to information of relevance for evaluation of the environmental situation.

**Information sources and interpretation.**

Much valuable information was presented during the Expert Group meetings hosted by the regional environmental authorities. Some of the information was of an official nature, while others comprised internal reports, specially prepared for the environmental authorities in question. On request by the Expert Group, the environmental authorities also prepared further notes on specific issues, and the Expert Group has further used any available relevant information sources, such as published reports or papers of Russian or international origin.

Some of the information presented to the Expert Group for the screening exercise was relatively detailed and comprehensive. However, the Expert Group has noted a general lack of well documented available information on field observations of the levels of different contaminants in air, water and biota. In addition, the Expert Group notes a lack of scientific studies on the pollution effects on nature and human health. At this point however, it should be noted that this is not only a Russian problem, since such studies are to a great extent also lacking on a world-wide scale, particularly in Arctic areas.

On the other hand, much information on the amount of emissions and discharges has been presented to the Expert Group. Thus, many environmental problems have been identified largely on the basis of levels of pollution discharges, but also with some anchoring in the federal and regional monitoring programmes. However, the Expert Group realises that the monitoring system in the Barents Region is currently declining in capacity, and to a certain extent in volume, due to the financial difficulties and priorities currently taking place in Russia. It should also be noted that, in many cases, the given figures on amounts of emissions and discharges are calculated figures, not measured amounts.

Furthermore, most given figures are expressed as annual averages, and data on peak emissions and discharges are lacking. For some pollutants, such as $SO_2$, high peaks during a short period can be more harmful than a lower dose over a longer period, both in terms of the environment as well as human health. The interpretation of the statistical material has in some cases been difficult, due to several factors. The definitions and categories used in Russia to define and describe environmental and human health parameters often differ considerably to those used in other countries. Furthermore, field observations are often based on a variety of different analytical methods and laboratory equipment. This makes interpretation of the data extremely time consuming. Some statistics show unrealistically high variations in the observed values between years, particularly in the case of health statistics. Thus, statistics of this kind must be studied with great care, in order to avoid misinterpretations.

During the period between 1991-1994, there has been a 40 % overall reduction in industrial production in Russia, the Barents Region being on the Russian average (Barents Euro-Arctic Council 1995). As a result, both air-borne emissions and waste-water discharges have shown a decline. For example, the $SO_2$ emissions from the smelter in Monchegorsk in 1994 were only 50 % of the levels recorded in 1990, while the emissions from the smelters in Nikel were constant between the two years (Section 2.1.6.1). In some cases, the reduction of emissions is due to the introduction of 'clean technology' equipment. However, the total investments in air purification equipment in Murmansk Province over the three-year period between 1989-91 were lower than for each of the three previous years (Castberg & Stokke 1992). Unfortunately, the Expert Group has not been able to find information on these types of investments for the more recent years.

In some western countries, a very important principle has been adopted for pollution monitoring and responsibility, known as PPP - 'Polluter Pays Principle!' This simple principle has motivated both the industries as well as municipalities to increase their efforts to reduce all types of pollution. A similar positive trend can be seen in the recycling industry. Due to the constant high price of energy in western countries, combined with 'environmental taxes', an increasing number of metals, chemical compounds and other items are now profitably recycled instead of being dumped. The Expert Group is of the opinion that development in this area must be encouraged.

In Russia, strict rules and classification systems of environmental quality have been introduced. This is also the case for air and fresh water quality, and maximum allowable concentrations (MAC) have been defined for a number of air- or waterborne pollutants, such as $SO_2$, $NO_2$ and dust (Igamberdiev *et al.* 1995). In general, these rules are stricter than WHO and Norwegian standards (Appendix 1).

Finally, the Expert Group wish to emphasise the complex picture of the environmental situation in the Russian part of the Barents Region. Most of the information presented to the Expert Group has originated from the industrialised centres and cities, while very few studies have been carried out in the vast sparsely populated areas. In general, there is a lack of background values of contaminant levels. Nevertheless, the information clarifies that the populated centres are suffering major environmental problems which require rapid remedial action. The industrialised areas border a wide and somewhat undefined zone, which to a varying degree suffers from the effects of air and water-borne pollutants, as well as from direct human impact, such as ditching, military activities etc. Beyond this border zone, such as in the eastern part of the Kola Peninsula, there are still areas of largely untouched wilderness. The future challenge for the environmental authorities will be to preserve these unique biotopes and their wildlife, as well as to integrate the monitoring of these areas into the general framework of environmental monitoring systems.

When evaluating the environmental and health problems and project proposals to amend these problems, it is important to bear in mind the extremely dynamic economic and political situation prevailing in Russia today. The on-going transition of the previous economy to some kind of market-driven economy leads to profound changes in the financial and political structure. The production forms, the geographical location of the production, the type of production etc. are constantly changing, and may change even more rapidly in the coming years. As a result, the pollution problems of today may not be the same tomorrow. During the feasibility studies, the potential of each project proposal must therefore be evaluated closely and cost-benefit analyses must be carried out, with this dynamic situation in mind.

## 2.1 MURMANSK PROVINCE

### 2.1.1 Population and basic geographical data

The Province of Murmansk is almost entirely situated north of the Arctic Circle, with a total area of 144 900 $km^2$ and a current population of 1 109 400 inhabitants. The average population density is 8.3 inhabitants per $km^2$. Murmansk Province is by far the most urbanised area in the Barents Region, with 93 % of the inhabitants living in cities. Approximately 40 % of the Province's population are resident in the capital Murmansk City (Seppänen 1995). The population is centred on the western and central parts of the Kola Peninsula, between the cities Murmansk and Kandalaksha (Fig. 2.1.1). During the year 1914, the number of inhabitants was approximately 13 000 (Varis 1992). The maximum population density occurred during the years 1991-92. Since then, the figures have started to decline slightly (Seppänen 1995). This population loss has been caused more by emigration than by the decline in birth rate. Emigration occurs as a result of job losses and the rise in living costs, as well as migration back to the newly independent republics of the former Soviet Union. The mean life expectancy of men in Murmansk Province is below 60 years (even below 50 in some areas) and for women a little over 70 years.

The dominant population in the area are Russians (83 %). The second largest population group is Ukrainian (9.0 %), followed by Belo-Russian (3.3 %) and Tatarian (1.0 %). Other nationalities residing in the area are Mordvinian, Karelian, Saami, Finnish, Komi and Mari (Seppänen 1995; Varis 1992). The Saami are the indigenous people of the Kola Peninsula. The number of Saami people in Murmansk Province in 1993 was 1 615 persons, mainly living in the Lovozero area (Seppänen 1995).

There are over a hundred thousand lakes in the Province of Murmansk. The largest of these is Lake Imandra, with an area of 812 $km^2$ and a maximum depth of 67 m. Lakes are connected with the sea basins by some thousands of streams and rivers, the longest of them being the Ponoy River, 426 km in length. Due to the northern Atlantic currents, the coastal waters of the western part of the Kola Peninsula never freezes, and the harbour of Murmansk City is ice-free all year round. The climate is the mildest in the Russian part of the Circumpolar North (Seppänen 1995), with low summer and winter air temperatures. The average January temperature is -8°C along the northern coast, and -12 to -15°C in the centre of the Kola Peninsula. The summer is short, generally cool and rainy, with average June temperatures ranging from +8 to +14 °C.

### 2.1.2 Administrative and territorial structure

For centuries, the Kola Peninsula was a part of the Archangel Province, until it was granted the rights of an independent administrative unit in 1938 (Seppänen 1995). Murmansk Province is organised into 14 administrative areas. Nine of them are so-called 'town rayons' (districts), where the towns are under the jurisdiction of the Province. The remaining five are 'rural districts' (counties) (Fig. 2.1.2, Seppänen 1995).

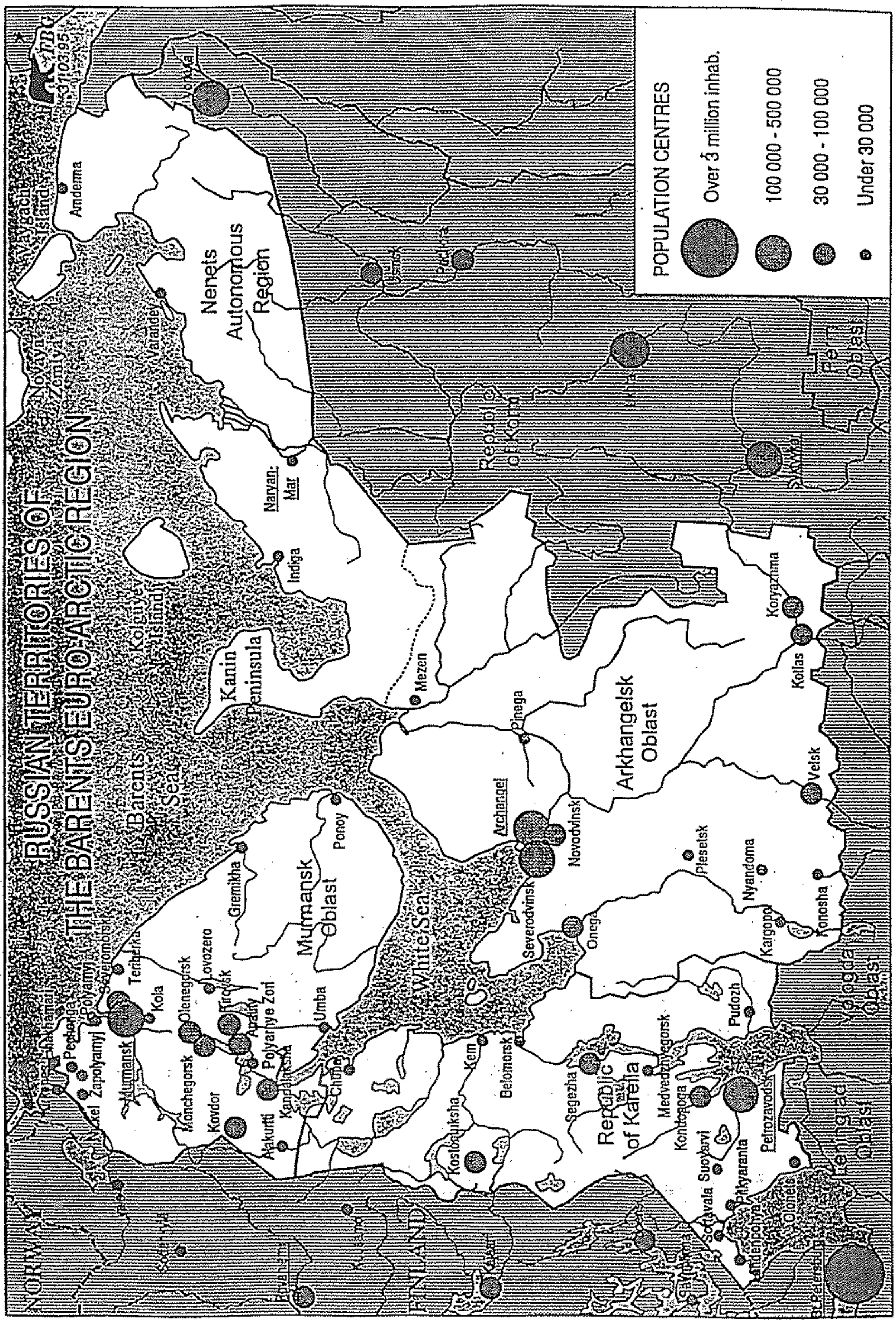



Figure 2.1.1 The largest population centres in the Russian part of the Barents Region (Seppänen 1995).

### 2.1.3 Economic structure

The Kola Peninsula is an indispensable supplier of raw materials for Russia. During the Soviet economic policy, Murmansk Province concentrated on fishing and mining activities and in 1994 the Province accounted for 100 % of the Russian apatite production, 10 % of the iron ore supplies, 41 % of nickel, 13 % of copper, and 16 % of fish and fish products (Barents Euro Arctic Concil 1995). Manufacturing accounts for 70 % of the gross domestic product of the Province. The primary occupations employ only 2.3 % of the labour force. Over 40 % of the employed population work in the processing industry (manufacturing and construction) and more than 50 % are employed in the service trade (Seppänen 1995).

### 2.1.4 Natural resources

Murmansk Province contains major reserves of such minerals and elements as phosphorus, iron, copper, nickel, cobalt, sulphur, bauxite, titanium, vanadium, sodium, potassium, zirconium, niobium, nepheline and tantalum. Large natural gas deposits have been discovered offshore in the Barents Sea. Western and Russian estimates have been between 4 and 10 trillion cubic meters of natural gas in the Russian part of the Barents Sea (Seppänen 1995).

Forests cover around one third of the area of Murmansk Province, approximately 4.9 million hectares. The three dominant species are coniferous trees such as the Scots pine and Norway spruce, birch, mountain ash and alder. The Arctic climate leads to relatively slow tree growth. The estimated total volume of wood in the Province is some 201 million $m^3$. Harvestable forest resources amount to approximately 138 million $m^3$. One fifth of Murmansk Province is covered by tundra (Seppänen 1995).

Another important resource is fish. The main commercial marine species are cod, haddock, polar cod, capelin and herring. The single most important species is the cod, and the fishery mainly takes place in the Barents Sea. The total Russian catch of cod in 1994 was just over 300 000 tonnes. The anadromous salmon is also an important resource of Murmansk Province, and internationally anglers have recently 'discovered' the possibilities for sports fishing excursions.

### 2.1.5 Transportation

The most important means of transportation in Murmansk Province is the railway, with approximately 65 % of the total freight volume in the area being transported by rail. The most important roads are the Murmansk - St. Petersburg road and the Kola - Pechenga road, both of which are federal roads. Murmansk port is the largest ice-free port in the northern part of Russia, with a handling capacity up to 7.5 million tonnes per year. This is mainly dry cargo, such as mining products and apatite concentrate. Approximately one million flight passengers annually travel to and from Murmansk via the civilian airport (Seppänen 1995).

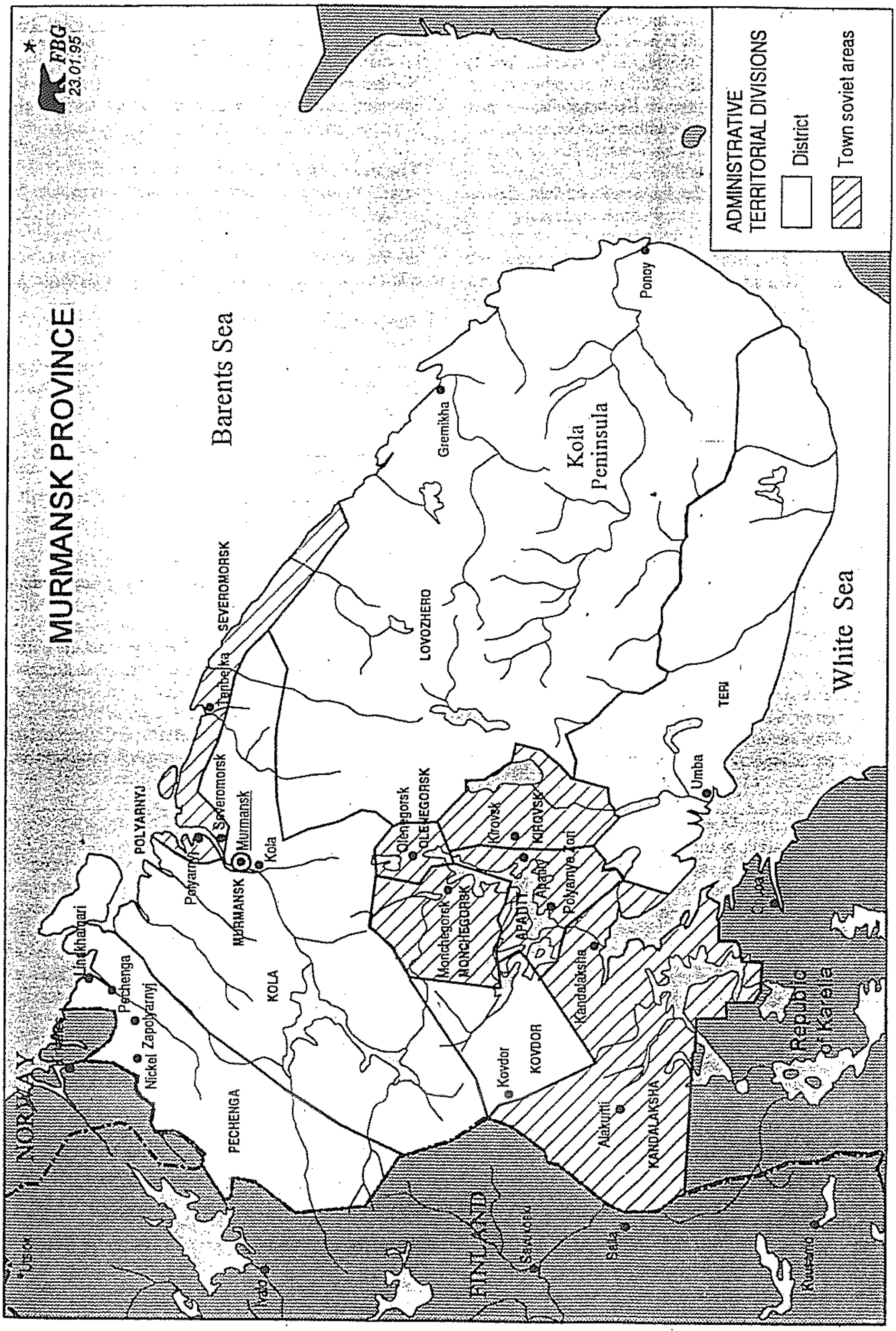



Figure 2.1.2 Administrative area boundaries in the Province of Murmansk (Seppänen 1995).

## 2.1.6 The state of the environment particularly related to the issues of concern

### *2.1.6.1 Air pollution*

In Murmansk Province, there are 5 196 stationary sources of air-borne emissions, which emitted 570 600 tonnes of pollutants in 1993, and 470 000 tonnes in 1994. Emissions from automobile transport in the Province is estimated to contribute 16% of the total emissions (Environmental Committee of Murmansk Province (ECMP 1995). The most significant pollutants emitted by industrial enterprises in 1993 are given in Table 2.1.1.

Table 2.1.1 Air-borne pollutant emissions in Murmansk Province, 1993 (ECMP 1995)

| Component | Amount emitted (tonnes ) | Percentage |
|---|---|---|
| Sulphur dioxide ($SO_2$) | 456 200 | 80.2 |
| Carbon oxide (CO) | 36 500 | 6.4 |
| Nitrogen Oxides ($NO_x$) | 16 000 | 2.8 |
| Dust (solid particles, soot) | 59 900 | 10.5 |

In 1994, industrial air-borne emissions also contained nickel (1 780 tonnes), copper (1097 tonnes), vanadium oxide (335 tonnes), hydrocarbons (924 tonnes), formaldehyde (926 tonnes), other volatile organic compounds (728 tonnes) gaseous fluorine compounds (848 tonnes). Emission of benzo(a)pyrene was estimated to 2.24 tonnes (ECMP 1995). The territorial distribution of air-borne emissions in 1994 is presented in Table 2.1.2, and levels of air contamination by main pollutants in the cities and towns of the Province are given in Table 2.1.3.

Table 2.1.2 Industrial air-borne emissions in the cities and counties of the Murmansk Province in 1994. Data expressed in 1000 tonnes (ECMP 1995).

| City (County) | Total | $SO_2$ | $NO_x$ | Solids | CO |
|---|---|---|---|---|---|
| Murmansk | 34.5 | 26.6 | 1.3 | 2.2 | 3.5 |
| Apatity | 24.9 | 14.6 | 5.1 | 4.9 | 0.3 |
| Kirovsk | 6.1 | 4.0 | 0.9 | 0.8 | 0.5 |
| Kandalaksha | 28.7 | 8.7 | 0.8 | 9.4 | 11.3 |
| Monchegorsk | 111.5 | 97.7 | 1.3 | 10.3 | 0.9 |
| Olenegorsk | 10.8 | 5.1 | 0.8 | 2.9 | 1.5 |
| Polyarny | 7.6 | 4.7 | 0.6 | 0.3 | 2.9 |
| Severomorsk | 9.8 | 6.5 | 0.8 | 1.6 | 1.7 |
| Kovdor County | 8.2 | 5.0 | 0.5 | 1.1 | 1.4 |
| Kola County | 5.7 | 2.9 | 0.3 | 1.2 | 1.3 |
| Lovozero County | 3.4 | 1.9 | 0.2 | 0.03 | 0.6 |
| Pechenga County | 215.2 | 199.0 | 0.5 | 12.7 | 2.9 |

Table 2.1.3 Air pollution in the cities/towns of Murmansk Province 1994 (ECMP 1995).

| City / town | Value | $SO_2$ | | | $NO_2$ | | | CO | | | Dust | | | Benzo(a)pyrene | | | | Ni | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1991 | | 1993 | 1991 | | 1993 | 1991 | | 1993 | 1991 | | 1993 | 1991 | | 1993 | | 1991 | | 1993 |
| | | $mg/m^3$ | MAC | MAC | $mg/m^3$ | MAC | MAC | $mg/m^3$ | MAC | MAC | $mg/m^3$ | MAC | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | MAC |
| Apatity | mean* | 0.002 | <0.1 | | 0.02 | 0.6 | | 1.5 | 0.5 | | 0.07 | 0.5 | | 0.5 | 0.5 | | | 0.19 | 0.2 | |
| | max** | 0.110 | 0.2 | | 0.37 | 4.4 | 1.4 | 15.0 | 3.0 | 2.6 | 1.00 | 2.0 | 4.8 | 1.4 | 1.4 | 2.7 | 2.7 | 0.75 | 0.8 | |
| Kandalaksha | mean | 0.022 | 0.4 | | 0.02 | 0.5 | | 0.1 | <0.1 | | 0.08 | 0.5 | | 2.2 | 2.2 | | | 0.18 | 0.2 | |
| | max | 0.470 | 0.9 | | 0.39 | 4.6 | 2.6 | 3.0 | 0.6 | | 0.9 | 1.8 | 2.2 | 5.8 | 5.8 | 9.5 | 9.5 | 0.68 | 0.7 | |
| Kirovsk | mean | 0.009 | 0.2 | | 0.02 | 0.4 | | 1.3 | 0.4 | | 0.05 | 0.3 | | | | | | | | |
| | max | 0.300 | 0.6 | | 0.17 | 2.0 | 2.2 | 6.0 | 1.2 | | 0.5 | 1.0 | | | | | | | | |
| Kovdor | mean | 0.004 | 0.1 | | 0.01 | 0.2 | | 0.8 | 0.3 | | 0.15 | 1.0 | | 0.8 | 0.8 | | | | | |
| | max | 0.170 | 0.3 | | 0.40 | 1.0 | 1.8 | 8.0 | 1.6 | | 3.5 | 7.0 | 1.4 | 2.5 | 2.5 | 1.8 | 1.8 | | | |
| Kola | mean | 0.027 | 0.5 | | 0.04 | 0.9 | | 1.0 | 0.3 | | 0.03 | 0.2 | | | | | | | | |
| | max | 0.250 | 0.5 | | 0.17 | 2.0 | 2.2 | 5.0 | 1.0 | 1.2 | 0.4 | 0.8 | | | | | | | | |
| Monchegorsk | mean | 0.029 | 0.6 | | 0.01 | 0.3 | | 0.4 | 0.1 | | 0.08 | 0.6 | | 2.2 | 2.2 | | | 0.51 | 0.5 | |
| | max | 1.820 | 3.6 | 5.6 | 0.10 | 1.2 | 1.6 | 6.0 | 1.2 | 2.4 | 0.60 | 1.2 | 1.2 | 8.6 | 8.6 | 8.1 | 8.1 | 1.10 | 1.1 | 2.2 |
| Murmansk | mean | 0.026 | 0.5 | | 0.04 | 0.9 | | 1.0 | 0.3 | | 0.06 | 0.4 | | 1.1 | 1.1 | | | 0.06 | <0.1 | |
| | max | 0.330 | 0.7 | | 0.27 | 3.2 | 2.2 | 9.0 | 1.8 | 2.2 | 0.5 | 1.0 | | 4.0 | 4.0 | 3.4 | 3.4 | 0.42 | 0.4 | |
| Nikel | mean | 0.048 | 1.0 | 1.0 | 0.01 | 0.2 | | 1.1 | 0.4 | | <0.01 | <0.1 | | 0.5 | 0.5 | | | 0.26 | 0.3 | |
| | max | 2.180 | 4.4 | 4.8 | 0.11 | 1.3 | | 6.0 | 1.2 | | 0.40 | 0.8 | | 2.9 | 2.9 | 2.2 | 2.2 | 0.95 | 1.0 | 1.4 |
| Olenegorsk | mean | 0.007 | 0.1 | | 0.02 | 0.4 | | 1.1 | 0.4 | | 0.12 | 0.8 | | | | | | 0.24 | 0.2 | |
| | max | 0.240 | 0.5 | | 0.30 | 0.8 | | 10.0 | 2.0 | 1.6 | 1.5 | 3.0 | 2.0 | | | | | 0.99 | 1.0 | 2.2 |
| Severomorsk | mean | 0.019 | 0.4 | | 0.05 | 1.2 | 1.5 | 1.2 | 0.4 | | | | | | | | | | | |
| | max | 0.330 | 0.7 | | 0.21 | 2.5 | 2.7 | 5.0 | 1.0 | 1.5 | | | | | | | | | | |
| Zapolyarny | mean | 0.064 | 1.3 | 1.0 | 0.01 | 0.1 | | 1.3 | 0.4 | | 0.01 | <0.1 | | | | | | 0.46 | 0.5 | |
| | max | 1.370 | 2.7 | 4.6 | 0.07 | 0.2 | 2.2 | 5.0 | 1.0 | | 0.40 | 0.8 | | | | | | 0.99 | 1.0 | 1.2 |

* Mean = Annual average.

** Max = The highest peak through the year, measured over a 20 minutes period.

The general state of human health in Murmansk Province is close to mean Russian values. At the same time, in some cities with high levels of environmental pollution, the Murmansk figures are considerably higher. For example, the total morbidity statistics of the adult population in Monchegorsk is 37.6 % higher than the mean provincial value and 19.3 % higher than mean values for Russia as a whole. Total child morbidity in the Province exceeds average Russian levels by 39 %. Incidences of cancer, skin and endocrine morbidity among the Monchegorsk population is particularly high and exceeded 75 % in 1989-1993. It should be noted that in 1989, this city was ranked 4th in the list of Former Soviet Union cities with the highest incidences of skin diseases (3.18 %) (National Report. USSR State Committee for Environmental Protection 1990).

Synergistic effects of environmental stress are also known from the Province. Thus, the children of Monchegorsk are particularly at risk due to the extreme chronic air pollution, combined with poor drinking water quality. A Russian investigation comparing Monchegorsk and Olenegorsk show a doubled frequency in respiratory diseases in Monchegorsk, relative to the situation in Olenegorsk. Similarly, anaemia was twice as frequent, asthma 4 times more frequent, gastro-intestinal problems 4.1 times more frequent in Monchegorsk than Olenegorsk. The particular Russian disorder, neurovegetative dystonia, is also much more prevalent in Monchegorsk teenagers than those in Olenegorsk.

The most urgent air pollution problems are found in Pechenga County (Zapolyarny town, population 22 200, and Nikel, population 20 100) and Monchegorsk, with a population of 66 300 (Tab. 2.1.3). The nickel smelters 'Pechenganickel' and 'Severonickel' situated here are responsible for significant $SO_2$ emissions, which create major air pollution problems, not only in the territory of Murmansk Province, but also in Northern Norway as well as Finland. Even though Nikel ranks only 16th on the list of the most air-polluted cities in Russia, Zapolyarny and Nikel have very high levels of $SO_2$ air pollution and increased concentrations of benzo(a)pyrene[1].

The levels of sulphur emissions from the smelters of Pechenganickel were highest during the late 1970's, when they were estimated at being over 400 000 tonnes of sulphur dioxide per year. Due to the recovery of sulphuric acid, as well as a fall in production, the emissions have decreased during the 1990's to approximately 200 000 tonnes of $SO_2$ per year. The annual emissions from Severonickel, during the 1980's, have been between 200-280 000 tonnes of $SO_2$. The high levels of sulphur emissions from the metal smelters on the Kola Peninsula mainly arise from large-scale production using raw materials with very high sulphur contents, as well as outdated technology throughout the process. The production process is mostly open, leading to diffuse emissions through the walls and roofs of the plant. However, poor performance at the sulphur acid generating $SO_2$ recovery units and poor flue gas treatment also results in increased emissions. The emissions increased remarkably during the early part of the 1970's when the smelters began using Norilsk ore, containing more than 30 % sulphur.

Murmansk City is the third most significant source of air-borne emissions in the Province. In spite of the fact that this City emits only 15 and 30 % of the emissions of Pechenga and

[1] In Russia it is common to analyse emissions of benzo(a)pyrene, while in the Nordic countries it is customary to analyse the whole group of polycyclic aromatics (PAH).

Monchegorsk respectively, it should be taken into consideration that more than 40% of the population of the Province live in Murmansk City and are affected by the emissions. The most significant pollutants in the City are $NO_2$, benzo(a)pyrene and mercury. The highest mercury levels in air reached 2.1 MAC (0.6 $\mu g/m^3$ air) in 1993, and 3.1 MAC (0.9 $\mu g/m^3$ air) in 1994. The source of mercury contamination has not yet been identified, but based on detection sites and distribution of potential sources, the pollution may arise from operation of the communal waste incineration plant.

Unlike the counties of Monchegorsk and Pechenga, there is no single dominant source of pollutants in Murmansk City. Three heat and power plants are together responsible for more than 45 % of the total air-borne emissions. According to the expansion plans for heat production in the City, the Southern heat and power plant will increase heat production by 60 %. If this plant will continue to use the existing technology, this expansion will cause a significant increase in emissions generated, and it is expected that the emissions will comprise more than half of the total emissions from the heat and power industries in the entire City, including 95 % of the total $SO_2$ emissions.

From an environmental perspective, the most detrimental air-borne emissions are sulphur dioxide, heavy metals and dust. Vegetation show acute leaf damage when exposed to approximately 1 mg $SO_2/m^3$ air (Sivertsen *et al.* 1994), either chronically or in concentration peaks. Nitrogen emissions within the Kola Peninsula have been relatively low. Dust poses another air pollution problem, and concentrations exceeding even the highest imposed health norms were recorded in Apatity, Kovdor and Olenegorsk (Tab. 2.1.3). The main source of air-borne emissions in Kandalaksha City is the aluminium plant. Due to the nature of the main pollutant source, the type of air pollution in this city differs from that in other areas in Murmansk Province. For example, in 1993, highest concentrations of hydrogen fluoride in the air reached 11.8 MAC and benzo(a)pyrene - 9.5 MAC.

In the City of Apatity (76 000 inhabitants), the main air-borne emissions originate from heat and energy production enterprises (70 %) as well as from the enterprise 'Apatite' (25 %). This enterprise has high level of apatite dust emission (3 000 tonnes in 1994) which can be considered as the major contaminant in air in the City. For example, in 1993, dust concentrations in the air reached a maximum of 4.8 MAC.

Compared with other Fennoscandian emissions, the industrial emissions of the Kola Peninsula are very high. Besides the emissions produced in the Norilsk smelters in Siberia, (estimated at 2 200 000 tonnes $SO_2$ per year), the emissions on the Kola Peninsula are the only significant sulphur dioxide sources north of the arctic circle. On the other hand, sulphur dioxide emission occurs in Europe, from where sulphur compounds are carried by the air to the northern areas (Fig 2.1.3). Their significance in relation to local emissions on the air quality as well as the sulphur depositions of the Kola Peninsula is however, significantly smaller. In practice, the measurable effect of sulphur emissions from local sources on Kola Peninsula ecosystems is within a 250 km radius from the sources (Fig. 2.1.4 and Section 2.1.6.5).

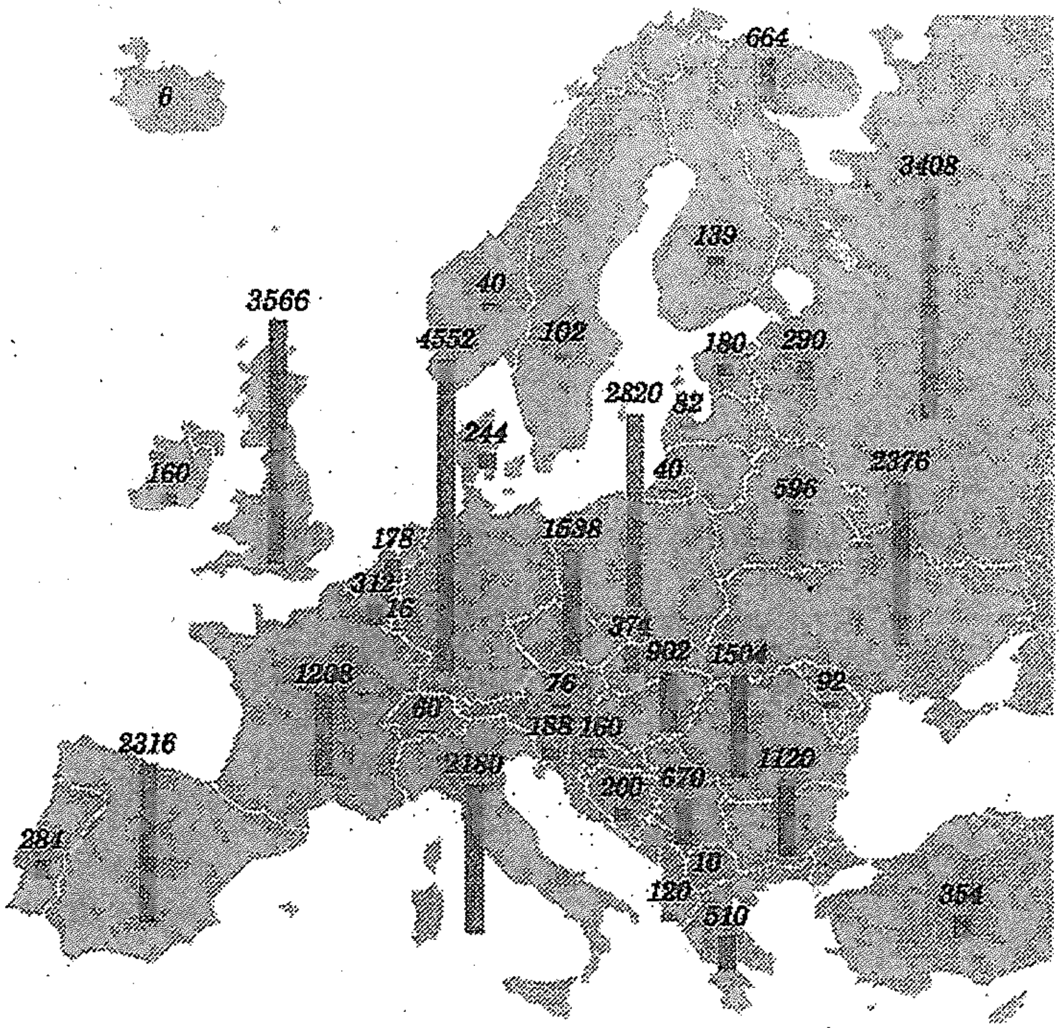



Figure 2.1.3 Sulphur dioxide emissions in Europe during 1992, expressed in units of 1000 tonnes $SO_2$ (Tikkanen 1995).

Typically, the proportion of dry deposition of sulphur relative to total sulphur deposition is extremely high, and can be as high as 70-80 %. At present, there is a lack of standardised methodology for measuring this deposition. As a result, in the northern regions the values of the total sulphur deposition are based upon calculated estimates.

For some contaminants, the peak values of emissions may cause more damage to both the ecosystem and human health than the lower average values, as is the case with $SO_2$ and its effects on forest. In order to interpret these emissions and their effects, both the peak concentrations as well as average emission values should be presented (Fig. 2.1.4).

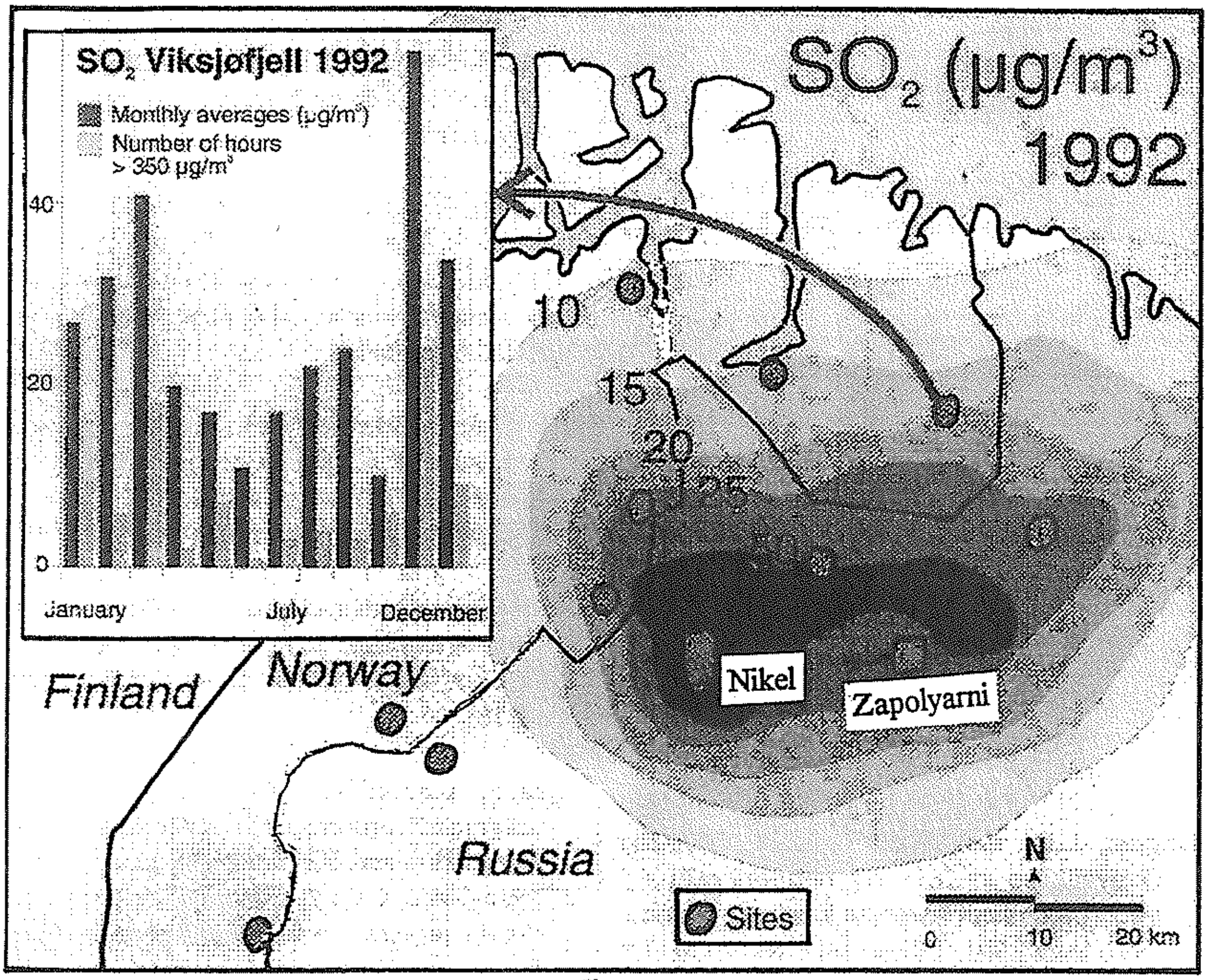



Figure 2.1.4 Model estimates of annual average $SO_2$ consentration distribution for 1992, and number of hours with > 350 microgrammes per $m^3$ (Sivertsen *et al.* 1994)

The problems caused by the activities of the large nickel smelters of the Kola Peninsula are without a doubt the greatest and most acute of the detrimental factors affecting the watercourses and the ecosystems of the Kola Peninsula. If the technology of the smelters could be modernised, and emission levels reduced to those of western standards, the ecological situation as well as the health of the population of the Kola Peninsula would show considerable improvement. However, in the commission of this project, it has been agreed that, while the problems caused by the Pechenganickel company will be presented in the report, NEFCO funding of remedial actions in this area will not be proposed as related Russian and international projects aimed at the modernisation of the smelters and decreasing levels of emissions are already in progress.

The major sources of $SO_2$ in the Murmansk Province are the Severonickel and Pechenganickel smelters as well as the heat power plants in Murmansk city. The environmental problems arise mainly from the smelters, while human health problems are caused by both the smelters and the power plants, due to the location of the heat-power palnts close to large population centers like e.g. Murmansk.

### 2.1.6.2 *Freshwater and drinking water resources*

Pollution of freshwater resources

During 1992, the volume of non-military waste water discharges in the Province of Murmansk was 2 226 million $m^3$ (Tab. 2.1.4), out of which 303 million $m^3$ were unsatisfactorily purified and 108 million $m^3$ were not purified at all. The military and military-related activities (garrisons, towns etc.) were responsible for the discharge of a total of 42 million $m^3$ of untreated waste water. During the period between 1992-1994, the amounts of discharged waste water were relatively constant, and the reduction in the total amount discharged mainly arises from reduced discharges from the Kola nuclear power plant (Tab. 2.1.4).

Table 2.1.4 Amounts of waste water discharged in the Province of Murmansk, expressed as million. $m^3$ (ECMP 1995).

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Total waste water discharges | 2 226 | 2 163 | 1 680 |
| Discharges from Kola nuclear power plant | 1 710 | 1 641 | 1 173 |
| Discharges from all other sources | 516 | 522 | 507 |
| Purification levels: | | | |
| Purified according to standards | no data | no data | 78.5 |
| Untreated | 108 | no data | 102.5 |
| Insufficiently purified | 303 | no data | 229.1 |
| Sufficiently pure, discharged without treatment. | no data | no data | 96.8 |

In 1994, only 4.7 % of the waste waters were treated according to specified purification standards. Approximately 6.1% of the waste waters (102.5 million. $m^3$) were discharged into water bodies without any treatment whatsoever and 13.6 % (229.1 million $m^3$) were considered insufficiently treated. Finally 75.6 % (1 269.8 million. $m^3$ in 1994), were classified as 'sufficiently pure' and were allowed to be discharged without treatment. This latter group is mostly generated by cooling waters of the Kola nuclear power plant (ECMP 1995).

Two thirds of municipal waste water remain impure even after the purification process. Out of 170 purification plants only 26 fulfil purification requirements according to set norms. In the towns of Murmansk as well as Kildinstroy and Lovozero, waste water purification plants are under construction, but progress is slow, due to financial difficulties (Ruokanen 1994).

Area distribution of waste water discharges and levels of contaminants are given in Table 2.1.5.

Table 2.1.5 Waste water discharges in the cities and counties of Murmansk Province in 1994 (ECMP 1995).

| City, district | Waste water volume, million $m^3$ | Amount of pollutants discharged, tonnes. | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxidative org. | Petroleum hydro-carbons | Suspended matter | N-NH4 | N-NO3 | Al | $Fe_{total}$ | Fats | SO4 | P-PO4 | F | $Cl^-$ | Deter-gents | $Mn^{2+}$ | $Ni^{2+}$ | $Co^{2+}$ |
| Murmansk Province (total) | 1680 | 11487 | 162 | 10387 | 1955 | 841 | 0.78 | 63.8 | 151 | 52151 | 332 | 415 | 18343 | 87.0 | 0.09 | 58.2 | 1.5 |
| Murmansk | 65.2 | 1429 | 56.4 | 5347 | 871 | 45.9 | | 27.6 | 151 | 1550 | 116 | | 4960 | 47.2 | | <0.1 | |
| Kirovsk and Apatity area | 1356 | 872 | 41.7 | 1637 | 416 | 4051 | | 15.0 | | 8190 | 7.0 | 297 | 2357 | 17.9 | | | |
| Kola NPP | 1172 | 8.6 | 1.3 | 9.3 | 4.6 | | | | | 110 | 0.3 | | 22 | | | | |
| Kandalaksha | 41.5 | 438 | 5.5 | 436 | 30.9 | 28.6 | 0.03 | 3.0 | | 0.8 | 2.1 | 1.1 | 313 | 2.4 | 0.09 | | |
| Monchegorsk | 24.6 | 139 | 3.0 | 721 | 53.0 | 11.3 | | 0.02 | | 34678 | 4.4 | | 7344 | | | 54.2 | 1.5 |
| Olenegorsk | 14.7 | 80 | 3.4 | 97.2 | 47.5 | 77.1 | | 1.6 | | 122 | 6.2 | | 235 | 0.9 | | <0.1 | |
| Polyarny | 16.1 | 430 | 8.2 | 445 | 167 | 18.8 | | <0.1 | | 377 | 2.6 | | 1088 | 4.3 | | | |
| Severomorsk | 17.6 | 913 | 6.1 | 520 | 146 | 15.7 | | 0.1 | | 236 | 8.5 | | 373 | 8.4 | | | |
| Kovdor County | 39.5 | 251 | 2.4 | 265 | 26.7 | 107 | 0.27 | 14.0 | | 4543 | 2.4 | | 876 | 1.3 | | | |
| Kola County | 44.8 | 490 | 1.7 | 303 | 75.7 | 46.8 | 0.48 | 1.4 | | 80.5 | 6.6 | 1.3 | 222 | 4.1 | | | |
| Lóvozero County | 17.7 | 103 | 2.3 | 317 | 25.4 | 7.3 | | 0.2 | | 103 | 4.6 | 116 | 131 | 0.3 | | | |
| Pechenga County | 37.7 | 490 | 31.3 | 368 | 116 | 101 | 0.48 | 1.4 | | 2315 | 7.9 | 1.3 | 551 | 3.6 | | 4.0 | |

Based on assessment of the spatial distribution of waste water discharges, it is possible to indicate the following areas where the most significant water pollution problems can be expected:

Murmansk City. Industrial enterprises and communal waste in this City are responsible for 65 % of discharged oxidative organic compounds, 35 % of petroleum hydrocarbons, more than 50 % of suspended matter, almost 45 % of ammonia and all fats entering the Kola Fjord with channelled waste waters. The waste waters of the City of Murmansk are discharged into the Kola fjord, and has seriously affected its marine ecosystems (Section 2.1.6.4).

Table 2.1.6 presents information on waste water discharges and contaminants from some of the other cities of the Province.

Monchegorsk City. The 'Severonickel' smelter is the main producer of waste water in the City. Approximately equal parts of waste waters from the smelter are discharged into lakes Imandra and Nud-Yarv. The discharged waste waters are considered insufficiently treated. River Nyuduay, which flows out of lake Nud-Yarv, is the most polluted water body on the Kola Peninsula. In 1993, the mean concentration of nickel in river water was 2.25 mg/l (224.5 MAC) with peak concentrations of 465 MAC. Copper levels reached 0.17 mg/l (167 MAC) with mean concentrations of 38 MAC. Water mineralisation in 1993 at times exceeded 3 g/l.

Monche Bay on the shores of lake Imandra, where half of the waste water from the smelter is discharged, is the most polluted part of the lake. In 1993, Nickel concentrations in this area reached 29-37 MAC, while copper levels were 17-20 MAC, mineralisation exceeded 500 mg/l.

Kirovsk City (38 000 innhabitants). The corporation plant 'Apatite' is responsible for almost 90% of the total waste waters in Kirovsk. River Belaya, where waste waters are discharged, is affected by increased fluoride levels. In 1990, the mean concentration of fluoride was 3.8 MAC (2.85 mg/l), while in 1993, this value rose to 4.5 MAC, with peak concentrations of up to 16 mg/l.

Apatity City. Approximately 90 % of waste waters from this City are of communal origin. This is considered to represent only a minor threat to the environment, compared with the many other sources of water pollution on Kola Peninsula at large. Nonetheless, the Schutchya Bay, where this city is situated, is considered as being contaminated, mostly by compounds typical for communal waste, such as phenols, suspended matter and nitrogen compounds.

Kovdor (26 000 innhabitants). The corporate Kovdor mining and extraction plant (Kovdor GOK) produces approximately 92 % of town's waste waters. Around 12 % of the GOK waste waters are discharged without prior treatment as 'standard pure' and only 1.4 % is treated according to set standards. The remainder of the waste water is discharged in a contaminated condition, as the treatment facilities at GOK cannot ensure adequate treatment according to standard levels. Contaminated waste waters are discharged to Lake Kovdor and River Kovdora. Based on assessments of the contaminant levels, these water bodies are considered to be moderately polluted.

Lovozero County (15 000 innhabitants). The 'Sevredmet', or 'Lovozero GOK' enterprise is the main source of contamination of water bodies in the Lovozero area. Approximately 30 % of the waste water from GOK is discharged into Lake Umbozero, while 50 % is discharged into River Sergevan and 20 % is released into Lake Rivdozero. Only about 5 % of waste waters are considered as 'standard pure'. All the rest are discharged in a polluted condition, either with only insufficient treatment or without any treatment at all. Despite the fact that fluoride levels in these water bodies have decreased during the past few years, these values still exceed MAC. For example, in 1993, the mean fluoride concentration in River Sergevan was 3.5 MAC (max. 6.1) and in Sergevan bay of Lake Lovozero this value was 3.4 MAC (max. 5.7). These water bodies are also contaminated with petroleum hydrocarbons (mean concentrations in 1993 were 0.3 mg/l and 0.09 mg/l respectively). River Virma in this area is affected by the discharges of communal waste waters from the village of Lovozero (4-5000 innhabitants). In the spring period, the River is prone to oxygen deficit (down to 2 mg/l), and periodically high levels of iron contamination have been observed.

Nikel. The nickel smelter 'Pechenganickel' is a major source of contamination of water bodies in Pechenga County. The waste water from the plant is discharged into the rivers Kolos-yoki (River Patso-yoki basin), Hauki-lampi-yoki (River Pechenga basin) and Lake Alla-akka-yarvi. Approximately 25% of the contaminated waste waters are discharged without any prior treatment and 63% are released after only insufficient treatment. At the mouth of River Kolos-yoki, the mean nickel concentration in 1993 was 0.44 mg/l (44 MAC) with a peak concentration close to 2 mg/l. High nickel concentrations have also been recorded in the tributaries of the River Pechenga (Hauki-lampi-yoki, Luottn-yoki, Nama-yoki). For example, in 1993, 62% of samples analysed from Luottn-yoki and 92% of those from Hauki-lampi-yoki indicated high levels of nickel pollution (>10 MAC) with peaks of 0.32 and 0.24 mg/l respectively. In some cases, high (up to 0.25 mg/l) concentrations of dithiophosphate, which is used for flotation in the nickel extraction process, were found in River Nama-yoki. Water percolating through barren rock storage sites causes contamination of the River Pechenga.

Table 2.1.6 Waste water discharges by some cities and counties in Murmansk Province 1994 (ECMP 1995).

| City, County | Waste water volume, million $m^3$ | Amount of pollutants discharged, tonnes | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxidative org. | Petroleum hydrocarbons | Suspended matter | N-NH4 | N-NO3 | Al | $Fe_{total}$ | SO4 | P-PO4 | F | $Cl^-$ | Deter-gents | $Ni^{2+}$ | $Co^{2+}$ |
| Monchegorsk | 24.6 | 139.5 | 2.98 | 721 | 53.0 | 11.3 | | <0.1 | 3467<br>8 | 14.4 | | 7344 | | 54.2 | 1.57 |
| 'Severonickel' | 24.5 | 137.5 | 2.97 | 706 | 52.0 | 11.2 | | 1 | 3467<br>8 | 14.4 | | 7343 | | 54.2 | 1.57 |
| Kirovsk | 154.3 | 471 | 18.3 | 1290 | 119 | 383 | | 5.1 | 6691 | 44.1 | 297 | 1530 | 8.5 | | |
| Vodokanal | 16.9 | 320 | 11.2 | 382 | 68 | 30 | | 5.1 | | 14.5 | | 368 | 7.3 | | |
| 'Apatite' | 137.4 | 151 | 7.1 | 908 | 51 | 353 | | | 6697 | 29.6 | 297 | 1161 | 1.2 | | |
| Apatity | 24.0 | 315 | 18.8 | 276 | 247 | 22.5 | | 10.0 | 137 | 32.5 | | 656 | 6.4 | | |
| Vodokanal | 21.5 | 303 | 16.7 | 250 | 245 | 21.6 | | 9.0 | | 32.1 | | 621 | 6.3 | | |
| Kovdor | 39.5 | 250 | 2.4 | 265 | 26.7 | 107 | 0.3 | 14.0 | 4543 | 32.4 | | 876 | 1.3 | | |
| Kovdor mining and concentration plant | 36.3 | 236 | 1.9 | 248 | 19.7 | 103 | 0.3 | 13.0 | 4522 | 31.6 | | 851 | 1.1 | | |
| Lovozero County | 17.7 | 103 | 2.3 | 317 | 25.4 | 7.3 | | 0.2 | 103 | 4.6 | 116 | 131 | 0.3 | | |
| Sevredmet | 17.1 | 78 | 2.2 | 302 | 17.8 | 7.1 | | | 103 | | 116 | 102 | | | |
| Nickel | 37.7 | 279 | 26.7 | 249 | 80.7 | 73.3 | | 0.08 | 2252 | <0.1 | | 378 | | 4.0 | |
| 'Pechenganickel | 27.2 | 100 | 14.9 | 139 | 38.8 | 69 | | 0.08 | 2219 | <0.1 | | 206 | | 4.0 | |

The discharge of oil products and nitrogen compounds in the waste waters has increased in recent years, relative to the situation in 1991, whereas there has been a decrease in the discharge of organic matter, solid matter, phosphate, grease and heavy metals. The cause of this latter decrease is not due to an increase in efficiency of purification plants but is rather a result of a decline in production (ECMP 1995).

The environmental status of freshwater bodies in the Province of Murmansk are regularly monitored. Forty-four watercourses are under continuous monitoring, and the environmental status is summarised in Table 2.1.7

Table 2.1.7 Environmental status of water bodies in Murmansk Province (Ruokanen 1994).

| Number of water bodies in category | Water bodies | Environmental situation |
|---|---|---|
| 16 | Lakes Umba and Tsuno, rivers Lotta, Ura, Kitsa, Teriberka | Unpolluted |
| 17 | Lake Monts, rivers Kola, Virma, Ena and Kovdor | Slightly polluted |
| 6 | Lakes Imandra and Kola, rivers Pechenga and Sergevan | Heavily polluted |
| 5 | Rivers Kolos, Nyduai, Komarini, Varnitsi and Rosta | Waste water areas with completely deteriorated ecosystems |

### *2.1.6.2.2 Drinking water supply*

The Ministry of Protection of the Environment and Natural Resources of the Russian Federation and the corresponding Environmental Committee of Murmansk Province, with reference to the Russian national regulations, did not give permission for the Expert Group to obtain information on the state of drinking water supply system in Murmansk Province. Thus, this lack of relevant information did not allow a comprehensive overview of the state of drinking water supply. As a result, this present report includes only information on drinking water in the cities Murmansk and Monchegorsk.

At present, a total of 16 tap water sources are used in the Province of Murmansk. Sanitary regulations are not implemented in any of these catchment areas. Drinking water quality in the cities and counties of the Province is shown in Table 2.1.8. According to this data, the most serious bacteriological problems are found in Murmansk. Tap water in Lovozero and Monchegorsk contain the most severe chemical contamination of the areas investigated.

Table 2.1.8 Number of drinking water samples (in %) which did not meet the Russian national standard in 1993 (ECMP 1995).

| | Chemical variables | Bacteriological variables |
|---|---|---|
| Total in Murmansk Province | 7.0 | 4.1 |
| Murmansk | * | 13.7 |
| Apatity | 1.21 | 0.74 |
| Kandalaksha | 8.47 | 2.71 |
| Kirovsk | 5.71 | 0.03 |
| Monchegorsk | 35.41 | 0.42 |
| Olenegorsk | * | 1.51 |
| Polyarny | * | 0.91 |
| Severomorsk | 0.19 | 3.18 |
| Kovdor County | * | * |
| Kola County | 0.54 | 1.47 |
| Pechenga County | 10.13 | 1.02 |
| Lovozero County | 68.41 | 1.97 |
| Tersky County | * | 0.59 |

* = no information

Murmansk. The water supply system of the City of Murmansk extracts water from three sources: the Kola River (45 %), the Tuloma River (40 %) and Lake Bolshoye (15 %). However, the water quality of these sources, particularly the Kola River, does not correspond to the Russian national standard of drinking water quality. Severe bacterial contamination is contributed by the following factors:

- Lack of protected sanitary zones.
- A number of pig (e.g. 'Prigorodny') and poultry (e.g. 'Murmanskaya' and 'Snezhnaya') farms on the banks of the Kola River.
- A number of settlements with poor sewage treatment systems, such as Kildinstroy upstream of the site of water extraction from the River Kola.

Almost 80 % of the extracted drinking water is treated before entering the pipeline system. Unfortunately however, the water pipelines are in a very poor condition. A total of 247 cases of damage or malfunction were reported in 1994. The sewage channel system in Murmansk has no sewage treatment facilities, and polluted effluents are discharged directly into the Kola Fjord.

Monchegorsk The tap water supply to the City of Monchegorsk is taken from Lake Moncha, without any filtration or treatment other than chlorination. Channelled waste waters are not discharged into the lake. Contaminants are transported to the lake by means of air deposition and with melt waters and surface runoff. Water flows into the pipeline network without being subjected to any prior treatment. Communal waste waters are discharged into Lake Imandra (Moncha bay) via the communal sewage treatment facilities (80 %) and canalisation system of the Severonickel smelter (20 %). According to the information presented to the Expert Group, the poor quality of the drinking water supply is a result of the high colour and turbidity. Recorded levels of the remainder of the variables (major ions, metals, nutrients BOD, petroleum hydrocarbons) conform to Russian national standards on drinking water quality

(ECMP 1995). It should be added, however, that permitted concentrations of some heavy metals, including nickel, in the current Russian standard are higher than in the European countries and also in the new Draft Russian State Standard 'Water Quality. Drinking Water. Quality Measurments'. After adoption of this Standard, the nickel concentrations in Monchegorsk tap water would reach more than double the permitted level.

#### *2.1.6.3 Industrial and communal solid waste*

Approximately 206 000 tonnes of household waste are generated annually in the Province of Murmansk (ECMP 1995). This waste is collected by pick-up vehicles or special trucks and then brought to dumping areas. Although collection systems for glass and waste-paper do exist, their performance is poor. Whereas previously, food waste was collected to be used for cattle feed, this type of waste is currently mixed with other waste and dumped.

The amount of waste generated by industrial plants is qualitatively assessed as being vast, but quantitative figures for the total amounts of industrial and communal waste in the Province of Murmansk are scarcely known. Information obtained by the Expert Group is at times contradictory and does not appear reliable. At the same time, some data connected with the most urgent solid waste problems of Murmansk Province, which was considered by the experts as reliable, is presented in Table 2.1.9.

The problems in handling most of the types of waste listed below may be solved by introduction of modern technology. Hazardous waste are at present not processed in the Province. Certain hazardous compounds are transported to other parts of the country for reprocessing, such as selenium slag from the Pechenganickel company (15 tonnes per year) and sulphuric acid from the Severonickel company (140 tonnes per year). There are no other plants in the Murmansk Province which are specialised in the handling of hazardous waste (Ruokanen 1994). Some time ago Murmansk authorities initiated the development of a project concerning the construction of an integrated plant for treatment of industrial and hazardous wastes in Murmansk City, Severomorsk City and Kola County. At present, this work has come to a halt due to financial constraints. Two years ago, a specialised plant was constructed in the vicinity of Apatity, for utilisation of used luminescent mercury-containing lamps. This plant has a capacity to handle 700 000 lamps/year which is equivalent to the annual production of used lamps in the Province. However, at present, this plant operates rather inefficiently due to problems concerning the collection and transportation of used lamps.

Table 2.1.9 Annual generation of industrial waste in the cities of Murmansk and Severomorsk and Kola County (ECMP 1995).

| Type of waste | Amount (tonnes) |
|---|---|
| Mercury containing waste (used luminescent lamps) | 43. |
| Ash and slag | 12 000 |
| Industrial and builders' refuse | 2660 |
| | |
| **Organic industrial waste (total)** | **22 656** |
| consisting of: | |
| solid waste (mazutted refuse and soil, varnish and pigment residue) | 13 967 |
| paste waste (oil slimes, thickened varnishes and pigments) | 2 794 |
| liquid waste (used petroleum products, oils, solvents) | 2.172 |
| organic waste from waste treatment facilities | 900 |
| halogenated organic solvents | 9 |
| waste waters with organic substances | 931 |
| used coal | 93 |
| fat and protein mass | 1 241 |
| used tires | 465 |
| useless pesticides etc. | 84 |
| | |
| **Mineral waste (total)** | **6 369** |
| consisting of: | |
| waste water residue | 4 655 |
| acid containing waste | 155 |
| chromium (VI) containing waste | 466 |
| cyanide containing waste | 310 |
| carbide sludge | 162 |
| salt waste | 621 |

The administration of the Murmansk Province has set goals and determined primary measures, aimed at improving the state of the environment of the Province. By 1996, all of the active purification plants in the Province should be able to guarantee a standard level of waste water purification. In the programme, it is presumed that by the year 1996, the construction of waste water purification plants, not only in Severomorsk and Zapolyarnyj, but also in the villages of Murmansk-130 and Murmansk-150 will be completed. Ships and boats by then should be equipped with waste and garbage collection and processing equipment as well as being offered recycling possibilities. In addition, pumping apparatuses for waste water and oily water should be installed on ships.

Waste such as soil and beneficiation slag from the mining industry contain many reclaimable minerals. Immense amounts of this type of waste is produced and in addition to the environmental risks, such as the leaching of heavy metals and dust nuisance, the piles of waste affect land usage. According to one estimate only less than 5 % of the waste from the mining industry is reclaimed. Further, according to one estimate, only 40 % of potentially valuable components are extracted from apatite and nepheline ore by the enterprises of the Industrial Association 'Apatite'. Thousands of tonnes of nepheline, titanium and other components are left to waste in barren rocks after extraction. A comprehensive assessment of landscape erosion as a result of mining activities is required, as the destruction of land areas for this purpose has increased by 2 400 hectares since 1985. The reclamation of waste and particularly recycling of mineral resources (dirt, refuse ore and slag) has, among other reasons, been hindered by the division of activities within different government departments (Ruokanen 1994).

More than 100 scrapped ships have been dumped along the shore of the Kola Fjord (Aagaard, pers. comm. 1995). These wrecks vary both in size and condition, and most of them have been stripped of instruments and other easy removable items. Some of the wrecks are stranded in the tidal zone, while others are more or less submerged. Leakage of oil has been observed, and the wrecks present a negative image of the entrance to Murmansk. At the same time, however, given a proper handling system, the wrecks could represent a valuable resource of a variety of recyclable metals.

It is expected that a relatively large number of ships will be scrapped in the coming years. At present, while it is most profitable to transport the largest of these ships to foreign countries such as India for scrapping, there is no system for decommissioning smaller vessels.

In general, waste recycling efforts are very poorly developed in both the communities as well as in the industrial sector. Of the different types of waste, it appears that wood-waste is recycled to the greatest extent. Other wastes which are reclaimed are waste paper, perishable printed matter, textile waste and down feathers. To some extent, scrap metal, which constitutes a serious problem in the Province, automobile tyres and glass are transported outside the area for reuse. The main obstacle for waste processing and reuse is that companies are not directly required to implement waste management policies. There are also no requirements for official permits for waste handling or processing (Ruokanen 1994).

The removal of contaminated sediments from harbours and subsequent dumping it in other areas has not been presented to the Expert Group as an environmental problem. However, in both the fishing harbour of Murmansk City and the oil terminal of the White Sea, it is claimed that there is a total annual accumulation of approximately 100 000 kg of hazardous sediments (Ruokanen 1994). No information is given on the disposal of this material. The practice of dredging has attracted world-wide attention, mostly due to severe effects caused in the areas where this contaminated sediment is dumped. Considering the reported amounts of oil hydrocarbons in Murmansk harbour (Section 2.1.6.4) this sediment will cause severe contamination, regardless of where it is dumped.

The number and condition of the dumping sites for solid waste in the Province of Murmansk is unknown. Information pertaining to certain dumping areas in the Province is shown in Table 2.1.10. Although waste has for decades been buried in a number of dumping areas, there is a lack of available adequate information pertaining to the composition of this waste. Dumping areas have generally not been established in military garrisons. It appears that petroleum waste, household waste, scrap metal etc. are heaped directly into the surrounding environment, both on land as well as into water. In the Kola Peninsula, there are many small unauthorised dumping areas which contain industrial and construction waste. These are normally located near small towns, on the sides of roads and under power lines. Monitoring of municipal dumping areas is non-existent and regulations concerning the dumping areas are continually violated. The monitoring of the dumping areas is the responsibility of the health authorities. Monitoring of the environmental impact of the dumping areas, by means of sampling is scarcely carried out. Permits for burying waste and related inspections are dealt with through the environmental authorities of the provincial administration and health monitoring activities (ECMP 1995).

Table 2.1.10 Size, age and material deposited at dumping areas in the Province of Murmansk (Ruokanen 1994).

| District/City | Starting year of storage | Surface area of dumping area (ha.) | Annual amount of buried waste | Type of waste |
|---|---|---|---|---|
| City of Murmansk | 1960 | 40 | 73 000 $m^3$ | industrial waste |
| Apatity district | 1970 | 5 | 80 000 tonnes | industrial waste |
| | 1980 | 1 | 45 000 tonnes | construction waste |
| | 1989 | 2 | 8000 tonnes | construction waste |
| | 1980 | 4 | 5000 tonnes | industrial waste |
| Kovdor district | 1965 | 3 | 300 000 tonnes | household waste |
| | 1965 | 1 | 70 tonnes | industrial waste |
| Monchegorsk district | 1975 | 5 | 90 000 $m^3$ | household waste |
| | 1950 | 55 | 860 000 tonnes | industrial waste * |
| | | 148 | 800 000 $m^3$ | industrial waste* |
| Olenegorsk district | 1983 | 6 | 6000 $m^3$ | industrial waste/ construction waste |
| Kola district | 1988 | 2 | 1000 $m^3$ | timber waste |
| | 1990 | 5 | 50 tonnes | household waste |
| Lovozero district | 1960 | | 2000 $m^3$ | household waste |
| | | 32 | 1 000 000 tonnes | industrial waste/mortalities |
| Teri district | 1979 | 4.5 | 100 $m^3$ | timber waste |
| | 1969 | 1.2 | 2000 $m^3$ | household waste |
| Severomorsk district | 1972 | 25 | | construction waste |
| Pečhenga district | 1991 | 3 | 25 000 $m^3$ | household waste |
| | 1968 | 1 | | industrial waste |
| | 1966 | 20 | 20 000 t | household waste |
| Kandalaksha district | 1965 | 8 | 100 000 $m^3$ | household waste |

* Metallurgy slag, solid waste.

The Murmansk incineration plant is situated in the northern part of the City, approximately 1 km from the nearest housing estate and 3-4 km from the City centre. The maximal annual turnover of the plant is 131 400 tonnes. At present, 107 000 tonnes of waste is treated at the plant annually. Technology and equipment developed and produced by the Czech company 'CzKD-Dukla' in the late seventies is used at the plant, which was put into operation in 1986. The daily amount of waste processed ranges between 300-500 tonnes. The most notable component is paper waste, 35 000 tonnes of which are incinerated annually. Other notable waste components are as follows: wood waste (12 500 tonnes), food waste (10 000 tonnes), textile waste (10 000 tonnes) as well as plastic waste (3 000 tonnes). In addition to Murmansk, the collection area of the plant includes Severomorsk and Kola. The annual emissions of contaminants from the incineration plant are given in Table 2.1.11 (Ruokanen 1994).

According to the existing information, burning of plastic waste using the present technology can cause by-production of dioxins and dibenzofurans. Since unsorted waste is treated at the plant, this problem cannot be excluded and requires further investigation.

Table 2.1.11 Annual emissions (solids and calculated air-borne) from the Murmansk waste incineration plant (Ruokanen 1994).

| Component | Solid emissions | Calculated emissions to air |
|---|---|---|
| Zinc | 480 kg | * |
| Lead | 310 kg | * |
| Cadmium | 30 kg | * |
| Nickel | 130 kg | * |
| Vanadium | 200 kg | * |
| Benzopyrene | 33 grams | * |
| Copper | 420 kg | * |
| Iron | 1 300 kg | |
| Total particles/slag | 58 100 kg | |
| Dust | | 69.3 tonnes |
| Carbon monoxide (CO) | | 829 tonnes |
| Sulphur dioxide ($SO_2$) | | 623 tonnes |
| Nitrogen dioxide ($NO_2$) | | 54.4 tonnes |
| Vanadium pentoxide ($V_2O_5$) | | 1.4 tonnes |

* = no data.

The farms in the Province of Murmansk have an annual accumulation of more than 1 250 000 tonnes of pig, cattle and poultry manure. Less than 430 000 tonnes of this is utilised as organic fertiliser, mostly in an untreated form. The remainder accumulates in natural depressions in the surrounding land areas. According to the information from the Committee for environmental protection in Murmansk Province, the total accumulation of manure in the area is approximately 9 million tonnes (Ruokanen 1994).

The livestock farms in Murmansk Province are equipped with a total of 25 liquid waste collection units, 15 manure repositories, 23 composting sites and 5 biological treatment stations. Most of them are now in an unsatisfactory condition. The biotreatment facilities at the state farms 'Arctica', 'Pechenga' and 'Prigorodny' are overloaded, and do not guarantee the required treatment. At the state farm 'Yena', waste treatment facilities were formally put into operation in 1987, but are still not operational due to incomplete construction. The state farm 'Polyarny', which is located in Murmansk City, has no treatment facilities at all. At the Prigorodny pig farm, new updated manure treatment technology is currently being tested, as part of the Russian - Norwegian 'Priroda' programme.

At present, the most critical situation is the waste management of poultry farms in the catchment area of the Kola River (Ruokanen 1994). The 'Snezhnaya' and 'Murmanskaya' poultry farms, which are both located upstream of the extraction site of the Murmansk water supply system, present the most serious threats to drinking water quality. The waste repositories of these farms are overloaded and each year wastes are accidentally discharged into the river, causing emergency situations in Murmansk. Such situations can have catastrophic consequences during periods of unfavourable hydrometeorological conditions.

#### *2.1.6.4 Marine pollution*

The most serious marine pollution of in the Province of Murmansk is concentrated in the most populated and industrialised areas around the Kola Fjord and the other fjords on the northern coast of the Kola Peninsula, such as Pechenga, Motovsky and Teriberka (Fig. 2.1.5) and Kandalaksha Bay in the White Sea.

The Pechenga Fjord is recipient for the effluents from the Pechenganickel smelter and the towns Pechenga and Zapolyarny. Surveys carried out in 1990-92 have revealed levels of oil hydrocarbons in the surface waters up to 0.15 mg/l (2 MAC), while HCHs were recorded up to a maximum concentration of 4.6 ng/l. (Hydromet 1994). In 1992, analyses of PCBs and phenols in bottom sediments showed values of 52 ng/g dry sediment (Hydromet 1994). Accor-ding to the Norwegian classification system for total PCBs in sediments (Knutzen & Skei 1990), a value of 52 ng $\sum$PCB/g sediment would be classified as 'significantly contaminated'.

The Motovsky Fjord separates the Ribachy Peninsula from the Kola Peninsula, and is the largest and most open fjord of the Kola Peninsula. In general, the levels of oil hydrocarbons in the surface waters are below MAC, but in 1992, values of 0.26 mg/l were detected at one sampling station in the northern part of the fjord. Only very low levels of the contaminants HCH and lindane were recorded, up to 5.2 ng/l (Hydromet 1994).

The Teriberka fjord is situated 65 km east of the Kola fjord on the northern coast of the Kola Peninsula. There is a good rate of water exchange in the fjord (Hydromet 1994), resulting in a relatively good water quality, even though effluents from a shipyard and a fish processing plant are discharged into the fjord. In 1991, the levels of oil hydrocarbons in the surface waters were up to 2 MAC, while oil was not recorded in 1992 (Hydromet 1994).

The Kola fjord is approximately 40 km in length, and has a maximum depth of some 300 meters. This fjord is by far the most heavily used recipient for anthropogenic discharges in the Province, and the southern part of the fjord, close to Murmansk City is assessed as being severely and chronically contaminated. In Murmansk City, 37 industrial enterprises, including the communal waste water system operating under the Industrial Association 'Vodokanal', discharge effluents directly into the Kola fjord. As shown in Table 2.1.12, more than 85 % of waste waters are discharged by the Vodokanal. The Murmansk communal sewage system has no treatment facilities. The discharges from Vodokanal are responsible for 93 % of the discharges of oxidative organic compounds, 87 % of petroleum hydrocarbons, almost 95 % of suspended matter and 99 % of ammonium nitrogen. Discharges of fatty substances almost exclusively originate from food and shipping industries, which have no facilities for fat extraction from waste waters. In 1993, a total of 105.5 million $m^3$ waste water was discharged into the Kola fjord (Hydromet 1994), of which Murmansk City contributed approximately 2/3rds. Information is not presented on the discharges form military installations, nor handling of hazardous waste by the military.

Field measurements in the surface waters of the Kola fjord have revealed levels of oil, approximately 16 MAC. In 1990, concentrations of up to 2.12 mg/g of oil hydrocarbons have been recorded in bottom sediments (Hydromet 1994). The bottom sediments of the Kola Fjord have also been shown to contain up to 74.9 ng/g of DDT (Hydromet 1994). Comparative data from Norway ($\sum$DDT+DDE) include 0.57-0.64 ng/g dry sediment in Tromsøsundet (Holte *et al.* 1992) and 3-8 ng/g dry sediment in Oslo harbour (Konieczny 1992).

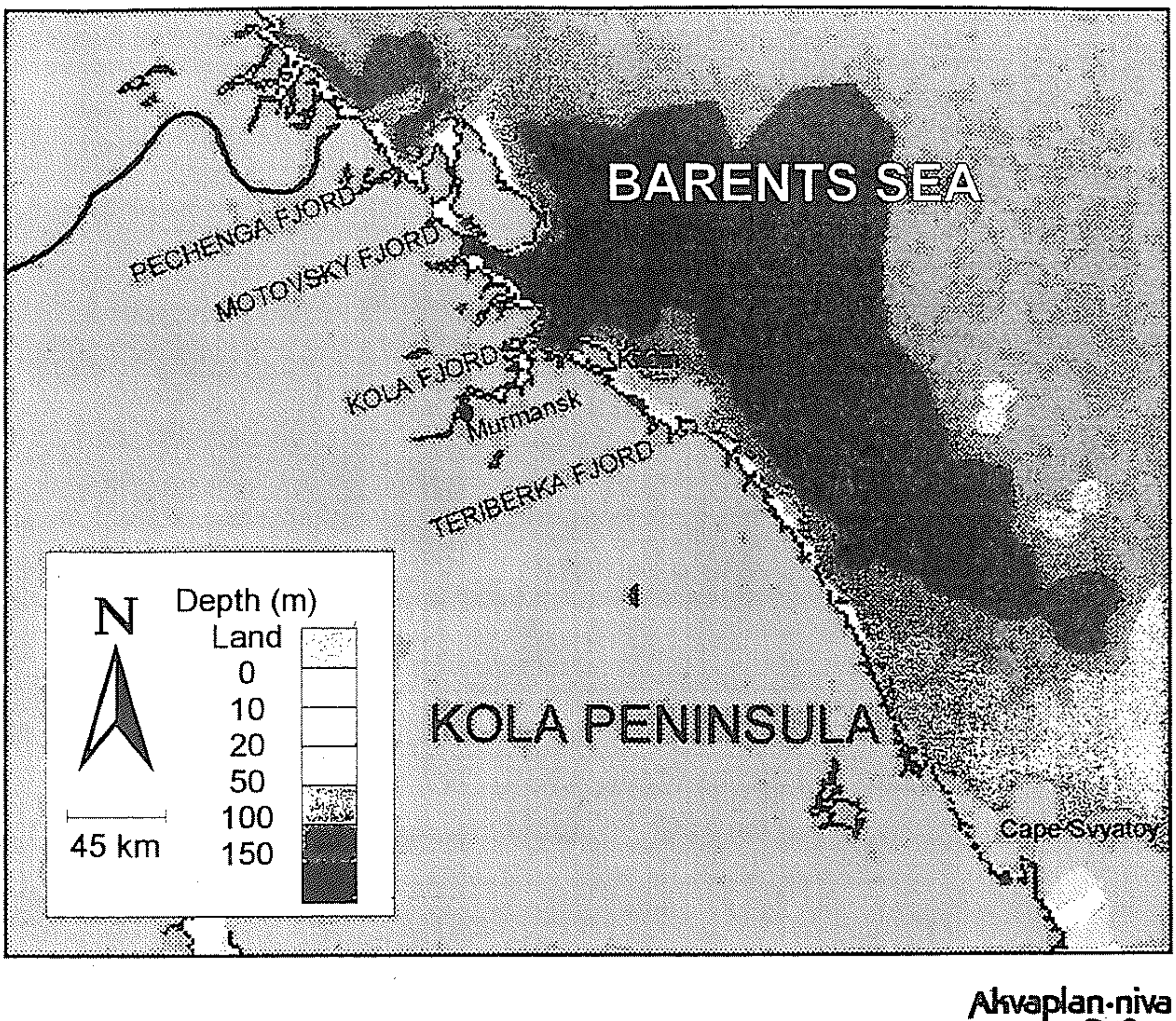



Figure 2.1.5 Fjords in the northern parts of the Kola Peninsula, where Hydromet Murmansk has collected information on levels of contaminants in the water.

The main visible effects of the discharges to the Kola Fjord are a decrease in the species diversity in the bottom fauna, and several animal communities have been completely destroyed. The observed decrease in the levels of oil products in the surface waters during 1991-1992 (Hydromet 1994) can be regarded as favourable, although the absolute concentration still exceeds the MAC. The water quality of the open sea of the Barents Region has remained unchanged since 1992 (Hydromet 1994). In these waters, the contents of oil products, detergents as well as other contaminants have not been recorded to exceeded permissible norms. However, the state of the environment along the coast of the Kola Peninsula has not been documented sufficiently. In order to evaluate the impact of contaminant-laden discharges and emissions from industrial activities and municipalities on the marine environment, the Expert Group particularly require field measurements on the levels of contaminants in sediment and biota. Some data have been presented by Hydromet in the previous sections, but only for a limited number of parameters and areas.

Table 2.1.12 Main sources of waste water discharges in Murmansk City in 1994 (ECMP 1995).

| Sources of waste waters | Waste water volume, mill. $m^3$ | Amount of pollutants discharged, tonnes | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxidative org. | Petroleum hydrocarbons | Suspended matter | $N\text{-}NH_4$ | $N\text{-}NO_3$ | Fe | Fats | $SO_4$ | $P\text{-}PO_4$ | $Cl^-$ | Detergents |
| Murmansk City | 65.2 | 7429 | 56.4 | 5347 | 871 | 45.9 | 27.6 | 151 | 1550 | 116 | 4960 | 47.2 |
| 'Arctic fish' | 0.2 | 12.7 | | 2.0 | 0.28 | <0.01 | | 2.1 | | 0.2 | 52.3 | <0.01 |
| 'Iceberg' | 0.001 | 38.0 | | 6.1 | | | | 7.7 | | | | |
| 'Polar-fish' | 0.2 | 18.2 | | 3.6 | 0.65 | | | 5.5 | 4.2 | 0.5 | 101 | |
| 'Sev. Palmira' | 0.3 | 4.9 | | 4.7 | 0.38 | | | 6.5 | | <0.1 | 10.4 | <0.01 |
| Bakery plant | 0.4 | 10.5 | 0.2 | 7.9 | 1.53 | 1.3 | | 6.6 | | 0.6 | 58.0 | <0.1 |
| Sevmorput (Northern Sea Route) | 2.4 | 49.4 | 1.1 | 41.3 | | | <0.1 | | | | | |
| Fish Sea Port | 2.8 | 270 | 0.9 | 161 | 3.4 | 1.8 | 0.2 | 27.4 | 26.7 | 1.5 | 1055 | 0.8 |
| Vodocanal (comm. waste water treatment) | 55.8 | 6909 | 48.8 | 5028 | 858 | 41.8 | 27.3 | | 1413 | 107 | 2101 | 45.2 |
| Murman oil | 0.3 | 37.5 | 3.5 | 3.9 | 0.2 | 0.1 | | | 47.1 | 0.5 | 1124 | 0.9 |
| Ship repair plant N2 | 0.6 | 23.2 | 0.3 | 31.6 | 1.6 | 0.2 | | 17.9 | 9.0 | | 13.7 | <0.1 |
| Dockyard | 0.3 | 15.7 | 0.3 | 21.4 | 2.8 | 0.1 | | 14.7 | 5.6 | | 4.9 | 0.1 |

### 2.1.6.5 *Preservation of forest resources*

The extent of the impacts of contamination of the forests of the Kola Peninsula Northern Norway and Finnish Lapland have been the subject of intensive investigations, mainly through the multidisciplinary Lapland forest damage project that has been carried out in Finland. Researchers from the Kola Peninsula have also participated in the realisation of this project. Based on the project research, it has been possible to obtain an image of the distribution of the forest damage caused primarily by emissions from the large metal smelters in Pechenga and Monchegorsk (Fig. 2.1.6).

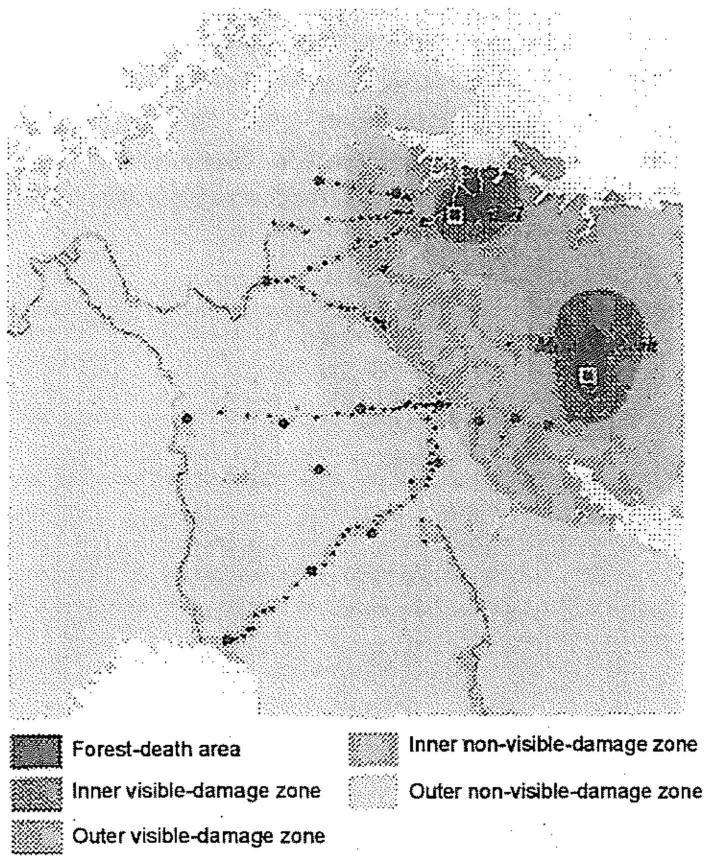



Figure 2.1.6

Forest death areas and zones of various degrees of impact on the environments surrounding Monchegorsk and Nikel, as well as the damage and action zones in the Kola Peninsula and Finnish Lapland (Tikkanen 1995).

The forest death area around Monchegorsk extends to approximately 450 km², while the area of environmental effects around Nikel is somewhat greater. The outer zone of visible damage extends into Finland and Norway (Tikkanen 1995). These effects are externally evident on pine tree needles as well as in the recorded elevated levels of sulphur and heavy metals in the ecosystem. The outer action zone, where the effects are still visible at the cellular level in pine needles, extends into the northern areas of Lapland and is also likely to extend into Finnmark County in Norway (Tikkanen 1995). Within the Kola Peninsula, the intensive forest logging that has taken place has significantly affected the condition of the forests. These problems are dealt with in more detail in connection with project proposal M71.

Based on the 1993 assessment of forest resources, it is calculated that forests cover an area of 4.9 million hectares in the Province of Murmansk. Of this forest covered area, 50.4 % is situated in protected sites, where only emergency and hygienic logging is permitted. The remaining forests have become exhausted by long-term overall logging.

It should be noted that industrial logging decreased to about 25 % during the period from 1991-1994 (a decrease from 807 000 $m^3$ to 198 000 $m^3$) due to the decline of the timber industry. At the same time, 'wipe-out' logging techniques are still used, where large areas are completely de-forested, causing significant damage to the ecosystems. Despite the decrease in timber production, forest rehabilitation efforts did not decline, and even increased somewhat. In 1994, forests were restored on 13 274 hectares (11 850 in 1991) including 1709 hectares of new plantations.

In 1994, a total of 443 forest fires were recorded (2.7 times greater than in 1991) which destroyed a total of 813 hectares of forest. By comparison, gas emissions from non-ferrous industrial activities were shown to have affected 34 900 hectares of forests around 'Pechenganickel' in 1988. In 1991, 59 300 hectares of forest around 'Severonickel' smelter in Monchegorsk were found to be in unsatisfactory condition. Since 1967, the area of damaged forests around this smelter has increased by a factor of more than 40. Even during the period 1986 to 1990, the area of affected forests has increased by 7 354 hectares (Tikkanen 1995).

## 2.2 THE REPUBLIC OF KARELIA

### 2.2.1 Population and basic geographical data

The total area of the Republic of Karelia is 180 500 $km^2$. The Republic is sparsely populated, with an average population density of only 4.4 persons per $km^2$, and a total population of 793 000 inhabitants. The cities and other urban centres house around 74 % of the inhabitants. The largest population centre is the Republic's capital, Petrozavodsk, housing approximately 280 000 persons, corresponding to almost one third of the entire Karelian population. The northern parts of the Republic are the most sparsely populated areas in Karelia. During the period between 1926-1993, the population almost tripled in size, but has now begun to decline in recent years, a trend which is expected to continue. The population decline in the Republic of Karelia is primarily due to an almost 50 % decline in the birth rate over the past ten years. A particularly alarming trend is that the average male life expectancy has fallen to below 60 years. The population structure is becoming very skewed, with a diminishing representation of working age persons in the population and an increasing proportion of elderly citizens (Ries 1994; Seppänen 1995).

More than 84 % of the population of Karelia are of Slavic origin (73.6 % Russians, 7 % Belo-Russians and 3.6 % Ukrainians) and around 13 % are Fenno-Ugric (10 % Karelians, 2.3 % Finns and 0.8 % Veps). Only approximately half of those registered as 'Karelian' actually speak the language (Ries 1994:13).

Approximately 85 % of Karelia is covered by forest (Plancenter 1991). Morasses cover 4 million hectares, which corresponds to 20 % of the territory, and swamp forest spreads over more than 1.8 million hectares (Lifshits *et al.* 1994). Coniferous species comprise 88.9 % of the forested area. The most widespread species are pine (which alone covers 62.7 %), as well as birch, aspen and alder. Pine is the most common species in the northern parts of the Republic, whereas spruce predominates in the south (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995). Due to the geological composition, the soil generally has a low buffering capacity and is thus sensitive to acidification.

There are more than 61 000 lakes and 26 000 rivers in Karelia. Most of the lakes are small, with a total area of less than 10 $km^2$, but the Republic also encompasses the two largest inland lakes in Europe; lakes Ladoga and Onega (Fig. 2.2.2). Approximately half of the lakes and rivers flow southwards, towards the Baltic Sea, while the other half flow northwards, towards the White Sea. The division between north and south-flowing rivers runs diagonally across Karelia from the north-west to the south-east (Ries 1994). The Karelian White Sea coastline is approximately 650 km in length (Lifshits *et al.* 1994).

The climate in Karelia is temperately continental. Long mild winters and short cool summers are characteristic of the region, together with considerable cloudiness, large amounts of precipitation and unstable weather conditions during all the seasons. The average annual precipitation is 550-755 mm. Maximum air humidities of over 80 % have been recorded in

November - January, but even the summer (May-June) humidities seldom drop below 50 %. The average annual temperature varies between 0°C in the north to +3°C in the south. February is generally the coldest month, with temperatures from -12°C in the north to -10°C in the south. The warmest month is July, with temperatures from +13 - +14°C in the north, and +16 - +17°C in the remainder of the area. Southern, south-westerly and westerly winds prevail in Karelia during the entire annual cycle (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

### 2.2.2 Administrative and territorial structure

Within the Russian Federation, the different republics each have their own constitution, government and legislative assembly. The Republic of Karelia has special financial funding for its economic development as well as its own ministry of foreign affairs. The Republic of Karelia is divided into 15 administrative districts, and 3 town districts; Petrozavodsk, Sortavala and Kostamuksha (Fig. 2.2.1). The rural districts have been divided into a total of 101 local units of village councils (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

### 2.2.3 Economic structure

The Karelian economy is currently in a poor state. As a heritage from the Soviet-period, the Karelian economy is limited to certain sectors within which the production is highly specialised. Paper production is essential for Karelia's economy, and in 1991, the Republic supplied 24 % of paper, and 42 % of all newsprint in the whole of Russia. The Segezha paper corporation, with an annual production of 630 000 tonnes, is the largest paper producer in Russia. However, many other important industries are almost non existent in Karelia. The Republic therefore depends heavily on importing essential commodities (50 % of food, 60 % of electricity and over 90 % of fossil fuels) from outside areas. The majority of Karelian production is based on crude extraction and primary processing industries. These raw materials have relatively little market value in the west and manufactured goods are of a non-marketable quality in the west (Ries 1994).

In 1990, the relative production of the different industries was as follows: 57 % industry, 6 % construction, 5 % agriculture and 32 % services. Heavy-industry dominated the economic structure, involving 28 % of the working-age population. The main sectors of heavy industry were forestry (44 % of industrial output), mining and basic metal industries (23 %), machinery and engineering (17 %). Between 1980 and 1992, industrial production has shown a steady decline in almost all sectors, with the exception of electricity (Ries 1994).

### 2.2.4 Natural resources

The forest is by far the most important natural resource in Karelia. The total reserve of forest resources in Karelia amounts to 849.5 million $m^3$, of which coniferous trees account for 764.7 million $m^3$ and hardwood 84.8 million $m^3$. The main reserves of industrial wood are concentrated in the regions with low population densities and underdeveloped infrastructures; the western border with Finland, northern Karelia, and the Pudozh district. The forest resources, particularly the coniferous forests, have been exhausted in the southern and central regions. Most of the remaining mature and over-mature forests are found in the Loukhi, Kalevala, Muezerskiy and Pudozh districts. The proportion of mature forest is less than 15 % in the districts of Kondopoga, Pryazha, Prionezhkiy and Olonets (Seppänen 1995).

Mineral resources are plentiful in the Republic of Karelia. There are 203 deposits of 23 different types of useful minerals, and 400 promising outlets. In addition, there are 11 basins and 16 outlets of fresh and mineral underground water. A considerable part of the useful mineral reserves of the Russian Federation are located in the Republic of Karelia; 45 % of pegmatite raw material, 13.8 % of facing stones, 7.7 % of muscovite, 4.3 % of building stone, as well as large reserves of iron ore etc. The most significant iron ore deposit is the Kostomuksha deposit, which is currently under development. Plans are also being made to start the development of Korpangskoye and Mezshozerskoye iron deposits. Of the non-ore raw materials, high-quality facing and building stones are located in many parts of Karelia, particularly in the Loukhi, Kem and Belomorsk districts. The reserves of these rocks are very large. There are also several smaller deposits of rare metals, including gold, silver, platinum, diamonds, as well as nickel, chromium, cobalt (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

Hydroelectric power resources comprise more than 80 % of the potential domestic energy sources. It has been estimated that the total hydroelectric power potential of the Karelian rivers is more than 13 TWh annually, and the feasible potential is 4.9 TWh. In 1992, approximately only 60 % of the feasible hydroelectric power potential was used for electricity generation. There are also very large peat reserves in Karelia amounting to 2.014 billion tonnes, according to recent estimates. The industrially useable peatland area is about 700 000 hectares, of which only 40 % has so far been investigated. Peat may be used in thermal power plants. Wood is currently used as heating fuel in rural areas, but production of fuel wood is not organised. However, the mechanical wood processing industry produces large amounts of wood residue, which is used for electricity generation in the pulp and paper industries. Some pulp and paper plants also use sulphate alkaline for thermal and electric energy generation. All other fuels have to be imported from other parts of Russia and the CIS countries (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

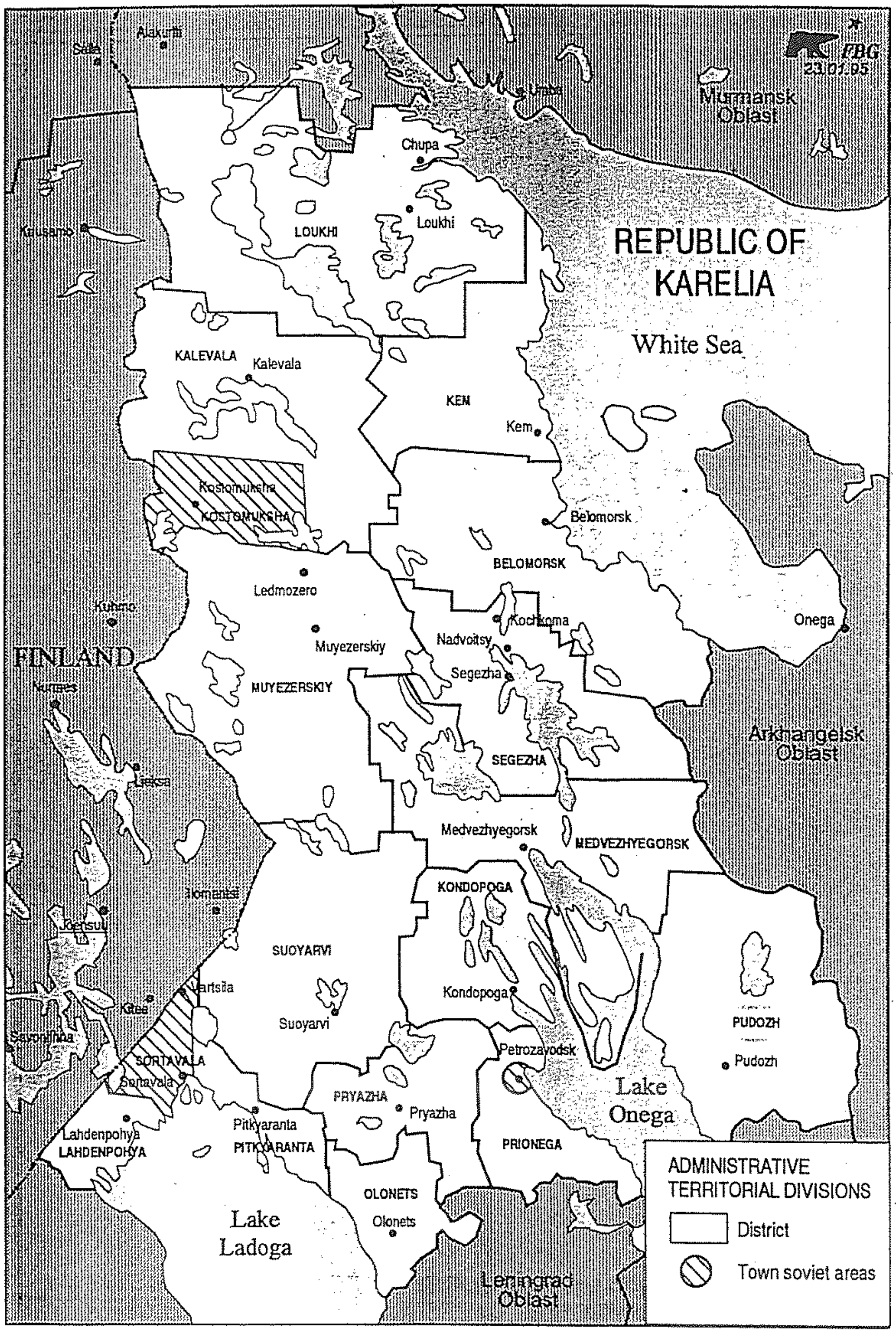



Figure 2.2.1 Administrative area boundaries in the Republic of Karelia (Seppänen 1995).

### 2.2.5 Transportation

The main transportation axis in Karelia runs from north to south via Petrozavodsk, as a part of the national rail and road link between St. Petersburg and Murmansk. The rest of the Karelian road and rail network is both sparse and primitive. The role of Karelia as an important transportation link is expected to increase further after the completion of the Ledmozero-Kochkoma railway and the Petrozavodsk-Parikkala (in Finland) motorway, both of which are currently under construction. Two major waterways exist in the Republic of Karelia. The 227 km long White Sea Canal links Belomorsk on the White Sea coast with Poventsa, at the northern tip of Lake Onega. In the south, Lake Onega is linked to the major Volga Canal System, by means of the Lenin Canal. From here, the waterway continues to St. Petersburg and the Baltic, passing along the southern shore of the Lake Onega, down the River Svir, the Lake Ladoga and River Neva. The main airport of Petrozavodsk, Besovets, is the destination of all international and federal flights to and from the Republic of Karelia. Within the Republic, a total of seven airports have regular connections to Petrozavodsk (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

### 2.2.6 The state of the environment, related to issues of concern

#### *2.2.6.1 Air pollution*

There are 469 registered stationary sources of gas emissions in the Republic of Karelia (i.e. not including automobile transport), which in 1994 emitted 200 800 tonnes of contaminants. It should be noted that between 1988-1994, the gas emissions from the industrial activities in the Republic decreased by a factor of 1.6, mainly due to a decline in production (Tab. 2.2.1). In 1994, automobile transportation was estimated to contribute an additional 19 % of the total gas emissions (Ministry of Ecology of the Republic of Karelia (MERK) 1995).

Table 2.2. 1 Dynamics of gas emissions from stationary sources in the Republic of Karelia, 1988 - 1994, expressed as total emissions in thousand tonnes (MERK 1995).

| | **1988** | **1989** | **1990** | **1991** | **1992** | **1993** | **1994** |
|---|---|---|---|---|---|---|---|
| Total emissions (x 1 000 tonnes) | 320.9 | 302.3 | 301.3 | 284.0 | 246.9 | 233.3 | 200.8 |

The most significant contaminants emitted by industrial enterprises are as follows:

- sulphur dioxide 59%,
- solid particles (dust) 19%,
- carbon oxide 17%,
- nitrogen oxides 3%.

Industrial gas emissions also contain specific toxic pollutants, mostly volatile organic (1.3 %) and fluoride compounds (0.4 %). The most significant gas emission problems exist in Kostomuksha, Petrozavodsk, Kondopoga and Segezha County (Tab. 2.2.2 and Tab. 2.2.3; Hydrometeorological Service, annual report 1994). It should be noted that not all persistent specific pollutants have been monitored in air.

Table 2.2.2 Industrial gas emissions in the cities and counties of the Republic of Karelia in 1994, expressed in thousand tonnes (MERK 1995).

| City/County | Total | $SO_2$ | $NO_x$ | Dust | CO | VOC | Fluoride compounds |
|---|---|---|---|---|---|---|---|
| Petrozavodsk | 30.0 | 21.8 | 2.2 | 2.4 | 3.1 | 0.5 | - |
| Kostomuksha | 57.6 | 48.1 | 1.5 | 6.4 | 0.6 | 1.0 | - |
| Kondopoga | 25.2 | 18.6 | 1.6 | 3.3 | 1.5 | <0.1 | - |
| Segezha | 16.7 | 9.3 | 0.6 | 4.9 | 0.8 | 0.7 | - |
| Nadvoitsy | 10.0 | 1.6 | 0.1 | 4.1 | 4.0 | <0.1 | 0.75 |
| Belomorsk | 6.6 | 1.5 | 0.1 | 3.5 | 1.4 | - | - |
| Medvezhyegorsk | 6.4 | 1.8 | 0.1 | 2.5 | 1.8 | - | - |
| Pugozha | 5.1 | 1.6 | 0.1 | 2.1 | 1.3 | - | - |
| Pitkyaranta | 6.0 | 2.5 | 0.3 | 1.8 | 1.1 | 0.3 | - |
| Olonets | 5.2 | 1.2 | <0.1 | 1.3 | 2.7 | - | - |
| Lahdenpohya | 4.3 | 1.1 | 0.1 | 1.7 | 1.4 | 0.1 | - |
| Sortavala | 7.6 | 2.5 | 0.3 | 2.6 | 2.0 | 0.2 | - |
| Suoyarvi | 7.6 | 2.5 | 0.3 | 2.6 | 2.0 | 0.2 | - |
| Loukhi | 3.5 | 1.2 | 0.1 | 1.2 | 1.0 | - | - |

Table 2.2.3 Air pollution in the cities and counties of the Republic of Karelia. The mean and maximum values for some air-borne emissions are given for the years 1991 and 1994, and their relation to the maximum allowable concentration (MAC) (MERK 1995).

| City/ County | Value | Pollutant | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $SO_2$ | | | | $NO_2$ | | | | CO | | | | Dust | | | | Specific pollutants | | | |
| | | 1991 | | 1994 | | 1991 | | 1994 | | 1991 | | 1994 | | 1991 | | 1994 | | 1991 | | 1994 | |
| | | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC | $mg/m^3$ | MAC |
| | | | | | | | | | | | | | | | | | | | Phenol | | |
| Petroz-avodsk | mean | 0.015 | 0.3 | 0.011 | 0.2 | 0.03 | 0.8 | 0.03 | 0.8 | 1.4 | 0.5 | 2.0 | 0.7 | 0.11 | 0.8 | 0.1 | 0.7 | 0.005 | 1.7 | 0.005 | 1.7 |
| | max | 0.253 | 0.5 | 0.488 | 1.0 | 0.97 | 11.4 | 0.53 | 6.2 | 16.0 | 3.2 | 12.0 | 2.4 | 1.8 | 3.6 | 5.7 | 11.4 | 0.056 | 5.6 | 0.061 | 6.1 |
| | | | | | | | | | | | | | | | | | | | Benzo(a)pyrene: $mg/m^3 \times 10^{-6}$ | | |
| | mean | | | | | | | | | | | | | | | | | 0.9 | 0.9 | | |
| | max | | | | | | | | | | | | | | | | | 2.2 | 2.2 | | |
| Kosto-muksha | mean | 0.04 | 0.8 | | | 0.01 | 0.3 | | | | | | | 0.1 | 0.7 | | | | | | |
| | max | 0.07 | 0.14 | | | 0.02 | 0.2 | | | | | | | 0.1 | 0.2 | | | | | | |
| | | | | | | | | | | | | | | | | | | | | Phenol | 1995 |
| Kondo-poga | mean | | | 0.01 | 0.2 | | | 0.0 | 0 | | | | | | | 0.1 | 0.7 | | | 0.001 | 0.3 |
| | max | | | 0.09 | 0.2 | | | 0.05 | 0.6 | | | | | | | 1.5 | 3.0 | | | 0.007 | 0.7 |
| Seg-ezha | mean | 0.07 | 1.4 | 0.06 | 1.2 | 0.02 | 0.6 | 0.02 | 0.6 | | | | | 0.3 | 2 | | | 0.015 | 1.9 | 0.01 | 1.0 |
| | max | 0.7 | 1.4 | 0.16 | 0.3 | 0.37 | 4.4 | 0.03 | 0.4 | | | | | 1.7 | 3.4 | | | 0.137 | 17.1 | 0.034 | 4.0 |
| | | | | | | | | | | | | | | | | | | Furfural | | | |
| | mean | | | | | | | | | | | | | | | | | 0.01 | 0.2 | 0.0 | 0 |
| | max | | | | | | | | | | | | | | | | | 0.22 | 4.4 | 0.02 | 0.4 |
| | | | | | | | | | | | | | | | | | | Hydrog. fluoride | | | |
| Nad-voitsy | mean | 0.003 | <0.1 | 0.004 | <0.1 | 0.02 | 0.5 | 0.02 | 0.5 | 1.0 | 0.3 | 1.0 | 0.3 | 0.1 | 0.7 | 0.1 | 0.7 | 0.011 | 2.2 | 1.2 | 1.2 |
| | max | 0.011 | <0.1 | 0.018 | <0.1 | 0.07 | 0.8 | 0.08 | 0.9 | 4.0 | 0.8 | 5.0 | 1.0 | 0.4 | 0.8 | 0.4 | 0.7 | 0.038 | 1.9 | 2.5 | 2.5 |

Table 2.2.4 Major air pollution sources in Karelia, expressed as tonnes per year (Plancenter 1991)

| Source | Sulphur dioxide | Dust |
|---|---|---|
| Petrozavodsk power plant | 13 000 | * |
| Pitkyäranta pulp and paper | 3 700 | 2 400 |
| Segezha pulp and paper | 25 000 | 20 000 |
| Kondopoga pulp and paper | 28 000 | * |
| Kostamuksha iron | 70 000 | 5 100 |
| Nadvoitsy aluminium | 2 100 | 3 500 |
| **Total** | **141 800** | **31 000** |

* No data. NB. The different amount of air emissions presented in Table 2.2.4 as compared to those in Table 2.2.2 reflects the decrease in emissions in recent years.

Kostomuksha. The stock company (SC) 'Karelsky okatysh', which is responsible for 99.6 % of gas emissions, is the main source of air contamination in the City. Besides the contaminants listed in Table 2.2.4, this enterprise also emits ammonia (10 tonnes/year), ethanol (800 tonnes/year) and hydrocarbons (130 tonnes/year). Within the last 5 years, gas emissions of the plant have been reduced by 16 750 tonnes, due to a decline in production.

Petrozavodsk. The main component of the air pollution in the capital of the Republic originates from the heat and power plant, which is responsible for almost 50 % of the total gas emissions in the City. This plant has no gas purification facilities. Around 15.7 % of the total gas emissions arise from enterprises in the machine-building industry, particularly the Onega tractor plant. These enterprises emit a large variety of specific pollutants including acetone (11 tonnes), xylole (20 tonnes), toluene (17 tonnes), white-spirit (49 tonnes) other organic solvents (14 tonnes). The air pollution in Petrozavodsk is generally below the average for the Russian Federation, although in the vicinity of the Onega tractor plant, the mean annual concentration of phenol in the air in 1994 was 1.7 times the MAC, and the peak concentration was 6.1 MAC (5.1 $\mu g/m^3$ and 0.21 $mg/m^3$ respectively, data from Hydromet annual report, 1994).

Kondopoga. Enterprises of the timber, pulp and paper industries (SC 'Kondopogabumprom') are responsible for 87.3 % of all gas emissions in the town. The rest of the emissions are generated by the remaining 25 enterprises in the town.

Segezha. The Segezha timber corporate plant, and particularly the pulp and paper plant 'Segezhabumprom' are responsible for 90 % of industrial gas emissions in the town. In 1994, the emissions of certain specific pollutants were as follows:

- hydrogen sulphide 440 tonnes/year
- turpentine 340 tonnes/year
- ethanol 78 tonnes/year
- butanol 32 tonnes/year
- methylmercaptane 26 tonnes/year

As a result of these emissions, the air quality in the town is poor. For example, almost 60 % of air samples have hydrogen sulphide concentrations in excess of MAC. During winter, the concentrations sometimes exceed 4 MAC. Methylmercaptane concentrations in the air exceed permissible levels up to extremely high values (62 MAC).

Nadvoitsy. The aluminium plant is responsible for 97 % of the total gas emissions in the town, the most severe component being the fluoride compounds.

When operating at full capacity, the plant emits 4 699 tonnes of dust (fluorides, resins, dust, ash etc.) as well as 9 985 tonnes of gases and liquid substances per year. An annual amount of 408 tonnes of gaseous fluorides are emitted. Only about 25 % of all contaminants are removed (Plancenter 1991). However, the current amount of contaminants released is somewhat less, due to a decline in production.

In 1994, in addition to general pollutants, the plant emitted the following (MERK 1995):

- tar 1 190 tonnes
- solid fluorides 500 tonnes
- hydrogen fluoride 240 tonnes

It should be noted that the two cities Segeza and Nadvoitsy are both situated at the shores of Lake Vyg at a distance of only 15 km. The combination of air-borne pollution from these cities and the discharge of waste waters render the area a zone of ecological disaster (Filatov 1992), with corresponding negative impacts on human health.

#### 2.2.6.2 *Freshwater and drinking water.*

The Republic of Karelia is rich in freshwater resources. The total surface water resources are estimated to be 195 km$^3$ with an average annual run-off of 56 km$^3$. Of the Karelian fresh-water resources, 54 % flows into the White Sea, while 46 % flows into the Gulf of Finland through Lake Onega (25 %) and Ladoga (21 %).

Industrial activities in Karelia have an annual consumption of approximately 245.4 million m$^3$ of water (1991 statistics), and represents the greatest consumer of water in Karelia. The greatest share (80 %) of industrial water consumption is used by the cellulose and paper production industries (Tab. 2.2.5). The annual water consumption of the communities of Karelia is approximately 71.9 million m$^3$, which comprises approximately 20 % of the total water consumption (Filatov *et al.* 1992).

Table 2.2.5 Water consumption by different industries in the Republic of Karelia, 1991.

| Industrial Sector | Water consumption | Water consumption |
|---|---|---|
| | Million $m^3$ | % |
| Cellulose and Paper Industry | 196.4 | 80.0 |
| Construction Material Industry | 10.0 | 4.1 |
| Manufactured Wood Product Industry | 7.0 | 2.9 |
| Chemical Forestry Industry | 2.9 | 1.2 |
| Machine and metal processing industry | 5.5 | 2.2 |
| Iron Metallurgy | 3.8 | 1.5 |
| Non ferrous Metallurgy | 2.4 | 1.0 |
| Food Industry | 3.0 | 1.2 |
| Other industries (light industry, book printing industry, traffic etc.) | 14.4 | 5.9 |
| TOTAL | 245.4 | 100 |

The amount of waste water discharges of the Republic has decreased in recent years, mainly due to reduced industrial production (Tab. 2.2.6). The pollution status of discharged waste waters are as follows: polluted waste waters without any treatment - 14 %; insufficiently treated polluted waste waters - 79 %; 'standard pure' waste waters discharged without treatment - <7 %, 'standard pure' waste waters after treatment - 0 % (MERK 1995).

Table 2.2.6 Waste water discharges in the Republic of Karelia, from 1988 to 1994, expressed in million $m^3$ (MERK 1995).

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|
| Total discharges (million $m^{3}$) | 288.1 | 281.7 | 273.3 | 263.2 | 240.9 | 206.1 | 216.0 |

The largest volumes of waste water are discharged by the industrial and communal enterprises of Kondopoga, Petrozavodsk, Segezha County, Pitkyaranta and Kostomuksha (Tab. 2.2.7). Six industrial and communal enterprises situated in these cities/towns are responsible for 84 % of all the waste waters of the Republic (Tab. 2.2.8).

Table 2.2.7 Discharge of waste water in the cities and counties of Karelia in 1994 (MERK 1995).

| City, County | Waste water volume mln $m^3$ | Amounts of pollutants discharged, tonnes | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oxidative org. comp. (BOD) | Petroleum hydrocarbons | Suspended matter | $N-NH_4$ | $NO_3$ | $P_{total}$ | Cl | $SO_4$ | $Fe_{total}$ | Detergents | Specific pollutants |
| Republic of Karelia | 216.0 | 8192 | 54.3 | 7506 | 721 | 659 | 228 | 4243 | 15495 | 109 | 30.0 | |
| Petrozavodsk | 53.9 | 710 | 4.5 | 1459 | 47.4 | 411 | 116 | 1774 | 934 | 96.1 | 3.7 | Mn-310. Zn-3.5. Ca-527 |
| Sortavala | 4.3 | 165 | 1.7 | 146 | 17.3 | 4.1 | 7.5 | 167 | 474 | 65.4 | 1.4 | Fats-1.8 |
| Kostomuksha | 15.9 | 70 | - | 121 | 22.4 | 80 | - | - | 1132 | - | 0.5 | K-1147 |
| Belemorsk County | 4.9 | 210 | 1.9 | 170 | 26.7 | 0.3 | 4.9 | 181 | 57.6 | 4.8 | 0.5 | Fats -2.1 |
| Kalevala County | 0.1 | 371 | 1.8 | 22.9 | 6.5 | - | - | 11.2 | 19.6 | - | 0.1 | |
| Kondopoga County | 56.3 | 4297 | 9.7 | 3319 | 101 | 74 | 64 | 364 | 4919 | 2.0 | 9.7 | Methanol-5.2. Phenol-1.2. Furfural- 0.2 |
| Kem County | 6.9 | 162 | 15.9 | 198 | 18.1 | 0.4 | 3.7 | 109 | 72.2 | - | 1.6 | ($H_2S$ -HS $S^{2-}$) - 31.7. Formaldehyde - 12.4 |
| Suoyarvi County | 2.5 | 126 | 1.8 | 83.1 | 5.2 | 13.7 | 0.3 | 110 | 3.4 | - | 0.3 | ($H_2S$ -HS $S^{2-}$) - 0.7 |
| Lahdepoha County | 0.9 | 206 | 1.6 | 102 | 12.3 | 0.7 | 2.2 | 73.1 | 29.5 | 1.5 | 0.8 | |
| Soukha County | 3.0 | 150 | 0.4 | 147 | 20.8 | 0.4 | 2.0 | 113 | 82.0 | 2.4 | 0.4 | |
| Medvezhyegorsk County | 2.0 | 445 | 0.2 | 262 | 26.3 | 1.6 | 7.5 | 97.7 | 49.2 | 1.7 | 1.6 | Fats - 7.4 |
| Muezevo County | 0.3 | 10.2 | 0.1 | 11.5 | 4.5 | 0.6 | 0.1 | 11.9 | 7.2 | 0.1 | - | |
| Olonents County | 0.9 | 20.3 | 0.6 | 21.5 | 5.5 | 0.8 | 0.7 | 251 | 100 | 0.2 | 0.1 | |
| Pitkyaranta County | 16.0 | 138 | 0.5 | 326 | 15.5 | 4.5 | 6.3 | 77.5 | 770 | - | 5.4 | Turpentine - 1.3. Tannides - 642. ($H_2S$ -HS $S^{2-}$) - 0.7 |
| Prionega County | 1.7 | 57.2 | 0.7 | 90.1 | 11.8 | 8.6 | 1.6 | 142 | 37.4 | 0.5 | 0.1 | |
| Pryazhinsk County | 0.5 | 8.1 | 0.3 | 11.0 | 2.8 | 3.6 | 1.0 | 25.4 | 9.9 | 0.1 | 0.1 | |
| Ladoga County | 1.4 | 20 | 2.0 | 122 | 31.4 | 0.2 | 3.4 | 45.5 | 22.7 | 2.8 | 0.6 | Tannides - 0.1 |
| Segezha County | 44 | 842 | 10.9 | 892 | 346 | 54.7 | 6.6 | 689 | 6776 | 0.9 | 3.1 | Turpentine - 1.5, Tannides - 961, Phenol - 0.2, F - 3.4, Furfural. ($H_2S$-HS $S^{2-}$) - 50.2, $S_{org}$ - 7.8 |

Table 2.2.8 Waste water discharge by selected cities and industrial enterprises in Karelia, 1994 (MERK 1995).

| City, enterprises | Total waste water discha. million $m^3$ | Polluted waste waters million $m^3$ | 'St. sure' waste waters mill. $m^3$ | Amount of pollutants discharged, tonnes: Oxidative compounds (BOD) | Petroleum hydro-carbons | Susp-ended matter | N-$NH_4$ | $NO_3$ | $P_{total}$ | Cl | $SO_4$ | $Fe_{total}$ | Specific pollutants |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Petrozavodsk city | 53.9 | 51.6 | 2.3 | 710 | 4.5 | 1459 | 47.4 | 412 | 116 | 1774 | 934 | 26.1 | Mn-310, Zn-3.5, Ca-527 |
| Petrozavodsk municipal Vodokanal | 52.9 | 50.6 | 2.3 | 701 | 3.6 | 1437 | 46.3 | 411 | 116 | 1735 | 873 | 25.1 | Mn-310, Zn-3.5, Ca-527 |
| Kostomuksha | 15.9 | 14.9 | 1.0 | 70 | - | 121 | 22.4 | 80 | - | - | 1132 | - | |
| BC 'Karelsky okatysh' | 15.9 | 14.9 | 1.0 | 70 | - | 121 | 22.4 | 80 | - | - | 1132 | - | |
| Kondopoga | 56.3 | 55.6 | 0.7 | 4255 | 9.5 | 3277 | 88.1 | 72.5 | 60.6 | 238 | 4889 | 0.3 | Methanol-5.2, Phenol-1.3, Furfural-0.2, ($H_2S$ -HS $S^{2-}$)-31.7, Formaldehyd-12.4 |
| C'Kondopoga' (PPM) | 54.7 | 54.7 | - | 4242 | 9.0 | 3256 | 87.5 | 72.4 | 60.6 | 232 | 4882 | - | Methanol-5.2, Phenol-1.3, Furfural-0.2, ($H_2S$ -HS $S^{2-}$)-31.7, Formaldehyd-12.4 |
| Pitkyaranta | 14.7 | 14.7 | - | 121 | 0.4 | 270 | 3.1 | 4.0 | 4.4 | 49.2 | 694 | - | Turpentine-1.3, Tannides-642, ($H_2S$ -HS $S^{2-}$)-0.7, $S_{org}$-1.4 |
| Pulp plant 'Pitkyaranta' | 14.4 | 14.4 | - | 120 | 0.4 | 268 | 2.9 | 3.9 | 4.4 | 48.5 | 693 | - | Turpentine-1.3, Tannides-642, ($H_2S$ -HS $S^{2-}$)-0.7, $S_{org}$-1.4 |
| Segezha County | 44.2 | 44.2 | - | 842 | 10.9 | 892 | 346 | 54.7 | 6.6 | 689 | 6776 | 0.9 | Turpentine-1.3. Tannides-961, Phenol-0.2, F-3.4, Furfural-0.2, ($H_2S$ -HS $S^{2-}$)-50.2, $S_{org}$-7.8 |
| 'Segezhalumprom' | 41.3 | 41.3 | - | 807 | 9.3 | 857 | 336 | 41.5 | 4.6 | 567 | 6683 | - | Turpentine-1.3. Tannides-961, Phenol-0.2, F-3.4, Furfural-0.2, ($H_2S$ -HS $S^{2-}$)-50.2, $S_{org}$-7.8 |
| Nadvoitsy aluminium plant | 2.1 | 2.1 | - | 11.5 | 0.7 | 7.5 | 6.4 | 10.9 | 1.6 | 78 | 39.0 | 0.6 | F-3.4 |

Petrozavodsk In Petrozavodsk, the municipal sewage system is responsible for 98% of waste waters discharged into Lake Onega. Approximately 4.5% of communal waste waters are considered as 'standard pure' and are discharged without prior treatment. A small amount of contaminated waste waters (<0.5 %) are discharged without treatment, but the main volume (95 %) is treated by the municipal waste water treatment plant. Waste waters are discharged into Lake Onega, 8 km from the intake site of the City's water supply system. Communal waste waters cause noticeable pollution of the Petrozavodsk Bay of Lake Onega. Due to increased nutrient loading, intensive development of blue-green algae (up to 1 million cells/litre, with a biomass of 0.4 grams/m$^3$) has in recent years been observed during the summer months in Petrozavodsk Bay. Influx of water from River Shuya, with a high humus content, also affects the water quality of Petrozavodsk Bay, particularly during periods of ice cover.

The waters in this part of Lake Onega is also strongly affected by intensive ship traffic which gives rise to petroleum contamination. For example, in 1991, 36 % of water samples analysed showed levels of petroleum hydrocarbons in excess of MAC. In some cases, levels of PHC contamination reached 0.45 mg/l, which corresponds to 9 MAC (Hydromet yearbook 1994).

Kostomuksha. Technological waste waters of the SC 'Karelsky okatysh' are discharged into Lake Verkhnee Kostomukshskoye (Upper Kostomuksha) of the lake-river system Kenti-Kento which was specifically reconstructed to serve as a return water storage and settling site. In 1994, its level reached critical values and an organised spill of 10 million m$^3$ was carried out. It is estimated that an annual release of up to 25 million m$^3$ of waste waters from this holding tank is required in order to keep the level constant. Waters in this holding tank have a high level of mineralisation (420 mg/l), with $K^+$ concentrations of 120 mg/l, $Li^+$ levels of 60 µg/l and $N_{total}$ values of 2.5 mg/l (Hydromet yearbook 1994). Due to the discharge of waste water from the plant, together with filtration from the reservoir, the mineralisation and concentrations of other water components in the Kenti-Kento system is increasing. As a result, the aquatic biological community structure is changing and the drinking water is becoming severely contaminated by metals and, in particular, infectious agents, resulting in a high incidence rate of child gastrointestinal diseases (Filatov *et al.* 1992).

Kondopoga The Kondopoga pulp and paper mill discharges 97 % of the waste water of this town. Approximately 6 % of the polluted waste waters are discharged without any treatment whatsoever, and the remainder are discharged after only insufficient treatment. Over the past 50 years, the waste water has been directed into Kondopoga Bay of Lake Onega. During the first 40 years, the plant operated without any kind of purification facilities. As a result, the Kondopoga bay is severely polluted and suffers eutrophication. There is significant elevation in levels of organic substances and solid matter as well as compounds foreign to the waters of the bay. These include lignosulphonates, volatile phenol acids, furfurals, tannic acid, methanol, hydrogen sulphide, sulphides, sulphites, and thiosulphites (MERK 1995).

In 1983, the factory began using biological filters as well as directing the waste water into the Kondopoga basin area. This resulted in a decrease in contamination levels in the remote areas of Kondopoga Bay, but at the same time, low-intensity contamination has spread out over the entire area of the bay, as far as its mouth. The amount of phytoplankton in the bay has increased since 1983. Fish species that were previously abundant in the bay, such as salmon, whitefish and vendace have almost entirely disappeared. The biomass of phyto- and zooplankton has increased five or six fold, compared to levels in 1970. The biomass of bottom-dwelling organisms has also increased 10-100 fold since 1970 (Filatov *et al.* 1992). During winter, the bottom water layers are subject to from oxygen deficit. In 1992-93, the total phosphorus concentration in this part of Lake Onega reached 37-48 mg/l, which corresponds to a eutrophic state (Hydromet yearbook 1994).

Segezha. The Segezha pulp and paper mill is responsible for almost 100 % of the waste waters of the town. Approximately 20 % of polluted waste waters are discharged without any kind of treatment and the remainder are discharged after only insufficient treatment. Waste waters are discharged into the northern part of Lake Vygozero, which is strongly affected by the effluents. Over an area of approximately 230 $km^2$ of the lake, the average annual concentration of phosphorus is 60-70 % higher than background values, and in winter-time the concentrations of contaminants such as lignin, phenol acid, resinoic acid, oil and synthetically surface active substances are between 2-10 times higher than background values (Filatov *et al.* 1992).

During winter, waste-waters spread along bottom depressions, resulting in oxygen deficit or complete anoxia in the bottom layers of the lake. Nitrate is often also absent due to denitrification processes and sulphate reduction, leading to 'dead' zones in the bottom water (Hydromet yearbook 1994). Such severe environmental impact has not been observed in the other water bodies in Karelia. Contaminants are further transported during spring floods to River Nizhny Vyg, resulting in its pollution. During the summer period, active algal blooming takes place, with a definite trend towards decreasing quantities of diatomic algae and an increase in green and blue-green algae.

In Nadvoidsy, close to the City of Segezha, the most significant atmospheric, soil and surface water contaminants are fluorine compounds from the aluminum plant. Waste-waters are formed from wet scrubbing, pot wash and plant run-off. The loading parameters (acids, fluorides, suspended solids, nutrients etc.) have not been recorded. Annual production of solid wastes are reported to comprise 1 050 tonnes of pot linings, 500 tonnes of electrolysis wastes and 3 500 tonnes of fluoride containing sediments. Liquid from wet scrubbing contains sulphur and nitrogen compounds, hydrogen fluorides and dust. The liquid is deposited on the ground, thus endangering the quality of the ground and surface waters (Plancenter 1991). Fluoride concentrations in melt-water within a radius of 5 km from the Nadviodsy aluminium factory, are on average 1.9 mg/l. In the vicinity of the factory, values as high as 16 mg/l have been recorded (Filatov *et al.* 1992).

The water courses of Karelia contain naturally low levels of inorganic compounds and have a low alkalinity. Thus, the water has only a weak buffering capacity, and sensitivity to acidification is high. Rainwater in Karelia has been shown to be acidic (pH 4.1-6.5), with high levels of sulphate, nitrate and ammonium. Of the total sulphur content in rain water, 95% occurs as a result of human activities. The levels of sulphate ($SO_4$) have been estimated at 1.8 g $m^{-2}$ $a^{-1}$, while those of strong acids ($H_2SO_4$, $HNO_3$) are estimated to be 11 mmol $m^{-2}$ $a^{-1}$ (Filatov *et al.* 1992). The annual sulphur dioxide ($SO_2$) emissions in the Karelian region are approximately 165 000 tonnes, of which the largest portion, 38 %, originates from the industrial region of Kostomuksha (Tabs. 2.2. 2 and 2.2.4).

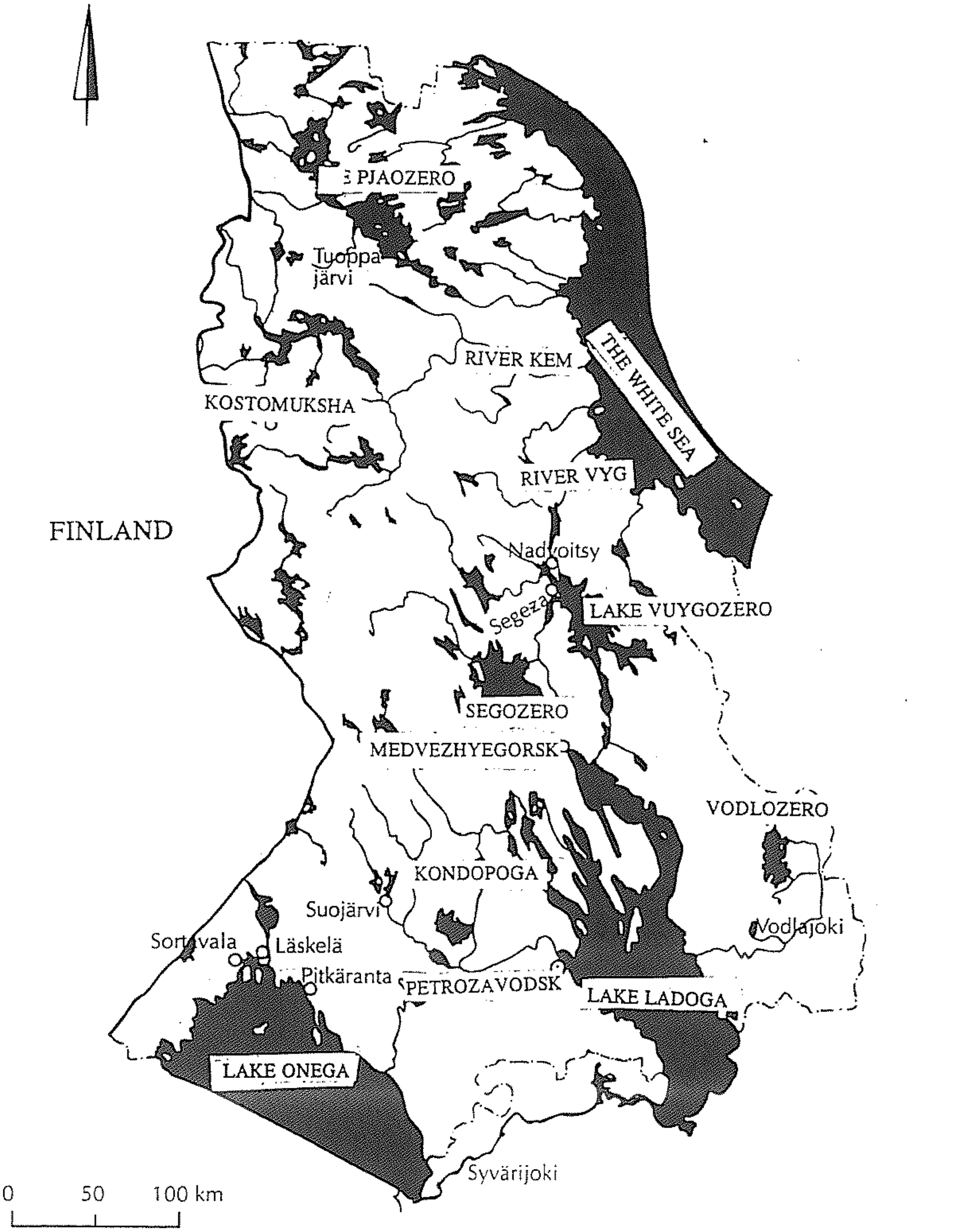



Figure 2.2.2 The main watercourses in the republic of Karelia (Filatov *et al.* 1992).

*Drinking water supply.*

Water supply systems in Karelia extract water mostly from surface sources. Among the 17 largest cities and towns of the Republic, 10 cities receive water from lakes and 6 from rivers. Only Olonets is supplied with water of artesian origin.

The drinking water supply in Karelia cannot be considered as being satisfactory. Of the 155 water sources, 40 do not correspond to the sanitary demands accepted within the Russian Federation. As a result, more than 50 % of tap water samples do not meet requirements for chemical quality and 15 % fall below microbiological requirements of the national standard for drinking water (MERK 1995).

The characteristics of water supply and canalisation systems in Karelia are presented in Table 2.2.9.

Table 2.2.9 Characteristics of water supply and canalisation systems in the Karelian cities and counties (MERK 1995).

| City/County | Output of pumping station $10^3$ $m^3$/ day | Output of water treatment plant $10^3$ $m^3$/ day | Output of pipeline system $10^3$ $m^3$/ day | Length of pipeline system km | Water wastes in a supply system | | Length of canalisation pipelines km | Output of annual waste water treatment plant | | Communal waste water discharge $10^3$ $m^3$/ year | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | absolute $10^3$ $m^3$/ year | specific $10^3$ $m^3$/km year | | $10^3$ $m^3$/ year | $10^3$ $m^3$/ year | total | without treatment |
| Belomorsk | 8,0 | 4.5 | 11.1 | 32 | 142 | 4.4 | 20.3 | 0.4 | 146 | 1121 | 982 |
| Kem | 9.0 | 9.0 | 15.2 | 45 | 57 | 1.3 | 36.1 | 0 | 0 | 2004 | 2004 |
| Kondopoga | 35.0 | 21.5 | 22.0 | 42.2 | 540 | 12.8 | 41.6 | 14.5 | 5294 | 10192 | 4897 |
| Kostomuksha | 32.0 | 32.0 | 32.0 | 92.5 | 0 | 0 | 119.7 | 14.5 | 5294 | 5307 | 20 |
| Lohdenpohya | 3.5 | 0.1 | 3.5 | 21.7 | 554 | 25.5 | 5.5 | 5.0 | 1825 | 439 | 439 |
| Medveshygorsk | 11.4 | 0 | 11.4 | 80.1 | 222 | 2.8 | 12.1 | 0 | 0 | 1062 | 1062 |
| Nadvoitsy | 19.6 | 15.9 | 25 | 42.3 | 2 | <0.05 | 23.3 | 7 | 2555 | 2105 | 0 |
| Olonets | 4.7 | 0 | 3.3 | 29.4 | 126 | 4.3 | 12.2 | 2 | 730 | 731 | 0 |
| Pitkyaranta | 20.1 | 20 | 8.1 | 13.0 | 0 | 0 | 13.0 | 6.8 | 2482 | 2474 | 0 |
| Pudozh | 6.0 | 6.0 | 6.0 | 19.6 | 62 | 4.8 | 20.4 | 0 | 0 | 1107 | 1107 |
| Segezha | 26.4 | 25.0 | 26.4 | 53.6 | 625 | 11.7 | 84.3 | 18.1 | 6607 | 8166 | 1546 |
| Suoyarvi | 6.5 | 0 | 4.7 | 22.7 | 56 | 2.5 | 15.1 | 4.0 | 1460 | 762 | 762 |
| Sortavala | 14.0 | 0 | 14.0 | 71.7 | 1042 | 22.9 | 33.3 | 6.8 | 2482 | 2981 | 416 |
| Petrozavodsk | 196.8 | 169 | 131.3 | 320.5 | 7092 | 22.1 | 282.6 | 110.6 | 40369 | 41582 | 1198 |

Based on the assessment of the AMAP Expert Group, the following cities/towns have drinking water supply problems:

Petrozavodsk. The Municipal water supply system extracts water from Petrozavodsk Bay on Lake Onega. The extraction site is located not far from the city's harbour front, only 8 km from the communal waste water outlet. Under unfavourable hydrometeorological conditions, communal waste waters can reach the inlet of the water supply system. As mentioned above, Petrozavodsk bay is affected by eutrophication and input of coloured water from River Shuya, with the corresponding decrease in water quality.

Raw water is mechanically treated and further chlorinated. The existing system of water treatment does not ensure drinking water of satisfactory quality, including bacterial pollution, according to the national standards. The quality of the water supply pipeline system in Petrozavodsk is one of the worst in Karelia. In spite of intensive work carried out by the communal service, residual leaking pipes resulted in an annual tap water wastage in the City in excess of 20 000 $m^3$/km.

Medvezhyegorsk. This town has neither water supply nor communal waste water treatment facilities. Water is both extracted from and discharged into Povenets Bay in Lake Onega. The water in this bay is of a naturally high quality, but it is currently affected by waste water discharges. The water extraction site is located in a shallow part of the bay with a lower water quality relative to other parts of the bay. Some of the water quality variables, such as colour, $Fe_{total}$ etc., do not meet sanitary requirements.

Pudozh. River Vodla is both a water supply source as well as a recipient for communal waste waters. The River water has a high humus content with the corresponding colour (>100°) and increased Fe concentrations (0.77 mg/l). Due to the discharge of effluents from human settlements on the river banks, its water contains high levels of Coli-index (up to 7000). Existing mechanical and chlorinisation water treatment facilities are not able sufficiently to improve tap water quality, and it is highly coloured, is highly oxidative (COD= 20 mg O/l) and contains elevated Fe levels.

Communal waste waters of the town are discharged into River Volda without any prior treatment, which causes drinking water problems for settlements downstream of this town.

Sortavala. Water is extracted from the small isolated bay of Sortavala skerries (Lake Ladoga). The same bay serves as a recipient for communal waste waters. Nutrient loading due to communal waste water discharges causes eutrophication in the bay during the summer periods as a result of algal blooming, with up to 10 million cells/litre and a biomass of >1 g/$m^3$. The water supply system of Sortavala has no water treatment facilities.

This town also has no communal canalisation system. A pipeline canalisation network covers only the central part of the town. The remaining areas are served by an open drainage network. The water supply pipeline network is of a very poor quality, and the annual leakage of tap water is in excess of 20 000 $m^3$/km.

Suoyarvi. This town has no water treatment facilities. Water is extracted from Lake Ikopuhyayarvi, which has a high colour and is extremely oxidative. Due to melioration activities in the catchment area of the lake in the late 1960s, the water quality deteriorated significantly, but adequate measures for improvement of the drinking water supply system were not taken.

Waste waters are discharged into Lake Suoyarvi. Existing communal waste water treatment does not ensure adequate water quality and severe eutrophication of the lake has been observed.

Segezha. This town is supplied by water from the River Segezha, with mechanical filtration and chlorinisation facilities. The River water has a high colour (which is typical for the entire Karelian region). The quality of the water decreases markedly during spring floods. The problem of communal waste water in this town is negligible compared to the problems caused by industrial waste waters.

Nadvoitsy. The town is supplied with water from the small bay of Lake Vygozero, which is separated from the main lake with a dam. The main concern for the drinking water supply of this town is the recorded high fluoride concentrations (up to 1.5 mg/l). Fluoride contamination of the water source is connected with atmospheric deposition from the Nadvoitsy aluminium plant in the catchment area of the bay, where fluoride concentrations in snow melt waters reach 16 mg/l. High levels of fluoride in drinking water has lead to high incidences of fluorosis among children in the City. As many as 84 % of the city's children are reported to be suffering from severe systemic fluorosis (Ministry of health, annual report 1993). Thus, high priority should be given to checking this information and to begin water purification procedures

Belomorsk and Kem. The population of both towns is supplied with water from two water systems: the communal system as well as that owned by the railway. The former system uses filtration and chlorinisation techniques for water treatment, the latter only chlorinisation. Water quality in both pipeline systems, especially in the railway's system, does not meet the standard requirements. Waste water treatment facilities in the town are almost non-existent, and most of the communal waste waters of Belomorsk and Kem are directly discharged into the White Sea and the mouth of the River Kem respectively.

#### *2.3.6.3 Solid waste*

In the Republic of Karelia, there is an annual accumulation of 750 000 tonnes of municipal waste. There are 80 authorised dumping areas in the region. Supervision of dumping areas is only carried out in the cities and in larger densely populated areas, but even this supervision is minimal. Various hazardous wastes are brought to the same dumping areas as municipal and regular industrial waste. Furthermore, the hazardous wastes are not separated from other wastes and the roadsides leading to the dumping areas are littered with waste. In addition, there are over 170 unauthorised dumping areas in the region, mainly located on the sides of the forest roads. The is a great shortage of dumping areas for industrial waste. Geological research on potential locations for these dumping areas was carried out in 1993, but the work has been halted due to a lack of funding (Ljovkina 1994).

Since 1990, attempts have been made to record the amounts of waste from industrial plants, as well as storage and re-use of waste. However, information has not been received from all of the plants and some of the information which has been received is inaccurate. The information received from 1993 is based on a total of 162 plants, of which 76 are situated in Petrozavodsk. Of those investigated, 116 plants of which 34 are in Petrozavodsk are documented to generate over 30 different types of hazardous wastes (Ljovkina 1994).

In Petrozavodsk, municipal waste is temporarily stored in metal containers, which fall below national sanitary standards. Approximately 1 100 cubic metres of waste is brought to the dumping area daily. High ground water levels at the 25 hectare dump site in Petrozavodsk render this a significant source of contamination in Lake Onega (Ljovkina 1994). During 1994, 212 of the enterprises monitored produced a total of 75 000 tonnes of toxic waste. Due to the absence of proper storage facilities for toxic waste, the material was stored in inadequate conditions at the enterprises concerned (Ljovkina 1994).

Close to the Nadvoitsy aluminium plant, the maximum concentrations of benzo(a)pyrene in soil were 240 times higher than the existing MAC, and at a distance of 1.5 kilometres from the plant, the levels were 2.5 times higher. These high levels are due to the burial of industrial waste which pollute soil and ground water (Ljovkina 1994).

Reclaiming and recycling.

The largest proportion of waste from the mining industry is produced by the pellet corporation of Kostamuksha. At present, the sludge from this mine as well as other mines in Karelia contain smaller amounts of metals and chemical compounds. With modern technology, these could be profitably reclaimed instead of causing pollution problems. This is also the case for waste from the forest industry, where a much larger proportion of the waste can now be used to fuel power and heating plants.

Problems in agriculture include the use of fertilisers and pesticides. Approximately 17 tonnes of prohibited and unusable pesticides are 'stored' in various locations in Karelia. There is no proper handling of waste from animal husbandry, manure, animal carcasses and utilisation of waste is minimal. A total of approximately 890 000 tonnes of waste accumulates from animal husbandry in Karelia each year (Ljovkina 1994).

A well organised system for the separation of the different components of waste is required, in order to recycle resources such as metals, glass, paper, chemical components. Such systems are established in some western countries and to a large extent cover their own costs. The establishment of these systems will at the same time largely reduce the environmental problems caused by the generation of solid wastes, both of industrial and municipal origin.

#### 2.2.6.4 *Marine pollution*

Karelia borders the White Sea, and has a 650 km coastline along the western banks of the sea, stretching from the Kandalaksha Bay in the North and to the western parts of the Onega Bay in the South. The largest Karelian cities, and most of the heavy industries are situated in the south and western parts of the country, and the waste water is discharged to rivers flowing south and west into lakes Onega and Ladoga. by the River Niva. Most of the area along the Karelian White Sea coast is covered by forest and moors, and is very sparsely populated. There are no significant agricultural activities in the area. In fact, the Karelian White Sea coast is ranked among the least polluted and least impacted areas of the Barents Region (Bryazgin & Klimov 1995).

However, in the inner parts of Kandalaksha Bay, impacts are evident from the River Niva and from the discharges from the town Kandalaksha as well as the nearby aluminium plant. The discharges from Kandalaksha are discussed in Section 2.1, Murmansk Province. The River Niva drains Lake Imandra, which is contaminated by industrial activities and municipal waste (Section 2.1). Data on the contaminant loads brought to the Kandalaksha Bay by the River Niva have not been available for the Expert Group.

A similar situation exists in the southern parts of the Onega Bay in the White Sea, where most of the inputs of contaminants originate from Archangel County. However, local organic overloading and eutrophication problems have been reported in the Karelian part of the White Sea (Bryazgin & Klimov 1995). These mainly arise from municipal sewage discharged from smaller villages and settlements. There are only three towns/settlements located on the Karelian White Sea coast; Chupa, Belomorsk and Kem. Belomorsk, at the mouth of the Onega-White Sea canal is the largest.

In the Western part of the Onega bay, the River Vyg enters the White Sea. This river drains the Vygozero lake, which acts as recipient for both the Nadvoitsy aluminium plant and the Segezha pulp and paper mill. However, data documenting the impacts from these major discharges in the White Sea have not been presented to the Expert Group.

#### 2.2.6.5 *Preservation of forest resources*

Forest resources in Karelia are outwith the areas affected by mining, industry or larger settlements, in relatively good shape. However, the forest industry is currently suffering a variety of infrastructural and managerial problems, as well as the common obstacle of lack of finances. Experience from the Kola Peninsula has shown that the vast quantities of $SO_2$ emissions have been shown to affect large areas of vegetation. Thus, similar problems may be expected in the Kostomuksha region, which generates the largest amounts of $SO_2$ emissions in Karelia. On the other hand, these emissions constitute only 10% of those generated by the Pechenganickel and Severonickel plants on the Kola Peninsula. Thus, it appears that the greatest threat to the forest resources may not be environmental contamination, but perhaps lies in poor forest management strategies (Ries 1994).

## 2.3 THE PROVINCE OF ARCHANGEL, INCLUDING NENETS AUTONOMOUS AREA.

### 2.3.1 Population and basic geographical data

The Province of Archangel is the largest administrative unite of the Barents Region, extending over some 587 400 km$^2$, including Novaya Zemlya and Franz Josef Land. The Province has a population of 1 561 000 inhabitants (1993 figures), and, although the area is larger than France, this figure corresponds to less than 3 % the French population, and 35.3 % of the total population of the Barents Region. The population development in the Barents Region is at present negative, with the birth-rate being less than half that in 1983. In 1992, the death-rate exceeded the birth-rate in the Province of Archangel. In addition, a net emigration of approximately 7 000 persons from the Province was recorded in 1992.

In 1960, 45 % of the population lived in rural settlements, while today approximately 27 % of the inhabitants live in rural districts (Seppänen 1995). The population of the Province is largely concentrated in the area around the mouth of the Northern Dvina River, where the cities Archangel, Severodvinsk and Novodvinsk are located. Towards the south, the largest population density is found along the banks of the Northern Dvina River. The population density is very low in the large northern parts of the Province. Franz Josef Land and Novaja Zemlja are uninhabited, with the exception of some military settlements and meteorological research stations.

The main population group in Archangel Province are Russians (Table 2.3.1). In the Province there is also an indigenous population of some 15 000 people (1989 figures), mainly Nenets and Komi (some 7 000 persons each). The majority of the indigenous people live in Nenets Autonomous Area (Nenets AA) (Seppänen 1995). Nenets AA has a geographical extent of 176 700 km$^2$.

Table 2.3.1 The main population groups in Archangel Province (Barents Euro Arctic Council 1995). Figures from 1989.

| Population groups | Percentage (%) | Inhabitants (thousands) |
|---|---|---|
| Russians | 92.1 | 1 446.2 |
| Ukrainians | 3.4 | 53.4 |
| Belo-Russians | 1.3 | 19.9 |
| Komi | 0.5 | 7.3 |
| Nenets | 0.5 | 7.2 |
| Tartars | 0.3 | 5.4 |
| Others | 1.9 | 30.3 |
| Total | 100 | 1 569.7 |

### 2.3.2 Administrative and territorial structure

The Province of Archangel consists of 19 counties as well as Nenets Autonomous Area and the islands Novaya Zemlya and Franz Josef Land. Six cities have the same administrative status as the rural counties and are placed directly under the Province administration. These are Archangel, Severodvinsk and Novodvinsk, all situated within Primorskij county, and Onega in the adjoining Onega county, Kotlas and Koryazma in Kotlas county in the south-east of the Province.

Nenets AA is linked to Archangel, but is at the same time recognised as a separate subject of the Russian Federation. The islands Kolgujev and Vaygach belong to Nenets AA. The geographical extent of the Province of Archangel is shown in Figure 2.3.1.

### 2.3.3 Economic structure

In 1992, the labour force in Archangel, represented by approximately 650 000 persons, was mainly employed in industry and transportation. Approximately 38 % of the work-force was employed in industry, considerably higher than the in the Nordic part of the Barents Region. The economic sector in Archangel consists of large units. In 1990, 2/3rds of the area's work-force was employed in enterprises employing more than 1 000 people. Industry in the area is furthermore characterised by heavy industry, with large plants and industrial complexes. The two most important types of industry in Archangel are forestry (timber, pulp and paper) and shipbuilding (ships, drilling platforms, etc.).

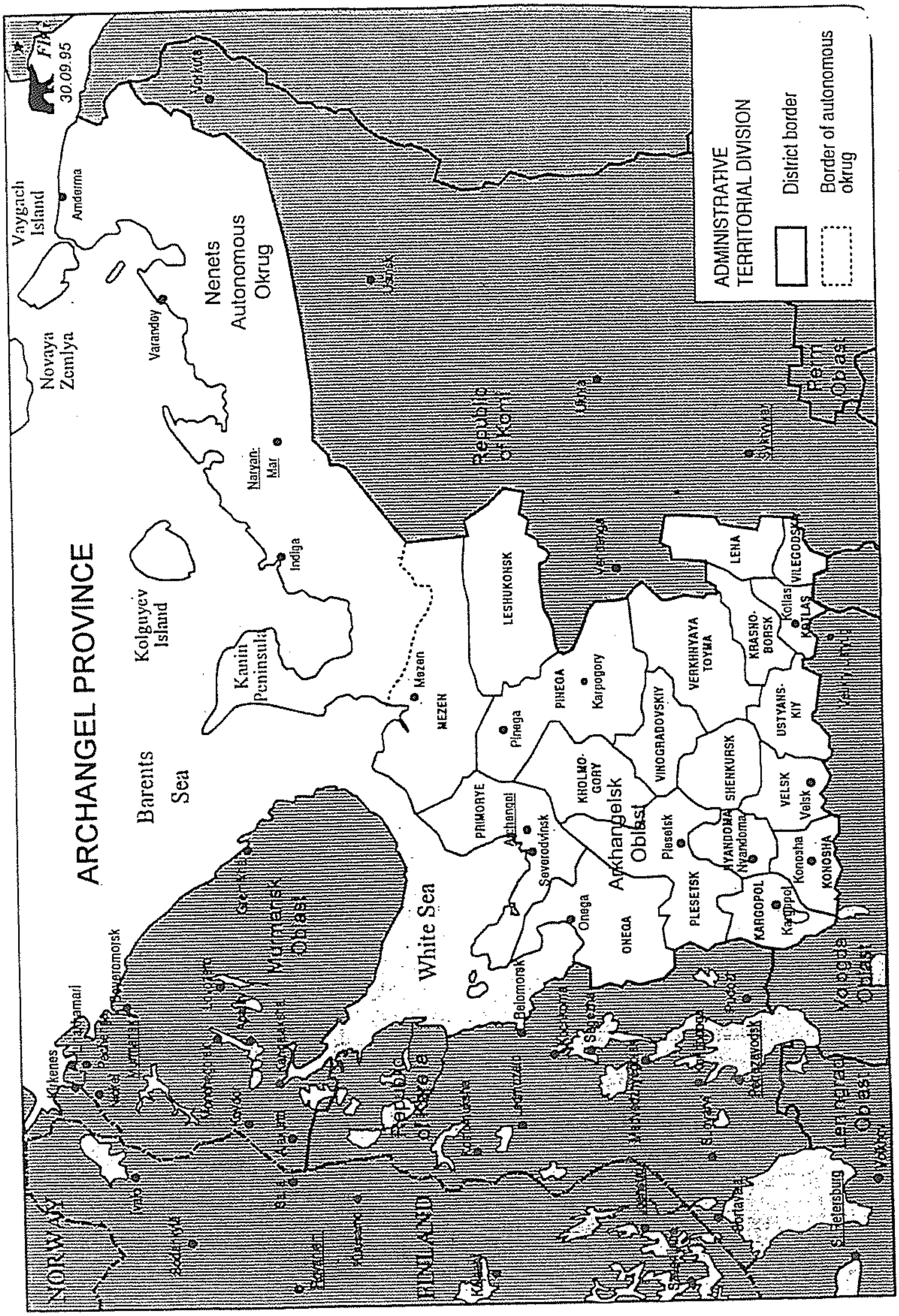



Figure 2.3.1 The geographic extent of the Province of Archangel (excluding Novaya Zemlja), showing administrative and county boundaries (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

### 2.3.4 Natural resources

At present, the forest is by far the most important natural resource in the Province of Archangel. Forest products are the main export goods from Archangel, and with a few local exceptions such as in the case of Nenets AA, the forestry and wood processing industries are the dominant industrial activities (Bjorvatn & Castberg 1994). The Province of Archangel contributes 33 % of Russia's total export of wood-products. However, the use of forest resources is hampered by the weak infrastructure in the Province, which has led to over-exploitation of the forest near roads and rivers, and under-exploitation in more remote areas (Bjorvatn & Castberg 1994). This over-exploitation and insufficient replanting of forest in the vicinity of roads and rivers has in turn led to soil erosion.

The Province is rich in various mineral resources, but these have up until now played a minor economic role. However, this situation may change dramatically in the coming years, due to the discovery of vast petroleum resources, both onshore and offshore in the Barents and Pechora seas. The majority of the petroleum resources are found in the Timan-Pechora structure, a geological structure which is present in Nenets AA and in the neighbouring Republic of Komi (Figure 2.3.2). The total reserves in Nenets AA are estimated by Archangelgeologia to be 730 million tonnes of oil and 1170 billion $m^3$ of gas (Barents nytt 1995). Exploitation of these resources began on a small scale a few years ago, and the area is expected to become a major contributor of oil and gas in the near future. The petroleum production is expected to bring major support to the economy in general and to raise the standard of living amongst the population. On the other hand, the industrial development, together with possible oilspills and accidents, in Nenets AA and in the neighbouring Komi Republic, is presently emerging as a potential threat to the environment as well as to the traditional lifestyles of the indigenous and traditional people of Nenets AA.

In Nenets AA, there are also large coal deposits which may be exploited in the future. Furthermore, the discovery of large resources of diamonds east of Archangel City is believed to represent an economic value twice that of the diamond-fields in Jakutia in central Siberia. In Plesetsk, the Severoonezjk field is one of the largest operational reserves of bauxite found in Russia. Other mineral resources exploited in Archangel are limestone, slate, pit coal, peat, gypsum, fluorite, phosphorite and mineral water.

A third group of natural resources is fish. In the freshwaters of the Province, recent fish catches of 642 tonnes have been recorded, while fish landings of 2600 tonnes have been recorded from the White Sea (ECAP 1995). Catches of cod and other marine fish are taken in the Barents Sea by trawlers registered in Archangel.

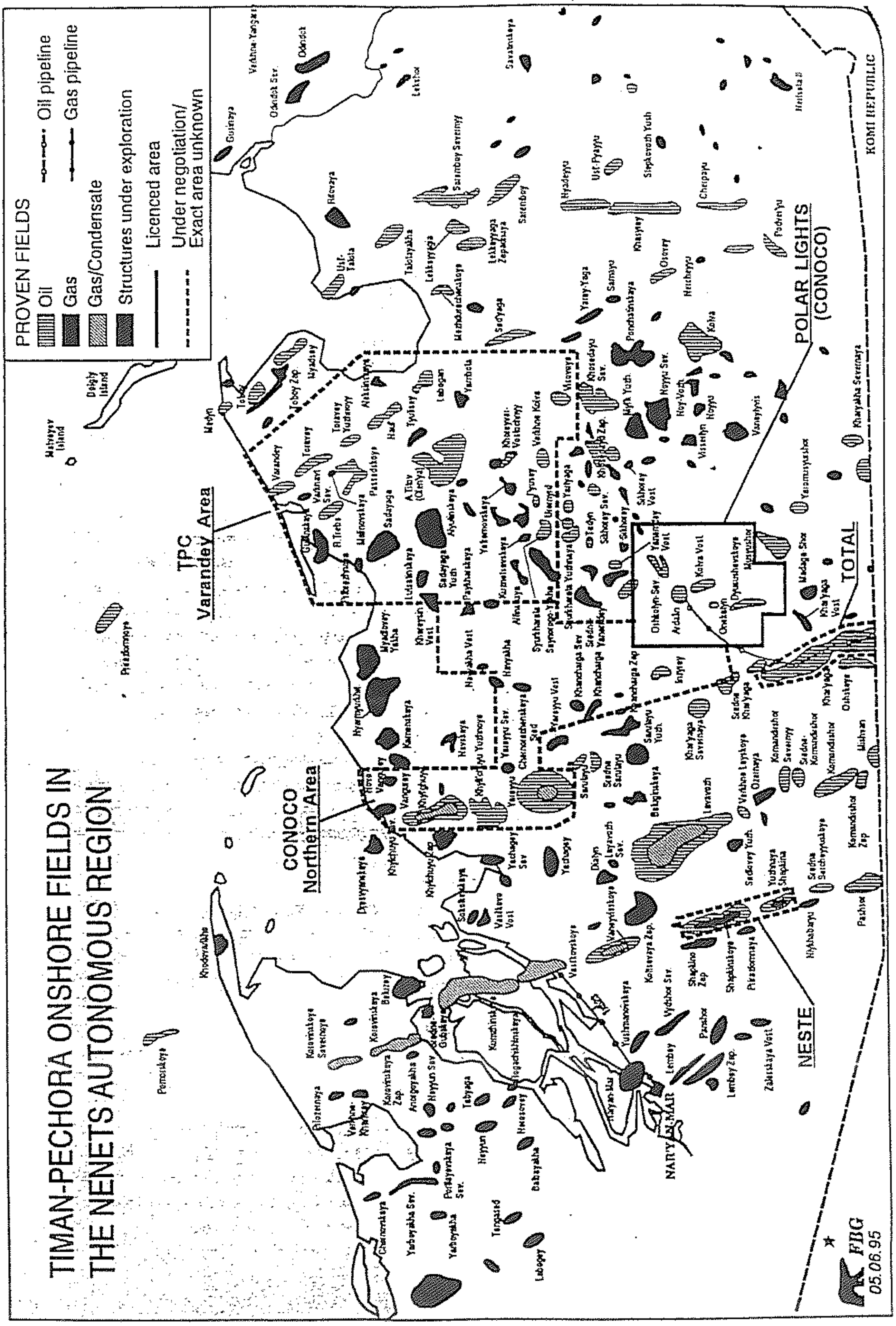



Figure 2.3.2 Proven oil and gas fields in the Nenets AA (The Barents Euro Arctic Council, Working Group on Economic Co-operation 1995).

### 2.3.5 Transportation

The centre of the Province is the City of Archangel, which extends over an area of 313 $km^2$, and has a population of 410 800 inhabitants. The City is situated at the mouth of the Northern Dvina River, and is a large industrial centre and communication link between the airport, river and sea ports, as well as rail and motorways. Roads are scarce in the Province, and the rivers have traditionally been the most important means of transportation. River traffic is still of significant importance. However, a navigability problem has developed in the rivers, due to the sedimentation of wood not recovered at the wood processing plants. The extent of the problem is not clear, but according to Bjorvatn & Castberg (1994), as much as 10 % of the total navigable waterways have become inaccessible over the past decade, mainly due to sunken timber.

### 2.3.6 The state of the environment, particularly related to issues of concern

#### *2.3.6.1 Air pollution*

Most of the data in this chapter are provided by the Environmental Committee of Archangel Province, and were presented during the mission to Archangel during May 22nd and June 1st, 1995. These data are herewith referred as ECAP 1995.

There are some 378 operational industrial enterprises in the Province of Archangel, which in 1993 emitted 457 100 tonnes of contaminants, including the following: 100 000 tonnes of dust, 126 900 tonnes of $SO_2$ - 37 800 tonnes of NOx, 69 700 tonnes of CO and 113 600 tonnes of hydrocarbons. There has been a reduction in air-borne emissions in the Province during recent years (ECAP 1995), mostly as a result of a decrease in production and, to some extent, the introduction of 'environmentally-friendly' technology (Tab. 2.3.2). Emissions from automobile transport, which in 1993 were estimated to comprise 14.6 % of the total gas emissions, are not included in these figures.

Table 2.3.2 Dynamics of industrial gas emissions from stationary sources in the Province of Archangel between 1988 - 1994, expressed in thousand tonne units (ECAP 1995).

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Total emissions | 505.2 | 515.9 | 545.8 | 584.2 | 505.8 | 457.1 |

Five major cities in the Province: Archangel, Koryazhma, Kotlas, Novodvinsk and Severodvinsk emitted totally 46.5% of this amount, including the following components, expressed in units of one thousand tonnes:

- dust 61.8
- $SO_2$ 91.6
- $NO_x$ 21.1
- CO 22.5

The distribution of gas emissions among these cities/towns is presented in Table 2.3.3.

Table 2.3.3 Industrial gas emissions in the cities of Archangel Province in 1993, expressed in thousand tonnes (ECAP 1995).

| City | Total | $SO_2$ | $NO_x$ | Dust | CO | Specific pollutants (tonnes) |
|---|---|---|---|---|---|---|
| Archangel | 67.0 | 32.3 | 6.8 | 17.7 | 9.0 | ammonia-33.1; acetic acid-42.9; $H_2S$-100.4; turpentine-45.8; methanol-79.6; ethanol-559.2; toluene-43.5; formaldehyde-32.2; ethylacetate-36.1; xylol-53.2; white spirit-50.1; furfural-46.9; methylmercaptane-82.1 |
| Koryashma | 19.0 | 4.3 | 4.2 | 4.8 | 2.0 | dimethyldisulphide-314.9; dimethylsulphide-198.2; $Cl_2$-30.7; $H_2S$-1524; acetic acid-64.0; turpentine-248.8; methanol-648.4; ethanol-46.6; methylmercaptane-504.8. |
| Kotlas | 7.8 | 1.8 | 0.6 | 2.2 | 3.1 | |
| Novodvinsk | 48.0 | 8.8 | 4.3 | 26.1 | 7.1 | $H_2SO_4$-35.0; $H_2S$-761.2; turpentine-150,8; methanol-66.2; ethanol-186.7; methylmercaptane-193.0. |
| Severodvinsk | 62.2 | 44.4 | 5.2 | 11.0 | 1.3 | PHC-88.2 |

Table 2.3.4 Air pollution in the cities in the Province of Archangel (ECAP 1995).

| Pollutant | 1991 | | | | 1993 | | | |
|---|---|---|---|---|---|---|---|---|
| | mean* | | max** | | mean | | max | |
| | mg/m$^3$ | MAC | mg/m$^3$ | MAC | mg/m$^3$ | MAC | mg/m$^3$ | MAC |
| **Archangel** | | | | | | | | |
| Dust | 0.1 | 0.7 | 0.5 | 1.0 | 0.1 | 0.7 | ? | <1 |
| $SO_2$ | 0.007 | 0.1 | 0.257 | 0.5 | 0.01 | 0.2 | ? | ? |
| CO | 0.9 | 0.3 | 16,0 | 3.2 | 1.0 | 0.3 | 15.0 | 3 |
| $NO_2$ | 0.02 | 0.4 | 0.22 | 2.6 | 0.02 | 0.5 | 0.26 | 3 |
| $H_2S$ | 0.001 | - | 0.051 | 6.3 | 0.001 | - | 0.024 | 3 |
| Formal-aldehyd | 0.004 | 1.2 | 0.147 | 4.2 | 0.006 | 2 | ? | ? |
| $CS_2$ | 0.011 | 2.1 | 0.093 | 3.1 | 0.01 | 2 | ? | ? |
| Phenol | 0.001 | 0.4 | 0.022 | 2.2 | 0.001 | 0.4 | ? | ? |
| $H_2SO_4$ | 0.01 | 0.1 | 0.71 | 2.4 | - | - | - | - |
| Methyl-mercapt. | 63.3x10$^{-6}$ | 7.0 | 104x10$^{-6}$ | 116 | 81x10$^{-6}$ | 9 | 1116x10$^{-6}$ | 124 |
| Methanol | 0.353 | 0.7 | 1.82 | 1.8 | 0.3 | 0.6 | 2.0 | 2 |
| Benzo(a)-pyrene | 1.6x10$^{-6}$ | 1.6 | 6.5x10$^{-6}$ | 6.5 | 4,8x10$^{-6}$ | 4.8 | 13x10$^{-6}$ | 13 |
| Phuphurol | 0.01 | 0.2 | 0.28 | 5.6 | 0.01 | 0.2 | 0.2 | 4 |
| **Koryazhma** | | | | | | | | |
| Dust | 0.04 | 0.3 | 0.5 | 1.0 | ? | <1 | ? | ? |
| $SO_2$ | 0.003 | 0.1 | 0.15 | 0.3 | ? | <1 | ? | <1 |
| CO | 3.0 | 1.0 | 5.0 | 1.0 | - | - | - | - |
| $NO_2$ | 0.02 | 0.5 | 0.15 | 1.8 | ? | <1 | ? | <1 |
| $H_2S$ | 0.003 | - | 0.08 | 10.0 | ? | ? | 0.016 | 2 |
| Methyl-mercapt | 159x10$^{-6}$ | 17.7 | 704x10$^{-6}$ | 78.2 | 117x10$^{-6}$ | 13 | 370x10$^{-6}$ | 41 |
| **Novodvinsk** | | | | | | | | |
| Dust | 0.09 | 0.6 | 0.5 | 1.0 | ? | <1 | ? | <1 |
| $SO_2$ | 0.004 | 0.1 | 0.188 | 0.4 | ? | <1 | ? | <1 |
| CO | 0.6 | 0.2 | 10.0 | 2.0 | ? | <1 | ? | <1 |
| $NO_2$ | 0.02 | 0.4 | 0.3 | 3.5 | ? | <1 | ? | <1 |
| $H_2S$ | 0.001 | - | 0.086 | 10.7 | 0.016 | 2 | 0.04 | 5 |
| $CS_2$ | 0.014 | 2.9 | 0.182 | 6.1 | - | - | - | - |
| Formal-aldehyde | 0.004 | 1.4 | 0.108 | 3.1 | 0.006 | 2 | ? | ? |
| Methyl-mercapt. | 136x10$^{-6}$ | 15.1 | 3453x10$^{-6}$ | 384 | 117x10$^{-6}$ | 13 | 927x10$^{-6}$ | 103 |
| Benzo(a)-pyrene | 0.9x10$^{-6}$ | 0.9 | 3.6x10$^{-6}$ | 3.6 | 1.0x10$^{-6}$ | 1 | 1.0x10$^{-6}$ | 3.0 |
| **Severodvinsk** | | | | | | | | |
| Dust | 0.1 | 0.7 | 1.3 | 2.6 | ? | <1 | ? | <1 |
| $SO_2$ | 0.004 | 0.1 | 0.144 | 0.3 | ? | <1 | ? | <1 |
| CO | 1.3 | 0.4 | 19.0 | 3.8 | ? | <1 | 20.0 | 4 |
| $NO_2$ | 0.02 | 0.5 | 0.4 | 4.7 | ? | <1 | 0.43 | 5 |
| Formal-aldehyd | 0.014 | 4.7 | 0.309 | 8.8 | 0.07 | 2 | ? | ? |
| Benzo(a)-pyrene | 0.9x10$^{-6}$ | 0.9 | 2.3x10$^{-6}$ | 2.3 | ? | <1 | ? | ? |

* Mean = Annual average.** Max = Highest peak throughout the year, measured over a 20 minute period.

The main component of industrial gas emissions is contributed by the power and heating plants (22%), the pulp and paper industry (17%) and the microbiological industry (3%). It should be noted that pulp and paper mills contribute to a number of specific pollutants which are particularly hazardous for both the environment and humans (Tab. 2.3.3). Levels of pollutants in the cities correspond to gas emissions from their surrounding areas (Tab. 2.3.4). The highest levels of air pollution are observed in Archangel, Koryazhma and Novodvinsk, where large pulp and paper mills are located (ECAP 1995).

Archangel City. Archangel City is among those cities of the Russian Federation with the highest levels of air pollution. The main component of the gas emissions in the City are produced by the Archangel heat and power plant (38.6 %) and Solombala pulp and paper mill (18.5 %). The latter contributes the largest amounts of specific pollutants. This plant is responsible for almost all emissions of hydrogen sulphide and methyl mercaptane in the area, which lead to poor air quality in the City (Tab. 2.3.4).

The mean annual concentration of $NO_2$ was below the MAC, with 3·MAC being the highest one-time recording made in areas with dense traffic. The mean annual and highest single recording of dust concentrations did not exceed the MAC. However, the mean annual concentration of benzo(a)pyrene near the railway and in one of the residential areas was 3-5 times above the MAC as well as WHO standards, and in some winter months, the values were 7-11 times higher (Igamberdiev *et al.* 1995). In the same year, the mean annual concentration of methyl mercaptane was 9 MAC, with the highest one-time concentration being 124 MAC. Within the year, five instances of extremely high methylmercaptane pollution levels were observed, caused by intensive emissions and insufficient reduction efforts at the pulp- and paper mills, combined with unfavourable meteorological conditions. The highest mean monthly values of methylmercaptane levels (14-16 MAC) were recorded in January and November under distinctive weather conditions, such as air stand-still and near-earth inversions.

The hydrolysis plant 'Inprobit' is another major contributor of specific organic pollutants. In 1993, the plant emitted 43.6 tonnes of furfural, 410.5 tonnes of ethanol, 22.2 tonnes of formaldehyde and 71.7 tonnes of methanol. Energy enterprises, such as the Archangel heat and power plant are responsible for 70 % of the emissions of $SO_2$ (ECAP 1995). The air pollution in Archangel City is intensified by the transport of pollutants from the Archangel pulp and paper mill situated in Novodvinsk, 14 km to the south-east of Archangel.

In 1992, the mean annual concentrations of carbon disulphide and formaldehyde were twice the MAC. The highest one-time concentration of furfural was equivalent to 4 MAC, that of hydrogen sulphide 3 MAC and methyl alcohol 2 MAC. The trend for the reported period from 1989 to 1992 is characterised by an increase in the mean concentration of dust, carbon disulphide and sulphur dioxide, with the concentrations of other substances remaining largely unchanged. These data and trends place Archangel high in the rank of cities with the poorest air qualities (Ministry of Environment Protection and natural resources of the Russian Federation 1994). Novodvinsk is also ranked high on this list, and for both cities, this is mainly as result of air-borne emissions from the pulp- and paper industries.

Koryazhma. The Kotlas pulp and paper mill is responsible for 99.5 % of the gas emissions in the town. In spite of the fact that the plant's industrial gas treatment facilities trap 95 % of produced pollutants, the plant still emits approximately 19 thousand tonnes of various gasses annually. In addition to 'general' contaminants, this plant emits large amounts of specific toxic organic compounds. These include 648 tonnes of methanol, 504 tonnes of methylmercaptane, 1523 tonnes of $H_2S$, 249 tonnes of turpentine and 315 tonnes of dimethyldisulphide. (Tab. 2.3.4). These emissions result in poor air quality in the town, with high concentrations of sulphurous compounds (ECAP 1995).

Novodvinsk. In the City of Novodvinsk (population 50 000), the Archangel pulp and paper mill is responsible for 99.2 % of contaminant emissions. In 1993, this plant emitted 761 tonnes of $H_2S$, 193 tonnes of methylmercaptane and 150 tonnes of turpentine. (Tab. 2.3.4). Emissions of these organic contaminants cause high levels of air pollution in the town and, to a great extent, in the Province of Archangel as a whole (ECAP 1995).

The period between 1989-1992 is characterised by reduced emissions from stationary sources, as a result of nature conservation actions and reduced production in major industries. The levels of sulphur dioxide pollution was low during this period. The mean annual concentration of nitrogen dioxide was within the MAC, with the highest one-time observation above 1 MAC (500 $\mu g/m^3$). The mean annual concentration of carbon disulphide and formaldehyde amounted to 2 MAC. The highest one-time hydrogen sulphide concentration of 5 MAC (40 $mg/m^3$) was observed at the leeward side of the Archangel pulp- and paper mill. The highest one-time phenol concentration, approximately 2 MAC - 20 $mg/m^3$, was observed in the industrial area. The most serious air contaminant is methylmercaptane, with a mean annual concentration amounting to 13 MAC (0.117 $mg/m^3$) and the highest one-time recording being 103 MAC (0.92 $mg/m^3$). During the same period, five instances were recorded where the methyl mercaptane level exceeded 50 MAC. This was during times of northerly and north-easterly winds from the site of the Archangel pulp and paper mill. The highest mean monthly concentrations were recorded in April and August (17 and 19 MAC respectively), with a predominance of northerly and north-easterly winds.

Severodvinsk is the third major city of the Dvina Bay (population 250 000). Severodvinsk is the second largest (i.e. after Archangel) contributor of air pollution in the Province. Contributions of different branches of industry to the total air-borne emissions in the City are as follows (1994 data):

- heat and electric power industry 95%
- machine-building industry 0.4%
- ship-building industry 4.5%
- building industry 0.1%

Heat and electric power plant **No 1** is the main contributor of air pollution in the City (63.5% of all emissions from stationary sources). In spite of the fact that machine- and ship-building enterprises contribute small amounts of air-borne emissions in the City, they are responsible for contamination with specific substances. For example, 'Severomash' emits 36 different specific contaminants, 'Zvezdocha' 19, and 'Polyarnaya Zvezda' 15. According to the statistical reports, presented by the enterprises to the Environmental Committtee, the total amounts of specific contaminants emitted in 1993 were as follows (ECAP 1995):

| Contaminant | Amount (tonnes) | Contaminant | Amount (tonnes) |
|---|---|---|---|
| ammonia | 0.7 | ethtyl acetate | 0.5 |
| $V_2O_5$ | 92.7 | xylol | 2.2 |
| iron oxides | 23.3 | white spirit | 2.5 |
| saturated hydrocarbons | 88.3 | $Al_2O_3$ | 0.5 |
| $MnO_2$ | 3.6 | $TiO_2$ | 0.8 |
| $H_2SO_4$ | 1.5 | NaOH | 0.6 |
| toluene | 1.1 | NiO | 1.3 |
| formalaldehyde | 0.3 | Cr compounds | 1.0 |

However, in certain cases, these data cannot be considered as reliable. For example, the reported amounts of emitted formalaldehyde cannot cause annual mean concentration of this compound in the air in the order of 4.7 MAC (see Tab. 2.3.4).

### *2.3.6.2 Freshwater and drinking water*

#### *2.3.6.2.1 Pollution of fresh water*

In 1994, industrial and communal enterprises in Archangel Province discharged 946 million $m^3$ of waste water. Almost 99 % of these were discharged into surface water bodies. Nenets AA discharged less than 1 % of the total discharges in Archangel Province.

The composition of the discharged waste waters includes the following components: Polluted - 570 million $m^3$, 'standard pure' untreated - 326 million $m^3$, treated according to the standards - 37 million $m^3$. The area-related distribution of waste water discharges and amounts of pollutants discharged are presented in Table 2.3.5. It is conclusively shown that the main source of water pollution originates from the three cities Archangel, Novodvinsk and Koryazhma. Information on the major pollution sources in these cities/towns indicates that pulp and paper industrial plants (Kotlas mill in Koryazhma, Archangel mill in Novodvinsk and Solombala mill in Archangel) are responsible for the largest component of freshwater pollution in the Province of Archangel (Tab. 2.3.6). At the same time, in some cases, even relatively small amounts of contaminants can result in severe pollution loading in minor water. For example, the waste waters of Cellulose Plant No 1 cause severe contamination of the small River Puksa (basin of the Northern Dvina). The mean 1993 concentrations in this river are shown below. The plant is currently non-operational, and the water quality of this river has significantly improved. For comparison, the current levels of contaminants are also given.

| Contaminant | 1993 levels | Current levels |
|---|---|---|
| lignosulphonate | 553 MAC | 2 MAC |
| N-NH4+ | 30 MAC | <2 MAC |
| phenols | 12 MAC | 6 MAC (ECAP 1995). |
| COD | 510 mg/l | 42.9 mg/l |
| BOD5 | 50.4 mg/l | 3.8 mg/l |

Table 2.3.5 Discharge of waste water in cities and counties in the Province of Archangel, 1994.

| | | Amount of pollutants discharged, tonnes. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| City/county | Waste water discharge million $m^3$ (polluted) | Oxidizable organic compound (BOD) | Petroleum hydrocarbon | Susp. matter | $SO_4$ | Cl | $P_{total}$ | $N\text{-}NH_4$ | $NO_3$ | Detergents | $Fe_{total}$ | Methanol | Turpen-tine | Lignosulphonates | Formaldehyd |
| Archangel Province | 946 | 36560 | 258 | 53140 | 7830 | 17280 | 613 | 4141 | 307 | 70.3 | 94.8 | 3065 | 151 | 70669 | 116 |
| Nenets Aut. Area | 2.8 | 80 | - | 60 | 10 | 80 | 3.65 | 10.4 | 0.4 | 1.11 | 0.4 | - | - | - | - |
| Archangel City | 226 | 3660 | 28 | 4430 | 43.3 | 163 | 118 | 1516 | 14.1 | 7.1 | 65.2 | 33.8 | 21.2 | 907 | 4.9 |
| Koryazhma | 292 | 14650 | 150 | 29418 | - | - | 230 | 1479 | - | 22.1 | - | 2644 | 68.1 | 11285 | 55.8 |
| Kotlas | 8.0 | 180 | - | 160 | 60 | 590 | 7.56 | 90.7 | 1.5 | 11.8 | 2.9 | 0.2 | - | - | 0.1 |
| Novodvinsk | 244 | 15660 | 60 | 11376 | - | - | 16.6 | 26.1 | <0.1 | 11.5 | - | 344 | 61.6 | 56904 | 51.3 |
| Onega | 16.6 | 610 | - | 630 | 2000 | 60 | 26.4 | 408 | <0.1 | <0.1 | - | 43.1 | - | - | 3.8 |
| Severodvinsk | 95 | 390 | 20 | 1180 | 4070 | 6010 | 138 | 259 | 141 | 5.4 | 24.4 | - | - | - | - |
| Solvychegodsk | 3.4 | 60 | - | 70 | 30 | 290 | 0.6 | 37.9 | 1.0 | 0.3 | 1.4 | - | - | - | - |
| Kotlas county | 4.8 | 90 | - | 100 | 70 | 410 | 0.8 | 45.9 | 5.0 | 2.3 | 1.5 | - | - | - | - |
| Plesetsk county | 28 | 320 | - | 440 | 1310 | 5730 | 11.4 | 93.1 | 115 | 0.1 | <0.1 | - | - | 0.6 | - |
| Primorsky county | 6.1 | 150 | - | 250 | 120 | 440 | 15.1 | 56.5 | 7.1 | 0.7 | - | - | - | - | - |

Table 2.3.6 Main sources of waste water discharges in Archangel Province 1994 (ECAP 1995).

| Sources of waste water | Waste water discharge, million. $m^3$ | | | | | Amount of pollutant discharged, t | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Polluted without treatment | Insuff-iency treated | Treated acc. to standards | 'Standard pure' without treatment | Oxidizable org. comp. (BOD) | Petr. hydro-carbon | Susp. matter | $SO_4$ | Cl | $P_{total}$ | N-$NH_4$ | $NO_3$ | Deter gents | $Fe_{total}$ | Meth anol | Turp-entine | Form alde hyd | Lign. sulp. |
| Archangel City | 230 | 12.6 | 71 | 3.7 | 142.7 | 3660 | 28.3 | 4430 | 43.3 | 163 | 118 | 1516 | 14.1 | 7.1 | 65.2 | 33.8 | 21.2 | 4.9 | 907 |
| Tsyglomen timber plant | 1.82 | 0.06 | - | 1.66 | 0.1 | 13.2 | - | 16.2 | - | - | 0.1 | 0.7 | 8.8 | - | - | - | - | - | <0.1 |
| Solombola pulp and paper mill | 70.7 | 0.8 | 69.9 | - | - | 3158 | 27.8 | 4156 | - | - | 115.8 | 1499 | - | 7.0 | 62.8 | 32.8 | 21.2 | 4.9 | 906 |
| Hydrolysis plant | 2.85 | 2.85 | - | - | - | 160 | - | 11.6 | - | - | 0.8 | 0.6 | - | - | - | 1.8 | - | - | - |
| Heat and power plant | 143 | 0.7 | - | 0.6 | 141.7 | 31.4 | 0.5 | 14.0 | - | - | - | 0.4 | - | - | 2.3 | - | - | - | - |
| Vodokanal | 6.8 | 6.8 | - | - | - | 225 | <0.1 | 78.6 | - | - | <0.1 | | - | <0.1 | 0.1 | - | - | - | - |
| Koryazhma: | 292.4 | 12.5 | 222.2 | 16.8 | 40.9 | 14650 | 151.1 | 29418 | - | - | 230 | 1479 | - | 22.1 | - | 2644 | 68.1 | 55.8 | 11285 |
| Kotlas pulp and paper mill | 292.3 | 12.4 | 222.2 | 16.8 | 40.9 | 14650 | 151.0 | 29418 | - | - | 230 | 1479 | - | 22.1 | - | 2644 | 68.1 | 55.8 | 11285 |
| Novodvinsk | 244.2 | 6.6 | 156.6 | - | 81.0 | 15660 | 60 | 11376 | - | - | 16.6 | 26.1 | <0.1 | 11.5 | - | 344 | 61.6 | 51.3 | 56904 |
| Archangel pulp and paper mill | 244.2 | 6.6 | 156.6 | - | 81.0 | 15660 | 60 | 11376 | - | - | 16.6 | 26.1 | <0.1 | 11.5 | - | 344 | 61.6 | 51.3 | 56904 |

Koryazhma. Waste waters from the Kotlas pulp and paper mill, which is responsible for almost all of the waste waters from this town, are discharged into the River Vychegda. The pollution levels in this river have recently decreased as a result of a decline in production, but still remain high. In 1994, the mean annual concentration of lignosulphonate was 5 MAC, while COD levels were 36.2 mg/l, and the levels of phenols and ammonia were 2 MAC. Accidental pollution of river water is caused by ineffective waste treatment facilities at the Kotlas mill. Considering that that most of the settlements are supplied with drinking water from this same river, corresponding sanitary problems arise as a result of this contamination. For example, the accidental release of untreated waste waters in September 1993 led to increased concentrations of lignosulphonates in river water in the downstream town of Solevychegodsk, with values up to 18 MAC (ECAP 1995).

Mouth of the Northern Dvina River. The cities of Archangel and Novodvinsk are situated 14 km apart on the banks of the Northern Dvina River, and their environmental destiny is extremely inter-linked. The waste water discharges of Novodvinsk are particularly hazardous as:

- Novodinsk is situated upstream of Archangel, the main City of the Province, with a population of more than 400 000.
- Waste waters of the Archangel pulp and paper mill in Novodvinsk are discharged into the main stream of the Northern Dvina River.

The combined pollution of these two cities, together with the river transport of contaminants from the upstream sources results in significant pollution of the water body. At a distance of 1 km downstream of the waste water discharge site of the Novodvinsk pulp and paper mill, mean annual concentrations in 1994 were recorded as follows:

| | |
|---|---|
| • methanol | 2 MAC |
| • lignosulphonates | 7 MAC |
| • petroleum hydrocarbons | 1 MAC |

Peak concentrations were 16, 38 and 5 MAC respectively (ECAP 1995).

Archangel also contributes to river pollution with its waste waters. Solombala pulp and paper mill is the main contributor of effluent, comprising 31 % of the City's total discharges. Archangel heat and power plant may be considered to discharge the largest volume of waste waters in the City (>60 %), but this water is relatively clean and is discharged almost without treatment. Small enterprises, which discharge low volumes of waste waters, are sometimes responsible for more severe environmental impact. For example, the Archangel hydrolysis plant, which discharges less than 2 % of that discharged by the heat and power plant, has no treatment facilities and consequently contributes 5 times the amount of oxidative organic matter and approximately the same amount of suspended matter (ECAP 1995).

Impact of small dairy and meat factories. Dairy and meat stock-breeding is a traditional branch of agriculture in the Province of Archangel. Factories for processing milk and meat products operate in many towns and counties of the Province. In general, these do not have waste-water treatment facilities and discharge the waste-waters directly into the water bodies. Information on these factories is presented in Table 2.3.7. It should be noted that the information on these factories is not comprehensive.

Table 2.3.7 Milk and meat processing factories in Archangel Province (ECAP 1995).

| County | Enterprise | Waste water discharge thousand m³ | $BOD_5$ t/year | $NH_4^+$ t/year | $P_{total}$ t/year |
|---|---|---|---|---|---|
| Velsky | Dairy factory | 21 | - | 3.9 | 0.21 |
| Vilegodsky | Butter factory | 10 | | 4 | no data |
| Verhnetoemsky | Butter factory | 1.7 | 0.7 | no data | no data |
| Vinogradovsky | Dairy factory | 2.2 | 0.5 | no data | no data |
| Kargopolsky | Dairy factory | 54.5 | 9.1 | 0.5 | 0.84 |
| Konoshsky | Dairy factory | 1.0 | no data* | no data* | no data* |
| Kotlassky | Dairy factory | 6.0 | 1.13 | 0.02 | no data |
| Krasnoborsky | Dairy factory | 20.2 | 6.5 | 0.06 | 0.1 |
| Lensky | Dairy factory | 3.1 | 0.3 | 0.04 | 0.02 |
| Leshukonsky | Butter factory | 1.4 | no data* | no data* | no data* |
| Mezensky | Dairy factory | 7.0 | 2.1 | 0.05 | 0.01 |
| | Meat factory | 2.4 | 0.4 | 0.012 | no data |
| Nyandomsky | Butter factory | 12.3 | no data* | no data* | no data* |
| Pinezhsky | Dairy factory | 6.5 | no data* | no data* | no data* |
| Plesetsky | Dairy factory | 3.3 | no data* | no data* | no data* |
| Ustyansky | Dairy factory | 27.9 | 25.1 | 0.91 | 0.07 |
| Kholmogorsky | Dairy factory | 16.9 | 33.5 | 0.33 | 0.33 |
| Shenkursky | Dairy factory | 12.3 | 8.73 | 0.02 | no data |

* - waste waters are either discharged into collectors, following transportation to dust-heaps or directly into landscape depressions.

Nitrogen concentrations in waste waters of such factories are usually in the range of 90-140 mg/l and phosphorus concentrations can reach 15 mg/l or even higher. The waste-water discharges of these factories increase nutrition loading in waters bodies (ECAP 1995).

Dioxin-type contamination. Based on the request of the Archangel environmental protection authorities, a joint expedition of Russian, German and Dutch experts to study dioxin-type environmental contamination took place in 1993. The data obtained during this expedition has shown that some areas within the Province of Archangel show contamination by dioxins at a level at least as high as in industrial areas in Central Europe. These levels show marked increases in the vicinities of pulp and paper mills.

The most pronounced high contamination levels were recorded from the estuarine area of the Northern Dvina River, including the river and delta within the precincts of Archangel City, and River Vychegda close to Koryazhma. Samples of bottom sediments in Archangel contained up to 5 ng/g of dioxin-type contaminants and a slime sample near the Solombala plant contained 10.9 ng/g (ECAP 1995).

The air in Novodvinsk is considerably contaminated by dioxin (43.8 pg/m³). However, the industrial gasses emitted by the Archangelsk pulp and paper mill contain moderately high levels of dioxins (about 1 pg/m³) and are of a different composition than that observed in the air samples of Novodvinsk City. Based on this information, the Expert Group suggest that another as yet unidentified source of dioxin emissions exists in this area.

The Dvina has for many years been intensively used for floating of timber, and some 50 % of the timber are usually allowed to drift without proper control (ECAP 1995). Thus, sunken and other lost timber as well as bark create a huge base of decomposing organic material, a process which consumes much oxygen and adds to the eutrophication level.

*2.3.6.2.2 Drinking water supply*

The state of the drinking water supply in the Province of Archangel can be considered to be critical. A total of 53.3 % of communal pipeline networks, and 38 % of pipeline networks belonging to industrial infrastructures, do not meet sanitary requirements. Correspondingly, 62.5 % and 74.3 % of water supply sites have no protected sanitary zones. In total, 62.5% of water supply systems lack the necessary sets of water treatment facilities. As a consequence, in the Province more than 55 % of tap water samples do not meet standards on chemical quality and 25 % fall below standards of microbiological quality (ECAP 1995).

All large cities and towns of the Province (Archangel, Severodvinsk, Novodvinsk, Kotlas, Koryazhma) use surface water bodies as a supply of drinking water. These sources are strongly affected by waste water discharges. A particularly alarming situation exists in Archangel and the near-by City Novodvinsk, supplied mostly by the Northern Dvina River. According to the Russian sanitary classification (Sanitary Rules and Standards No 4630-88), the lower flow of this river is classified as being extremely polluted by bacteriological variables, highly polluted by organic matter (COD and BOD) and moderately polluted by toxic chemicals (ECAP 1995).

Archangel City. The population of Archangel City is supplied with tap water by means of 15 pipeline networks, of which only one belongs to the communal pipeline network. The remaining 14 belong to the infrastructures of the various industrial enterprises in the City. All the outskirts of the City, with the exception of the settlement Isakogorka, is taken from the Northern Dvina River. A total of 5 out of 15 pipeline networks do not ensure sanitary water quality and were officially closed down by the Sanitary Inspection some years ago.

Most of the City population is supplies from the communal water supply system which is overloaded (actually 180 ths. m³/day with planned capacity 155 ths. m³/day). According to the decision of the City administration, a special timetable of water supply was adopted. According to this timetable, normal water pressure is kept only in morning and evening hours. The quality of tap water in the City pipeline systems has decreased in recent years (Tab. 2.3.8).

Table 2.3.8 Percentage of tap water samples below sanitary standards in Archangel City, expressed as % of total no. of samples (ECAP 1995).

| | 1992 | | 1993 | | 1994 | |
|---|---|---|---|---|---|---|
| Water supply systems | Chemical* | Microbial | Chemical | Microbial | Chemical | Microbial |
| Communal | 65.3 | 7.1 | 83.8 | 3.3 | 84.2 | 5.7 |
| Belonging to industrial enterprises | 83.3 | 15.7 | 89.8 | 29.9 | 91.9 | 31.7 |
| Mean value | 73.5 | 10.0 | 86.6 | 12.6 | 87.8 | 16.1 |

* Chemical = non bacterial contamination

### 2.3.6.3 *Solid wastes*

The information obtained by the AMAP Expert Group on the formation and handling of solid waste is not complete, and at times appears contradictory. An overview of formation and disposal of hazardous waste in Archangel Province is presented in Table 2.3.9 (Archangel regional committee of state statistics, ECAP)

In the beginning of 1994, a total of 5.2 million tonnes of hazardous waste was registered in the Province of Archangel. During the year, this quantity increased by 486 600 tonnes. Most of the waste deposited in landfills is deposited in controlled (organised) land fills.

Table 2.3.9 Formation and disposal of hazardous waste in Archangel Province, 1994. Data are expressed in units of thousand tonnes (ECAP 1995).

| | **Present by 1.1.1994** | **Formation during 1994** | **Quantity used** | **Totally neutral-ised** | **Deposited in organised storage** | **Deposited in non-organised storage** |
|---|---|---|---|---|---|---|
| **Regional total** | 5233.8 | 486.6 | 19.0 | 2.2 | 423.7 | 5.0 |
| **Nenets AA** | 0.1 | 0.1 | | | 0.1 | |
| **Total industrial** | 5223.2 | 473.0 | 16.7 | 2.2 | 418.4 | 5.0 |
| **Electro-energy** | 5220.7 | 197.6 | 0.1 | | 197.5 | |
| **Chemicals and oil** | no data | 0.01 | | | 0.01 | |
| **Machine construction and metal** | 2.4 | 33.2 | 12.5 | 2.2 | 4.2 | 5.0 |
| **Cellulose/paper-wood** | 0.1 | 239.3 | 1.2 | 0.01 | 216.7 | |
| **Micro-biological** | no data | 2.9 | 2.9 | | | |
| **Agriculture** | 0.02 | | | | | |
| **Transport** | no data | 5.8 | 23 | 0.02 | 0.1 | 0.01 |
| **Others** | 10.6 | 7.8 | | | 5.2 | |

### 2.3.6.4 *Marine pollution*

The White Sea is a large sill fjord. The maximum depth is some 300 meters in the outer Kandalaksha Bay, while the depth at the mouth, between the Kola Peninsula and Cape Kanin is only 34 meters. Thus, the water exchange with the Barents Sea mostly takes place in the surface waters. The White Sea is strongly stratified during summer, and at depths greater than 60 meters, the water temperature is always negative (Zenkevich, 1963, Scarlato (Ed.) 1991, Larsen 1994). The White Sea receives a large fresh water input; 19 $km^3$ of freshwater enters the sea annually from the rivers (Zenkevich 1963). Water samples taken in 1993 indicated only slight or no contamination in the Dvina bay, and the open parts of the sea are relatively clean (ECAP 1995, Ministry of Environmental Protection and Natural Resources of the Russian Federation 1995).

The Northern Dvina alone accounts for more than half of the river water entering the White Sea, thus the state of contamination of the River is largely responsible for the state of contamination in the White Sea. Approximately 10 % of the fresh water comes from smaller rivers in Karelia and on the Kola peninsula. Among these are the River Niva, arising from the polluted Lake Imandra, where the Kola nuclear power station and PO Apatit are situated.

Data on field measurements of levels of contaminants in the White Sea biota and sediments are sparse. However, data on total hydrocarbon content in sediments collected in 1994 indicate a certain elevation in the Kandalaksha and Dvina bays (Akvaplan-niva, unpublished data). Data on chlororganic contaminants in sediments and biota from the White Sea have not been available for the Expert Group.

Another major source of contaminants to the White Sea is shipping traffic as well as operational and accidental discharge from harbours. Archangel City seaport consists of 5 cargo areas and 1 passenger area. The port deals with the processing of general cargoes, heaping cargoes (coal, ore, building material) and timber, metallurgical works etc. The seaport is open throughout the year assisted by ice-breaker during the period from December to May. Annually, 500 to 865 ships are serviced in the seaport. The seaport alone uses 0.96 million $m^3$ of freshwater per year. Of this, 0.75 million $m^3$ are discharged after use, and 0.6 $m^3$ flows into the city's sewage system and 0.19 $m^3$ are discharged without purification.

Severodvinsk sea port is a naval base and there is no available official information regarding the pollution sources and the condition of the water. However, chronic pollution of the water is reported around this seaport (Hydromet annual report 1993). The main sources of pollution are warships and auxiliary ships, which dispose of oily water and faecal-sewage near or in the seaport. Furthermore, ships in the docks clean their fuel capacities and machine rooms with water, which is then poured untreated into the sea (Igamberdiev *et al.* 1995).

The Onega sea port is operational for 8-9 months a year. The Onega seaport has an annual water consumption of 100 000 $m^3$, which is provided by the city's water supply system. It is reported that approximately half of this volume is discharged to the Onega River after some purification. However, there are four industrial establishments on the coast of the Onega River, all of which dispose of their polluted industrial effluent into the River. In addition, the domestic effluent from the City is released into the River. There is a trend for increasing concentrations of detergents, nitrates and phenols, particularly as a result of accidents occurring when timber is floated without being securely bound. The Mesen sea port does not significantly contribute to the pollution of the White Sea (ECAP 1995)

In recent years, dumping of military chemicals and ammunition in the White Sea has been reported (Fedorov 1995). However, no further information has been avalaible.

A major part of the catchment area of the Pechora River lies in the Republic of Komi. The River crosses the Nenets AA on its way north to the Pechora Sea. The capital of Nenets AA, Narjan Mar, is situated on the banks of the Pechora River, as are other settlements housing around 75 % of the Nenets AA population. In the mainland Nenets AA area, exploitation of petroleum began in 1987 (gas exploitation already began in 1977). Two fields are currently in production: Kharjaginskoje and Ardalinsk. According to plans, production will commence at the off-shore field Prirazlomnje in the eastern Pechora Sea within two years.

In the neighbouring Komi Republic, oil exploitation has taken place for more than 20 years. As a result of the Usinsk oil spill in late 1994 and also other oil spills of the same magnitude in earlier years, concern has arisen in Nenets AA of possible contamination of the Pechora River as well as the Pechora bay estuary. However, studies from the Pechora bay in 1992 show close to background level of oil hydrocarbons and very low values of metals and chlororganic contaminants (Loring et al 1995). Nevertheless, the situation in the River Pechora and the possible contamination from the petroleum industry in Komi should be monitored carefully. According to Yablokov, the environmental advisor to president Jeltsin, only 1 % of the total financial budget of the oil companies was used to maintain the pipelines in Russia as compared with 12-15 % in some western countries (Yablokov 1995).

#### *2.3.6.5 Preservation of forest resources*

The extent of contaminant damage to the forest resources is badly documented in the material presented to the Expert Group.

With the exception of a few areas (Severodvinsk, Plesetsk and Nenets AA), the forestry and wood processing industries are both directly and indirectly the dominant economical factor in the Province, with most of the secondary and service industries being dependent on the woodlands. The woodland harvest has decreased during the last years due to overexploitation in the central parts of the Province, where the railway tracks, roads and rivers are located. An almost colonial management regime has traditionally governed the forest industry, with the easiest accessible resources of the highest quality being exploited as much as possible. Long-term rational and sustainable management of the forest industry has not been practised.

It should be noted that, in contrast to the other areas of the Barents region, in the northern part of the Archangel Province there are still north taiga virgin forests which are not affected by anthropogenic impact including economic exploitation. The issue of the special decree of the former USSR Government of 1959, which prohibited logging in these forests, has contributed to their preservation. These forests are mostly situated in Mezen County. The forests cover an area of 3.5 million hectares, which comprise some 50 % of the county's area. The genetic age of these forests is between 7 and 15 thousand years, and can be considered as the largest forest tract of natural origin in Europe. Therefore, these forests are of great scientific and ecological importance. However, there is an increasing anthropogenic impact on these resources, due to economic development of adjacent areas.

## 2.4 LIFESTYLE OF INDIGENOUS AND TRADITIONAL PEOPLE

The indigenous and traditional populations of the Russian part of the Barents Region constitute less than 3 % of the total population of the area. In this study we have chosen to concentrate on the Provinces of Murmansk and Archangel, including Nenets AA.

<u>Murmansk Province</u>

The most numerous indigenous people of the Kola Peninsula are the Saami. There are also some small groups of Komi and Nenets. The number of Saami people in Murmansk Province in 1993 was 1 615 persons, mainly living in the Lovozero area (Seppänen 1995).

The community of Lovozero is the main centre of the indigenous people in Kola Peninsula, with approximately 5 000 inhabitants in the town and some 15 000 in the Lovozero County. Lovozero town has a small hospital catering mainly for out-patients. The people mainly live in block apartments, with the children being sent to boarding school in winter. In summer, the children are together with parents in the tundra. The birth rate has shown a dramatic decline over the last years, but is now stable at the Russian average, which is currently less than 2 children per couple. However, the general birth rate in Russia appears to have ceased declining, and a slight increase has even become apparent. This mostly seems to correlate with the social/economic situation. There are many small communities in the region, each with only a few hundred inhabitants. A main problem in all these villages is the water supply, which is from a very primitive ground water supply in the centre of the village, with an uncontrolled flow of surface water into it. This makes it a perfect reservoir for bacteria and viruses, and is a cause of the high incidences of gastrointestinal diseases, particularly in small children.

The total perinatal mortality (stillborn and infants dying within 7 days of birth, in relation to the total numbers of births) in Murmansk Province was 13.6 ‰ in 1992. In the case of Lovozero, the rates have changed between 7.5 ‰ and 51.7 ‰ during recent years. This mostly illustrates the difficulty in interpreting data for small populations. The corresponding rates for Nikel/Pechenga range from 6.3 to 18.2, showing the same problem. Congenital malformations in the Province of Murmansk as a whole was 20.8 in 1992, according to Russian definitions. However, this figure would be considerably lower using western definitions. In a town such as Monchegorsk, the rates range from 15.9 to 26.3. In Lovozero the rates have varied between 0 and 13.4 over the past 5 years (Ministry of health, annual report 1992; Perminova 1994).

The health problems in Lovozero are mostly related to industrial pollution and the infectious diseases. Based on a screening study of radiation in parts of the population of Lovozero, the results from whole body counting show very low levels of radioactivity (Ministry of health, annual report 1992; Perminova 1994; Odland in press).

Archangel Province, including Nenets Autonomous Area (Nenets AA).

**Indigenous people**

The main groups of indigenous people in Archangel Province are the Nenets and the Komi people (Table 2.3.1), most of whom live in Nenets AA. In this report, the main emphasis is placed on the Nenets and on the administrative unit Nenets AA.

In 1989, a total of 54 000 persons inhabited the Nenets AA, while in 1995, this number had decreased to 50 000. In 1995, the population of Nenets AA was mainly concentrated in three towns (approximately 62.6 % of the population), in villages along banks of the Pechora River and near the river mouths along the Barents Sea coast. The capital Narjan-Mar had 20 000 inhabitants, while approximately 5500 and 8 700 persons lived in the towns of Amderma and Iskateli respectively. Some 20 000 persons lived in various smaller villages structured around collective units and approximately 350 were nomadic. According to Russian definitions, there were over 75 different population groups present in the Nenets AA, of which the main groups are listed in Table 2.4.1. In 1995, the population density in Nenets AA was as low as 0.31 inhabitants per km$^2$, compared to 8.7 inhabitants per km$^2$ in the rest of Russia.

Table 2.4.1 The main population groups in Nenets AA (Figures from 1989, Barents Euro-Arctic Concil 1995).

| Population groups | Percentage (%) | Inhabitants |
|---|---|---|
| Russians | 66.0 | 36.168 |
| Nenets | 12.0 | 6.576 |
| Komi | 9.5 | 5.206 |
| Ukrainians | 6.9 | 3.781 |
| Belo-Russians | 2.0 | 1.096 |
| Others | 3.6 | 1.900 |

The main means of support of the rural population is reindeer husbandry, supplemented by some fishing and hunting. Reindeer husbandry, which also provides employment in the reindeer processing industry, is therefore the most important cultural and economic influence on the identity of the Nenets people. In Narjan-Mar, a wood processing plant uses wood transported down the Pechora River from the Komi Republic.

The entire farming land of the area is pasture, offering very little flexibility in its use. According to the agricultural authorities, all potential pasture land is in use, and there is already over-exploitation. As a consequence, any activity requiring land area will affect reindeer husbandry in Nenets.

The only existing economic structure in Nenets AA is the co-operative unit. Despite the transition into a market economy and privatisation, it has proven difficult to phase out the co-operative units, which have been the foundation of most settlements for three generations. Today, the units represent perhaps the only source of social and economic security in an otherwise very turbulent existence. To date, an environmental impact assessment has not been carried out to assess the consequences of the petroleum activity on reindeer husbandry.

The general state of human health in the Archangel Province is the most critical in the Russian part of the Barents region. Total morbidity is 12 % higher than the Russian average. Children are particularly heavily affected and, while primary morbidity of the adult population in 1994 was 9 % higher than the Russian mean, child primary morbidity was almost 21 % higher. One out of three pregnant women in the Province suffers from anaemia (63 % higher than the Russian average). As a consequence of this and other illnesses of pregnant women, new-born infant morbidity increased by 58.1% between 1991 and 1993. In 1993, birth anomalies comprised 3.34 % of new-born infants, as compared to the average Russian value of 2.3 %.

In addition to the general human health problems in Archangel Province, the Nenets population also appears to have increased immunological deficiency (Tkatchev 1995). In spite of the fact that there is no direct evidence, local medical experts connect this with the consequences of atmospheric nuclear tests carried out at the near-by archipelago Novaya Zemlya between 1955-1962, as these health problems are found to occur 1.6 times more frequently among the native population relative to newcomers. It should be noted that from 1982-1992, the average annual increase of cancer morbidity among the Nenets people was 9.8 %, relative to 2.4 % among the Russian population. This suggests that external factors may exert a stronger influence on disease incidence than the genetic traits of the indigenous population. There is therefore a need for a rigorous health screening system for the people living in these areas.

The drinking water supply in Narjan-Mar is taken from the Pechora River. The frequent accidents which occur along the oil pipeline in the Komi Republic has led to the release of vast quantities of petroleum hydrocarbons. There is a fear that some of the petroleum may be transported with the Pechora River to the Nenets AA. Infection poses another major problem, with enterovirus, hepatitis and dysentery, mainly from *E. coli* bacteria. In order to improve the quality of the drinking water, better treatment of drinking water and renovation of the distribution system is needed. Also, there is a need for a better system for handling of the waste water and the sewage.

An in-depth report concerning the quality of life among the indigenous population of Nelmin Nos has been released. It is important to consider this information from the point of view of the indigenous people, and to bear in mind that the medical information is based on Russian definitions. A Russian state programme entitled 'Children of Russia' exists, with a sub programme known as 'Children of North', illustrating that particular attention is paid to the problems of northern and indigenous people. However, although good medical specialists are regularly sent to these districts, a particular obstacle is the local habit of only seeking medical help in extremely severe cases, and often too late for the patient to be treated adequately.

**The Pomors**

The Pomor settlements have been established for several centuries, mostly along the White Sea coast. These settlements, which mainly are inhabited by population groups of Russian origin, have traditionally made their living by utilising the natural resources, of which, in many cases, fish was the most important. Traditionally, some trading was also carried out with the inland population, and the larger centres even had overseas connections, such as to Norway. During the Soviet period, many of the smaller settlements were linked to collective units, and industrial structures to support large-scale production of fish and fish products, timber or other natural resources were established.

The Pertominsk settlement, situated on the peninsula west of Severodvinsk in Archangel Province, may be used to illustrate the typical development pattern of the Pomors (Holm-Hansen *et al* 1995). The only connection from Pertominsk to the provincial centre is by boat or plane, and sometimes also in winter by car, using solid ice routes. The population in Pertominsk, and neighbouring villages belonging to the same collective, is 800 persons (1992). The fish-producing collective unit used to be the main centre of the settlements, being responsible not only for the supply of financial needs, but also organising and taking care of the infrastructure, the electricity supply, the harbour, the transport etc. as well as social and cultural activities such as kindergartens. In the recent decade, however, the fish-producing collective has not been able to compete on the market. Its tinned products are not sold, and the collective has had no means to buy enough fish on the market to keep up the production.

As a result, the economic base of the Pertominsk settlement has collapsed, and with it many of the services provided by the collective. At the same time, the familiar flow of people from the rural districts to the town and city centres take place. The younger, more mobile groups are leaving the settlements, seeking education and employment in larger towns elsewhere in the Province.

## 2.5 ENVIRONMENTAL AND HUMAN HEALTH MONITORING SYSTEM.

To achieve an efficient environmental protection strategy and its practical implementation, it is neccessary to have access to reliable and adequate information on the state of the environment as well as environmental impacts. The system of environmental monitoring is the main means of achieving this information. This environmental monitoring consists of a system of standardised observations with specified spatial, temporal and component recordings, as well as assessment and prediction of the state of the environment and natural resources, including their biotic components, and sources of anthropogenic impact.

The aim of the environmental monitoring is to provide information for environmental protection and ecological safety management. According to this goal, the environmental monitoring system should provide sufficient information for reliable environmental assessment from the following viewpoints:

- influence on human health
- ecological state
- suitability for specific types of use of natural resources

To achieve this aim, the monitoring system should satisfy the following objectives:

- provision of full scale, reliable and comparable information on the state of the natural environment and the sources of anthropogenic impact
- provision of compatible environmental information on the entire area, as well as neighbouring regions and countries
- development and implementation of environmental data banks and their harmonisation with the corresponding elements of international information systems;
- implementation of the unified scientific and technical policy in the field of environmental monitoring.

According to the distribution of responsibilities among the federal executive bodies in the Russian Federation, environmental and health monitoring in the different areas should be implemented by the regional authorities (Tab. 2.5.1).

It should be confessed that none of the monitoring or control systems, which are currently in operation in the Russian part of the Barents region, fully conform to the modern requirements to the environmental monitoring system. These systems are poorly inter-compatible in terms of organisation, methodology and meteorology.

Table 2.5.1 Roles of different regional authorities within a monitoring programme

| Authority | Responsibility within a monitoring programme |
|---|---|
| Ministry of Protection of the Environment and Natural Resources | inter-agency co-ordination, terrestrial ecosystems, sources of anthropogenic impact |
| Federal Service for Hydrometeorology and Environmental Monitoring | atmospheric air, fresh and marine waters, soil, radioactive pollution of the environment |
| Committee for Geological Resources | geological environment including ground waters |
| Committee for Land Resources | land resources |
| Forest Committee | forest resources |
| State Committee for Sanitary and Epidemiological Surveillance | state of human habitation, human health monitoring |
| Other regional authorities | elements of environmental monitoring connected with certain types of use of natural resources and impact on the environment |

**Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet).**

The regional branches of Roshydromet implement the main routine monitoring activities in the country. The state environmental monitoring system has been operational within the hydrometeorological service since 1972, when the USSR National Service for Observation and Control of Environmental Pollution (NSOCEP, or OGSNK in Russian abbreviations) was established.

The environmental monitoring system operates under the local branches of Roshydromet, whose boundaries do not correspond with the administrative structure of the Russian Federation (with the exception of the Murmansk branch, which operates within the area of Murmansk Province). Archangel Province is covered by the Northern Branch, with the centre in Archangel, and which includes also the Komi Republic and Vologda Province. The Republic of Karelia is included into the North-western Territorial Board, with the centre located in St.-Petersburg. The Karelian Republic's Centre for Hydrometeorology and Environmental Monitoring is established within the North-western regional branch of Roshydromet.

Murmansk Province.

Air quality monitoring is carried out at 20 monitoring stations situated in 11 cities/towns. These monitoring stations carried out a total of 10 1496 recordings in 1993. One additional monitoring station (Yaniskoski) operates as an EMEP station. A total of 22 variables are monitored. In 1994, two stations were closed (1 of 6 in Murmansk and 1 of 2 in Zapolyarny). In 1995, one new station (Maayarvi) was established within the framework of the Joint Russian-Norwegian Commission activities. Analyses are carried out by 5 laboratories. Murmansk (head laboratory), Nikel, Apatity, Monchegorsk and Kandalaksha. The head laboratory is included into the Federal inter-laboratory quality control exercise and provides inter-laboratory control for the other 4 laboratories.

Until 1994, freshwater monitoring was carried out at 56 monitoring stations situated on 36 rivers, 10 lakes and 4 reservoirs. In 1993, 1 046 samples were taken for chemical monitoring and 732 for hydrobiological monitoring, on which a total of 28 174 analyses were conducted. In 1994, due to financial constraints, three stations were closed and on a number of stations, the extent of the monitoring programme was reduced. Samples were analysed in the laboratories of the Monitoring Centre in Murmansk. Data quality is ensured by the following means:

- intra-laboratory quality control exercises
- Roshydromet inter-laboratory quality control
- intercalibration exercises

Before 1992, marine monitoring was carried out in the following regions of the Barents Sea: the open part, Kola, Motovsky, Pechenga and Teribersky Fjords and the Pechora Bay. In addition, some monitoring activities were conducted in the Norwegian and Geenland Seas, according to the USSR international commitments. At that time, the Murmansk branch of Roshydromet operated 426 monitoring stations. Observations were made in the Kola Fjord at ten day intervals. Since 1992, monitoring activities have been markedly reduced and in 1993, less than 20 % of the 1991 programme was carried out. In 1994, only one survey of the Kola Fjord was completed. At present, only the Murmansk part of the Kola Fjord and Kandalaksha Bay of the White Sea are subjected to monitoring programmes.

The local branches of Roshydromet also conduct monitoring of radioactive contamination of the environment, but information on this scheme has not been presented to the Expert Group.

Republic of Karelia. Air quality was monitored in a total of 6 cities/towns in Karelia: Kondopoga, Kostomuksha, Petrozavodsk, Segezha, Sortavala and Nadvoitsy at a total of 12 monitoring stations. Of these stations, 4 belonged to the Karelian Centre for Hydrometeorology and 8 to industrial enterprises which operated under methodological and organisational supervision of the Centre. A total of 11 variables were monitored. At present, air quality monitoring is only carried out by 3 monitoring stations in Petrozavodsk, Nadvoitsy and Kondopoga.

The acidity of precipitation is monitored at 4 monitoring stations (Kalevala, Rugozero, Petrozavodsk and Olonets) and atmospheric loads are recorded at 14 meteorological stations by snow sampling in the period of maximum precipitation.

The freshwater monitoring network in the Republic of Karelia is presented in Table 2.5.2.

Table 2.5.2 The freshwater monitoring network in Karelia

| Water bodies, programme | 1984 | 1986 | 1994 |
|---|---|---|---|
| Rivers | 33 | 24 | 25 |
| Lakes | 4 | 5 | 5 |
| Reservoirs | 5 | 5 | 5 |
| Monitoring stations | 84 | 71 | 77 |
| Samples | 616 | 577 | 649 |
| Determinations | 15 059 | 12 637 | 12 682 |

Besides chemical monitoring, hydrobiological monitoring of Lake Onega is carried out on zooplankton (26 stations, 128 samples/year) and zoobenthos (6 stations, 34 samples/year). Radioactivity (γ-radiation) is monitored daily at 25 stations. Radioactive atmospheric deposition is monitored at 3 stations (Petrozavodsk, Kalevala, Sortavala) and radioactivity of aerosols at 1 station (Petrozavodsk).

Archangel Province. In this province, air quality monitoring is carried out in 5 cities by a total of 12 monitoring stations: Archangel (6 stations), Novodvinsk (2 stations), Severodvinsk (2 stations), Koryazhma and Onega. The monitoring programme includes measurement of 14 variables. The general variables ($SO_2$, $NO_2$ and CO) are monitored by all participating stations, while specific variables are selected on the basis of the nature of pollution in the City. Sampling is carried out 3 times per day. The chemical composition of atmospheric precipitation is monitored by 16 meteorological stations.

Freshwater quality monitoring in the Province of Archangel is conducted by 50 monitoring stations situated on 26 rivers and 3 lakes. The overall hydrochemical programme includes determination of 50 variables, but each individual station determines a significantly lower number of variables. Hydrobiological monitoring is conducted in entire cross-sections of the rivers Onega, Pinega, Mezen and Pechora.

Marine water monitoring is carried out at 49 stations (Dvina, Onega and Mezen Bays of the White Sea). The White Sea Monitoring programme includes determination of 17 variables. In addition, hydrobiological monitoring is carried out at 27 of the 49 stations. It should be stressed that the marine monitoring programme was drastically reduced in 1994-1995 due to financial constraints.

γ-radioactivity is monitored by 40 stations on a daily basis, while β-radioactivity is monitored at 17 stations.

The Roshydromet environmental pollution monitoring network is integrated with the meteorological and hydrological network. This integration creates good opportunities for environmental assessment. At the same time, it should be confessed that these opportunities are not used by the regional branches of Hydromet, and the information provided is usually limited by the level of data compilation.

General comments. The regional branches of Roshydromet are part of the Federal service and obtain finance from the federal budget. At present, according to the information from the

Roshydromet authorities, a maximum of 20-25 % of the organisation's financial requirements are covered, and this only in a very irregular manner. Lack of financing creates problems for the stable operation of the network. Both federal and territorial levels of the Service have joint financing of all activities without specification of what part of the available finances should be allotted to environmental monitoring. As a rule, in conditions of financial restraints, budget cutbacks primarily affect monitoring activities.

The federal environmental monitoring network is operated independent of information from local environmental protection activities. The federal budget covers (to certain extent) only federal objectives of the monitoring system (preparation of yearbooks, informational documents for the Government etc.). This monitoring network often causes conflict between local environmental protection authorities and the various branches of Roshydromet. Lack of local financial support to the province/republic monitoring systems leads to technical degradation. At the same time, for local environmental protection, more detailed and operative information is required for efficient remedial actions.

**Regional bodies of the Ministry of Protection of the Environment and Natural Resources.**

According to the distribution of responsibilities, the regional executive bodies of the Ministry of the Environment (Committees for Environmental Protection of Murmansk and Archangel Provinces and the Republic of Karelia) are directly responsible for the monitoring of terrestrial ecosystems and sources of anthropogenic impact.

Based on the Russian environmental protection regulations, monitoring of contaminant sources should be provided by the polluting bodies, under the control of the local environmental protection authorities. Most of the large-scale polluting bodies have their own laboratories or analytical groups which monitor their emissions and discharges. Unfortunately however, a large number of pollution sources do not have any system of instrumental monitoring of their emissions and discharges, and these organisations document their impacts to the environmental protection authorities in the form of statistics based on evaluations. For example, 378 industrial enterprises of Archangel Province which are controlled by the Environmental Committee, have a total of 12 857 point sources of gas emissions and only 923 of them are instrumentally controlled.

To ensure the effectivity of controls, the local environmental authorities established their own analytical laboratories which are generally better equipped than Roshydromet monitoring laboratories financed from the federal budget. The main disadvantage of the existing monitoring systems is poor inter-compatibility between the different components which monitor the state of the environment and those which monitor environmental impacts.

Monitoring of terrestrial ecosystems is only at the initial stage of its development and cannot yet be considered as a routine system. Most of the activities are based on natural reserves and the Ministry of Environment did not develop guideline documents which regulate the operation of this monitoring sub-system.

## State Automated Information System 'Health' (AGIS 'Zdorovye').

The state Automated Information system 'SAIS-Health' was established in Russia in a step-by-step manner. The system is based on information compiled on the following topics:

- morbidity
- mortality
- pregnancy and birth pathology
- environmental pollution

The objectives of the programme is to monitor human health in relation to the state of the environment. State-of-the-art of the system is shown below using the example of Murmansk Province. SAIS-Health include three cities of Murmansk Province; Murmansk, Monchegorsk and Kandalaksha. The sanitary inspection centres in these cities collect monthly data on human health (morbidity, mortality and birth rate) as well as atmospheric pollution.

Information on morbidity is received from the following sources:

- adult populations, based on medical clinic records and sick-leave certificates
- child populations, based on statistical documents
- mortality, based on registry statistics

Characteristics of atmospheric pollution based on data obtained by stationary monitoring stations are presented monthly by the hydrometeorological service. Information on diseases is processed, coded according to international classification on disease, injuries and causes of death and grouped according to age and sex. After this, the information is tabulated and sent to the State Committee on Sanitary Inspection in Moscow for final processing, i.e. an information is mostly just accumulated without further use.

The deficiencies of the system may be summarised as follows:

- due to lack of computer facilities and corresponding software, there is no possibility to provide computerised local data processing
- information provided by the hydrometeorological service is not sufficient to allow comprehensive assessment
- the reliability of statistical morbidity data is generally low

The monitoring sub-systems described are the main components for establishment of a joint environmental and human health monitoring system. Among the general deficiencies of the existing monitoring system the most important are as follows:

- there is no legislation and economical mechanism of operation of the existing systems, which belong to different executive bodies, within one monitoring system;
- the existing monitoring networks are not designed to satisfy informational needs for environmental protection activities especially on local level
- existing monitoring systems do not ensure inter-comparable data of the state of the environment and the sources of anthropogenic environmental impact. This is required for effective detection of impacts and carrying out impact assessment studies.
- the monitoring networks have poor technical capacity, data quality control system and methodological basis.

The experts concluded that measures to eliminate the above drawbacks shouls precede technical improvement of the monitoring networks. In addition, an efficient monitoring system should be organised, based on joint organisation and methodology.

Taking into consideration the fact that there is a high concentration of potential sources of radioactive contamination in the region, particular attention should be paid to radioactive monitoring, including automated monitoring systems of the main sources. Radioactivity should be a sub-system of the regional integrated environmental and human health monitoring system.

# CHAPTER 3 SUMMARY TABLES OF ALL PROJECTS

This chapter lists all 66 project proposals (24 from Murmansk Province, 17 from the Republic of Karelia, 18 from Archangel Province, 1 general project and 6 projects concerning indigenous and traditional populations) prepared by the AMAP Expert Group. The projects recommended for Phase II of the NEFCO-Programme are presented in more detail in Chapter 4.

The identification of the 66 project proposals is based on the information on environmental and health issues, which has been available to the AMAP Expert Group (Chapter 2). The main source of information has been in the form of documents presented by the regional environmental authorities, but other papers and reports, both Russian and international, have also been used.

The project name and the location is given in the first column of the tables, while column two states the 'problem' (most often the type of pollution emission or discharge). Column three briefly describes the effect(s) caused by the emissions, whether these be environmental or human health problems, or both. Column four presents possible actions or other comments. It is emphasised that the actions suggested are to be regarded as possible actions presented to or identified by the Expert Group during Phase I, and that more complete studies may suggest other solutions.

Reference number

Column 5 contains the unique reference number for the project. The projects are numbered within each issue of concern (1 - 10, see Chapter 1 for explanation).

The first character of the reference number identifies to which part of the Barents Region the project belongs, i.e. M for Murmansk Province, K for the Republic of Karelia and A for Archangel Province including Nenets AA. The projects concerning the Barents Region in general is assigned the letter G. The first figure reflects which issue of concern the project is classified under and the second figure is the given project number. The numbering system does not reflect any priority among the projects, e.g. the projects M51 and M53 are both located in Murmansk Province, and both deal with issue no 5: solid waste and the projects have equal priority.

Table 3.1 Summary of projects concerning Murmansk Province.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| The Pechenganickel smelters in Nikel and Zapolyarny; reduction of $SO_2$ emissions and waste water discharges. | Gas and dust emissions, of which the annual $SO_2$ emissions of 200 000 tonnes are consideredto be the most serious.<br><br>The smelter produces 27.2 million $m^3$ of waste water annually, which is discharged into Lake Alla-Akka-Yarvi and the rivers of Pechenga County, causing severe contamination. | The $SO_2$ emissions contribute to acidification of fresh waters and soil, elimination of fish stocks, and destruction of forests and vegetation in the vicinity of the smelters. The emissions have negative effects on large parts of the Kola peninsula, as well as parts of northern Finland and Norway. Human health in the vicinity of the discharges is also negatively affected.<br><br>The contamination of the surface waters also affects the Pechenga River, which in the past used to host a large spawning stock of Atlantic salmon. Ground water has become contaminated due to filtration. | Introduction of modern 'environmentally-friendly' production technology, along with implementation of improved cleaning procedures and equipment to reduce the emissions of gas and dust, as well as the waste water discharges.<br><br>The Pechenganickel smelters are the target of Norwegian-Russian-Finnish joint projects, and it is anticipated that financial solutions are underway. The project is therefore not a main target of the NEFCO-AMAP initiative. | M31 |
| The Severonickel smelter in Monchegorsk; reduction of $SO_2$ emissions and waste water discharges. | Gas and dust emissions, of which the annual $SO_2$ emissions of 100 000 tonnes, are considered most serious.<br><br>Annually, the plant discharges 24.5 million $m^3$ of insufficiently treated waste water into lakes Imandra and Nudyarv. Discharges of nickel and copper causine the most serious problems. | The emissions of $SO_2$ cause severe local impacts, and long range atmospheric transport mechanisms distribute the emissions to large areas of the Arctic, causing acidification of fresh waters and damage to forest ecosystems. The emissions further increase respiratory diseases in humans in the vicinity of the plant.<br><br>Peak nickel concentrations of up to 5.6 mg/l have been measured in River Nyuduay, whose eco-system is almost entirely destroyed. Strong negative impact on Imandra lake. | Introduction of modern 'environmentally-friendly' production technology along with implementation of improved cleaning procedures and equipment to reduce the emissions of gas and dust, as well as waste water discharges. | M32 |
| Kandalaksha aluminium plant, reduction of gas emissions and waste water discharges. | Local air pollution, emissions of benzo(a)pyrene, carbon monoxide and hydrogen fluoride to air, plus an annual discharge of 41.5 million $m^3$ of waste water. | The emissions deteriorate air quality and contaminate drinking water sources. The major specific air pollutant is fluoride, which may cause increased human morbidity. | The benzo(a)pyrene and air-borne fluoride emissions from the plant should be amended by installation of 'clean technology' equipment. | M33 |
| The iron ore plant in Kovdor, reduction of gas emissions and waste water discharges. | Annual discharges of 36.5 million $m^3$ of waste water containing iron, sulphate and chloride. Among the air-borne emissions are dust and benzo(a)pyrene. | Water quality in Lake Kovdor and the River Kovdora is negatively affected. | Installation of waste water treatment equipment at the plant. This project could also be implemented at the iron ore plant in Olenegorsk | M34 |
| Murmansk City waste incineration plant. | The annual emissions of the plant includes large quantities of lead, zinc, cadmium and a number of other heavy metals, benzo(a)pyrene and dust. Elevated levels of mercury in the air in Murmansk possibly also originate from the waste incineration plant, processing 100 000 tonnes of communal waste annually. | The plant is located in the northern part of Murmansk City, exposing a large number of people to the gas emissions. | Installation of filtering/cleaning devices at the plant. Sorting of the material brought to the plant before incineration will make it possible to remove components which are known to produce poisonous compounds on combustion. This will also stimulate extensive recycling of valuable waste, which is currently burned. | M35 |

Table 3.1(cont.) Summary of projects concerning Murmansk Province, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| **Improvement of Murmansk City water supply system.**<br><br>M41 Construction of communal waste water treatment system in the town of Kildinstroy.<br>M52 Treatment of faeces and effluents from the Murmanskaya (or Snezhnaya) poultry farm (Kola River water shed).<br>M53 Treatment of faeces and effluents from the Prigorodny pig farm (Kola River water shed).<br>M42 Improve the plants for treatment of household water in Murmansk City.<br>M43 Improve the distribution system for household water in Murmansk City. | There is high waste-water loading of the Kola River, which is the main source of household water in the cities of Murmansk and Kola. The most significant contributors are the town of Kildinstroy (10 000 inhabitants), the Prigorodny pig farm and two poultry farms in the vicinity of Kildinstroy. The water supply system has inadequate treatment procedures, and the pipeline network is weak. | Almost 15 % of the tap water samples in Murmansk City do not conform to sanitary requirements.<br><br>The Kola River contributes to the organic overloading of the inner parts of the Kola Fjord. | A project is in operation on the Prigorodny pig farm within the framework of the 'Priroda' project between Murmansk Province and Finnmark County (Norway).<br><br>Plans have been made for construction of waste treatment facilities for the Murmanskaya poultry farm, but due to financial problems, the plans have not been implemented. | M41<br>M42<br>M43<br>M52<br>M53 |
| Improvement of Monchegorsk City water supply system. | Surface water, contaminated by the heavy metal depositions from the Severonickel smelter is used as a source of household water. The drinking water supply system has no treatment facilities. | Poor drinking water quality causes increased morbidity, particularly among children. | A preliminary study has been fulfilled under the Finnish-Russian co-operation programme. Two alternatives were suggested:<br><br>Construction of water treatment plant<br>Development of ground water supply system with preceding survey of ground water resources in the Monchegorsk area. | M44 |
| Improvement of waste water treatment at the 'Sevredmet' enterprise in Lovozero County. | This enterprise is the main polluter of fresh waters in Lovozero County, which currently has the lowest drinking water quality in the Province. | The recipient water bodies are affected by discharges, which have increased the fluoride concentrations to mean annual values of up to 3.5 MAC. | Waste water treatment facilities are overloaded and do not ensure required treatment levels. Approximately 55 % of waste waters are discharged without any treatment. | M45 |
| Improvement of the waste water treatment at the 'Apatite' industrial association in Kirovsk. | This enterprise annually discharges 137 million $m^3$ of insufficiently treated waste water into River Belaya, which flows into Lake Imandra. | The River Belaya and lake Imandra are affected by high levels of pollution, particularly fluoride. | Approximately half the waste water is treated to a standard level. The rest is discharged in an insufficiently treated state. | M46 |

Table 3.1(cont.) Summary of projects concerning Murmansk Province, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Establishment of a system for treatment of non-radioactive hazardous waste in Murmansk Province. | Lack of a hazardous waste handling system, including inefficient control-system. The wastes are accumulated at the plant sites, transported to the communal rubbish-heaps or illegally dumped in the countryside. | The uncontrolled handling of hazardous waste constitutes a threat to both the environment and the persons handling the waste, as well as to human health in general. | Legislations should support the development of profitable re-use of as many waste components as possible. The question of responsibility for handling the produced waste must be decided, as well as transport costs and treatment of the different types of waste.<br>The environmental protection authorities in Murmansk developed proposals for construction of a treatment plant, but further development was halted due to lack of funding. | M51 |
| Removing scrapped ships from the Kola Fjord and recycling of the metal. | More than 100 scrapped ships have been dumped along the shores of the Kola Fjord. These wrecks contain a large amount of recyclable metals. | Leakage of oil and pollutants from wrecks has been observed, but the problem is mainly aesthetic. | Develop technology and infrastructure for commercial recycling of the metals and other re-useable compounds from the scrapped ships. | M54 |
| Improve the treatment of municipal waste water discharged into the Kola Fjord<br><br>M61 Murmansk City, the northern treatment plant<br>M62 Murmansk City, the southern treatment plant<br>M63 Severomorsk City treatment plant<br>M64 Kola City treatment plant | More than 80 % of the total amount of waste water from Murmansk City is discharged without any purification. The waste water from Severomorsk City is discharged untreated. | Organic overload of the Kola Fjord has in several places seriously affected marine life, and oxygen depletion has been observed in the bottom water layers of the Fjord. | Treatment plants must be established. In Murmansk City, plans have been developed and construction started, but been halted due to lack of funding. | M61<br>M62<br>M63<br>M64 |
| Decomposition plant for organic waste from fish factories in Murmansk City | There are no existing facilities for proper treatment of organic waste from fish factories, leading to major discharges of organic material to the Kola Fjord. | Organic overloading of the Fjord has seriously affected marine life in several areas, and oxygen depletion has been observed. | Improvement of procedures and production technology at the plants. The plant Sev. Palmira could act as pilot project due to large discharges of fats. Establishment of a closed system for waste water and construction of a decomposition plant. | M65 |
| Collection and cleansing of shipyard effluents in Murmansk | Heavy metals and hazardous compounds arising from anti-fouling paints etc. are released during sand blasting and ship maintenance. | Sediments and biota in the Kola Fjord are contaminated by components released from the shipyards. | 1) Identification of the most significant sources.<br>2) Installation of collection or cleansing devices for discharged waste water and effluents at the shipyards. | M66 |
| Receiving and handling facilities for waste from ships. | Most harbours in the area do not have satisfactory facilities for receiving and handling both liquid and solid waste from ships. As a result, this waste is dumped along the sailing routes. | Discharges of oil-containing waste from ships has led to contamination of waters, sediments and the coastal zone along sailing routes. | Satisfactory facilities for waste collection from ships in harbours and at docks should be available along the major waterways in the entire Barents Region. | M67 |
| Improvement of the forestry economy and sustainable use of forest resources. | Uncontrolled and uncoordinated logging of forests has negative environmental and economic consequences. | Mismatch between logging and regrowth, has led to ineffective use of forest resources. | Introduction of modern forest management. Establishment of a logging budget for different forest areas, balanced with replanting and regrowth rates. | M71 |

Table 3.1(cont.) Summary of projects concerning Murmansk Province, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Energy saving and reduction of the air-borne emissions from the Southern heating and power plant in Murmansk City. | The efficiency of the Murmansk heating and power plants and the energy network is low, and considerable amounts of energy are wasted.<br><br>The heat and power plants are responsible for 45 % of the gas and dust emissions in Murmansk City, the most important of these being $SO_2$, NOx and PAH. The southern plant is the main contributor among them. Using today's technology, the planned expansion of this plant will cause a significant increase in emissions. | The prevailing winds in the winter season transport the emissions of the plants to living quarters, causing respiratory and other health problems for the population as well as affecting the urban environment. | In connection with the planned expansion of the southern heat and power plant, this plant may serve as a pilot project for introduction of modern techniques and methods and in this way reduce energy consumption as well as gas emissions.<br>1. Inventory of the state of the heat production units and networks in the Murmansk City area.<br>2. Masterplan for energy saving and heat production in the Murmansk City area.<br>3. Selection of one pilot unit and network in the Murmansk City area. The southern power and heating plant may serve a pilot project.<br>3.1 Inventory of the renovation needs in the plant and network.<br>3.2 Renovating the plant and the combined network.<br>3.3 Training programme for the local personnel | M101 |

Table 3.2 Summary of projects concerning the Republic of Karelia.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Segezha pulp and paper mill, reduction of gas and dust emissions and waste water discharges | The state of the environment in the Segeza-Nadvoitsy area is very poor, as a result of heavy pollution of both air and waterways.<br><br>The pulp and paper mill has major emissions of $SO_2$ (25 000 tonnes in 1992), dust (20 000 tons in 1992) as well as odorous compounds.<br><br>A total of 36 000 m³/day (1992) of untreated waste water is also discharged. | In Segezha, the levels of $SO_2$, dust and odorous compounds grossly exceed the MAC. Waste water discharges have caused severe environmental effects in Lake Northern Vygozero, where the levels of a number of contaminants (such as lignin, phenol acid, resinous acid) in winter are up to 10 times higher than natural values. The mill is responsible for 90 % of gas emissions and almost 100 % of the discharges of contaminated waste water in the town of Segezha. High concentrations of specific sulphur-containing pollutants severely affect the environment and human populations in particular. Due to polluted waste waters from the mill, Lake Vygozero suffers from oxygen deficits to total absence of oxygen, with the formation of dead zones. | An integrated solution to the problem of reducing emissions and discharges, based on the use of modern technology, is recommended<br><br>Reconstruction of the mill, in cooperation with the Finnish Company 'Alstrem', was halted due to lack of finances. An application to the Russian Government for financial assistance was not supported. | K31 |
| Nadvoitsy aluminium plant, reduction of gas and dust emissions and waste water discharges. | The aluminium plant emitted more than 4 000 tonnes of dust (fluorides, resins, dust ash etc.) and close to 10 000 tonnes of gasses and liquid substances (1992). There is no satisfactory storage for the solid waste. | The emissions to air and water have severe effects on air quality as well as surface and ground water resources. There are very high levels of fluoride in drinking water and a there is a high rate of fluorosis in the population (84 % of children). | There are ready made plans to introduce improved processes and clean technology, which will reduce future waste problems. This modernisation will also reduce energy consumption.<br>The on-going cleaning up of the waste water reservoir and the waste dump site should be continued. | K32 |
| Construction of industrial gas treatment facilities at the Petrozavodsk heat and power plant. | The plant is responsible for almost 50 % of industrial gas emissions in the City. The plant emits gasses without any prior treatment. | Annual emissions of almost 14 000 tonnes of $SO_2$ causes acidification of the surrounding environment and increased incidences of human respiratory diseases. | | K33 |
| Construction of industrial gas treatment facilities at the Onega tractor plant in Petrozavodsk. | The plant emits 95 % of all gasses produced at the plant without treatment (more than 1 200 tonnes of contaminants). The plant is responsible for air contamination by phenols (up to 6 MAC) and other specific contaminants. | Increased respiratory problems in the vicinity of the plant. | | K34 |

Table 3.2 (cont.) Summary of projects concerning the Republic of Karelia, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Kostamuksha iron pellet plant 'Karelsky Okatysh', reduction of waste water discharges and industrial gas emissions. | Kostamuksha emitted 48 137 tonnes of $SO_2$ in 1994 (41 % of total emissions in Karelia). The reservoir for waste water and sludge is overfilled and the waste penetrates into the watershed used for drinking water. | The $SO_2$ emissions cause acidification and damage to the forests; as well as human respiratory problems. The most urgent problem is to prevent the waste water from penetrating into the waterways, thereby contaminating the drinking water and aquatic life in the City of Kostamuksha and downstream areas. | A cleaning programme has started, implemented in co-operation with Finland and including installing of modern technology to reduce the gas emissions.<br><br>However, multiple international efforts to solve the problem have so far not produced visible results. | K41 |
| Kondopoga pulp and paper mill, waste water treatment and gas and dust emissions. | The mill discharges 55 million $m^3$ of polluted waste waters into Lake Onega annually. Air-borne emissions comprise 83 % of the total emissions in the City (22 000 tonnes annually). | The discharges cause oxygen deficit and eutrophication in Kondopoga Bay. | Installation of new, cleaner process technology at the plant. | K42 |
| Improvement of drinking water supply and communal sewage system in Petrozavodsk | Municipal sewage system is responsible for 98 % of waste waters of the City, of which the majority are insufficiently treated. The water supply intake site is situated 8 km from the sewage discharge site in Lake Onega. | Water treatment does not ensure adequate water quality, including bacterial contamination. The quality of the pipeline network is one of the poorest in Karelia. Poor tap water quality increases the population morbidity, and the waste waters cause eutrophication of lakes and rivers of the Republic. | The problem requires complex measures:<br><br>• new water extraction site<br>• efficient water treatment<br>• renovation of the pipeline network<br>• improvement of sewage treatment efficiency | K43 |
| Water management in a number of smaller towns in Karelia.<br><br>K44 Medvezhyegorsk town<br>K45 Pudozh town<br>K46 Suoyarvi town<br>K46 Sortavala<br>K48 Kalevala | A major part of the household water is taken from contaminated surface water and the treatment of the drinking water is generally poor. The condition of the pipeline network is also weak. Ground water technology is not used in the area. | The poor quality of household water is considered to be one of the most serious problems connected to human health. | This problem is typical for small towns in Karelia. One of these issues can be used as a pilot project to install modern technology with a low treatment capacity.<br><br>The actions could include:<br>• Reduction of the discharges of polluted waste water and sewage by establishing more efficient treatment plants.<br>• Improved treatment of household water.<br>• Inventory and exploitation of ground water resources.<br>• 'Systematic renewal and modernisation of water supply networks. | K44<br>K45<br>K46<br>K47<br>K48 |
| Construction of non-radioactive hazardous waste treatment plant in the Republic of Karelia. | Lack of handling system for hazardous waste, and inefficient control-system. Wastes are accumulated at the plant sites, transported to communal rubbish-heaps or illegally dumped in the countryside. | Uncontrolled waste handling constitutes a threat to both the environment and persons handling the waste, as well as to human health in general. | The legislation must support the development towards profitable re-use of as many waste components as possible. The question of responsibility for handling the produced waste must be resolved, as well as the costs of transport and treatment of the different types of waste. Systems for separating hazardous waste from other solid waste and treatments plants for hazardous waste should be established. | K51 |

Table 3.2 (cont.) Summary of projects concerning the Republic of Karelia, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Sewage sludge treatment in Petrozavodsk City. | Large quantities of sewage sludge from the Petrozavodsk sewage treatment plant causes waste problems at dumping sites. The sludge is contaminated by heavy metals, and therefore cannot be used as agricultural fertiliser. | There is accumulation of sewage sludge awaiting disposal, and the sewage sludge at the dump sites causes environmental contamination of the general environment and the water bodies in the vicinity of the dump sites. | Establishment of more organised and controlled dumping sites.<br>A utilisation programme for alternative sludge treatment after separation of the contaminants from the sludge, may be developed, such as composting, pelletising for forest fertiliser, energy production by incineration in industry. | K52 |
| Municipal waste management in Petrozavodsk City. | Unorganised waste management. | Pollution risks. | Actions such as those listed below, may be considered:<br>- renewing the container/ vehicle system.<br>- introducing a new collection system for waste paper.<br>- introducing bio-waste separation and treatment.<br>- remedial actions at the municipal landfill.<br>- waste treatment plant. | K53 |
| Artificial rearing of Atlantic salmon (*Salmo salar*) in the Karelian part of the White Sea, in order to increase the stock of salmon in the Karelian rivers. | Decreasing salmon stocks in the White Sea mostly caused by damming, over-exploitation and pollution. | Increasing salmon stocks will improve the income of local fishermen, reduce the unemployment and improve the social conditions. | Reduction of the pollution in the main salmon rivers.<br>Construction of hatchery and rearing plant<br><br>Pilot project: The River Keret. | K61 |
| International training and research station in Pongoma, White Sea. | Lack of facilities for education and training of scientific and governmental staff. | By raising the educational level of the staff, the monitoring of natural resources and the environment will improve. | Building and running an international research and training centre in Pongoma. | K62 |

Table 3.3 Summary of projects concerning Archangel Province including Nenets autonomous area

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Reduction of gas emissions from heat and power plants. The two major contributors are:<br>A31 Archangel heat and power plant<br>A32 Severodvinsk heat and power plant. | The heat and power plants are major emitters of $SO_2$ and other gasses. The plants are each responsible for 1/3 of all gaseous emissions in Archangel (total $SO_2$ emissions in 1992: 33 700 tonnes/year) and Severodvinsk (total $SO_2$ emissions in 1992: 47 400 tonnes/year). | These emissions cause damage to forest and plants, increase acidification and affect human health. | Change of process technology, treatment of emissions. | A31<br>A32 |
| Drinking water supply in Archangel 'megapolis'<br>A42 Drinking water supply in Archangel City.<br>A43 Drinking water supply in Novodvinsk City. | The water supply for the two cities is currently taken from the Northern Dvina, which at the same time is used as a recipient for industrial waste, sewage, waste water etc. The water is only poorly treated, and the pipelines are of an unsatisfactory quality. | The poor drinking water quality gives rise to a variety of human health problems (diseases, infections etc.) and causes great problems for the food processing industry. | Establishment of improved treatment of household water, combined with reduction of the pollution in the River Dvina and renewal of the pipeline system.<br>Another possibility is exploitation of underground water deposits south of Archangel. | A42<br>A43 |
| Reduction of organic run-off from dairy plants. Pilot project: Kargopol dairy plant. | The organic waste from dairy production is discharged into the River Onega. | The discharges pollute the River Onega with organic matter, leading to eutrophication and bacterial contamination of the watershed. | Installation of modern equipment in process and cleaning devices. | A44 |
| Reduction of organic run-off from the Mezen dairy plant and meat factory. | The organic waste from milk and meat production is discharged untreated into countryside surrounding the plant. | The waste contaminate the surface water bodies and presents a major hygienic problem in the vicinity of the plant. The waste has further penetrated into the ground water. | Installation of modern equipment in process and cleaning devices | A45 |
| Archangel pulp and paper mill in Novodvinsk; reduction of waste water discharges and gas and dust emissions. | Insufficient treated waste water is discharged from the plant into the Northern Dvina River. The major contaminants are lignosulphates, formaldehyde, methanol, mercury and dioxin. Vast quantities of organic matter are also discharged.<br>The pulp and paper mill in Novodvinsk contributes 99 % of all gas emissions in Novodvinsk. | The discharges are a major polluter of the Dvina River and thereby of the drinking water in the City of Archangel, which is taken from the River. The discharges also have a negative effect on aquatic life in general.<br>Archangel and Novodvinsk are some of the most air polluted cities in Russia. Particular attention should be given to very high concentrations of methylmercaptane | Reduction of the discharged waste water and gas and dust emissions by:<br>1) Replacement of outdated equipment and introduction of modern production methods.<br>2) Installation of cleaning facilities for the waste water and the gas and dust emissions.<br>The plant has developed a plan for environmentally sound reconstruction and had preliminary agreements with Nordic companies, which are not being implemented due to financial problems. | A46 |

Table 3.3 (cont.) Summary of projects concerning Archangel Province including Nenets autonomous area, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Solombola pulp and paper mill in Archangel City; reduction of waste water discharges and gas and dust emissions. | The discharges from Solombola pulp and paper mill cause contamination of the water in the Northern Dvina.<br>The pulp and paper mills contribute to the poor air quality in Archangel City by producing 11 % of the total emissions in the City, including a major part of specific pollutants. | The discharges contribute to negative environmental conditions in the Dvina Estuary. During high water, the water in the estuary may be transported many kilometres upstream in the River Dvina. | Reduction of the discharged waste water and gas and dust emissions by updating and replacing process- and cleaning equipment. | A47 |
| Kotlas pulp and paper mill in Koryazma; reduction of waste water discharges and gas and dust emissions. | The discharges from Kotlas pulp and paper mill cause contamination of the upper parts of the Northern Dvina River.The mill is responsible for poor air quality in Koryazhma | The discharges are the major source of pollution of the upper Dvina River and seriously affect the ecosystem in this part of the River. The gas emissions negatively affect the environment and human health in Koryazma. | Reduction of the discharged waste water and gas and dust emissions by updating and replacing process- and cleaning equipment | A48 |
| Construction of a non-radioactive hazardous waste treatment plant in Archangel Province. | Lack of a proper system for handling of hazardous waste, and an inefficient controll system. Wastes are accumulated at the plant sites, transported to the communal rubbish heaps or illegally dumped in the countryside. | The uncontrolled handling of waste constitutes a threat to the environment as well as to humans handling the waste, and to human health in general. | Archangel environmental protection authorities developed proposals on construction of the plant, but further development was halted due to lack of finances. | A51 |
| Sewage sludge treatment in the cities of Archangel and Severodvisk. | Large quantities of sewage sludge from the Archangel and Severodvinsk sewage treatment plant cause waste problems at dumping sites. | Pollution risks in the Dvina River, other surface water and in the groundwater at landfill sites.<br>The sludge contains high levels of heavy metals. | Establishment of more controlled dumpsites.<br>A utilisation programme for alternative sludge treatment after separation of the contaminants from the sludge, may be developed, such as composting, pelletising for forest fertiliser, energy production by incineration in industry. | A52 |
| Municipal waste management in the cities of Archangel and Severodvisk. | Unorganised waste management. | Pollution risks | Actions such as listed below, may be considered:<br>- renewing the container/ vehicle system.<br>- introducing a new collection system for waste paper.<br>- introducing bio-waste separation and treatment.<br>-remediation of the municipal landfill.<br>- waste treatment plant. | A53 |
| Handling of solid waste in Nenets Autonomous Area. | There is no satisfactory system for handling and storage of waste in Narjan-Mar. | The waste causes contamination of surface and ground water at the dumping sites in Narjan-Mar. Drinking water sources are particularly threatened. | Establishment of proper storage and treatment facilities for municipal waste. Establishment of a separation system for hazardous and other wastes. | A54 |

Table 3.3 (cont.) Summary of projects concerning Archangel Province including Nenets autonomous area, continued.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Removal of sunken timber from the mouth of the Pinega River (junction of rivers Pinega and Northern Dvina is some 80 km east of Archangel City). | The rivers in Archangel Province were heavily used for transportation of timber for many years. A high percentage of the timber is lost during floating. As well as being a waste of valuable resources, this increases the organic loading of the river and in some case impedes river navigability. | The sunken timber strongly contributes to the organic loading of the river. This sunken timber traps sediments and reduce the original speed of water flow. This changes the ecosystem of the river and may destroy the whitefish spawning grounds. | Clean-up of the river by collection and removal of sunken timber.<br>Introduction of more efficient rafting of timber will reduce the problem in the future. The clean-up will in the long run help restore the natural whitefish spawning grounds, however, on short terms, a removal of the sunken timber may release quantities of trapped sediments. | A55 |
| Run-off from waste from large collective meat producing farms (pigs, chickens or cattle).<br><br>Pilot project: Konosha piggery complex. | A complex containing 50 000 pigs produces more than a million $m^3$ of extremely contaminated waste water as well as sludge and solid fractions up to 1 920 tonnes/year. There are no proper waste treatment facilities. | At present, the wastes are dumped on sludge areas. Rain and thawing increase leakage to the river, which also serves as a main drinking water resource for the district. This results in environmental pollution and poor drinking water quality. | Construction of a waste treatment system with separation of solid fractions and a biological treatment plant for separated waste water. A bio-gas production unit could be established as a part of the system. | A56 |
| Restoration of whitefish stocks in the Northern Dvina. | Declining whitefish stocks in the North Dvina. This decrease is due to the combined effects of the use of the River for timber rafting, which over the years has altered the ecosystem of the River, as well as increased pollution and overfishing. | The previously very abundant Dvina whitefish species are in the process of becoming very rare. The current harvest of whitefish is much less than in previous years. This causes reduced income to the fishermen. | Establishment of a reproduction plant for whitefish.<br>Reduce the pollution of the Dvina River, in order to improve the conditions for the whitefish stocks. | A66 |
| Preservation of virgin north taiga forest in Mezen county. | Intensive economic development of adjacent areas cause strong antropogenic impact on the largest virgin north taiga forest in Europe. | The antropogenic impact decreas the biological diversity of this unique forest biotope. | Establishment of a reservation to preserve the untouched northern taiga forest in parts of the Mezen county. A program for forest monitoring and reconstruction should be implemented | A71 |
| Forest and land rehabilitation along rivers. | Over-exploitation of forest resources along the rivers. | Over-exploitation of the forest resources along the rivers, and neglecting the need for replantation has led to soil erosion along the river banks. | Replantation of deforested areas is recommended to reduce the washing out of valuable soil to the rivers. Different species of trees must be selected, according to the severity of the erosion. In agricultural areas, the replantation of the river banks will increase the water-transportation capacities, due to reduced growth of aquatic macrophytes. A pilot stretch of river should be selected in co-operation with the environmental committee of Archangel Province. | A72 |

Table 3.4 Summary of projects concerning indigenous and traditional populations.

| Project name | Problem | Environmental and health impacts/effects | Possible action/comments | Ref. no |
|---|---|---|---|---|
| Water supply in the town of Lovozero. | The household water is contaminated by municipal sewage and industrial waste. The water supply system has no sufficient treatment, and the pipeline network is weak | Lovozero village has the worst drinking water quality in Murmansk Province. Almost 70 % of samples analysed do not meet water quality requirements on chemical variables. The contaminated drinking water is affecting human health | 1) Inventory of ground water resources. Development of ground water supply if resources are discovered.<br>2) Planning and implementation of a new pipeline system for household and municipal waste water<br>3) Improvement of the waste water purification plant | M81 |
| Ecotourism carried out by the indigenous people | The economical potential of modern ecotourism is not yet fully exploited, and the needs of the local and indigenous populations must be satisfied. | In many areas, ecotourism by western tourists offers a great potential in. This growing business should be developed in co-operation with the local and indigenous populations. | Production and marketing of products; development of a training programme for different parts of the ecotourism concept such as marketing, production of handicraft, angling, sustainable exploitation of natural resources. | M82 |
| Improvement of the quality of reindeer meat | Poor hygiene during handling of reindeer meat causes reduction in quality and nutritional value, which also reduces the sales profit. | Reindeer meat is the major source of nourishment of indigenous people in the area, and poor quality of reindeer meat has negative health effects as well as reducing the sales profit | Introduction of slaughterhouses and other facilities with high hygienic standards and satisfactory storage and transportation routines. | M83 |
| Improvement of environmental aspects of human health of the Nenets population<br><br>Pilot project: The settlement of Nelmin Nos | In this settlement, there is a lack of pure drinking water, and the inhabitants obtain inadequate nutrition. Food availability is to a great extent dependent upon supplies from outside, and in a poor economical situation, these supplies are insufficient. | Human health is negatively affected by the harsh living and environmental conditions in the village of Nelmin Nos. The population suffers a high mortality rate and a general low life expectancy. High unemployment rates, crime, alcoholism etc. are prevalent. | - Establishing of a constant supply of drinking water of good quality.<br>- Increasing the use of natural resources, especially a more optimal use of local fishery and reindeers resources.<br>- Improvement of housing and medical service. | A81 |
| Drinking water and sewage treatment in small villages.<br><br>Pilot project: Kenozero National Park | This is a general problem in the entire Barents Region. Surface water polluted by sewage and waste water is used as household water. | Penetration of sewage and waste water into the watersheds used for drinking water causes increased incidences of disease. | Developing of local-scale, simple technology and operational systems to handle waste and sewage separately from drinking water.<br>Establishing of wells, pipelines and treating plants with sufficient capacity to supply the villages with high quality water.<br>A good operational system should be developed and introduced as a pilot project. | A82 |
| Improvement of environmental aspects of human health in the traditional pomor population.<br>Pilot project: The settlement of Pertominsk | The economy of the settlement is based on a fishing co-operative which in the recent years have been partly out of work. There is a lack of pure drinking water and the settlement is dependent on food supplies from outside. | Human health is negatively affected by the harsh living conditions in the village of Pertominsk. | Establishment of a steady supply of drinking water, improvement of housing and medical services and optimisation of natural resource utilisation. | A83 |

Table 3.5 Summary of projects concerning the entire Barents Region.

| Project name | Problem | Environmental and health impacts/effects | Possible action/Comments | Ref. no |
|---|---|---|---|---|
| Installation of oil-skimming tanks in drainage outlets in harbours | Severe oil pollution in the harbours has been observed. | Fish and shellfish are contaminated and the harbour in general is affected by oil products. | Establish a system (infra-structure and technology) for collection of oil and oil products from a large number of outlets.<br>Pilot project: Oil pollution has been observed in Kola Fjord, thus making this area highly relevant as a pilot area. | G61 |
| Integrated environmental and human health monitoring system | Environmental and human health monitoring in Russia is at present not properly integrated, although authorities are aware of the most severe problems in this context. Environmental monitoring as well as human health monitoring committed by several governmental and local authorities and institutes have a very weak international computability. The monitoring network has generally poor laboratory equipment, QA/QC systems, data handling capacity etc. | The monitoring system has a generally low information capacity. Human and environmental effects as well as improvements remain unidentified. It is not possible to organise a follow-up survey on the cost-effectiveness of environmental measures. Steering environmental measures for combating emissions is accidental. | 1. The three regions should have a joint environmental and human health monitoring system that is compatible with the corresponding systems of the neighbouring countries.<br><br>2 The monitoring system should integrate data on: levels and effects of environmental pollution;<br>sources of emissions and discharges<br>general environmental conditions. eg. meteorology, hydrology and oceanography<br>environmental aspects of human health.<br><br>3 The monitoring system should have three operational levels:<br>- inter-regional (Russian part of the Barents region),<br>- regional Province, Republic),<br>- local (city)<br>with the adequate for each level component, spatial and temporal solutions.<br><br>4 The priorities of the monitoring system development should be selected, based on the importance/urgency of informational needs. | G91 |

# CHAPTER 4 RECOMMENDED PROJECTS

Chapter 3 describes 66 important investment projects to amend non-radioactive environmental contamination and human health problems. Successful implementation of these projects will lead to a significant reduction in pollution and consequently, improvement of the environment and the health of the human population in the Russian part of the Barents Region. The project identification was based on assessment of the environmental situation presented in Chapter 2.

Among the project proposals, the AMAP Expert Group selected 16 priority projects which are recommended for further feasibility studies and possible implementation. In addition, the regional project on development of the integrated environmental and human health monitoring system was recommended for implementation. This total of 17 project proposals is described in some more detail in this chapter, however, the background information on emissions and discharges, environmental and health effects are to be found in Chapter 2 and are not repeated in this chapter.

The selection of recommended projects was based on the selection criteria presented in Chapter 1. The priorities of the regional environmental authorities have been taken into account, as well as the fact that the projects should be investment projects aiming to amend an environmental or health problem, rather than being purely for research or education. The selected projects should have a strong environmental or human health perspective, but also commercial aspects have been considered, although the economical evaluations of the recommended projects are a part of the feasibility study in the second phase of the NEFCO-Programme. In this way it is ensured that the selected projects should not be strictly 'win-win-projects' (projects which are initiated because they are commercially profitable, but which also have environmental benefits). During the selection procedure, particular attention was paid to projects where the environmental improvement was based not merely on better treatment of production wastes (industrial gasses, waste waters, hazardous solid wastes etc.), but rather on installation of new environmentally clean and energy saving technology.

Projects which are the subject of bilateral or multilateral environmental and technical co-operation and for which significant steps have already been taken towards their implementation, were not selected as priority projects for the NEFCO-Programme.

The projects recommended for further study may all be divided into two groups:

- projects of particular importance to the environment or human health in the area concerned
- pilot projects which are important for the entire Barents Region, and which can be duplicated in the other areas of the Region after appropriate adjustments

It should be noted that the second group of projects were selected in areas where their implementation is most urgent for the local population as well as the environment.

A number of possible actions are listed for most of the recommended projects. It should be emphasised that this is not an authorised list, but rather a presentation of possible actions which have been presented to the AMAP Expert Group. The Expert Group has not carried out any specific research in this field, since this part of the NEFCO-Programme belongs to the feasibility study in Phase II. Also, for some projects the regional environmental authorities presented budgets. These budgets have not been evaluated by the Expert Group, but will be handed over to the feasibility study.

The Expert Group further wish to emphasise that projects which have not been included in the list of recommended projects for the NEFCO-Programme, are also of significant environmental importance and can be recommended for future implementation, with technical and financial participation of international partners and investors as well.

Projects for the Province of Murmansk.

As it was shown in Chapter 2, the environmental impact of nickel smelters is one of the most important issues for this province. At the same time, due to the above-mentioned approach, the project M31 'The Pechenganickel smelters in Nickel and Zapolyarny, reduction of $SO_2$ and waste water discharges' was not included into the priority list since it is covered by the Russian-Norwegian Agreement. This project can be considered as a pilot venture for this branch of non-ferrous metallurgy, and it was agreed not to recommend the project on the 'Severonickel' smelter in Monchegorsk (M32) for implementation until sufficient results from the 'Pechenganickel' project are obtained. At the same time, due to the severe impact of the 'Severonickel' smelter, causing human health problems in Monchegorsk, the implementation of remedial measures cannot be delayed, thus the project dealing with improvement of drinking water supply in this city (M44) was included into the priority list.

It should be stressed that drinking water supply problems are considered to be among the most urgent for the entire Barents Region and these projects are therefore given special attention.

The situation concerning the water supply of Murmansk City and the impact of communal effluents on the Kola Fjord is a large integrated human health and environmental problem of the Province. At present, the water supply problems in this City cannot be solved by implementation of one single project, since the main source of the City's water supply system - the River Kola - is affected by contamination of different origins. This is why two pilot projects (M41 and M52) were recommended for implementation in the basin of this river. These two projects will also improve the local environmental situation as well as reducing the anthropogenic impacts on the Kola River. Construction of communal waste water treatment in Murmansk (M61) was also selected as a priority project since Murmansk is the only large city in the Province without any treatment facilities at all.

Projects for the Republic of Karelia.

Based on assessment of the environmental situation, the Expert Group concluded that the most serious environmental situation and corresponding human health problems exist in the Segezha County of the Republic. There are several pulp and paper mills in Karelia which have similar contamination problems, but the Segezha pulp and paper mill is situated close to the Nadvoitsy aluminium plant, with its own significant environmental problems. Selection of two integrated projects connected with reduction of environmental and human health impacts of these plants (K 31 and K32) will allow the situation to be improved in the whole of Segezha County, where environmental and human health problems give rise to significant social tension.

The waste water problem of the Kostomuksha iron pellet plant 'Karelsky Okatysh' (K41) is a specific and complicated large scale environmental problem of the Republic. It should be stressed that there have been several attempts, including at the international level, to solve this problem. However, so far, success has been limited. On the basis of the seriousness of the problem, this project was still recommended, but the final decision as to its implementation should be made after the feasibility study has been carried out.

Projects for Archangel Province.

The impact of large pulp and paper enterprises is the most significant environmental problem in Archangel Province. The three major plants of this type in the Province are all among the biggest in the whole of Russia. The three plants are located in the Cities of Koryazhma, Novodvinsk and Archangel, and the waste water is discharged into the Northern Dvina River system. Each of the plants can be included into the priority list. Based on environmental impact, location and the number of population affected, the Expert Group concluded that reduction of the impact on environmental and human health of the Archangel pulp and paper mill in Novodvinsk (A46) should be recommended as the pilot project on pulp and paper mills specifically for this province. Other initiatives are also under way to remedy the contamination from this pulp and paper mill, and this needs to be clarified during the feasibility study.

The supply of drinking water to the Cities of Archangel and Novodvinsk is another important issue. The tap water quality in these two cities is alarmingly poor. On the basis of this conclusion, the joint A42/A43 project on drinking water supply of Archangel and Novodvinsk was included into the priority list. The feasibility study should show that either these two projects can have a joint solution or each requires a separate solution. In the latter case, one of the projects will be selected as the priority project.

Archangel Province has the only large virgin taiga forest in Europe. In order to take urgent action for preservation of this unique forest in Mezen County, the specific project A71 is included into the list of priority projects.

Pilot projects.

Based on the assessment of the environmental situation in the Barents Region, the following items were selected to be dealt with by pilot projects which can be duplicated in the other locations of the Region after their implementation:

1. Energy saving and reduction of air-borne emissions of heat and power plants. Air pollution problems related to the operation of such plants are typical for almost all of the large cities in the Region. At the same time, in some cases (such as Archangel City), implementation of such a pilot project would not sufficiently improve air quality, since there are other significant pollution sources in these cities. Two alternatives were discussed by the Expert Group as proposals for the pilot project: Murmansk and Petrozavodsk. Since two large specific projects relevant to gas emissions are proposed for the Republic of Karelia (Segezha and

Nadvoitsy), the pilot project on the Murmansk heat and power plant (M101) is recommended as a priority project.

2. Environmental impact of poultry farms. This problem is to a certain extent typical for all the Barents Region, but it is most urgent in Murmansk Province, particularly in the basin of the Kola River. To involve this type of pilot project with the large scale integrated environmental protection measures (drinking water supply of Murmansk City), the pilot project M52 on reduction of effluents from Murmanskaya (or Snezhnaya) poultry farm is recommended.

3. Construction of communal waste treatment systems in small towns is another significant environmental problem in the Russian part of the Barents Region. Taking into account the adopted approach to solve an integrated problem of the Murmansk City water supply, it is recommended to include the project M41 'Construction of communal waste water treatment system in the town of Kildinstroy' into the list of priority pilot projects.

4. Water supply of small settlements can be considered as a pilot project which can be implemented in almost any town or village in the Barents Region. The Expert Group recommended implementation of such types of pilot projects in the areas of concentrated indigenous and traditional populations. As an exclusion, it was recommended to implement these pilot projects in three areas simultaneously: in Lovozero village (the centre of Saami population in Murmansk Province), Nelmin Nos settlement (compact living of Nenets population) and Kenozero (traditional Russian population in Archangel Province). It is recommended thast the latter project be combined with the project on improvement of the Kenozero National Park management system.

5. Treatment of non-radioactive hazardous wastes is to some extent an urgent issue for the whole of the Russian part of the Barents Region. At the same time, the information on the amounts of wastes produced by industrial enterprises as well as the state of their handling, is contradictory and unreliable. The Expert Group conclude that environmental protection authorities and relevant communal services in Murmansk Province are better prepared to take part in implementation of such a pilot project (M51).

6. Artificial rearing of Atlantic salmon (*Salmo salar*). The rivers of the Russian part of the Barents Region are a significant spawning area for this valuable fish. Due to industrial development of the Region with the corresponding pollution and changes in hydrological regime of these rivers, the salmon stock has been reduced. To restore the stock, artificial rearing of Atlantic salmon can play an important role. In the Karelian part of the White Sea, there are many rivers which traditionally had rich salmon stocks. This is also a very little contaminated marine area, and a pilot project on artificial rearing of salmon to support the natural stock, was recommended for implementation in this area (K61).

The summary of the projects recommend for a feasibility study within the NEFCO-Programme is presented below.

Overview of the recommended projects

The project proposals have been assigned a unique reference number. A letter identifies to which part of the Barents Region the project belongs, i.e. M for Murmansk Province, K for The Republic of Karelia and A for Archangel Province including Nenets AA. The projects concerning the Barents Region in general are assigned the letter G. The first numeral denotes which of the 10 issues of concern the project is classified under, and the second numeral refers to the assigned project number.

## PROJECTS IN MURMANSK PROVINCE

| | |
|---|---|
| M41 | Construction of a communal waste water treatment system in the town of Kildinstroy (Kola River water shed) |
| M44 | Improvement of Monchegorsk City water supply system |
| M51 | Establishment of a system for treatment of non-radioactive hazardous waste in Murmansk Province |
| M52 | Treatment of faeces and effluents from the Murmanskaya (or Snezhnaya) poultry farm (Kola River water shed) |
| M61 | Improvement of the treatment of municipal waste-water discharged into the Kola Fjord from Murmansk City, the Northern sewage treatment plant |
| M101 | Energy saving and reduction of the air-borne emissions from the Southern heating and power plant in Murmansk City |

## PROJECTS IN THE REPUBLIC OF KARELIA

| | |
|---|---|
| K31 | Segezha pulp and paper mill, reduction of gas and dust emission and waste-water discharges |
| K32 | Nadvoitsy aluminium plant, reduction of gas and dust emission and waste-water discharges |
| K41 | Kostamuksha iron pellet plant 'Karelsky Okatysh', reduction of waste-water discharges and industrial gas emissions |
| K61 | Artificial rearing of Atlantic salmon (*Salmo salar*) in the Karelian part of the White Sea, to increase salmon stocks in the Karelian rivers. |

## PROJECTS IN ARCHANGEL PROVINCE INCLUDING NENETS AA.

| | |
|---|---|
| A42/A43 | Drinking water supply in the cities of Archangel and Novodvinsk |
| A46 | Archangel pulp and paper mill in Novodvinsk, reduction of waste-water discharges and gas and dust emission |
| A71 | Preservation of virgin north taiga forests in Mezen county |

## PROJECTS CONCERNING INDIGENOUS AND TRADITIONAL PEOPLE

| | |
|---|---|
| M81 | Water supply in Lovozero town |
| A81 | Improvement of environmental aspects of human health in the settlement of Nelmin Nos |
| A82 | Drinking water and sewage treatment in small villages in Kenozero National Park |

## PROJECTS CONCERNING THE ENTIRE BARENTS REGION

| | |
|---|---|
| G91 | Integrated environmental and human health monitoring systems |

*NB! The projects on radioactive contamination are presented in a separate volume.*

The geographical and environmental issue distribution of the recommended projects is summarised in Table 4.1, and presented in Figure 4.1.

Table 4.1 Projects recommended for the feasibility study in Phase II of the NEFCO Barents Region Environmental Programme. Some projects deal with more than one environmental issue. These projects are therefore repeated, but they are described and will occur as one project.

| **Environmental issue** | **Murmansk Province** | **Republic of Karelia** | **Archangel Province** |
|---|---|---|---|
| 3. Gas emissions | M101 | K31, K32, K41 | A46 |
| 4. Freshwater resources | M41 | K31, K32, K41 | A46, A82 |
| 4. Drinking water supply | M41, M44, M52, M81 | | A42/A43, A46 A81, A82 |
| 5. Solid wastes | M51, M52 | | |
| 6. Marine issues | M61 | K61 | - |
| 7. Forest resources | | | A71 |
| 8. Indigenous and traditional populations | M81 | | A81, A82 |
| 10. Energy saving | M101 | | |
| Total: | 7 | 4 | 5 |

In addition, the Expert Group recommend the 'Integrated environmental and human health monitoring system' for implementation in the Barents Region

Structure of the project descriptions

The information for each project is presented in a standard format. The guidelines are given below.

| | | |
|---|---|---|
| A | **Name and reference number** | *Name of project and internal reference number.* |
| B | **Geographic location** | *Location of the project. See also Figure 4.1.* |
| C | **Environmental problem** | *A brief description of the environmental problem.* |
| D | **Description of problem and environmental impact** | *The main background information of the environmental situation are to be found in Chapter 2. This chapter presents the more project spesific information on environmental and human health impacts.* |
| E | **Possible action/remedy** | *Description of some possible actions or remedies* |
| F | **Estimated cost of action** | *If available, estimated costs to carry out the proposed actions are presented. The estimates have not been evaluated by the Expert Group.* |

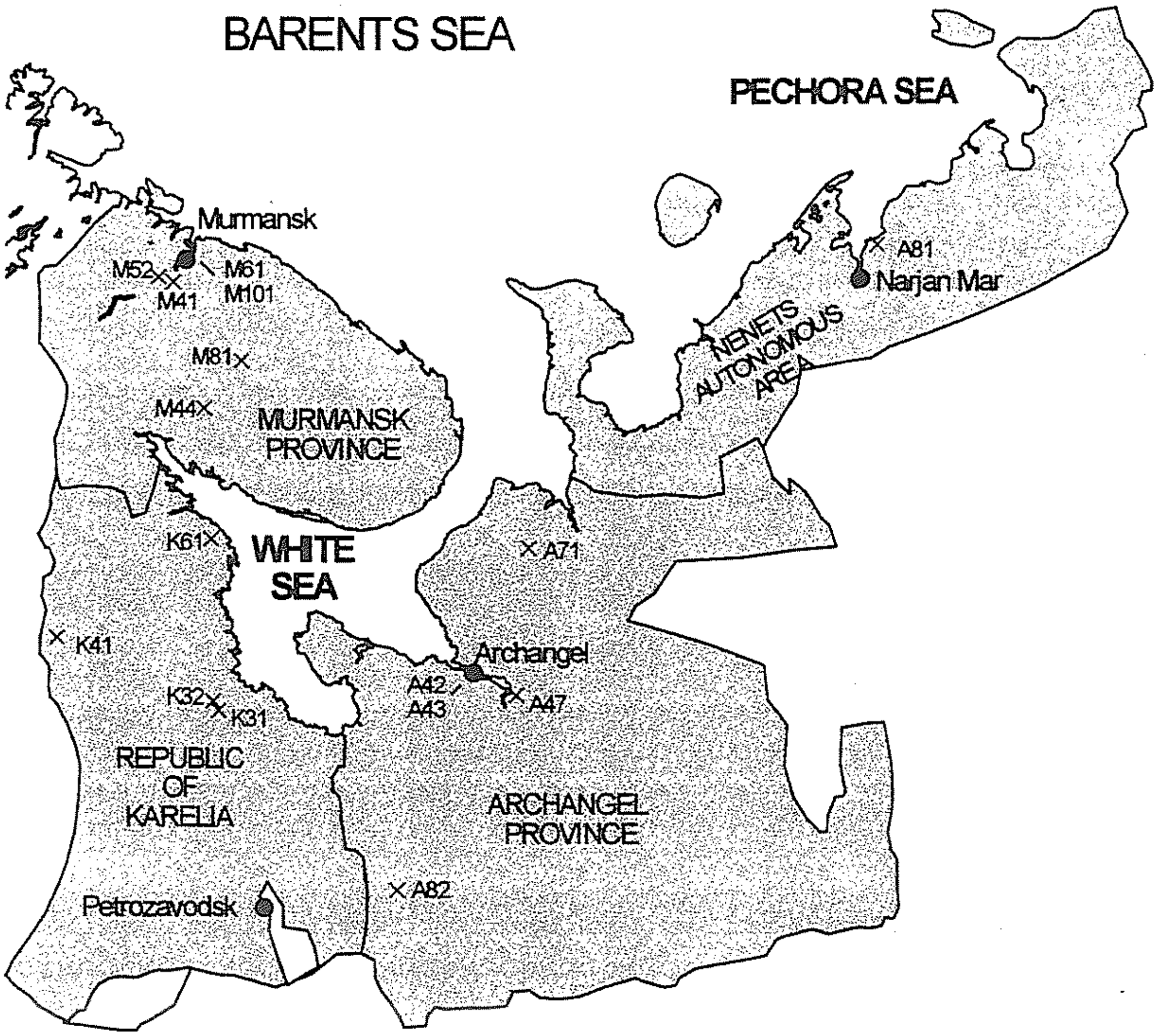



Figure 4.1.1

Geographic location of the recommended projects.
Projects without specific geographic location (M51, G91) are not shown.

Akvaplan-niva

## A. Name and reference number

M41 Construction of communal waste water treatment system in the town of | Kildinstroy

## B. Geographic location

Kildinstroy town is situated on the banks of the Kola River, 10-15 km south of Kola City.

## C. Environmental problem

Kildinstroy town (some 10 000 inhabitants) has no treatment plant for waste water and sewage. The wastes are discharged into the Kola River, which provides 45 % of the tap water in the City of Murmansk.

## D. Description of the problem

Poor quality of tap water is considered to be one of the most serious threats to human health. The waste water treatment in Kildinstroy is closely connected with tap water problems in the largest population centre of the Province, Murmansk City. More than 13 % of the samples did not meet the National Standard for tap water in 1993 due to bacteriological contamination.

Infectious agents are primarily related to contamination of drinking water by human waste, as well as hygienic standards in food-handling and drinking habits. Regular samples are taken from drinking water for analysis of microbial agents at the regional microbiological laboratory in Murmansk. The most important agents are *Escherichia coli*, hepatitus viruses and cytomegalovirus. This is reflected in the child morbidity statistics, with 40-50 % of child illnesses being gastro-intestinal disorders. When associated with other illnesses, combined with children receiving a poor nutritional diet, infection by these agents is also responsible for increasing the mortality rates in children in the 0 - 10 age group.

In Murmansk, there are much fewer incidences of respiratory diseases, compared to Monchegorsk, but the incidence rate of gastro-intestinal disease is 20 - 30 % of the total infectious diseases where. Although there is a lack of supporting information, the high rate of gastro-intestinal diseases is likely to be related to poor drinking water quality and insufficient handling of waste-water from a population of approximately 450 000 inhabitants.

## E. Possible action/remedy

Construction of a treatment plant for communal waste water and sewage in Kildinstroy will improve the quality of the main source for tap water in the cities of Kola and Murmansk. A reduction of the organic loading of the Kola River will also improve the environmental situation in the Kola River.

This project is part of a larger concept: Water supply to Murmansk City with the following components:

- Protection of the watershed used for Murmansk City household water.
- Better treatment of household water
- Investigation of the potential for shallow ground water exploitation
- Improvement of water supply system (pipelines, pumps etc.)
- There is also a need to develop a masterplan for water supply in Murmansk Province

## F. Estimated cost of action

Not given

**A. Name and reference number**

M42 Improvement of Monchegorsk City water supply system.

**B. Geographic location**

Monchegorsk City at the north-western shore of Lake Imandra

**C. Environmental problem**

In Monchegorsk City, some 70 000 consumers are connected to the tap water network. The water is pumped from Lake Monche, situated 3 kilometres from the Severonickel smelters. The only treatment carried out is chlorination with only approximately 30 minutes contact time. The water pH is not controlled. Approximately 1/3 of the monitoring samples did not meet chemical sanitary requirements in 1993.

**D. Description of the problem**

As a result of pollution of Lake Monche, insufficient treatment of the water, as well as heavy metal leaching from pipelines, the quality of household water presents a threat to the population in the form of chemical contamination and hygienic risks The recorded nickel concentrations in tap-water from Nikel, Zapolyarny and Monchegorsk are between 0.013 and 0.064 mg/l. Nickel values in urine are higher in Russian patients than in their Norwegian counterparts.

**E. Possible action/remedy**

Two main options are apparent. In either case, a better water treatment plant and distribution system must be established.

1) Use of surface water resources, either continuous use of water from the Monche Lake or exploitation of other fresh water bodies.

2) Exploitation of shallow ground water as an alternative source for tap water. Ground waters are generally not used as a source of household water (only 8 % in the Murmansk Province). The technology for ground water utilisation, as used for instance in the Scandinavian countries, has until recently not been available in Russia.

**F. Estimated cost of action**

No total figures have been available.

In co-operation with Finland, a pilot project in Monchegorsk has started by compiling an inventory of the problem as well as by investigating potential ground water sources. Financing of the pilot project has so far been provided by the Finnish state, with approximately 400 000 FMK (appr: 93 500 USD). Both the Severonickel corporation and the Environmental Committee of Murmansk Province are interested in the project, and several sources of funding are thus available.

## A. Name and reference number

M51 Handling and conversion of hazardous, non-radioactive waste in Murmansk Province.

## B. Geographic location

An integrated system of treatment plants for different types of hazardous wastes should be established according to the specific requirements and needs of the Province. The chosen locations must be both geographical and communication centres, which minimise transportation costs and distances. The exact locations should be determined during the planning process.

## C. Environmental problem

Due to the lack of an organised treatment system for hazardous non-radioactive wastes, the wastes are stored at dumping sites at many different locations in the Province. Runoff from the landfills are in some case already penetrating into the ground water and nearby waterways and in this way contaminating both the environment and the drinking water resources.

## D. Description of problem and environmental impact

In general, the availability of precise information concerning the formation of non-radioactive hazardous wastes in the Barents Region is poor. Nevertheless, available information shows that each year a variety of mining and other industrial activities, harbour services etc. generate vast quantities of different types of hazardous non-radioactive waste, containing contaminants such as metals, chlororganic and petrochemical substances. During the time of the Soviet Union, hazardous waste should be transported to national dumping sites specifically intended for hazardous waste. This system did not function satisfactorily. Today, the provincial administrative units are themselves responsible for the waste produced in their Province, despite the lack of proper resources for handling hazardous waste.

Of particular concern are the hazardous wastes from the metal and galvanising industries and the pulp mills. These wastes are either transported to landfills for industrial wastes, stored at the sites of industrial enterprises or burned. Different types of hazardous wastes are brought to the same dumping areas as municipal and regular industrial wastes and furthermore, the hazardous wastes are generally not separated from other wastes.

In recent years, the recycling of metals and valuable chemical compounds has been developed into a profitable business. This also includes several types of hazardous waste. Advanced technology is used, and recycling companies are able to manufacture a range of price-competitive products. Since recycling reduces both waste problems and exploitation of natural resources, this enterprise has been supported by national and international legislation. This development is expected to continue at an even greater rate in the future and should be taken into account during the feasibility study.

## E. Possible action/remedy

Several actions may be applied in order to reduce the non-radioactive hazardous waste problem. It is of fundamental importance to continue the development of the legislation concerning the responsibility for the waste and the treatment and recycling of the waste. The legislation should support the development towards profitable recycling of as many waste compounds as possible. It is further of great importance that authorities are able to enforce the laws.

Other actions may be defined as follows:

- Inventory of the status of existing dumpsites and the continuous generation of non-radioactive hazardous wastes. To what degree can waste from mine dumps and other dumpsites be reprocessed and in this way profitably reclaim different compounds?
- Establishment of a treatment strategy for handling of hazardous waste. This includes construction of treatment plants and evaluation of the recycling potential. The treatment plants or dumping sites must be optimally located in order to reduce transport costs and to secure optimal deposition of the residues. The treatment strategy must be integrated in the international system of profitable recycling of a range of waste products.
- Establishment of a satisfactory system for monitoring of the treatment plants and dump sites.

## F. Estimated cost of action

No cost estimate has been available.

The economic foundation of the treatment plant(s) can be partly public funding (treatment fees paid by the industries concerned) and partly commercial. The plant(s) should be encouraged to increase their income(s) by selling recycled products.

**A. Name and reference number**

M52 Treatment of faeces and effluents from the poultry farm Murmanskaya (or Snezhnaya) in Murmansk Province.

**B. Geographic location**

The poultry farms Murmanskaya and Snezhnaya are both situated on the banks of the Kola River, 10-15 km south of Kola City.

**C. Environmental problem**

These two poultry farms have up to now accumulated some 2 million tonnes of droppings. The waste depositories are overloaded and the overflow is discharged into the Kola River, which is also a main source of tap water to the Cities of Kola and Murmansk. The overfilled waste deposits also negatively affect the environment in the vicinity of the farms and the Kola River itself. The problem is most pronounced during snow melting and in periods with heavy rain.

**D. Description of the problem**

Poor tap water quality is considered to be one of the most serious threats to human health. The tap water in the largest population centre of the Province, the City of Murmansk, is of very poor quality. More than 13 % of the samples did not meet the National Standard for tap water in 1993. The main problem is bacterial contamination (see also M41).

**E. Possible action/remedy**

- The overloaded land fill must be taken care of in order to stop the runoff to the Kola River.
- A plant for treatment of the droppings must be constructed. The plant must be able to convert the droppings into valuable compounds such as dry fertiliser and methane gas.

This project is part of a bigger concept: Water supply to Murmansk City with the following elements:

- Protection of the watershed used for Murmansk City household water.
- Better treatment of the household water
- Investigation of the shallow ground water potential
- Improvement of water supply system (pipelines and pumps)
- There is also a need to develop a masterplan for water supply in Murmansk Province

**F. Estimated cost of action.**

No estimates were presented

**A. Name and reference number**

M61 Improvement of the treatment of municipal waste-water discharged into the Kola Fjord from Murmansk City, the Northern sewage treatment plant

**B. Geographic location**

Murmansk City on the Kola Fjord

**C. Environmental problem**

The cities of Murmansk, Kola and Severomorsk discharge their waste water into the Kola Fjord. The discharges are a major contributor to the organic overloading of the Kola Fjord, as well as to the input of a variety of contaminants of domestic and industrial origin. The communal waste water from Murmansk City is mixed with waste water from 37 industrial enterprises and comprises some 85 % of the total discharges from Murmansk City. According to information from ECMP, the waste water is at present discharged untreated into the Kola Fjord.

**D. Description of problem and environmental impact**

The Kola Fjord is the most polluted part of the Barents Sea (Hydromet 1994 Annual report; Gluchov *et al.* 1992). The highest concentrations of petroleum products are 20-30 times higher than MAC. The concentration of phenols is on average 5-6 times above MAC. The water is also contaminated by detergents, ammonia nitrogen, as well as heavy loads of suspended and particulate organic matter. Although there is a lack of supporting data on the levels of different contaminants in the Fjord sediments and organisms (particularly data on the Fjord's populations of fish which are exploited for human consumption), the highest level of pollution seems to be in the harbour areas and in the inner parts of the Fjord where a large proportion of the sewage water is discharged.

**E. Proposed action/remedy**

There are two major outlets for municipal sewage in the City of Murmansk, and plans have been made for the construction of mechanical treatment plants. The plans and the cost estimates have not been evaluated by the Expert Group. Their status may be summarised as follows:

1) The Northern waste-water treatment plant is designed for mechanical treatment of waste-water of the Northern and central parts of the City. The capacity of the plant is 260 000 $m^3$ pr day. The construction was started in 1986, but halted in 1991 due to lack of funding. Approximately 90 % of the construction is completed and necessary equipment was purchased in 1991, since when it has been in storage. If proper funding is available, the plant can be put into operation in 1996 (ECMP 1995).

2) The Southern waste-water mechanical treatment plant is designed to clean the waste-water from the southern part of the City and from the City of Kola. The capacity of this plant is 60. 000 $m^3$. The construction work stopped in 1993 due to lack of funding and only some preliminary work has so far been carried out (ECMP 1995).

3) The sewage treatment plants in Severomorsk consist of 9 separate systems which independently discharge untreated waste water into the Kola Fjord. The sewage volume is in the range of 60-80 000 $m^3$ pr day, depending on the development within the Northern Fleet. Due to the lack of funding, the technical-economical background work has not been initiated (ECMP 1995).

**F. Estimated cost of action**

Completion of the Northern waste-water treatment plant in Murmansk City requires approximately 10 billion roubles (appr. 2 million USD) (estimate provided by ECMP in 1995).

**A. Name and reference number**

M 101 Energy saving and reduction of the air-borne emissions from the Southern heating and power plant in Murmansk City

**B. Geographic location**

Murmansk City.

**C. Environmental problem**

In Murmansk City, the heating and power plants are fueled by coal and oil, with an average of 2 % sulphur content. The heating and power plants are responsible for 45 % of the total air-borne emissions in Murmansk City, and the emissions and energy consumption of the plants are considerably higher relative to that in Scandinavian cities of the same size.

**D. Description of the problem**

Because of the cold climate, houses in the Barents Region are required to be heated for a substantial part of the year. The current local heating system in Murmansk City is old-fashioned and technically inadequate, since the cost of energy until recently has been heavily subsidised. The energy consumption of the average Murmansk City household is three times higher than that in comparable houses in Finland. Heating costs comprise about 60 % of the total housing costs in Murmansk City. Another reason for the poor condition of the heating network is due to the corrosion damages caused by oxygen in the network water. The average 'life expectancy' of heating network pipes is approximately 1/10 of that in Finland. The average efficiency of the remote heating plant and network in Murmansk City is about 20-30 %. In western countries, the efficiency is usually around 80 %. Almost any improvement in the heating systems will be economically profitable, as this will lead to significant savings in energy consumption.

Local air-borne emissions of sulphur dioxide and other gasses and dust originating from the combustion of coal and oil in power and heating plants, cause damage to the environment and endanger the health of the citizens. The Southern power and heating plant is alone responsible for 30 % of the air-borne emissions in Murmansk City, the most important are $SO_2$, NOx and PAH. According to the plans of heat production expansion at this plant, air-borne emissions will increase and reach 95 % of total sulphur emissions in Murmansk City.

**E. Proposed action/remedy**

1. Inventory of the state of the heat production units and networks in the Murmansk City area.
2. Master plan for energy saving and heat production in the Murmansk City area.
3. Selection of one pilot unit and network in the Murmansk City area. The Southern power and heating plant is the largest, and is also the proposed target for a planned expansion, and may thus serve as a pilot project.
    3.1 Inventory of the renovation needs in the plant and network.
    3.2 Renovating the plant and the combined network.
    3.3 Training programme for personnel.

**F. Estimated cost of action**

No cost estimation has been presented

**A. Name and reference number**

K31 Segezha pulp and paper mill, reduction of gas and dust emission and waste water discharges

**B. Geographic location**

Segezha pulp and paper mill, owned by the joint corporation Segezhabumprom, is located approximately 220 km north of Petrozavodsk in the town of Segezha (37 000 inhabitants). The plant is located on the shore of Lake Vyg, approximately 170 km east of the Finnish border.

**C. Environmental problem**

The combined effects of air-borne emissions, waste water discharges and dumping of hazardous waste from the pulp and paper mill in Segeza and the aluminium plant in Nadvoitsy, both situated on Lake Vyg, have reduced the Segeza-Nadvoitsy area to a zone of ecological disaster, in terms of the effect of pollution on human health (Filatov *et al.* 1992).

The emissions of $SO_2$ and odorous compounds arising from the Segezha pulp and paper mill are the most serious environmental problem. The discharges of poorly treated waste water, containing compounds such as lignin, phenol acid, resinoic acid, oil and synthetically surface active substances are seriously affecting conditions in Lake Vyg.

**D. Description of the problem**

The Segezha pulp and paper mill was established in 1936. The capacity of the mill today is 660 000 tonnes kraft pulp per year and 660 000 tonnes kraft paper per year. The plant is the largest in Karelia, and one of the largest in Russia. The plant uses 1 000 - 1 300 tonnes of heavy fuel oil daily, depending on the time of the year. The sulphur content of the heavy fuel oil is probably 3 %. The mill has a continuous Kamyr cooking process in use.

In the City of Segezha, up to 90 % of the City's contaminants are emitted by the joint stock company Segezhabumprom. The atmospheric pollution levels exceed the existing sanitary standards for hydrosulphur and methylmercaptane. A laboratory study of atmospheric air quality undertaken in 1994 showed that methylmercaptane concentrations were 62 times higher than the maximum allowable concentration (MAC) and hydrosulphur concentrations were 4.3 times higher than MAC.

The amount of sludge from the primary and secondary treatment process in the Segezha pulp and paper mill is 4 300 tonnes per year and approximately 6 000 - 12 000 tonnes per year of lignin remains. The total amount of ashes is 4 000 tonnes per year and there are 600 tonnes per year of paper remains. The amount of the fibre-free effluent discharged directly into the recipient is approximately 36 000 $m^3$ per day (Plancenter 1991). The long-term waste-water discharges of the Segezha cellulose and paper plant have altered the consistency of the bottom sediments in Lake Vyg.

**E. Possible action/remedy**

A programme to improve the existing ecological situation has been prepared by Segezhabumprom (Plancenter 1991). The Expert Group has not evaluated this programme or the cost estimates. One of the goals of the programme is to update the production technology. Part of the programme has been fulfilled. However, due to the poor economic situation, the programme has not been fully accomplished.

According to this programme, the environmental problems of the mill could be reduced in the following ways:

- process technology modifications,
- air pollution abatement measures,
- effluent treatment.

**F. Estimated cost of action**

A detailed cost estimate to implement the programme referred above (point E) has been presented to the Expert Group. The total costs are 1 300 FMK (appr. 314 million USD).

**A. Name and reference number**

K32 Nadvoitsy aluminium plant, reduction of gas and dust emission and waste water discharges

**B. Geographic location**

Nadvoitsy aluminium plant is located in the town of Nadvoitsy (some 15 000 inhabitants), 15 km north of Segezha and some 235 km north of Petrozavodsk. The plant is located on the shore of the Lake Vyg, about 170 km east of the Finnish-Russian border.

**C. Environmental problem**

The combined effects of air-borne emissions, waste water discharges and dumping of hazardous waste from the pulp and paper mill in Segeza and the aluminium plant in Nadvoitsy, both situated on Lake Vyg, have rendered the Segeza-Nadvoitsy area a zone of ecological disaster in terms of the effect of pollution on human health (Filatov *et al.* 1992). The discharges and emissions of fluorides appear to be the most hazardous component. The water supply of the town has become affected, and high fluoride levels are known to have serious effects on human health. A major part of the area affected by the pollution from the plant is agricultural area, and based on experiences from Norway, animal livestock is also expected to be affected by the high levels of fluorides. However, no data documenting this anticipation has been available.

**D. Description of the problem**

The Nadvoitsy aluminium plant produces industrial quality aluminium and pure aluminium powder. To produce aluminium, an obsolete technology based on Söderberg anodes is used. The plant consists of two series of electrolyses. In the first series no gas is removed, whereas in the second series, the purification facilities are out-dated. Since 1954, the plant has emited large amounts of harmful substances into the air. The fluoride concentration in the melt-water, within the range of 0-5 km from the aluminium factory of Nadvoitsy has averaged 1.9 mg/l, and as much as 16 mg/l in the immediate vicinity of the plant (Filatov *et al* 1992).

Laboratory observations (the air sampling station is located at a distance of 1000 metres from the industrial zone) have shown that in Nadvoitsy town, the mean annual concentrations of hydrogen fluoride are three times higher than the maximum allowable concentrations (MAC). The maximum hydrogen fluoride concentrations are three to four times higher than existing sanitary standards. The benzo(a)pyrene content of the air is 2-3 times higher than MAC. Studies conducted by AEROgeologia company in 1991 showed that both the soil and vegetation were contaminated with benzo(a)pyrene. Close to the plant, the maximum concentrations were 240 times higher than the existing standards, and at a distance of 1.5 kilometres from the plant, the concentrations were 2.5 times higher than MAC. The conclusion of the study was that the contamination was caused by the burial of industrial waste in the vicinity of the aluminium plant (Filatov *et al.* 1992). The average concentration of hydrogen fluoride in the air varies from 0.013 to 0.014 $mg/m^3$. The population receives an excess of fluoride, not only in the air, but also from drinking water. The health statistics on the local and county levels show a significant incidence of fluorosis in the children of this area, based mostly on clinical criteria. Some data indicate that as much as 84 % of the children in the area are suffering from very severe systemic fluorosis (Karelian Ministry of Health annual report 1993).

**E. Possible action/remedy**

The plant has compiled a programme to install new technology at the plant and decrease emissions and discharges, and parts of the plan have been carried out. However, the implementation of the programme has been halted due to lack of finances.

The programme includes installation of new modern technology for aluminium production by means of burnt anodes in the second series of electrolysis. In addition, dry gas purification will be carried out. Further, a reservoir has been built to keep the waste and the polluted surface water within a limited area in the industrial zone.

**F. Estimated cost of action**

Taking into consideration the measures already carried out, listed under point E concerning the Nadvoitsy aluminium plant, the management of the plant has estimated that a credit of 20 million USD over a five year period is necessary. The Expert Group leaves to the NEFCO-feasibility the evaluation of the measures already taken and the estimated costs for the continuation of the programme

**A. Name and reference number**

K 41 Kostamuksha iron pellet plant 'Karelsky Okatysh', reduction of waste water discharges and industrial gas emissions.

**B. Geographic location**

The Kostamuksha iron pellet plant and the City of Kostamuksha with 32 000 inhabitants are situated in the western part of the Republic of Karelia, 35 km from the Finnish/Karelian border.

**C. Environmental problem**

Waste-water from iron-pellet production as well as sewage from the Kostumuksha City are polluting the waterways. Of particular concern is the overfilled waste water lake which is used as a basin for slag-water suspension. The problem is how to dispose of this waste with minimum impact, without destroying the aquatic environments, as well as avoiding health risks downstream, where surface water is used for drinking water.

There is no proper system for the treatment of sewage and other industrial waste-water in the town, which causes accessory health problems.

**D. Description of the problem**

The Kostamuksha corporation (Karelsky okatysh) produces approximately 10 million tonnes of iron pellets annually, which contain 65 % pure iron. The reduction of air pollution has been assigned top priority. In 1990, the $SO_2$ emissions were 70 000 tonnes per year, corresponding to 40 % of the total emissions in Karelia. In 1994, the emissions of $SO_2$ had been reduced to 48 137 tonnes, which amounted to 41 % of the total emissions in Karelia.

The mining activities in Kostamuksha have been in operation since the mid 1980's, producing iron pellets, based on magnetic separation. Process waters are internally circulated, with the exception of the waste-waters from the separation process. This waste water is conveyed into a dammed basin. Water from the pits is pumped into this same basin, in order to keep the mine drained. This basin has a surface area of 34 $km^2$, an average depth of 12.5 meters and the volume of the basin is approximately 430 million $m^3$. The basin is now overfilled, and intensive natural precipitation compounds the problem. The result is that waste-water is now conveyed into the water course, instead of the basin. The amount of waste-water discharged into the lower water course in 1994 was 8 million $m^3$. In future, the annual amount of discharged waste-water will be in the range of 20-25 million $m^3$. Approximately 3 million $m^3$ of waste-water currently seeps through the dams and into the lower water course each year.

Although the waste-waters are hazardous to aquatic organisms, they are not acutely poisonous. They have been proven to cause a decrease in species numbers (e.g. valuable fish stocks) inhabiting the water course, but the long-term effects have not yet been clarified. The most hazardous component of the waste-water is its high salt concentration and in particular the unnatural ion proportions. The potassium concentration of the water is over 100 times that compared to the 'natural value' in this area and the alkaline and alkaline-earth metals are many times that of the natural state. The waste water can be conveyed into the lower water course of the Kenti-Kento River. It is also possible to use the watercourse of the Lahna River. By both routes, the waste water is directed into the Kem River watercourse, which flows into the White Sea.

From the point of view of human health, the most serious problem documented (in addition to the ambient air pollution effects) is the waste-water, which is contaminated by metals and sediments. Downstream of the plant, drinking water is severely contaminated by metals and, in particular, infectious agents resulting in a high incidence of gastro-intestinal diseases in children (Karelian Ministry of Health, annual report 1993).

**E. Possible action/remedy**

The process which leads to an implementable solution to the waste-water and sludge basin problem urgently requires financing and advisory help. Planning of the waste-water treatment of Kostamuksha City should be combined with this process. However, multiple international efforts to solve the problem has so far not been successful.

At present, a cleaning programme has started, implemented in co-operation with Finland. The Expert Group has not evaluated this programme which includes installing of modern technology to reduce the gas emissions. The programme also deals with waste-water treatment. This can be achieved by minimising the amount of water conveyed from the waste basins to the water courses as well as by conveying this water in an optimal way. Alternative solutions such as addition of calcium to the waste water should be evaluated.

**F. Estimated cost of action**

Not given

**A. Name and reference number**

K61 Artificial rearing of Atlantic salmon (*Salmo salar*) in the Karelian part of the White Sea, to increase salmon stocks in the Karelian rivers.

**B. Geographic location**

River Keret on the western shore of the White Sea.

**C. Environmental problem**

A complex series of human activities, such as general pollution, damming, over-exploitation and illegal fishing have led to a decline in the harvest of Atlantic salmon in the Karelian rivers and coastal areas

**D. Description of problem and environmental impact**

Salmon currently spawn in 16 Karelian river systems which flow into the White Sea. During the early part of this century, large-scale fisheries were carried out in the lower parts of the rivers Kem, Vyg and Keret. In 1895-1899, the average annual landings ranged between 28.8 and 30.4 tonnes. Today only the Keret River yields salmon on a commercial scale. It has been calculated that the Keret River salmon stock should be able to yield approximately 2 200 individuals of salmon each year. However, present-day catches are only some 100 individuals (Bryazgin & Klimov 1995). In 1993, the official figures for the total Karelian catch of salmon was 4 tonnes (Seppänen 1995). Tagging experiments have shown that in the early 1980's, 28 % of the Keret River salmon were caught in the Norwegian Sea, 15 % were caught in the White Sea, and 57 % returned to the river (Bryazgin & Klimov 1995). No specific contaminant source or activity has been identified as being the sole reason for this decline. The impact of decreasing salmon catches is more of a socio-environmental problem than a purely environmental issue.

**E. Possible action/remedy**

The construction of an Atlantic salmon farm on the River Keret in combination with a better environmental monitoring system in the Keret River and improved control of the illegal fishing.

**F. Estimated cost of action**

No data presented

**A. Name and reference number**

A42/A43 Drinking water supply of the cities of Archangel (A42) and Novodvinsk (A43)

**B. Geographic location**

The cities of Archangel and Novodvinsk are located at the banks of Northern Dvina River. Possible ground water sources are located in the vicinity of the Cities.

**C. Environmental problem**

The Northern Dvina River supplies 98 % of the drinking water to the 500 000 inhabitants in the cities of Archangel and Novodvinsk, and close to 70 % of the total population of the Province rely upon this River for their water supply. At the same time, the Dvina River water is contaminated by effluents from industry and sewage from a large number of outlets, causing elevated levels of a variety of contaminants. Due to insufficient waste-water treatment of the sewage, the River water is also reported to be contaminated by human enterobacteria and hepatitis viruses, which give rise to a great infection problem, particularly in the case of gastrointestinal diseases. The catchment area of the River Dvina is further exposed to heavy air pollution from the industrial and heating plants in the Province. There is onlt insufficient treatment of the drinking water, and as a result, the drinking water in these cities is ranked as the third most polluted in Russia and constitutes one of the largest health problems.

**D. Description of problem and environmental impact**

The general poor quality of the household water in Archangel City is documented in several reports and documents presented to the Expert Group (Section 2.3.6.2). In 1994, more than 85 % of tap water samples did not meet the standard on chemical quality and 16 % on microbiological quality (ECAP 1995). It should also be noted that the water quality has been reduced the recent years.

The main contaminants are waste from the pulp and paper mill industry, such as lignosulphonates, formaldehyde, methanol as well as oil products, copper, nickel, ammonium and other nitrogen (section 2.3.6.2). Four large pulp and paper mills (in the City of Syktyvkar in the Komi Republic, and in the cities Koryazma, Novodvinsk and Archangel) as well as a number of different industrial plants, discharge insufficiently treated waste-water into the Dvina River. The total amount of waste-water in 1993 was 1.27 km$^3$ (State of the environment of the Russian Federation - 1993), of which only 5 % underwent treatment to meet established quality standards.

The municipal enterprise Archangel Vodokanal which is responsible for the water supply to the City of Archangel, produced in 1995 180 000 m$^3$ /day. There is insufficient treatment of the drinking water, and old and dirty pipelines only increase the problems. However, plans have been made to install better cleaning facilities in the existing water treatment plants, and also to increase the capacity of Vodokanal by building a new plant equipped with modern cleaning facilities (ECAP 1995). The need to improve the treatment of drinking water may be illustrated by the findings of organic chlorinated compounds such as trihalomethanes (suspected to be mutagenic and carcinogenic) in the drinking water. These are thought to be released into the water in the drinking water treatment plants where disinfecting of the high organic content water by chlorinating takes place (ECAP 1995).

The intake of drinking water to Archangel is downstream of the Archangel pulp and paper mill in Novodvinsk, and thus the discharges from this mill are a very important contributor to the poor state of the drinking water quality. However, the tidal flow influences the environment in the lower part of the Dvina River up to the junction with Pinega River (70 km) which is well above the Archangel pulp and paper mill (ECAP 1995).

Discharges of lignin-containing and other organic compounds from the mill increase the biochemical oxygen demand (BOD) of the river-water and is partly responsible for the oxygen deficiency (oxygen concentrations as low as 2.9 mg/l) recorded during winter-time near Archangel City. In addition, these chemicals may support the growth of bacteria and fungus, particularly during summer. Some species of *Klebsiella,* members of the coliform bacteria group, have been demonstrated to multiply in surface waters affected by discharges from pulp and paper mills.

In Archangel City is a high rate of gastrointestinal diseases. There is substantial evidence of high concentrations of enteroviruses, *E.coli* bacteria and the hepatitis viruses. The number of incidences of tuberculosis has also increased in the past years (Odland 1995). Nickel levels in the urine of pregnant women and their offspring have been analysed. The results show mean values of 2.5 μg/l in childrens' samples, and 8 μg/l in the mothers' samples. This pattern follows similar trends to the values found in Nikel and Monchegorsk, and are significantly higher than the Norwegian reference values (Odland 1995).

Accidental mercury releases from Archangel pulp and paper mill in the range of 16 tonnes were reported in the winter of 1995 (ECAP 1995). However, the Environmental Committee report on only slightly elevated values of mercury in the vicinity of the plant based on sediment sampling in spring 1995. The mercury levels in human blood samples are within the 'normal' values, less than 25 nmol/l, and therefore do not reflect the high concentrations found in the drinking water (Odland 1995). The results point to the need for further investigation, particularly specification of total mercury and methyl-mercury. Also the situation concerning dioxin released from the pulp and paper mills into the River Dvina needs investigation (Section 2.3.6.2).

**E. Possible action/remedy**

The Expert Group suggest two alternative actions:

1) Continuous use of Northern Dvina River water,
2) Alternative water source.

In any case there should a total renovation of the water supply system. Old pipes, pumps and basins must be cleaned or renewed. If the feasibility study chooses the latter solution, the water supply of the two cities may have a joint solution. If the choice is continuous use of Dvina water, the feasibility study should also evaluate which of the two projects, A42 or A43, should be recommended for implementation.

The proposed actions may be further detailed as follows:
1) Installation of better cleaning equipment in existing water treatment plants. Reduction of the pollution of the Northern Dvina River which is the main source for drinking water.
2) Alternatively, since the clean-up of the Northern Dvina will be a major task which will involve a number of industrial and municipal outlets and may take many years, it has been suggested that other sources of drinking water should be investigated.

An alternative water source may solve the water problems for both cities. Several freshwater sources have been considered. One of them is a ground water source in Permilovskoje, some 140 km south of Archangel. It is estimated that this source can supply the cities Archangel and Novodvinsk with pure drinking water of high quality. This solution, however, needs major investment in order to construct the necessary production and distribution system.

Two alternative solutions for using this source have been proposed (ECAP 1995):
alternative 1): construction of a pipeline from the aquifer to the cities.
alternative 2): establishing a plant for bottling of water for sale

## F. Estimated cost of action

Not available

**A. Name and reference number**

A46 Archangel pulp and paper mill in Novodvinsk, reduction of waste-water discharges and gas and dust emissions

**B. Geographic location**

Archangel pulp and paper mill is located in the City of Novodvinsk at the Northern Dvina River some 40 km upstream of the City of Archangel.

**C. Environmental problem**

The Archangel pulp and paper mill is responsible for 98 % of the gas emissions in Novodvinsk, such as $SO_2$ and $NO_x$, and the plant also has a daily discharge of untreated waste-water into the Dvina River of more than 600 000 m³. The waste-water is composed of a variety of organic compounds, such as lignosulphonate, fibre, methanol, formaldehyde, phosphate and ammonium nitrogen. This effluent from the Archangel pulp and paper mill is a major contributor to the extremely poor water quality in the Dvina River, and is regarded by the Environmental Committee of Archangel Province as being the main source of contamination of the drinking water taken from the Dvina River.

**D. Description of the problem and environmental impact**

The total annual production of Archangel pulp and paper mill is 113 500 tonnes of paper, 360 000 tonnes of paperboard, 924 400 tonnes of chemical pulp and 329 290 tonnes of marked pulp (Melamies 1994). Approximately 330 000 tonnes of the chemical pulp is bleached by using 50 - 70 kg chlorine per tonne pulp.

Daily water use and effluent release rates of contaminants from the processing of pulp and paper are shown in Table 4.2. Organic compounds (mainly lignin-containing residues such as lignosulphonates), are the dominant contaminants in terms of kg per day. The total organic discharge, measured as biochemical oxygen demand after 5 days ($BOD_5$), is of the same order of magnitude as untreated effluent from 1 million people. Some nitrogen and phosphorus is also discharged from the mill. The content of the wood fibre and pH values of the waste-water are not reported. Mercury is also a constituent of the processes at the mill. Accidental discharges of mercury from the pulp and paper industry along the Dvina River have been reported in the press (see Section 2.3).

Table 4.2. Daily water use and discharge rate of contaminants from Archangel pulp and paper mill in 1994 (ECAP 1995).

| | |
|---|---|
| Fresh water inlet, m³/day | 800 000 |
| Waste-water outlet, m³/day | 664 000 |
| Organic compounds ($BOD_5$), kg/day | 43 100 |
| Lignosulphonates, kg/day | 155 900 |
| Methanol, kg/day | 940 |
| Formaldehyde, kg/day | 140 |
| Phosphates, kg/day | 45 |
| Ammonium nitrogen, kg/day | 60 |
| Absorbable organic halogen (AOH) | not reported |

Increased attention should be drawn to the use of chlorine in the bleaching processes and the release of chlorinated organic compounds which include small amounts of highly persistent and toxic compounds such as dioxins. Using current technology, it is expected that 3 to 6 kg of chlororganic compounds will be released per tonne of bleached pulp. With a production rate of 330 000 tonnes per year, a total of between 990 and 1980 tonnes of chlororganic compounds will be discharged every year. Regeneration or re-use of waste-water from the bleaching process is difficult because of the chemical content. A part of the waste-water from pulping and bleaching is reported to be transported to biological treatment plants for two-stage treatment, but the efficiency of these plants is not documented.

## E. Possible action/remedy

The general claim that 'pollution is lost resources' is in many ways true as far as the pulp and paper industry is concerned. One solution is to allow measures for pollution abatement to focus on internal actions such as re-use, conversion of residues, recycling and modification of polluting processes. Evaporation and conversion of lignin and re-use of other chemicals in many cases lead to better economical management of the mill as a whole. Thereafter, the best available technology should be used to treat the remaining effluent.

*Trace the pollution sources*

It is important to know the composition of the waste-water, and from which parts of the industrial process the different constituents originate, in order to modify these processes and reduce the amount of discharges. It is however, difficult to trace the origin of major emissions merely by sampling from the end of the main effluent pipe. Therefore, locating sources of contamination by means of an extended sampling programme should be included in a total 'emission abatement analysis' of the mill. This will allow compilation of a priority list of actions to be taken.

*Decrease water use*

In general, pollution loading of recipient waterways will increase as the water consumption increases. Efforts should therefore be made to internalise processes as much as possible by reducing the water inlet and increasing the degree of internal counter-current recycling for washing. By necessity however, water used for chlorine bleaching has to be discharged after two or three step pulp washing due to its chemical content.

*Decrease emission of lignin-containing residues and other organic compounds*

Release of lignin should be minimised by improved washing of the pulp. Approximately 95 - 99 % delignification is technically possible, as compared to the 80 - 85 % achieved by the Archangel pulp and paper mill (ECAP 1995). As reported, the equipment for pulp washing is old and should be replaced. After cooking, all the sulphite liquor should be withheld for further processing. As reported (ECAP 1995), methanol production and yeast production are carried out before evaporation and burning. An interesting alternative to burning is re-processing lignin-containing residues to form valuable products. A Norwegian lignin mill, for example, produces additives for concrete production, drilling fluid and animal food and reports a good economy.

## F. Estimated cost of action

The cost of a total technical upgrading of internal and external processes to reduce the pollution from the Novodvinsk pulp and paper mill will obviously be very high.

A report on reduction of chlororganic discharge in the Nordic pulp industry compiled by the Nordic Council of Ministers, Copenhagen (Nordic Council of Ministers 1989), concludes with the following remarks: In mills with no previous measures taken for reducing the discharge of chlororganic compounds (AOH), it would be fairly easy to reach a discharge level of 2 kg AOH per tonne of bleached softwood pulp. An algorithmic calculation of the total production cost (including also interest on and depreciation of the invested capital), indicates an increase by SEK 50 - 60 (appr 9 USD) per tonne pulp in relation to the production cost in a conventional mill with a discharge of approximately 6 kg AOH/tonne pulp. To reach a discharge level of 1 kg AOH per tonne of softwood pulp, advanced processing technology is required, and the additional increase in production costs is estimated to be SEK 70 - 95 (appr 11-13 USD) per tonne pulp.

The figures quoted here indicate the high cost of process-modification, but seen as long term investments, many of them will be worthwhile as the operational costs will be reduced. The major cost-cuts will be saving of both energy and chemicals, plus a reduced need for waste-water treatment. Furthermore, the possibilities for producing valuable products from the sulphite liquor and lignin residues, improved paper quality, and the improved environmental situation, should be included in the total calculation.

The first step to reduce environmental impacts from the mill should be the preparation of a 'clean production assessment'. Such analysis should be made by experts in the field of process and waste-water treatment technology, and result in recommended actions based on cost/efficiency. Existing strategies for pollution control should be consulted.

The Expert Group has noted that Archangel pulp and paper mill has taken several initiatives to reconstruct the plant in an environmentally sound manner. This includes contacts and pre-feasibility studies in co-operation with Nordic counterparts. Several cost estimates of both Russian and Western groups have been done, and some of the estimates have been presented to the Expert Group. During the NEFCO-feasibility study these initiatives and the cost estimates have to be clarified and evaluated.

**A. Name and reference number**

A71 Preservation of virgin north taiga forests in Mezen County

**B. Geographical location**

The virgin north taiga forests are mostly found in Mezen County, in the northern part of Archangel Province, and cover an area of 3.5 million hectares.

B. **Environmental problem**

A governmental decree of 1959 states that the virgin north taiga forests in Mezen county belong to the circum-tundra category, and therefore industrial wood logging is prohibited. However, an intensive industrial development including forest exploitation, takes place in the adjacent territories. This development has a strong impact on the border zones of the protected forest, such as wood fires, construction of electric lines and geological explorations. The virgin forest also is visited by an increasing number of tourists, hunters and fishermen. This impact gradually decreases the area of virgin forest land and the unique biological diversity is being reduced.

**C. Description of the problem and environmental impact**

The Mezen forests consist of spruce (70 %), pine (20 %), birch (8 %) and larch (2 %). Approximately 85 % of the forest is characterised as mature and over-mature. The average forest density is 111 $m^3$ per hectares, with variations from 40 to 300 $m^3$ per hectares. One part of the forest is situated on a plateau 150-200 m above the sea level, formed by carbonate and gypseous rocks. Here, the forest has high productivity and a high larch content, with a genetic age of 15 thousand years. Another part of the forest is situated on a low littoral plain of 10-15 m above sea level and has a genetic age of 7 thousand years (ECAP 1995). As the largest forest of natural origin in Europe, the Mezen forests are of great scientific and environmental importance.

Nowadays, the Mezen forests are under increasing anthropogenic pressure due to the industrial development of the adjoining territories. At the same time, the existing system of financing does not allocate sufficient means for protection and reproduction of forests that have no industrial logging. During the last five years, an increasing number of forest fires have occurred in the Mezen County. This is thought to be related to the large number of expeditions, tourists, hunters and fishermen visiting this area of virgin countryside. Around 15-20 fires occur annually, each covering an average area of 3 hectares. The biggest fire so far occurred in 1994, spreading to an area of 80 hectares. The natural conditions in some parts of Mezen forests are favourable for outbreaks and spreading of fire. These are valuable forest ranges on the Belomor-Kuloy plateau (600 thousand hectares) as well as dry piny woods along the rivers Kuloy, Mezen and Peza (150 thousand hectares). These are also the areas which suffer the greatest anthropogenic influences.

## E. Proposed action/remedy

The Expert Group was presented to a plan to preserve and improve the protection of the Mezen virgin forest (M. Kudryashov, head of Forest Department, Archangel Province). The plan included replanting of burned-out sites, reclamation of marshland and other lands by planting coniferous species (a total of 476 hectares).

Other actions presented by ECAP (1995) were:

- Strengthening of fire-preventive protection of forests.
- Organisation of forest monitoring.
- Investigation of genetic forest reserves.
- Construction and improvement of networks of forest cordons-shelters.

## F. Estimated cost of action

The replanting programme presented above should run for a period of three years, and the total costs were estimated to 690 000 USD, including planting material.

## A. Name and reference number

M81 Water supply in Lovozero town

## B. Geographic location

Lovozero town is situated at Lake Lovozero in the central part of Kola Peninsula.

## C. Environmental problem

In 1993, more than 2/3 of the water samples taken from the household water in the town of Lovozero (some 4-5000 inhabitants) did not meet the Russian national standards on chemical variables. The problems were mainly due to different types of industrial contamination (such as fluoride, petroleum hydrocarbons and metals).

## D. Description of the problem and environmental impact

Poor tap water quality is considered to be one of the most serious threats to human health. The household water in Lovozero is contaminated both by the waste from industrial enterprises located in the vicinity and by the municipal sewage. Neither of these discharges of waste water are satisfactorily treated. The treatment system for household water is poor, and the pipeline network is weak.

## E. Possible action/remedy

Two possible solutions are apparent:

1) Continuous use of the present water source

2) Alternatively, exploitation of other sources of water supply (ground water or unpolluted surface water)

In either case, there is a need for a better treatment plant and a renovated water distribution system.

## F. Estimated cost of action

Not given

**A. Name and reference number**

A81 Improvement of environmental aspects of human health of the indigenous population in the settlement of Nelmin Nos

**B. Geographical location**

Nelmin Nos is situated in the Pechora River estuary, some 70-80 km downstream of Narjan-Mar, the main city of Nenets AA.

**C. Environmental problem**

Nelmin Nos has a total population of 1 063, of which 1 037 are indigenous Nenets. The Nenets is one of 26 native tribes in northern Russia. Most of the Nenets live in small villages on the tundra, each with 70 - 1200 inhabitants. Each village is organised as a co-operative and most are based on reindeer herding, with hunting and fishing as important secondary means of living.

The traditional life style of the inhabitants of the settlement Nelmin Nos depends upon the Pechora River for both drinking water and local fisheries. The water consumption is estimated to 60 $m^3$ per day. At the same time, the Pechora River is recipient to municipal and industrial waste as well as oil field leakage and runoff from mining. Drinking water is taken directly from the River. The Regional Environmental Committee of Nenets AA reports that the drinking water in Nelmin Nos is of poor quality, with microbiological parameters exceeding health standards, giving rise to high incidences of infectious diseases. In the upper parts of the Pechora River watershed, oil from the spills in Komi has contaminated the water, and there is a fear that the oil may be transported in particular form by the River to the estuarine areas.

**D. Description of the problem and environmental impact**

A report on the life conditions of the people in Nelmin Nos has been compiled by the indigenous peoples' organisation (ECAP 1995). This report is based on a questionnaire completed by selected inhabitants and clinical investigations of selected inhabitants of the village. The methods used differ considerably for those used in international scientific and epidemiological investigations, but the report offers some very valuable information concerning living conditions in this village. The Nenets people was the first ethnic group to be organised within the former Soviet-Union, with an established union in 1929. Despite this, modern society has gradually destroyed the culture of the tribe, and a federal rehabilitation programme, GOSKOMSEVER, has been created, with the purpose of social and economical development of the northern people from 1996 to the year 2000.

The indigenous people themselves regard this kind of work as being useless, without expertise and resources from international co-operation. The local people are of the opinion that the most effective way to protect culture, as well as to promote social and economic development, is to create ecological parks in the multi-ethnic areas. The Nelmin Nos village is regarded as a very suitable place for such work. The creation of such an ethnic-ecological park must be supported by medical, biological, social, economical and human rights fundaments.

The quality of nutrition is regarded as a severe problem that has increased over the last years. The consumption of vegetables, fruits and milk products has decreased, mainly due to high prices, rather than the lack of these food items. It seems important to organise local markets and price-regulation. Only 20 % of the people appear to have money and opportunity to go to a larger place, such as Narjan-Mar, in order to buy additional food. Only very few people produce some of their own food products.

The conclusion of the investigation based on the questionnaire is as follows:
More than half of the people interviewed feel it is important to maintain the traditional way of living, but to incorporate it with modern technology. The people most strongly connected to their 'roots', appear to be those most positive to questions regarding development and international contacts. This gives a very important basis for further co-operation and development, with full attention paid to the tradition and culture into which the modern technology and knowledge in incorporated. The common people of Nelmin Nos appear positive to establishing Nelmin Nos as a 'project' village for developing environmental aspects of human health. The local administration, the local health authorities and the Narjan-Mar administration also appear positive to this work.

### E. Possible action/remedy

Through the feasibility study a project group must be established. The Expert Group suggest that the project group should have representatives from the authorities in Nenets AA, the settlement Nelmin Nos and the NEFCO-Programme. The project group must co-ordinate their activities with other ongoing initiatives in the Nenets AA.

The Expert Group further suggest the following actions to be evaluated by the feasibility study:

- Establish a year around supply of good quality drinking water, perhaps two or three wells in the village.
- Supporting the local hospital and staff by providing equipment, based on the established traditions. Open discussion on the type of paramedical knowledge from the native tradition most suited to put into practical application.
- Education programme that also emphasises traditional knowledge and culture, as well as preserving the native language.
- Support and develop the local fishery, traditional hunting and exploitation of natural resources, including the herding of reindeer, in order to increase self-sufficiency for food and to increase the consumption of nutrient-rich foodstuffs.
- Evaluate the potential of eco-tourism within the framework of an ecological multi-ethnic park as a source of income for the village.

### G. Estimated cost of action

Not given

**A. Name and reference number**

A82 Drinking water and sewage treatment in small villages in Kenozero National Park.

**B. Geographic location**

Kenozero National Park is situated in the south-west part of Archangel Province between the counties Plesetski and Kargopolski - and borders the Republic of Karelia (Figure 4.2). On the park's territory is situated two major lakes, Lake Kenozero and Lake Lekshmozero. In the park are found a number of smaller villages and 9 farms. The agriculture enterprise 'Lekshmozero' aimed at producing environmentally clean products is integrated into the park.

**C. Environmental problem**

The lakes and rivers of the park are polluted as a result of unsatisfactory waste treatment systems. The main contamination is from the municipal waste water, waste water and sewage from the agriculture enterprises and farms and from food processing (diary and meat). The heavy loads of organic waste cause eutrophication in the fresh water systems in the park, and since local surface water is the main source for household water, the drinking water is of very poor quality. There is also an urgent need for improved process water quality used in food processing. Infectious diseases related to poor drinking water quality are common.

**D. Description of the problem and environmental impact**

The total area of the Kenozero National Park is some 140 thousand hectares. Land for agriculture purpose situated within park's territory are 7673 hectares sustaining a total of some 3400 animals (E. Shatkovskaya, Director of Kenozero Park 1995). A dairy in the village of Vershinino has a production capacity of 300 kg butter per day, there is also a dairy in neighbouring Kargopol County, and meat-processing plants in neighbouring counties Plesetsk and Niandoma which treat agricultural production made on the park's territory. The Kenozero National Park is not heavily affected by industrial and urban pollutants.

Most farms are situated in the water protection zones of Kenozero and Lekshmozero Lakes. Each day some 8.5 tonnes of manure is drained into the waterways. Chemical analyses of the water in the waterways in the park reveal enlarged values of fertiliser products (2 times MAC) and the iron values are 4 times MAC in the flood period (Shatkovskaya, Director of Kenozero Park 1995).

This situation is typical for many rural areas and villages, such as Kenozero, where the local rivers and lakes are been used as a source of drinking water, as well as being a recipient for waste water from the community. As a result, there is a high health risk for infectious diseases and illnesses. The negative effects may be summarised as follows: eutrophication of surface waters (the most severe indications are oxygen deficit in lakes and toxic blue-green algae blooming), epidemic diseases caused by hepatitus viruses, enteroviruses and *E. coli* in contaminated drinking water. The official county statistics of infectious diseases showing that there is a high incidence of gastro-intestinal diseases, especially among children (Odland 1995

## E. Possible action/remedy

The Expert Group was presented a plan from ECAP: 'Clean water to the lakes of Kenozero Park'. The plan aims at promoting a strong environmental input for the development work of the Kenozero National Park area and a selected village in the park.

The Expert Group support this idea and suggest to include the following in the pilot project:

- Drinking water supply and sewage treatment in a selected village in the park.
- Educational aspects of the environmental and sanitary pilot projects in connection to other activities in the national park.

Drinking water and sewage treatment in small villages, a pilot project.

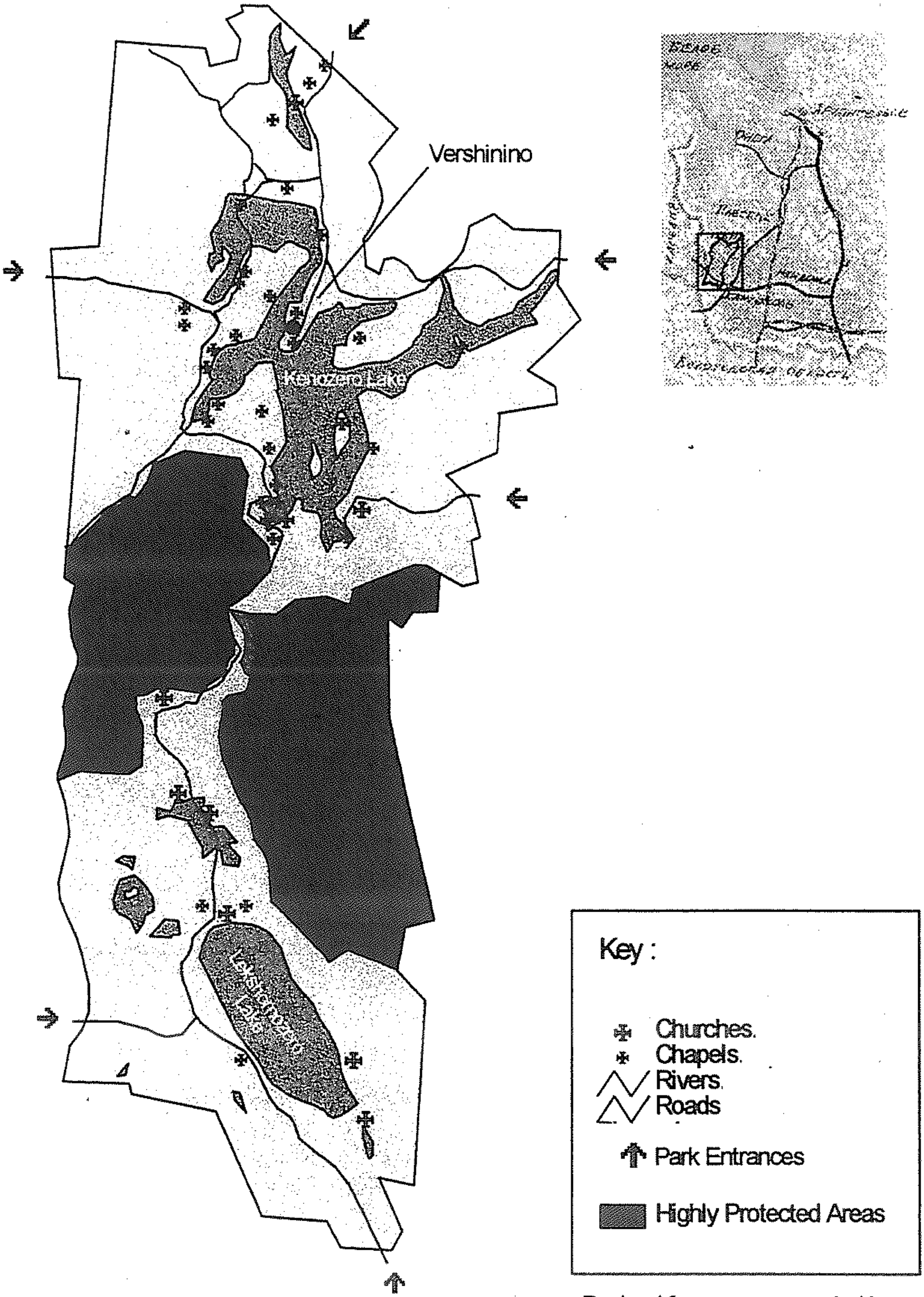
Many small villages (500 - 10 000 inhabitants) in the Russian part of the Barents Region have drinking water of poor quality. This causes a number of health problems. Often the problem is directly related to pollution of the surface water bodies (which are used as water sources) by the waste water and sewage from the villages themselves.

The Kenozero National Park

This park is a unique area, where traditional skills and modern populations still co-exist. The characteristic and intrinsic value of the park area has been realised, which is why efforts have been made to preserve the status, despite the low economic profit of traditional livelihoods. A development and implementation project for new environmental techniques has been requested. This area is likely to have a good possibility for organising systematic waste treatment systems, which allow recycling and minimising waste effects. From an educational viewpoint (school visits, scientific interest etc.), the Kenozero National Park offers many cultural attractions. The area as a whole represents the traditional way of life, with small units forming an ideal basis for demonstrations of environmentally sound remedial actions. Through the pilot project valuable experience could be gained, and the projects could be implemented in similar cases also elsewhere in Russian countryside.

## F. Estimated cost of action

A cost estimate for the 5 year projects 'Clean water to the lakes of Kenozero Park' has been presented to the Expert Group (ECAP 1995). The estimate has not been evaluated by the Expert Group. The costs are estimated to more than 1 mill USD and with a split financing between provincial bodies (the Environmental Committee and the Agriculture and Food Department) and international agencies.




Revised from map presented by
Archangel Environment Committee

Figure 4.2 The Kenozero National Park.

Akvaplan-niva

**A. Name and reference number**

**G 91** Integrated environmental and human health monitoring

**B. Geographic location**

The Province of Murmansk, The Republic of Karelia and the Province of Archangel including Nenets Autonomous Area.

**C. Problem**

Environmental and human health monitoring in Russia is at present not adequately implemented in Russia, although authorities are aware of the most severe problems in this context. Environmental, as well as human health monitoring is carried out by several governmental and local authorities and institutes, which are not in full co-operation. As a consequence, overlapping of monitoring programs exists, and on the other hand, there are often large gaps in the information needed to identify environmental impacts. In general, laboratories are not equipped with up dated instruments and have a low standard with a low international compatibility.

**D. Description of the problem**

Human and environmental effects, as well as any improvements, are difficult to quantify. It is not possible to follow-up the cost-effectiveness of environmental actions carried out. In addition, the steering of measures for combating discharges is not properly systematised.

**E. Possible action/remedy**

The Russian part of the Barents Region should have a joint environmental and human health monitoring system that is compatible with the corresponding systems of the neighbouring countries.

The monitoring system should integrate data on:

- levels and effects of environmental pollution;
- sources of emissions and discharges
- general environmental conditions, eg. meteorology, hydrology and oceanography
- environmental aspects of human health.

The monitoring system should have three operational levels:
- inter-regional (Russian part of the Barents Region),
- regional (Province, Republic),
- local (City)
with the appropriate component, spatial and temporal solutions for each level.

The priorities of the monitoring system development should be selected, based on the importance/urgency of informational needs through a feasibility study.

**F. Estimated costs**

Not available

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## APPENDICES

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| **Appendix 3** | **Projects supported by other financial bodies.** |

## Appendix 1 Russian MAC for selected components in air and water

In this report, the abbreviation MAC (Maximal Allowed Cocentration) is used in place of the Russian 'PDK'. In some of the literature and information used, the translations MPL (Maximal Permissible Level), MAL (Maximal Allowed Level) and HAC (Highest Allowed Concentration) have been used synonymously for the Russian PDK. Thus, in the present report, the term MAC covers all these abbrevations.

Appendix table 1.1 Criteria for evaluation of water pollution in fresh water. (Annual report of Hydrochemical institute of Hydromet no. 100, 1994).

| Substance index | Limiting index for harmfullness | MAC milligrams/litre |
|---|---|---|
| Dissolved oxygen | common request | Winter: not less than 4.0<br>Summer: not less than 6.0. |
| $BOD_5$ | common request | 2.0 |
| Ammonium ($NH_4$) | toxicological | 0.5 $N(NH_4) = 0.39$ |
| Nitrate ($NO_3$) | hygenic toxicological (Hyg. tox.) | 40 $N(NO_3^-) = 9.0$ |
| Nitrite ($NO_2$) | Toxicological | 0.08 $N (NO_2^-) = 0.02$ |
| Oil and oil products | Commercial fishing purposes | 0.05 |
| Phenols | Commercial fishing purposes | 0.001 |
| Detergents | Toxicological | 0.1 |
| Iron ($Fe^{+++}$) | Organoleptic | 0.1 |
| Cuprum ($Cu^{++}$) | Toxicological | 0.001 |
| Zinc ($Zn^{++}$) | Toxicological | 0.01 |
| Chromium ($Cr^{+++}$) | Hyg. tox. | 0.5 |
| Chromium ($Cr^{6+}$) | Toxicological | 0.02 |
| Nickel ($Ni^{2+}$) | Toxicological | 0.01 |
| Cobalt ($Co^{2+}$) | Toxicological | 0.01 |
| Manganese ($Mn^{2+}$) | Hyg. tox. | 0.01 |
| Lead ($Pb^{2+}$) | Hyg. tox. | 0.03 |
| Mercury ($Hg^{2+}$) | Hyg. tox. | 0.0005 |
| Cadmium ($Cd^{2+}$) | Toxicological | 0.001 |
| Fluor ($F^-$) | Hyg. tox | 0.75 |
| Cyanide (CN) | Toxicological | 0.01 |
| DDT | Toxicological | ---- |
| HCH | Toxicological | ---- |
| Methylmercaptane | Organoleptic | 0.0002 |
| Benzol | Toxicological | 0.5 |
| Furforol | organoleptic | 0.1 |
| Methanol | Toxicological | 0.1 |
| Formaline | Hyg. tox. | 0.1 |
| Aluminium ($Al^{3+}$) | Toxicological | 0.04 |
| Tin ($Sn^{4+}$) | Toxicological | 0.01 |
| Lignosulphonate | common request | 1.0 |
| Potassium ($K^+$) | Hyg. tox. | 50.0 |
| Calsium ($Ca^{++}$) | Hyg. tox. | 180 |
| Magnesium ($Mg^{++}$) | Hyg. tox. | 40.0 |
| Sodium ($Na^+$) | Hyg. tox. | 120.0 |
| Sulphate ($SO_4^{--}$) | Hyg. tox. | 100.0 |
| Phosphate ($P\text{-}PO_4^{--}$) | Hyg. tox. | 0.2 |
| Mineralisation | Common request | 1000 |
| Chloride ($Cl^-$) | Hyg. tox. | 300.00 |

Appendix Table 1.2 MAC for selected different contaminants in atmospheric air.
(Geophysical observatory of Hydromet, St. Petersburg 1992).

| **Substances** | **MAC milligrams /$m^3$** | **MAC milligrams /$m^3$** |
|---|---|---|
| | Maximal 20 minutes exposure | Average for 24 hours |
| Nitrogen dioxide | 0.085 | 0.04 |
| Nitrogen oxide | 0.4 | 0.06 |
| $NH_4$ | 0.2 | 0.04 |
| Benzo(a)pyrene | -- | 0.1 μg/100 m3 air |
| Dust | 0.5 | 0.15 |
| HCl | 0.2 | 0.2 |
| Methylmercaptane | $9 \times 10^{-6}$ | --- |
| Nickel | --- | 0.001 |
| Metallic mercury | --- | 0.0003 |
| Hydrogen di sulphide | 0.008 | --- |
| Sulphur dioxide | 0.5 | 0.05 |
| Formaldehyde | 0.075 | 0.003 |
| Hydrogenfluoride | 0.2 | 0.005 |
| Chlor | 0.1 | 0.03 |
| Furfurol | 0.05 | 0.05 |

## Appendix 2 Composition of the Steering Committee and the Expert Group

**The AMAP Expert Group**[1]

Nordic experts:

Gas, freshwater and terrestrial issues: Kari Kinnunen, Marjaleena Nenonen, Outi Mähönen, Lauri Havarinen, Lapland Regional Environment Centre, Finland
Human health issues: Jon Øyvind Odland, University of Tromsø, Norway
Marine issues: Salve Dahle, Akvaplan-niva, Tromsø, Norway

Russian experts:
The following experts were apointed by the regional environmental protection authorities to participate in the Expert Group on issues covering own geographic area:

Murmansk Province:

| | |
|---|---|
| Vladimir Uljanov, | Deputy Chairman of the Environmental Committee |
| Valery Artobolevsky, | The Environmental Committee, Head of Division for Social and Ecological Appraisal |
| Alexander Lopatkin, | Director of the Institute "Murmansk promproject". |
| Lev Solovyev, | Regional Centre for Sanitary Inspection, Deputy Head |

Republic of Karelia:

| | |
|---|---|
| Valery Bryazgin, | Karelian State Pedagogical Institute, Zoological Department |
| Peter Lozovik, | Institute of Water Problems in the North (RAS), Head of Chemistry laboratory |
| Pavel Shvetz, | Karelia Branch of Hydrometeorological Service, Director |
| Oleg Anikin, | Ministry of Ecology, Head of Ecological Evaluation Department |
| Nina Romanova, | Ministry of Ecology, Head of Air Quality Department |

Archangel Province:

| | |
|---|---|
| Galina Zaitseva, | Environmental committee, waste water |
| Galina Komarova, | Archangel Forestry - Engineering Institute |
| Liliya Dobrodeeva, | Institute of Physiology, Archangel Branch (RAS) |
| Valerij Stanislavets, | Environmental committee, marine hydrobioloy |

Akvaplan-niva v. Salve Dahle, Lars-Henrik Larsen, Sabine Cochrane & Charlotte Winsnes has functioned as secretary to the Expert Group and has composed the report.

[1] The names of the experts on radioactivity issues are given in volume two: 'Radioactive contamination'.

**The Steering Committee** of the project has consisted of representatives from

The Ministry of Protection of the Environment and Natural resources of the Russian Federation:
Peter Bogdanov, head of Department of International Co-operation
Larisa Yanchik, head of division, departement of International Co-operation,

Ministry of Defence of the Russian Federation:
Major-general Yuri Savin

Republic of Karelia:
Mikhail Festchenko, Minister of Ecology and Natural resources

Arkhangelsk Region:
Anatoly Minyaev, Chairman of the Regional Committee for Environmental Protection

Murmansk Region:
Ivan Vishnyakov, Chairman of the Regional Committee for Environmental Protection

NEFCO:
Harro Pitkänen, Managing Director
Tore Selvig, representativ of the Nordic Investment Bank

AMAP Secretariat:
Lars-Otto Reiersen, Executive Secretary
Vitaly Kimstach, Deputy Secretary

Norway:
Olav Berstad, Norwegian Embassy in Moscow

## Appendix 3 Projects supported by other financial bodies.

This appendix is a summary of initiatives and activities, currently ongoing within the same fields of interest which the present screening have worked on. The list is not claiming to be absolutely comprehensive with regard to private initiatives, but contains information on projects that are supported by official Norwegian and Finnish financing institutions.

| PROJECT NAME | SECTOR | FINANCIAL BODY | IMPLEMENTATIVE STATUS |
|---|---|---|---|
| Monitoring of discharges from the Pechenga nickel smelter (water, air, terrestrial) | Environmental co-operation | Norwegian Ministry of Foreign Affairs, action programme for Eastern Europe 1995 | Application accepted 1995 |
| Norwegian - Russian health investigations | Environmental co-operation | Norwegian Ministry of Foreign Affairs, action programme for Eastern Europe 1995 | Application accepted 1995 |
| Environmental training for Russian Engineers | Environmental co-operation | Norwegian Ministry of Foreign Affairs, action programme for Eastern Europe 1995 | Application accepted 1995 |
| Transfer of technology for treatment of waste water from pulp and paper industry in North West Russia (Archangel Pulp & Paper Combine) | Environmental co-operation | Norwegian Ministry of Foreign Affairs, action programme for Eastern Europe 1995 | Application accepted 1995 |
| Cleaning of the emissions from the nickel smelters in Nikel | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Environmental effects on human health | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Improvement of drinking water quality in North West Russia | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Anadromous salmonids | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Environmental conditions in the White Sea | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Securing of the nuclear waste onboard Lepse | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Establishing of competence centre within environmentally adjusted waste water cleaning. | Environmental co-operation | The Barents Secretariat | Started 1995 |
| Incineration control, Monchegorsk | Environmental improvements | Priroda | Completed 31.12.93 |
| Operation system for heating | Environmental improvements | Priroda | Running |
| Phase 1, sludge de-watering, Prigorodny | Environmental improvements | Priroda | Completed 31.12.93 |
| Building of de-watering plant at Prigorodny | Environmental improvements | Priroda | Running |
| Pre study on operation, Prigorodny | Environmental improvements | Priroda | Running |
| Full scale experiment with nefeline as coagulant | Environmental improvements | Priroda | Completed 31.12.94 |
| Processing of marine waste | Environmental improvements | Priroda | Completed |
| Cleaning of air-borne emissions - Technical/economical solutions | Environmental improvements | Priroda | Running |

| PROJECT NAME | SECTOR | FINANCIAL BODY | IMPLEMENTATIVE STATUS |
|---|---|---|---|
| Pre separation of waste water | Environmental improvements | Priroda | Running |
| Energy saving activities, correct use of ventilation, heating and light. | Environmental improvements | Priroda | Running |
| Air Pollution Project Europe | Environmental management | Norway - Ministry of Environment | 1993-1996 |
| Murmansk Region Environmental Data Centre | Environmental management | Finland (Ministry of Environment) | completed 1996 |
| Water laboratory project and identification of the acidification status of the lakes in Murmansk region | Environmental management | Finland (Ministry of Environment) | completed 1995 |
| Development Projects at Svanhovd Environment Centre | Environmental management | Norway | |
| Nature Resource Management and Planning | Environmental management | Norway (Ministry of Environment/Ministry of Foreign Affairs) | 1993-1996 |
| Provision of technical and material assistance etc. | Environmental management | Norway (County Governor of Finmark) | 1994 |
| Development of environmental (emission measurement) technology in the Barents Region | Environmental management | Finland (Studio Village Ltd) | 1992-1999 |
| Air pollution in the border areas of Norway and Russia | Environmental monitoring | Norway | continuos 1989- |
| Measurements and Control of Atmospheric Emissions in Murmansk Province | Environmental monitoring | Nordic Council of Ministers | completed June 95 |
| Large-scale dispersion of heavy metals from mining industry in Norrbotten and on the Kola Peninsula | Environmental monitoring | Sweden (County Administration of Norrbotten) | completed summer 96 |
| Air quality measurements at Jäniskoski, Kola Peninsula | Environmental monitoring | Finland (Finish Meteorological Institute) | |
| Environmental contaminants in Arctic marine foodchains and seabird from the Barents Sea | Environmental monitoring | Norway (Ministry of Environment) | 1991-94 |
| Acidification of surface waters and critical loads, and heavy metals in lake sediments in the Russian-Norwegian border areas | Environmental monitoring | Norway (Ministry of Environment) | continuos monitoring programme 1989- |

| PROJECT NAME | SECTOR | FINANCIAL BODY | IMPLEMENTATIVE STATUS |
|---|---|---|---|
| Ground-based monitoring of environmental parameters in forest ecosystems around pollution sources | Environmental monitoring | Norway/Russia | 1995-1996 |
| The Lappland forest damage project | Environmental monitoring | Finland (Ministry of Agriculture and Forestry)/Russia | completed January -95 |
| Studies on health effects from pollution in the Norwegian-Russian boarder areas | Human health | Norway (Ministry of Environmen/Ministry on Health | 1994-96 |
| $SO_2$ and dust removal at the Kostomuksha combine, for the first production line | Monitoring - Technology | grant: Finland | 1994 |
| Modernisation of a recovery boiler at the Segezha Pulp and Paper Mill | Monitoring - Technology | grant: Finland | completed Oct. 95 |
| The Russian - Norwegian Cleaner Production Programme | Monitoring - Technology | Norway/(Russia) | completed -96 |
| Prefeasibility studies in the Barents Region | Monitoring - Technology | The Nordic Council | 94-95 |
| Modernisation of Kandalaksha aluminium smelter | Monitoring - Technology | Finland/Russia | open |
| Planning of sewage treatment of the Kostomuksha Combine | Monitoring - Technology | Finland (Ministry of Environment?) | |
| Water supply for Murmansk region, pilot study in Monchegorsk | Environmental technology | Finland | completed April 95 |
| Construction of a sewage treatment plant in the town of Lahdenpohja | Environmental technology | grant: Finland | completed June- 95 |
| Training and demonstration video concerning the waste water treatment project in Lahdenpohja | Environmental technology | Finland (Ministry of Environment) | completed Dec. 94 |
| Disposal of waste products | Environmental technology | Nordic Council of Ministers | completed 94/95 |
| Creation of production of coagulant for drinking water purification for drinking water purification based on "white" bauxite in Iksinsky deposit of Archangel area | Environmental technology | | |
| Coagulant production for drinking water treatment | Environmental technology | | |
| Creation of International pilot and scientific Centre for sewage waters purification in Archangel city | Environmental technology | | |
| The Environmental Impact of the Emission to water from pulp and paper mills in the Archangel Region | Environmental technology | Sweden (County Administration of Norrbotten) | 1995 |

| PROJECT NAME | SECTOR | FINANCIAL BODY | IMPLEMENTATIVE STATUS |
|---|---|---|---|
| Improve the quality of drinking water in Northwest Russia | Environmental technology | Finland/Norway/Sweden | 1995 |
| Survey on airborne emissions of the Kostomuksha area | Local environmental monitoring and assessment | Finland (Ministry of Environment) | completed Dec 94 |
| Research on the impact of the Kostomuksha combine on the Karealian water system | Environmental technology | Finland (Ministry of Environment) | completed Dec 94 |
| Research project on the Ladoga Lake | Environmental technology | Finland (Ministry of Environment) | completed Dec 94 |
| Surveys on air pollution | Environmental technology | Nordic Council of Ministers | completed 94/95 |
| Environmental conditions in the White Sea | Environmental technology | Norway | 1995 |
| Strategic work and co-operation between authorities | Environmental education | Nordic Council of Ministers | completed 94/95 |
| Ecological monitoring of forests in South Eastern Finland, in the Leningrad Region and in'Karelia | Nature conservation | Finland (Ministry of Environment) | completed Dec 94 |
| Construction of a ship-breaking plant and a cargo terminal on the Belokamennaya Bay in Murmansk Province | Harbour construction/Infrastructure | Project recommended by the Barents Euro-Arctic Counsil, Working group on Economic co-operation. Proposal from Murmansk Province | Not yet initiated. Recommended for financiation |
| Development of energy efficiency and conservation programmes for the Murmansk and Archangel provinces and the Republic of Karelia | Energy/Infrastructure | Project recommended by the Barents Euro-Arctic Counsil, Working group on Economic co-operation. Proposal from Finland/Planora OY | Not yet initiated. Recommended for financiation |
| Reconstruction and modernisation of the Pechenganickel melting works | Environmental project | Project recommended by the Barents Euro-Arctic Counsil, Working group on Economic co-operation. Proposal from Norway and Sweden | Not yet initiated. Recommended for financiation |
| Development and modernisation of the Kandalaksha aluminium works | Environmental project | Project recommended by the Barents Euro-Arctic Counsil, Working group on Economic co-operation. Proposal from Murmansk Province | Not yet initiated. Recommended for financiation |
| Conversion and development of the Zvezdochka shipyard in Severodvinsk | Military industry conversion | Project recommended by the Barents Euro-Arctic Counsil, Working group on Economic co-operation. Proposal from Norway, Finland, Sweden and Archangel Province | Not yet initiated. Recommended for financiation |

Trykket med digitaltrykk hos TRANSFER AS

**Arctic Monitoring and Assessment Programme**
Strømsveien 96, P.O. Box 8100 Dep., N - 0032 Oslo, Norway, Phone 47 - 22 57 34 00, Fax 47 - 22 67 67 06

Arctic Monitoring and Assessment Programme (AMAP) was initiated by the ministers from the eight Arctic countries, Canada, Denmark, Finland, Iceland, Norway, Federation of Russia, Sweden and USA, at a Ministerial Meeting in Rovaniemi, Finland in June 1991.

The primary objective of AMAP is the measurement of the levels of anthropogenic pollutants and the assessment of their effects in relevant component parts of the Arctic environment. The monitoring will cover the atmospheric, terrestrial, freshwater and marine environment and human health. The assessment will be presented in status reports to the Ministers as a basis for necessary steps to be taken to reduce pollution.

As an initial priority, AMAP will focus on persistent organics , selected heavy metals and radionuclides. Monitoring of acidification and Arctic haze, oil, eutrophication and biodiversity are also part of the programme and will provide the basis for the assessments.

In order to implement AMAP, the eight Arctic countries established a Working Group. Representatives from the Indigenous people and from countries and international organisations involved in significant research and monitoring relevant to the Arctic are also acting as observers. A permanent Secretariat has been established in Oslo, Norway. Please contact the Secretariat if you require more information concerning AMAP.

The Nordic Environment Finance Corporation (NEFCO) was established in 1990 by the five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) as a multilateral venture capital institution. The purpose is to promote financially viable projects that help to improve the environmental situation in the Central and Eastern European countries neighbouring the Nordic region. NEFCO participates as risk-capital financier providing equity investments and/ or loan financing. Normally, the projects involve participation by one or more co-operating partners from the Nordic region.