

## **NATIONAL IMPLEMENTATION PLAN 2004+ FOR THE AMAP TRENDS AND EFFECTS PROGRAMME**

### **PREFACE**

The monitoring work within AMAP is based, as far as possible, on existing national and international monitoring and research programmes. The Finnish National Implementation Plan (NIP) has been prepared in accordance with the principle that the individual environmental research institutes and other relevant bodies include AMAP issues in their own research and monitoring programmes. The existing or planned programmes are being directed to better meet the needs of AMAP.

The Finnish NIP is a comprehensive tentative list of the research and long-term monitoring programmes and other supporting studies that produce data relevant to the AMAP objectives. The environmental research and monitoring programmes are carried out by national research institutes, local authorities and universities, under the auspices of five different ministries. The Finnish NIP is prepared, and will be updated, by the Finnish National AMAP Working Group, which is composed of representatives from the following relevant national bodies:

- Ministry of the Environment
- Finnish Environment Institute (SYKE)
- Lapland Regional Environment Centre (LAP)
- Finnish Meteorological Institute (FMI)
- Finnish Forest Research Institute (METLA)
- Geological Survey of Finland (GTK)
- National Veterinary and Food Research Institute (EELA)
- Radiation and Nuclear Safety Authority (STUK)
- Finnish Game and Fisheries Research Institute (RKTL)
- Finnish Institute of Marine Research (FIMR)
- State Provincial Office of Lapland
- Saami Parliament, Finland

The Finnish NIP includes six sub-programmes, which are described in this report: the atmosphere, terrestrial ecosystems, freshwater ecosystems, human health, radioactivity and marine environment. These sub-programmes are defined in terms of parameters and media to be monitored with respect to the priority contaminants, such as persistent organic contaminants (POPs), heavy metals and radioactivity. Acidification and the effects of pollution on the health of humans living in the Arctic, including the possible effects of increased UV radiation and climate change, are also priorities. Only part of the data (e.g. atmospheric data and freshwater contaminants) will be submitted regularly to the thematic data centres (TDCs). Other data, such as terrestrial data and hydrological data supporting the effects of climate change, will be available for the assessment procedure on request. Additional supporting studies are listed at the end of each sub-programme.

The strategy for further development of the monitoring activities in Finland is to promote the integration of the sub-programmes. This will enable the sub-programmes to utilise data from other media in their assessments. An integrated monitoring station of this sort has been planned for the Pallas atmospheric monitoring site, and there are plans to include terrestrial and freshwater sampling in the future. This station will provide an integral contribution to the monitoring of the Northern Fennoscandian Key area.

## 1. ATMOSPHERIC SUB-PROGRAMME

### 1.1 Objective and structure

The atmospheric monitoring provides data for the future assessment of the state of the Arctic environment, especially temporal and spatial trends in concentrations of heavy metals, POPs and acidifying substances in air and precipitation.

The Finnish monitoring programme consists of measurements performed within the framework of international and national programmes, supplemented by a number of parameter measurements established for the AMAP programme at Pallas.

The international programmes are:

- EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Pollutants in Europe) co-ordinated by UN/ECE.
- WMO/GAW (Global Atmosphere Watch of the World Meteorological Organisation). The purpose and long-term goal is to provide data, scientific assessments and other information on changes in the chemical composition and related physical characteristics of background atmosphere from all parts of the Globe.
- Integrated Monitoring, also co-ordinated by ECE, for estimation of the long-term effects of air pollutants on a complete ecosystem in a restricted catchment area.

### 1.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/ Examination	Programme and/or responsible institute
Air/aerosol	PAH, HCH, PCB, DDE, DDD, DDT, chlordan, trans-nonachlor	1 week / month	Pallas	AMAP/FMI, IVL
Bulk precipitation	PAH, HCH, PCB, DDE, DDD, DDT, chlordan, trans-nonachlor	1 week / month	Pallas	AMAP/FMI, IVL
Air/aerosol	Cd, Cu, Pb, Zn, Cr, Ni, As, Al, V	Weekly	Pallas	AMAP/FMI
Bulk precipitation	Cd, Cu, Pb, Zn, Cr, Ni, As, Al, V	Monthly	Pallas	AMAP/FMI
Air/aerosol	Hg; particulate	Weekly	Pallas	AMAP/FMI, IVL
Air/aerosol	Hg; gaseous	2 days / week	Pallas	AMAP/FMI, IVL
Bulk precipitation	Hg	Monthly	Pallas	AMAP/FMI, IVL

<b>Air/aerosol</b>	SO <sub>2</sub> , SO <sub>4</sub> <sup>2-</sup> , sum NO <sub>3</sub> <sup>-</sup> + HNO <sub>3</sub> , sum NH <sub>3</sub> + NH <sub>4</sub> <sup>+</sup>	Daily	Pallas	GAW/FMI
<b>Air/aerosol</b>	NO, NO <sub>2</sub> , SO <sub>2</sub> , O <sub>3</sub> , CO <sub>2</sub> , CO, N <sub>2</sub> O, CH <sub>4</sub> , SF <sub>6</sub> , condensation nuclei, black carbon, <sup>222</sup> Rn, light scattering, aerosol size distribution	Continuous	Pallas	GAW/FMI
<b>Air/aerosol</b>	CO <sub>2</sub> flux, sensible and latent heat flux, solar radiation	Continuous	Pallas	FMI
<b>Air/aerosol</b>	VOCs	2 / week	Pallas	GAW/FMI
<b>Bulk precipitation</b>	SO <sub>4</sub> <sup>2-</sup> , NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , Cl <sup>-</sup> , K <sup>+</sup> , pH, conductivity	Weekly	Pallas	EMEP/FMI
	Meteorology, at three sites, 300-760 m a. s. l.	Continuous	Pallas	FMI
<b>Air/aerosol</b>	SO <sub>2</sub> , SO <sub>4</sub> <sup>2-</sup> , sum NO <sub>3</sub> <sup>-</sup> + HNO <sub>3</sub> , sum NH <sub>3</sub> + NH <sub>4</sub> <sup>+</sup>	Weekly	Oulanka	EMEP/FMI
<b>Air/aerosol</b>	NO <sub>2</sub> , O <sub>3</sub> , SO <sub>2</sub>	Continuous	Oulanka	EMEP/FMI
<b>Bulk precipitation</b>	SO <sub>4</sub> <sup>2-</sup> , NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , Cl <sup>-</sup> , K <sup>+</sup> , pH, conductivity	Weekly	Oulanka	EMEP/FMI
<b>Bulk precipitation</b>	Cd, Cu, Pb, Zn, Cr, Ni, As, Al, V	Monthly	Kevo, Oulanka	IM/FMI
<b>Bulk precipitation</b>	SO <sub>4</sub> <sup>2-</sup> , NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , Cl <sup>-</sup> , K <sup>+</sup> , pH, conductivity	Monthly	Kevo, Sodankylä	FMI
<b>Air/aerosol</b>	O <sub>3</sub>	Continuous	Sodankylä	GAW/FMI
<b>Air/aerosol</b>	<sup>210</sup> Pb, <sup>7</sup> Be	Daily	Sodankylä	GAW/FMI
<b>Air/aerosol</b>	<sup>222</sup> Rn	Continuous	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	Upper air soundings	2 / day	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	Ozone soundings	1 / week	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	Backscatter soundings	5 / winter	Sodankylä	FMI
<b>Ozone/UV-B</b>	Total column ozone (Brewer #037, Saoz)	Continuous	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	NO <sub>2</sub> (Saoz)	Continuous	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	UV-B (290 - 325 nm); spectral Brewer	Continuous	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	CIE-weighted total UV-dose	Continuous	Sodankylä	GAW/FMI
<b>Ozone/UV-B</b>	Solar radiation: global, diffuse, reflected	Continuous	Sodankylä	FMI
<b>Ozone/UV-B</b>	Radiation balance, sunshine hours	Continuous	Sodankylä	FMI
	Meteorology	Continuous	Sodankylä	FMI

AMAP  
EMEP

Arctic Monitoring and Assessment Programme  
Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe

FMI	Finnish Meteorological Institute
GAW	Global Atmosphere Watch of the World Meteorological Organization
IM	Integrated Monitoring
IVL	Swedish Environmental Research Institute

### 1.3 Supporting studies

In addition to the air monitoring stations mentioned above, the Finnish Meteorological Institute has an air research station at Sevettijärvi, NE Finland, close to the Norwegian and Russian borders. Separate measurement programmes, primarily for aerosol research, have been carried out at Sevettijärvi since 1991. There is also a DOAS instrument continuously measuring NO<sub>x</sub>, SO<sub>2</sub> and O<sub>3</sub> concentrations.

FMI measures continuously concentrations of the most important greenhouse gases at Pallas as part of the Global Atmosphere Watch activities. We monitor concentration trends and analyze source areas within European projects, such as the Integrated Project CARBOEUROPE. Within that project, greenhouse gas fluxes between the atmosphere and forest and wetland ecosystems are extensively studied using micrometeorological methods. At Pallas, there is long-term monitoring on a spruce forest and on an aapa mire sites, at Sodankylä on a Scots pine forest and at Kaamanen, Inari on an aapa mire. We use the measured carbon balances to study how terrestrial biosphere in Lapland affects greenhouse gas concentrations observed at Pallas, what are the annual carbon balances in cold climate, and how the biospheric carbon sink is affected by climate changes.

Ozone research is based on measurements and models. FMI is collaborating with NCAR in the field of 3-D stratospheric chemistry and dynamics modelling. The ROSE model has been developed further for Arctic and Antarctic ozone simulation purposes. FMI is also collaborating with MPI (Hamburg) in the field of (stratospheric) climate modelling based on ECHAM4 Middle Atmosphere GCM model. The following topics are currently of interest:

- The roles of chemistry and dynamics in the observed ozone depletion at high latitudes
- Interactions between (stratospheric) climate change and ozone chemistry
- Ozone scenarios
- Observed changes in polar vortex behaviour

In addition to carrying out its own UV measurements, FMI is also hosting a European UV database containing spectral UV data from about 30 European stations and ancillary data. The database consists of single files and an Oracle relational database accessible through www. Methodology on space-born retrieval of UV radiation at the Earth's surface is also being developed as a part of FMI, NASA and IASB collaboration. The following items are being studied:

- The impacts of ozone depletion, snowcover and cloudiness on UV radiation
- UV trends based on different techniques
- Space-born UV retrieval and its validation
- UV scenarios
- UV measurement methodologies and their errors

Satellite activities:

- EUMETSAT Satellite Application Facility on Ozone Monitoring (Ozone SAF)
- ESA ENVISAT-1 Global Ozone Monitoring by Stellar Occultation (GOMOS)

A new UV research centre, Finland's Ultraviolet International Research Centre (FUVIRC), has been established at Sodankylä. The centre serves ecosystem research, human health research and

atmospheric chemistry research by providing UV monitoring data and guidance, research facilities, instruments and equipment.

In addition, the following Finnish studies are considered relevant for the AMAP Programme:

- Aerosols in the atmosphere and cloud formation (University of Oulu, University of Helsinki, University of Kuopio, FMI).

## 2. TERRESTRIAL ECOSYSTEMS SUB-PROGRAMME

### 2.1 Objective and structure

The purpose of the terrestrial ecosystems part of the NIP is:

- 1) to monitor the effects of anthropogenic air pollutants and contaminants on tundra and forest ecosystems,
- 2) to assess the impact of possible climate change on tundra and forest ecosystems, and
- 3) to determine the effects of UV-B radiation on tundra and forest ecosystems.

The terrestrial part of the monitoring programme is subdivided into intensive monitoring and regional monitoring.

The intensive monitoring plots include the ICP-Forests (Level II) and ICP-IM plots, which form part of the Pan-European Forest Condition Monitoring Programme, originally instigated under the auspices of the UN/ECE, and now funded by the EU (Finland and Sweden only). There are 13 such plots in Northern Fennoscandia. The purpose of the monitoring and research activity carried out by the Finnish Forest Research Institute within the programme is to investigate the relationships between anthropogenic and abiotic stress factors and the condition and vitality of forest ecosystems. The monitoring includes physical and chemical parameters in the soil and soil solution, as well as biological parameters related to the functioning of the forests.

A number of different organisations are responsible for carrying out monitoring on the regional scale. The Geological Survey of Finland carried out a survey of metals in mosses and soil in 1995, and a new survey was carried out in the year 2000. The Finnish Forest Research Institute conducts surveys of forest condition in Northern Fennoscandia, as part of the ICP-Forests programme, on a network of about 120 plots at the so-called Level I. In addition to the annual assessment of parameters relating to forest condition (defoliation, discoloration), needle chemistry surveys are carried out at 2-year intervals. A soil survey was carried out during 1986-89 and 1995, and will be repeated in 2006. A heavy-metal survey was carried out on moss, lichen and bark samples in 1985, 1990, 1995 and 2000, and will be repeated in the year 2005.

### 2.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/examination	Programme and/or responsible institute
Tree stand	Tree growth	Every 5 years	Sevettijärvi (pine)	ICP Forests (UN/ECE/LRTAP) METLA
	Defoliation	Every year	Kevo (pine) (ex IM) Pallas (pine)	
	Needle chemistry (N, S, P, B, Ca, Mg, K, Cu, Zn, Mo)	Every 2 years	Pallas (spruce) Sodankylä (pine) Kivalo (pine)	

<b>Ground vegetation</b>	Species composition	Every 5 years	Kivalo (spruce) Oulanka (spruce) (ex IM) Oulanka (pine) Oulanka (spruce)	
<b>Mosses, epiphytic lichens, pine bark</b>	As, Cd, Cr, Cu, Fe, Pb, Ni, V, Zn, S	Every 5 years, next sampling 2000	Ca. 100 plots	METLA
<b>Stand throughfall</b>	pH, Ca, Mg, K, Na, Mn, Cu, Zn, DOC, NH <sub>4</sub> , NO <sub>3</sub> , SO <sub>4</sub> , PO <sub>4</sub>	4-week intervals	Sevettijärvi (pine) Pallas (spruce) Kivalo (pine) Kivalo (spruce) Oulanka (spruce) (ex IM)	ICP Forests (UN/ECE/LRTAP) METLA
<b>Soil solution</b>	pH, Ca, Mg, K, Na, Mn, Cu, Zn, total Al, Al <sup>3+</sup> , Fe, DOC, NH <sub>4</sub> , NO <sub>3</sub> , SO <sub>4</sub> , PO <sub>4</sub>			
<b>Litterfall</b>	Ca, Mg, K, Na, Fe, Cu, Zn			
<b>Snow water</b>	Snow water equivalents mm/m <sup>2</sup>	Monthly (winter)	Ca. 40 in Lapland	FEI
<b>Stand climate</b>	<b>Above stand</b> Air temperature Wind speed Wind direction Solar radiation PAR  <b>Within stand</b> Relative humidity Air temperature Soil temperature Soil moisture	Continuous (1 h) Continuous (1 h) Continuous (1 h) Continuous (1 h) Continuous (1 h)  Continuous (1 h) Continuous (1 h) Continuous (1 h) Continuous (1 h)	Pallas (spruce) Kivalo (pine) Kivalo (spruce)	ICP Forests (UN/ECE/LRTAP) METLA
<b>Mosses</b>	Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Tl, U, V, Y, Zn	Sampling in 1995	About 200 sampling points, each point representing 100 km <sup>2</sup> catchment areas	KOLA Ecogeochemistry Project, Geological Survey of Finland
<b>Organic layer</b>	Cu, Fe, H, Hg, K, La, Li, Mg, Mn, Mo, N, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Ti, Tl, U, V, Y, Zn		Norwegian-Russian-Finnish	
<b>Mineral soil</b>	<b>(upper 5 cm)</b> Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, La, Lu, Mo, Na, Nd, Ni, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, U, W, Yb, Zn  <b>B horizon</b> Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Se, Si, Sr, Te, Th, Ti, V, Y, Zn  <b>C horizon</b> Ag, Al, As, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Eu, Fe, Hf, Hg, I, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sm, Sr, Ta, Tb, Te, Th, Ti, U, V, W, Y, Yb, Zn			

<b>Mosses</b>	Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Tl, U, V, Y, Zn	Sampling in 2000	About 1500 sampling points, each point representing 100 km <sup>2</sup> catchment areas in the Barents-area	BARENTS Ecogeochemistry Project, Geological Survey of Finland
<b>Organic layer</b>	Ag, Al, As, B, Ba, Be, Bi, C, Ca, Cd, Co, Cr, Cu, Fe, H, Hg, K, La, Li, Mg, Mn, Mo, N, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Ti, Tl, U, V, Y, Zn		Finnish-Russian-Norwegian	
<b>Mineral soil</b>	<b>C horizon</b> Ag, Al, As, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Eu, Fe, Hf, Hg, I, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sm, Sr, Ta, Tb, Te, Th, Ti, U, V, W, Y, Yb, Zn			
<b>Reindeer</b>	DDT, PCBs, HCB, chlordanes, lindane, Cd, Pb, Hg, Se	Every 2 years	Lapland county	National residue control program, EELA
<b>Elk</b>	Cd, Pb	Every 5 years	Lapland county (whole Finland)	National residue control Program, EELA
<b>Common shrew (Sorex araneus)</b>	PCB, HCH, HCB, Cd, Pb, others	1 to 2 year interval	Kevo, Pallas, Oulanka	National, FEI
<b>Wood ant (Formica sp.)</b>	PCB, HCH, HCB, Cd, Pb, others	1 to 2 year interval	Kevo, Pallas, Oulanka	National, FEI

ICP Forests International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests

UN/ ECE United Nations/ Economic Commission for Europe

LRTAP Long-Range Transboundary Air Pollution

METLA Finnish Forest Research Institute

EELA National Veterinary and Food Research Institute

SYKE Finnish Environment Institute

### 2.3 Supporting studies

A large number of supporting studies are already being carried out, or will be started in the near future, in the arctic region of Finland. These include both studies on topics directly connected to the unique features of the region, and more general studies based on the climatic gradient running through the whole of Finland. Some of the studies are being carried out as joint efforts between Finland, Sweden and Norway. Some of the most important studies are listed in the following:

- Ecology and management of timberline areas, 1994-1998, 1999-2003, 2004- (Metla)
- UV radiation stress in plants at the timberline (METLA, University of Lapland)
- Paleoclimate studies on Antarctic blue ice fields with ground-penetrating radar in Spitzbergen (University of Lapland, Metla)
- Global Change in Subarctic Environment: Physiological and Ecological Stress Responses and Recovery of Wild Plants (University of Oulu)

- Factors affecting microbial production of nitrous oxide and nitric oxide in agricultural soils (AGROGAS) (University of Kuopio, Agricultural Research Centre of Finland, FMI, University of Joensuu)
- Dynamics and modelling of the functioning and structure of forest ecosystems with implications for sustainability of the forest production and climate change impact (University of Joensuu)
- Climate-biOsphERE interactions (CORE) (University of Helsinki, University of Kuopio, FMI)
- Modelling past global change - forecasting the future (Geological Survey of Finland)
- The impact of increased UV-B on plant ecosystems (University of Oulu)
- Paleoenvironment and Climate in the North (University of Oulu)
- Reindeer husbandry and the changing environment (2002-2005) (Metla)
- Integration and harmonization of monitoring activities on the effects of emissions from the Pechenganikel smelter on the environment in the Pasvik area (2003-2006) (Metla)
- Heavy metal concentrations in berries and edible mushrooms in Eastern Lapland and the Laplandia Biosphere Reserve (Russia) and related areas (2004-2007) (Metla)
- Discovery of Arctic microorganisms for biotechnical applications (2001-2005) (Metla, Geological Survey of Finland)

### **3. FRESHWATER ECOSYSTEMS SUB-PROGRAMME**

#### **3.1 Objective and structure**

The objective of the freshwater programme is to provide both spatial and temporal monitoring data for the assessment on heavy metals, acidification, and the effects of climate change. Most of the projects have been established for national needs or as part of international activities other than AMAP.

A project on contaminants in sediment and fish has reported POP and heavy metal data to the first assessment according to the AMAP Monitoring guidelines. One of the lakes (Pahtajärvi) is now included in the national monitoring network on bioaccumulating compounds in freshwaters.

Several long-term hydrological monitoring programmes provide useful data for assessing the effects of climate change; ice freeze-up and break-up in rivers and lakes, ice cover thickness in lakes, and lake surface temperatures.

Monitoring acidification in lakes in Lapland provides regional information about long-term changes in small lakes, as well as empirical data for e.g. critical load calculations. Monitoring at river streamflow stations provides information about trends in overall water quality.

National lake surveys, co-ordinated with respect to lake selection, analytical methods, sampling techniques and sampling period, were conducted in the Northern Europe (Finland, Sweden, Norway, the Kola Peninsula, NW Russian) in 1995. The key objectives were to assess the status of the lakes with respect to overall water quality, and the occurrence and large-scale regional variation of acidification, eutrophication and heavy metal concentrations. Heavy metals have been analysed on a sub-sample (90 lakes) of the survey. The Geological Survey of Finland has conducted several surveys of a wide set of elements in stream water and stream sediments throughout the country.

### 3.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/examination	Programme and/or responsible institute
Lake water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N, Cd, Cu, Pb, Zn, Ni, As, Cr, Co, V, Fe, Mn, Al	10 year interval	184 throughout Lapland	North European Lake Survey (SYKE)
Lake water	General water chemistry, including major ions, pH, alkalinity, colour, conductivity, N, P	3 year interval	200 throughout Lapland	Regional (LAP)
Lake water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N, Cd, Cu, Pb, Zn, Ni, As, Cr, Co, V, Fe, Mn, Al	6 per year	Vasikkajärvi, Sodankylä	(SYKE+LAP) ECE/ICP waters
Stream water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N	15 per year	Laanioja	National stream network (SYKE)
Lake sediment	Heavy metals incl. Cd, Cu, Pb, As, Hg, Ni, PAH, 33 congeners PCBs, DDT/DDD/DDE, PCDD/F	20 year interval	3-5 small lakes in Lapland	AMAP (SYKE)
Lake sediment	Diatom inferred acidification and climate change history from sediment cores	20 year interval	3-5 lakes in Northern Lapland	University of Helsinki
Surface temperature	Surface temperature of open waters	Daily	5 lakes north of Arctic circle	SYKE
Ice freeze-up and break-up	Ice freeze-up and break-up dates	Yearly	Ca. 10 lakes north of Arctic Circle, River Tornion-joki	SYKE
Thickness of ice cover	Thickness of ice cover in lakes	3 /month (winter)	Ca. 11 sampling points in Lapland	SYKE
Stream water	(filtered and acidified sample): Ca, Na, Mg, Al, Fe, K, Mn, Ag, As, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Li, Mo, Ni, Pb, Sb, Se, Sr, Th, Tl, U, V Zn  (unfiltered sample): pH, Eh, conductivity, KMnO <sub>4</sub> , colour, alkalinity, SO <sub>4</sub> <sup>2-</sup> , Cl <sup>-</sup> , Br <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , SiO <sub>2</sub> , F <sup>-</sup> , PO <sub>4</sub> <sup>3-</sup> , chlorophenols	Every 5 years	110 sampling points, each point representing 30-40 km <sup>2</sup> catchment areas	GTK
Stream sediments	Ca, Na, Mg, Al, Fe, K, Mn, Ag, As, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, La, Li, Mo, Ni, P, Pb, Sb, Se, Sr, Th, Ti, Tl, U, V, Y, Zn and C, H, N, S	Every 5 years	110 sampling points, each point representing 30-40 km <sup>2</sup> catchment areas	GTK
Groundwater	In the field: temperature, pH, conductivity, O and CO <sub>2</sub>  In the lab: pH, conductivity, colour, KMnO <sub>4</sub> ,	4 times every year	22 sampling points from 18 catchment areas	GTK

	alkalinity (HCO <sub>3</sub> <sup>-</sup> ), SO <sub>4</sub> <sup>2-</sup> , Cl <sup>-</sup> , F <sup>-</sup> , Br <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , PO <sub>4</sub> <sup>3-</sup> , Ca, Mg, Sr, Ba, Be, Na, K, Li, Rb, SiO <sub>2</sub> and total hardness, Al, B, Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb, Cd, V, Mo, Se, Ag, Tl, As, Sb, Bi, Rn, U, Th, δD, δ <sup>18</sup> O			
<b>Groundwater</b>	In the field: temperature, pH, conductivity, O and CO <sub>2</sub>  In the lab: pH, conductivity, colour, KMnO <sub>4</sub> , alkalinity (HCO <sub>3</sub> <sup>-</sup> ), SO <sub>4</sub> <sup>2-</sup> , Cl <sup>-</sup> , F <sup>-</sup> , Br <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , PO <sub>4</sub> <sup>3-</sup> , Ca, Mg, Sr, Ba, Be, Na, K, Li, Rb, SiO <sub>2</sub> and total hardness, Al, B, Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb, Cd, V, Mo, Se, Ag, Tl, As, Sb, Bi, Rn, U, Th, δD, δ <sup>18</sup> O	Once every year	7 sampling points from 7 catchment areas	GTK
<b>Fish</b>	Population trends	5-10 years	10-20 lakes and streams, north-eastern Lapland	RKTL
<b>Fish (muscle)</b>	Hg, 15 cong. PCBs, 4 HCHs, HCB, 3 DDTs, 4 chlordanes	1 to 3 year interval	Pahtajärvi (Arctic char, burbot)  Lake Inari (whitefish, pike)  Lokka reservoir (whitefish, pike)  River Tornionjoki (whitefish)	AMAP (SYKE)  National /SYKE  National/SYKE  National /SYKE
<b>Fish (muscle)</b>	Cd, Pb, DDT, PCBs, HCB, Chlordane, lindane, Hg, Se	2 to 5 year interval	Lapland county Several species	EELA

AMAP Arctic Monitoring and Assessment Programme  
 ICP waters International Co-operative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes  
 ECE Economic Commission for Europe (UN)  
 SYKE Finnish Environment Institute  
 LAP Lapland Regional Environment Centre  
 GTK Geological Survey of Finland  
 RKTL Finnish Game and Fisheries Research Institute  
 EELA National Veterinary and Food Research Institute

### 3.3 Supporting studies

A model system for predicting watercourse discharges is being developed by FEI and is operated jointly by FEI and the Lapland Regional Environmental Centre. This system has been used for evaluating hydrological responses to climate change.

A water quality survey of small tributaries of the River Teno (most important salmon river of the area) is planned. This may subsequently lead to a new monitoring programme in northeastern Lapland. Also a survey of benthic invertebrate population trends is planned to investigate acidic pulses in stream water in northern Lapland. A survey of fish populations (gillnets, electrofishing) in small lakes in the NE Lapland has been started as a joint undertaking (Norway and the Kola

Peninsula included). Lakes studied in the early 1990's will be again sampled in 2004 or 2005. Juvenile salmon (*Salmo salar*) are monitored annually in the River Tenjoki and River Tornionjoki. Time series data of ca. 20 years exist, which may be of use in regard of long term environmental changes.

A survey of mercury in fish (pike, whitefish, roach) in lakes was conducted in years 2000-02 by FEI.

Screening of new contaminants, mainly EU Water Framework Directive's priority substances (e.g. BFR-compounds, PAHs, phthalates, nonyl- and octylphenols) in sediment cores and fish from a lake in Pallas area is planned for 2004-2005.

In addition, the following Finnish studies are considered relevant for the AMAP Programme:

- European Mountain lake Ecosystems: Regionalisation, diagnostics & socio-economic Evaluation (EMERGE) (2000-2003)" (University of Helsinki, Department of Geography)
- Carbon pathways through Boreal lakes: a multiscale approach (CARBO) (University of Helsinki, FEI)
- Solar UV-B actions on aquatic ecosystems (University of Jyväskylä)

#### 4. HUMAN HEALTH SUB-PROGRAMME

##### 4.1 Objective and structure

The objective of human health sub-programme in Finnish Lapland is thus far to be a reference area, because people in Lapland do not eat marine mammals or much marine fish, which are on the top of arctic food chains. Also until now the pollution from northwest Russia has not had influence on the population in Lapland. The food chain of radioactive caesium: lichen-reindeer- humans is monitored by the radioactive group of AMAP.

Monitoring Target media	Parameters	Frequency	Programme and/or responsible institute
Maternal blood	Cd, Hg, Pb, Se, PCB, DDTgroup HCH, HCB, Chlordan Dieldrin, Toxaphene (PCC)	with 10 year intervals 20 mothers	Ministry of environment
Mothers/ food	Food questionnaire	10 years intervals 50-100 mothers	State Provincial Office of Lapland

Survey		Target Population	
Health statistics	Morbidity/ Mortality data	Lapland, Sami population	State Provincial Office of Lapland
Statistics	Abortion Gestational age	Population of Lapland	State Provincial Office of Lapland
Statistics	Developmental malformations	Population of Finland	State Provincial Office of Lapland

## 5. RADIOACTIVITY SUB-PROGRAMME

### 5.1 Objective and structure

The main goal of the surveillance of environmental radioactivity of the Radiation and Nuclear Safety Authority (STUK) is to be always aware of the levels of radiation to which the public is exposed. Another goal is to detect all remarkable changes in the levels of environmental radiation and radioactivity. Running of surveillance programmes on a continuous basis also maintains and develops competence and readiness to respond to radiological emergencies.

The surveillance programme on environmental radioactivity (YSV) of STUK includes continuous and automated monitoring of external dose rate, regular monitoring of radioactive substances in outdoor air, in deposition, in surface and drinking water, milk, foodstuffs, and in human body. Since 2002 the surveillance of the Baltic Sea is also included in the programme.

The research programs of STUK's Regional Laboratory in Northern Finland include several environmental research projects in which the transport and accumulation of anthropogenic radionuclides in Arctic food chains, and the concentration in locally produced foodstuffs, are studied. The results of these long time series were extensively used in the first and second phase of the AMAP program.

### 5.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/examination	Programme and/or responsible institute
<b>External radiation</b>	Dose rate, $\mu\text{Sv/h}$	Continuous	50 stations/Lapland	YSV/STUK
<b>Atmospheric: Air/aerosol</b>	Gamma nuclides ( $^{137}\text{Cs}$ , $^{134}\text{Cs}$ , $^{131}\text{I}$ ), $\text{Bq/m}^3$	Weekly	Ivalo Sodankylä Rovaniemi	YSV/STUK
<b>Atmospheric: Precipitation/fallout</b>	Gamma nuclides ( $^{137}\text{Cs}$ , $^{134}\text{Cs}$ , $^{131}\text{I}$ ), $\text{Bq/m}^2$ Beta nuclide $^{90}\text{Sr}$ , $\text{Bq/m}^2$	4 / year	Ivalo Sodankylä Rovaniemi	YSV/STUK
<b>Atmospheric: Precipitation</b>	$^3\text{H}$ , $\text{Bq/m}^3$	4 / year	Rovaniemi (Apukka)	STUK
<b>Terrestrial: Permanent lichen plots, surface soil</b>	Gamma nuclides ( $^{137}\text{Cs}$ , $^{134}\text{Cs}$ ), $\text{Bq/kg}$ , $\text{Bq/m}^2$ and	Every 3-5 years	Utsjoki (Koihkenjavepakti) Inari (Kaamanen) Inari (Kutuharju)	STUK
<b>Terrestrial: Vascular plants, mosses</b>	Gamma nuclides ( $^{137}\text{Cs}$ , $^{134}\text{Cs}$ ), $\text{Bq/kg}$	Every 3-5 years  annually	Utsjoki (Koihkenjavepakti) Inari (Kaamanen) Rovaniemi (Apukka) Kittilä (Pahtavuoma)  Kuusamo (Oulanka)	STUK  STUK  STUK/Oulanka biological station

<b>Terrestrial: Reindeer meat</b>	Gamma nuclides ( <sup>137</sup> Cs, <sup>134</sup> Cs), Bq/kg	Annually  Every 5 years	Co-operatives: Paistunturi Ivalo Kemin-Sompio Lohijärvi  Other co-operatives	STUK
<b>Terrestrial: Willow grouse</b>	Gamma nuclide <sup>137</sup> Cs, Bq/kg	Every 5 years	Utsjoki	STUK
<b>Terrestrial: Dairy milk</b>	Gamma nuclides ( <sup>137</sup> Cs, <sup>131</sup> I), Bq/kg Beta-nuclide <sup>90</sup> Sr, Bq/kg	6 / year (γ) 4 / year (β)	Oulu dairy (milk from Lapland)	YSV/STUK
<b>Terrestrial: Farm milk</b>	Gamma nuclides ( <sup>137</sup> Cs, <sup>131</sup> I), Bq/kg Beta-nuclide <sup>90</sup> Sr, Bq/kg	monthly  2 / year 2 / year 2/ year	Rovaniemi  Kittilä Muonio Kemijärvi	YSV/STUK  STUK
<b>Terrestrial: Mushrooms</b>	Gamma nuclide <sup>137</sup> Cs, Bq/kg	Annually	Kivalo	STUK/ METLA
<b>Terrestrial: soil profiles</b>	Gamma nuclide <sup>137</sup> Cs, Bq/kg, Bq/m <sup>2</sup>	Every 3 years	Kivalo	STUK/ METLA
<b>Terrestrial: wild berries</b>	Gamma nuclide <sup>137</sup> Cs, Bq/kg	Annually	Inari, Nellim	STUK
<b>Terrestrial: River water</b>	Gamma nuclide, <sup>137</sup> Cs, Bq/m <sup>3</sup> Beta nuclide, <sup>90</sup> Sr, Bq/m <sup>3</sup>	4 / year 2 /year	River Kemijoki River Teno	YVS/STUK STUK/LAP
<b>Fresh water: Lake water</b>	Gamma nuclide <sup>137</sup> Cs, Bq/m <sup>3</sup> Beta nuclide <sup>90</sup> Sr, Bq/m <sup>3</sup>	Annually	Lake Apukkajärvi  Lake Nitsijärvi Lake Luobmusjärvi	STUK  STUK/LAP
<b>Fresh water: Fish (muscle) - pike - perch -burbot -whitefish -trout -vendace -roach</b>	Gamma nuclide <sup>137</sup> Cs, Bq/kg	Annually  Every 3 years	Lake Apukkajärvi Lake Inari  Lake Jerisjärvi Lake Äkäsjärvi Lake Nitsijärvi	STUK  STUK
<b>Brackish water: Salmon (muscle) (bone)</b>	Gamma nuclide <sup>137</sup> Cs, beta nuclide <sup>90</sup> Sr, alfa nuclide <sup>239,240</sup> Pu, Bq/kg	Annually	River Kemijoki River Simojoki	STUK/ RKTl
<b>Marine: Salmon (muscle) (bone)</b>	Gamma nuclide <sup>137</sup> Cs, beta nuclide <sup>90</sup> Sr, alfa nuclide <sup>239,240</sup> Pu, Bq/kg	Annually	River Teno	STUK/ RKTl
<b>Grey seal</b>	Gamma nuclide <sup>137</sup> Cs, beta nuclide <sup>90</sup> Sr, alfa nuclide <sup>239,240</sup> Pu, Bq/kg	When available	Baltic Sea, Bohmian Bay	STUK/EELA

STUK	Radiation and Nuclear Safety Authority, Regional Laboratory in Northern Finland
YSV/STUK	The permanent environmental monitoring program of Radiation and Nuclear Safety Authority
METLA	Finnish Forest Research Institute
RKTL	Finnish Game and Fisheries Research Institute
LAP	Lapland Regional Environment Centre
EELA	National Veterinary and Food Research Institute

### 5.3 Supporting studies

Whole-body counting of the Finnish Saami reindeer herders in Utsjoki and Ivalo was an important part of the first and second phases of the AMAP program. The long measurement series from 1960 to 1997, 2002 together with the food consumption data, illustrated the effects of atomic-weapon testing and the Chernobyl accident on the Saami population. Continuation of these measurements was highly recommended by the AMAP expert groups for Radioactivity and Human Health. STUK plans to continue these measurements with a frequency of 3-5 years.

## 6. MARINE SUB-PROGRAMME

Finland has defined the Arctic Circle as the southern limit of the regions participating in co-operation under the Arctic Council. Despite the fact that the Bay of Bothnia, as well as some other parts of the Baltic Sea, are cold and covered at least partly by ice during winter, the Baltic Sea has not been included in the Arctic co-operative programmes. However, Finland has participated in Arctic marine research and could contribute to the AMAP marine sub-programme with selected supporting studies. Actually Finland is not doing any monitoring work in the arctic area.

Between 1991-1995, the Finnish Institute of Marine Research (FIMR) participated in ecological studies in the Pechora Sea area within the framework of a co-operation agreement drawn up between FIMR and the Murmansk Marine Biological Institute (MMBI). Recently, the extensive benthos data set collected from the Pechora Sea, Cheshskaya Bay and Pechora Bay has been under development to publications in international pre-reviewed journals.

FIMR takes part in the project "The current state of the Russian Marine Ecosystem Monitoring for the White Sea and its relevance to the EU Directive on Water Policy and UN Agenda 21", FP6-2002-INCO-Russia+NIS/SSA-4. 2004-2005, in cooperation with

1. Scientific Foundation "Nansen International Environmental and Remote Sensing Centre", St. Petersburg, Russia
2. Murmansk Marine Biological Institute, Russian Academy of Sciences, Murmansk, Russia
3. Northern Water Problem Institute, Karelian Research Centre, Russian Academy of Sciences, Petrozavodsk, Republic of Karelia, Russia
4. Nansen Environmental and Remote Sensing Centre, Bergen, Norway

This is the follow up project of the project "Sustainable management of the Marine ecosystem and living resources and living resources of the White Sea", ICA2-CT-2000-10014, with the same partners during the years 2000-2002.

FIMR will also, within the framework of AMAP, follow the situation in Arctic waters, participate in relevant programmes and, on request, place the knowledge and expertise of the FIMR about the ecology of polar seas at the disposal of the programme.

In addition, the following Finnish studies are considered relevant for the AMAP Programme:

- Arctic snow, sea-ice and glaciers in a changing climate (University of Helsinki, Arctic Centre)
- Sedimentary and geochemical indicators of climatic and environmental change in polar margins (University of Oulu)
- Arctic sea ice dynamics and air-sea-ice interaction (Finnish Institute of Marine Research)
- Physical oceanography in the Arctic Ocean and the marginal seas (Finnish Institute of Marine Research).