EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D – Nuclear energy, safety and ITER
D.3 – Radiation protection and nuclear safety

Verification under the terms of Article 35 of the Euratom Treaty

Technical Report

FINLAND

Helsinki capital region

Routine and emergency radioactivity monitoring arrangements
Monitoring of radioactivity in drinking water and foodstuffs

28 – 30 August 2023

Reference: FI 23-02

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	- Facilities for monitoring environmental radioactivity - Facilities for monitoring food and drinking water radioactivity - Associated analytical laboratories
LOCATIONS	- Helsinki and the surrounding area
DATES	28 – 30 August 2023
REFERENCE	FI 23-02
TEAM MEMBERS	Mr Vesa Tanner, DG ENER (team leader) Mr Raf Van Ammel, DG JRC
REPORT DATE	29 November 2023
SIGNATURES	

V. Tanner

R. Van Ammel

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Annex 1 Verification programme

Legend

Abbreviation	Explanation
ALMERA	Analytical Laboratories for the Measurement of Environmental Radioactivity
CBSS	Council of Baltic Sea States
CTBTO	Comprehensive Nuclear Test Ban Treaty Organization
EC	European Commission
EPR	Emergency Preparedness and Response
EU	European Union
EURDEP	EUropean Radiological Data Exchange Platform
FINAS	Finnish Accreditation Service
FMI	Finnish Meteorological Institute
HPGe	High-purity Germanium (detector)
HELCOM	Baltic Marine Environment Protection Commission
IAEA	International Atomic Energy Agency
LIMS	Laboratory Information Management System
LLD	Lower Limit of Detection
LSC	Liquid Scintillation Counting
MPK	National Defence Training Association of Finland
NaI	Sodium Iodine (detector)
NESA	National Emergency Supply Agency
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
PvTT	Finnish Defence Forces Research Centre
STUK	Radiation and Nuclear Safety Authority
TCP/IP	Transmission Control Protocol/Internet Protocol
TLD	Thermoluminescent dosimeter
Uljas	Name of dose rate monitoring network
USVA	Name of information system handling dose rate monitoring network Uljas
YLE	Finnish Broadcasting Company

TECHNICAL REPORT

1 INTRODUCTION

Under Article 35 of the Euratom Treaty, all Member States must establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the basic safety standards[1]. Article 35 gives the European Commission (EC) the right of access to such facilities to verify their operation and efficiency. The radiation protection and nuclear safety unit of the European Commission's Directorate-General for Energy is responsible for undertaking these verifications. The EC's Joint Research Centre (JRC) provides technical support during the verification visits and in drawing up the reports.

The main purpose of the verifications under Article 35 of the Euratom Treaty is to provide an independent assessment of the adequacy of monitoring facilities for:

- liquid and airborne discharges of radioactivity from a site into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant exposure pathways;
- levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] describing practical arrangements for Article 35 verification visits in Member States was published in the *Official Journal of the European Union* on 4 July 2006.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The EC notified Finland of its decision to conduct an Article 35 verification in a letter addressed to the Permanent Representation of Finland to the European Union. The Finnish Government subsequently designated the Radiation and Nuclear Safety Authority (STUK) to lead the preparations for this visit.

2.2 PROGRAMME OF THE VISIT

The EC and STUK agreed on a programme of verification activities in line with the Commission Communication of 4 July 2006 (Annex 1).

The opening meeting held at the STUK premises included presentations on the following:

- Commission Article 35 verification programme
- STUK introduction
- Routine environmental radioactivity monitoring in Finland
- Mobile monitoring systems
- Emergency monitoring systems
- Public information arrangements

1 Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018 (OJ L 13 of 17.1.2014)

2 Commission Communication *Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States* (OJ C 155, 4.7.2006, pp. 2-5)

- R&D activities and studies

The verification team pointed to the quality and comprehensiveness of all the presentations and documentation. The team carried out the verifications in accordance with the programme in Annex 1. It met the following representatives of the national authorities and other parties involved:

Radiation and Nuclear Safety Authority (STUK)

- Mr. Petteri Tiippana, Director General
- Dr. Pia Keski-Jaskari, Director, Measurements and Environmental Surveillance Department
- Dr. Aleksi Mattila, Head of Laboratory, Environmental Surveillance Laboratory
- Mr. Tuomas Peltonen, Senior Inspector, Environmental Surveillance Laboratory. Dose rate monitoring network and emergency preparedness
- Dr. Juha Sorri, Senior Inspector, Environmental Surveillance Laboratory. Dose rate monitoring network
- Mr. Tero Karhunen, Senior Inspector, Environmental Surveillance Laboratory. Airborne Radioactivity monitoring
- Mr. Vesa-Pekka Vartti, Senior Inspector, Environmental Surveillance Laboratory. Environmental monitoring of Finnish nuclear power plants and monitoring of the radioactivity in the Baltic Sea (HELCOM-MORS EG)
- Ms. Sinikka Virtanen, Senior Inspector, Food, milk and water monitoring, Environmental Surveillance Laboratory
- Dr. Jani Turunen, Senior Inspector, Fallout monitoring, FIL07 CTBTO laboratory manager, Environmental Surveillance Laboratory
- Dr. Kaisa Vaaramaa, Head of Laboratory, Measurement and Analysis Laboratory
- Dr. Roy Pöllänen, Principal Advisor, Measurement and Analysis Laboratory
- Mr. Petri Smolander, Senior Inspector, Monitoring and Situation Awareness Laboratory, field measurements, mobile laboratory
- Mr. Valtteri Suorsa, Senior Inspector, Monitoring and situation Awareness Laboratory, field measurements, Reachback
- Dr. Maarit Muikku, Head of Laboratory, Monitoring and situation Awareness Laboratory

Finnish Meteorological Institute (FMI)

- Dr. Jussi Paatero, Research Director

Helsinki City Rescue Department

- Mr. Vesa Paatelma, Fire Officer
- Ms. Nina Järvenkylä, Communications Specialist
- Mr. Juha Laine, Fire Station Manager

3 RADIOLOGICAL MONITORING FRAMEWORK IN FINLAND

3.1 RADIOLOGICAL SITUATION IN FINLAND

Monitoring of environmental radioactivity in Finland is carried out in the context of an active national nuclear programme, several nuclear facilities in the neighbouring countries, environmental Cs-137 contamination caused by the Chernobyl accident and in certain regions high natural radon concentrations.

There are two nuclear power plant sites in Finland:

- NPP in Loviisa including:
  - 2 PWR reactors in operation;
  - 1 spent fuel storage facility in operation;
  - 1 radioactive waste treatment plant in operation;
  - 1 radioactive waste disposal facility in operation;
- NPP in Olkiluoto including:
  - 2 BWR reactors in operation;
  - 1 PWR reactor in operation;
  - 1 spent fuel storage facility in operation;
  - 1 spent fuel final disposal facility (repository) in construction (Onkalo);
  - 1 radioactive waste treatment plant in operation;
  - 1 radioactive waste disposal facility in operation.

Additionally, there is a research reactor FiR1 (TRIGA Mark II) in Espoo, which is under decommissioning. This reactor was in operation from 1962 until 2015.

There are several facilities using open radioactive sources in Finland:

- Accelerator laboratory at the University of Jyväskylä hosts three large-scale accelerators: the K130 cyclotron, MCC30/15 cyclotron and the 1.7 MV Pelletron.
- Cyclotron facilities for radiopharmaceutical production are located in Kuopio, Turku and Helsinki.
- Nuclear medicine research is active in Turku, Kuopio and Helsinki.
- There are five university hospitals with full nuclear medicine services.
- 26 licensees are practicing nuclear medicine in Finland with approximatively the same number of laboratories.

The list of medical and industrial facilities using radioactive sources is long in Finland. The number of facilities, types of radiation practices in health care, industry and research and in laboratories can be found in the appendix 1 of the STUK annual reports[3].

Additionally, other possible sources of radioactivity in the environment are present in Finland, such as radioactive waste storage facilities and industries giving raise to NORM discharges (peat production, metal processing, phosphate industry, titanium oxide pigment production, refractory products and brick manufacture, cement production). Accidental smelting of radioactive sources in steel production has also caused contaminated slag.

There are three NPPs nearby Finland: Sosnovy Bor NPP near Saint Petersburg, Kola NPP in Northern Russia and Forsmark NPP in Sweden.

Radon concentrations are highest in the southern part of Finland and in some areas in the north, more specifically the regions of Itä-Uusimaa, Päijät-Häme, Kymenlaakso, Kanta-Häme, Pirkanmaa and South

[3] https://www.julkari.fi/handle/10024/146774

Karelia. In these regions the measured radon concentration exceeds 200 Bq/m^3 in more than 30% of houses.

In the south of Finland, areas with elevated Cs-137 activity exist as a result of the Chernobyl fallout. In some areas a ground contamination of up to 35 kBq/m^2 is still present.

In the Sotkamo area, an incident at the Talvivaara (now Terrafame) mine occurred in 2012. A leakage of a gypsum waste pond discharged metals and uranium into nearby surroundings (lake and environment). Any extra uranium in the environment is reported being deposited at lake bottom sediments and not active in the lake biological processes. Therefore, environmental remediation of uranium contaminated lakes is not necessary.

Finland conducts routine monitoring of radioactivity in the environment, foodstuffs and drinking water, as well as source related monitoring of radioactivity. These monitoring programmes are also available during emergency situations. The sampling and analysis strategy can be adjusted according to emergency monitoring needs.

3.2 NATIONAL LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING

The main legislative document organising the radiological monitoring in Finland is the Radiation Act 859/2018.

Other legislative documents include:

- For environmental radioactivity monitoring the Decree on STUK 2022/1164;
- For monitoring of radioactivity content of foodstuffs, the Food Act 2021/297;
- For monitoring of radioactivity content of drinking water, the Act on Drinking Water 2015/1352.

3.3 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

The list below includes the main international legislative and guidance documents issued by the European Union (EU) and the International Atomic Energy Agency (IAEA). They form the basis for environmental radioactivity monitoring, radiological surveillance of foodstuffs and surveillance of radioactive discharges.

Euratom and European Union legislation

- The Euratom Treaty
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom
- Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption
- Council Decision 87/600/Euratom of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency
- Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
- Council Regulation (Euratom) 2016/52 of 15 January 2016 laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency, and repealing Regulation (Euratom) No 3954/87 and Commission Regulations (Euratom) No 944/89 and (Euratom) No 770/90

- Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole
- Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation

International guidance documents, issued mainly by the International Atomic Energy Agency (IAEA)

- *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards*, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna, 2014
- *Clearance of materials resulting from the use of radionuclides in medicine, industry and research*, IAEA-TECDOC-1000, IAEA, Vienna, 1998
- *Generic models for use in assessing the impact of discharges of radioactive substances to the environment*, Safety Reports Series No 19, IAEA, Vienna, 2001
- *Management of radioactive waste from the use of radionuclides in medicine*, IAEA-TECDOC-1183, IAEA, Vienna, 2000
- *Regulatory control of radioactive discharges to the environment: Safety Guide*, Safety Standards Series No. WS-G-2.3, IAEA, Vienna, 2000
- *Sources and effects of ionizing radiation*, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2008, Report to the General Assembly, Vol. I, United Nations, New York, 2011
- *Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda*, 2022, World Health Organisation (WHO)

4 BODIES HAVING COMPETENCE IN THE FIELD OF ENVIRONMENTAL RADIOACTIVITY MONITORING

4.1 RADIATION AND NUCLEAR SAFETY AUTHORITY

The Finnish Radiation and Nuclear Safety Authority (STUK) acts as the supervisory body referred to in Article 35 of the Euratom treaty and carries out the regulatory duties, liaising duties and reporting duties (Radiation act, 14 §). STUK's operations are based on the Act on Radiation and Nuclear Safety Authority. The first section of the Act defines STUK's mission and position: "*The Radiation and Nuclear Safety Authority operates under the Ministry of Social Affairs and Health with the purpose of preventing and limiting the adverse effects of radiation, controlling the safety of the use of radiation and nuclear energy, and engaging in associated research, education and communications*".

STUK prepares and implements an environmental radiation monitoring programme to monitor the amounts of radioactive substances in the environment and the magnitude of the public exposure resulting from them.

Surveillance of artificial radioactivity in foodstuffs and in household water is conducted by STUK as a part of the national environmental monitoring. It should be noted that compliance with the action level applicable to foodstuffs and animal feed and the prohibition to use radioactive substances is supervised by the Finnish Food Authority (Food Act, (297/2021), Feed Act (1263/2020) 26 §) and that the municipalities health protection authorities supervise compliance with the reference levels of the radioactivity in household water.

For nuclear and radiological emergency preparedness the main expert body is STUK. Responsibilities of various authors are set in the Rescue Act (379/2011) with the Rescue Services being the main decision-making body on protective actions concerning the population. STUK maintains and develops emergency preparedness with the aim of ensuring safety of all members of the public and workers in radiological and nuclear emergencies. STUK is the national warning point and the national competent authority in nuclear emergencies and is responsible for all drafts of recommendations for protective actions.

Further information on emergency preparedness arrangements is given in the document 'Säteilytilanneohje' (Ministry of Interior Publication 10/2016). A national radiation monitoring strategy paper (Ministry of Interior Publication 31/2022) has been recently published. The main goal of the strategy paper is to guide further development of monitoring capabilities and competencies in Finland.

In the case of a radiological emergency, STUK is the central laboratory performing radiological surveillance and measurements. There are three additional places in addition to Vantaa (Ylöjärvi, Kuopio and Rovaniemi), which are able to perform gamma spectrometric measurements. The laboratories in Vantaa and Rovaniemi are STUK's own laboratories; the laboratory in Ylöjärvi is run by PvTT and the laboratory in Kuopio by FMI.

STUK participates in the IAEA ALMERA network and operates a CTBTO Radionuclide Laboratory. STUK offers expert services to clients both within Finland and abroad in the field of radiation and nuclear safety, as well as safeguards. At the end of 2022, STUK had 303 employees. Of regularly employed staff, 88% have a doctoral, licentiate, M.Sc. or M.A. degree. The average age of the employees is 47,9 years. A detailed description of STUK's activities can be found on their website[4].

[4] www.stuk.fi

4.2 FINNISH METEOROLOGICAL INSTITUTE

The Finnish Meteorological Institute (FMI)[5] is the government agency responsible for gathering and reporting weather data and forecasts in Finland. It is a part of the Ministry of Transport and Communications, but it operates semi-autonomously. The Institute is an impartial research and service organisation with expertise covering a range of atmospheric science activities other than gathering and reporting weather data and forecasts. The headquarters of the Institute is at the Kumpula Campus, Helsinki.

The main objective of the institute is to provide Finland with the best possible information about the atmosphere above and around Finland, for ensuring public safety relating to atmospheric and airborne hazards and for satisfying requirements for specialised meteorological products. Within the national programme of environmental radiation surveillance the FMI performs the surveillance of airborne total beta activity in Finland. It operates one sampling station in Helsinki and eight others across the country. FMI radiological laboratory is located in Helsinki.

As STUK, FMI is authorized and recognized by the regulatory authority for performing its analyses, although it does not have ISO 17025 accreditation. FMI is involved in the environmental radioactivity monitoring programme in both routine and emergency circumstances.

4.3 HELSINKI CITY RESCUE DEPARTMENT

Helsinki City Rescue Department[6] is one of the 21 rescue departments in Finland, which are managed by municipalities. The departments carry out rescue service duties in their regions. Rescue departments cooperate with other authorities and with local residents and communities to prevent accidents and maintain security. Their tasks also include preparedness for radiological hazards. Therefore, the Department maintains the capability to monitor radiation dose rate and carry out preliminary nuclide identification in the event of a radiological accident.

5 https://en.ilmatieteenlaitos.fi

6 https://pelastustoimi.fi/en/home

5 ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME IN FINLAND

5.1 GENERAL

Finland carries out a comprehensive environmental monitoring programme which is summarised in the Table I below. In addition to the continuously running programme, environmental monitoring includes thematic investigations. Previous thematic investigations have been done on radon in outdoor air, radon in kindergartens and schools, radon in new residential buildings, radioactivity in meat and eggs, in the ashes of waste incinerator plants, building materials, sawn timber, wastewater sludge and in biomass material. In addition, radioactivity in man is followed with yearly measurements of study cohorts in Helsinki, Tampere and Rovaniemi.

The national environmental monitoring program covers the national territory and the Helsinki capital region extensively. Ambient gamma dose rate in Helsinki is monitored in real time at 8 stations. Airborne radioactivity is monitored at two locations and fallout at one location. Environmental monitoring activities based on periodic samples collected from the capital region include mixed diet, both individual ingredients and complete meals, household water and wastewater sludge. Radioactivity in human body by whole body counting is also monitored regularly from a group of people residing in the capital region.

Monitoring activities are carried out by STUK and all the samples are analysed in the STUK laboratory, except for the monitoring of gross beta activity of aerosols which is carried out by the Finnish Meteorological Institute. The STUK laboratory is the only laboratory in Finland capable of carrying out a comprehensive environmental radioactivity monitoring programme.

Table I. Environmental monitoring programme in Finland

Media	Monitoring places	Monitored quantity	Frequency	Responsible organisation
Ambient dose rate	255 automatic stations	Dose rate, µSv/h	Continuous, 10 min. interval	STUK
Airborne radioactivity	Vantaa, Kotka, Imatra, Kuopio, Rovaniemi, Kajaani, Sodankylä, Ivalo (8 stations)	Gamma emitting radionuclides	From 1/day to 1/week	STUK
Airborne total beta-activity	Helsinki, Utö, Nurmijärvi, Virolahti, Hyytiälä, Tikkakoski, Oulanka, Rovaniemi, Sodankylä, Kevo (10 stations)	Total beta-activity	1/day or 1/week	FMI
Fallout of radionuclides	Vantaa, Kotka, Imatra, Kuopio, Rovaniemi, Kajaani, Sodankylä, Ivalo (8 stations)	Gamma emitting radionuclides, ^{90}Sr, ^{3}H (Vantaa, Rovaniemi)	Gamma, 4/year ^{90}Sr, 1/year. ^{3}H 12/year	STUK
Radionuclides in surface water	Kymijoki, Oulujoki, Kemijoki, Kokemäenjoki	Gamma emitting radionuclides	1/year	STUK
Radionuclides in drinking water	Vantaa, Turku, Tampere, Oulu, Rovaniemi	Gamma emitting radionuclides, ^{3}H, ^{90}Sr	1/year	STUK
Radionuclides in milk	Riihimäki, Joensuu, Jyväskylä, Seinäjoki, Oulu (dairies)	Gamma emitting radionuclides, ^{90}Sr	Gamma, 12/year ^{90}Sr ,4/year	STUK
Radionuclides in foodstuffs	Helsinki, Tampere, Rovaniemi, (Main hospitals + foodstuffs on the market)	Gamma emitting radionuclides, ^{90}Sr	1/year	STUK
Radionuclides in wastewater sludge	Helsinki	Gamma emitting radionuclides	2/year	STUK
Radionuclides in human body	Helsinki, Tampere, Rovaniemi	Gamma emitting radionuclides	1/year	STUK
Indoor radon	Whole of Finland	^{222}Rn	Continuous	STUK
Radioactivity in the Baltic Sea (seawater, bottom sediments, fish, and other biota)	See Section 5.8	^{137}Cs	1/year	STUK

5.2 EXTERNAL GAMMA DOSE AND DOSE RATE

5.2.1 National monitoring network

Finland has an automatic nationwide monitoring network for external dose rate (Fig. 1) which has two main functions: alarming and providing information on the radiological situation. The network has 255 stations equipped with GM-tubes. The maintenance and development of the network is carried out by STUK in close co-operation with local emergency authorities. The map below shows the locations of the stations.

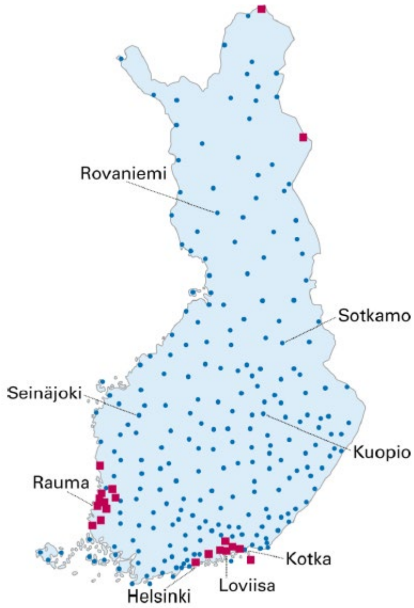

Figure 1. Network of automatic dose rate monitoring stations in Finland. Red squares indicate stations that have both a GM detector and a $LaBr_3$ spectrometer probes.

The monitoring network was renewed between 2005 and 2007. The monitoring stations are manufactured by Envinet GmbH. Dose rate probes are manufactured by Scienta Envinet (previously Envinet) and Bertin Technologies SAS (previously Saphymo GmbH). Technical specifications are listed in Table II below.

The monitoring stations are equipped with a Linux based computer. The computer gives the possibility to connect different types of detectors to the monitoring station. Currently STUK is using probes equipped with GM-tubes, rain detectors and detectors with nuclide identification capability. The software for the monitoring stations is either bought from different companies or developed in-house. Flexibility of software and detectors is very important as an operation time of 20 years needs to be achieved.

The probes that are used in monitoring stations have three GM-tubes. Two of the GM-tubes are for monitoring the low dose rates and one the high dose rate. This gives better statistics at background level. It also enables to recognise GM-tube failures.

Each monitoring station sends its results automatically every ten minutes to two different locations, namely STUK and a back-up system located at the Finnish Meteorological institute. Communication is done using a secure Tetra radio network (VIRVE) dedicated only for the Finnish authorities. Due to this 10-minute reporting interval, the radiological situation will be available from the whole of Finland in almost real-time.

Each monitoring station has an individual alarm threshold limit which is the 7-day average background at the monitoring station plus 0.1 µSv/h. If it is raining, the alarm limit is the background plus 0.15 µSv/h.

Passive radiation dose monitors (TLD) are not used for environmental monitoring in Finland.

Table II. Technical specifications of the GM detectors

Envinet IGS421A1-H	
Measuring range	0.01 µSv/h - 10 Sv/h
Measured value	Gamma dose rate H*(10)
Number of GM-tubes	3, two for low dose rate and one for high dose rate
Operating temp.	-40 - +60 C
Connector interface	RS232
Internal memory	77 results

Genitron GammaTracer XL3	
Measuring range	0.01 µSv/h - 10 Sv/h
Measured value	Gamma dose rate H*(10)
Number of GM-tubes	3, two for low dose rate and one for high dose rate
Operating temp.	-40 - +60 C
Connector interface	RS232
Internal memory	12800 results

Monitoring stations around the Finnish nuclear power plants are equipped with $LaBr_3$ spectrometers, installed in 2010 and 2011. They operate at the same 10-minute monitoring interval as the GM-detectors. The recorded spectra are sent to STUK where they are analysed automatically for 65 different gamma-ray emitting nuclides. If any of these nuclides is identified, the STUK's expert on duty is alerted. The detection limit for example for ^{131}I is 35 Bq/m^3 in a 10-minute measurement. The spectroscopic stations have no battery back-up.

Data coming from the monitoring stations is managed and presented by the USVA system, which is an authority only system administered by STUK, the Finnish Defence Forces, the Finnish Meteorological Institute and the Ministry of the Interior. In addition to administrating organizations, rescue services and nuclear power plant operators have access to the closed system. One of the main tasks of USVA is to provide information on the radiological situation to the defined authorities.

10-minute average and one minute pulse counts from individual GM-tubes are stored in an SQL database. Users can view the results on a map and create time series and reports. The system creates alarms if the dose rate exceeds the 7-day average background of the monitoring station by 0.1 µSv/h. The alarm is sent to the STUK's expert on duty. An alarm is also sent to the emergency response centre, which orders the rescue service to make confirmatory measurements using handheld meters at the alarming monitoring station.

5.2.2 Data management and control centre

Messages are transferred to central system(s) via the governmental TETRA network VIRVE, which is operated by Erillisverkot Oy. Data transfer is performed over TCP/IP using a custom application protocol. The data logger has enough disk space to hold queued messages for a few days. The station runtime on backup battery is approximately 72 hours; the TETRA base stations are also battery backed.

Server installations of the central system(s) are duplicated in physically separate locations. The installations have no interdependencies. The server software is connected to the alarm management system of the Emergency Response Centre[7]. Notifications to STUK employees are delivered via a web service provided by SecApp Oy.

National dose rate and airborne radionuclide data is made available to the EURDEP and CBSS data exchange systems.

5.2.3 Monitoring network in Helsinki

In Helsinki there are altogether nine ULJAS stations (Fig. 2). Töölö and Vuosaari stations are equipped with spectroscopic probes.

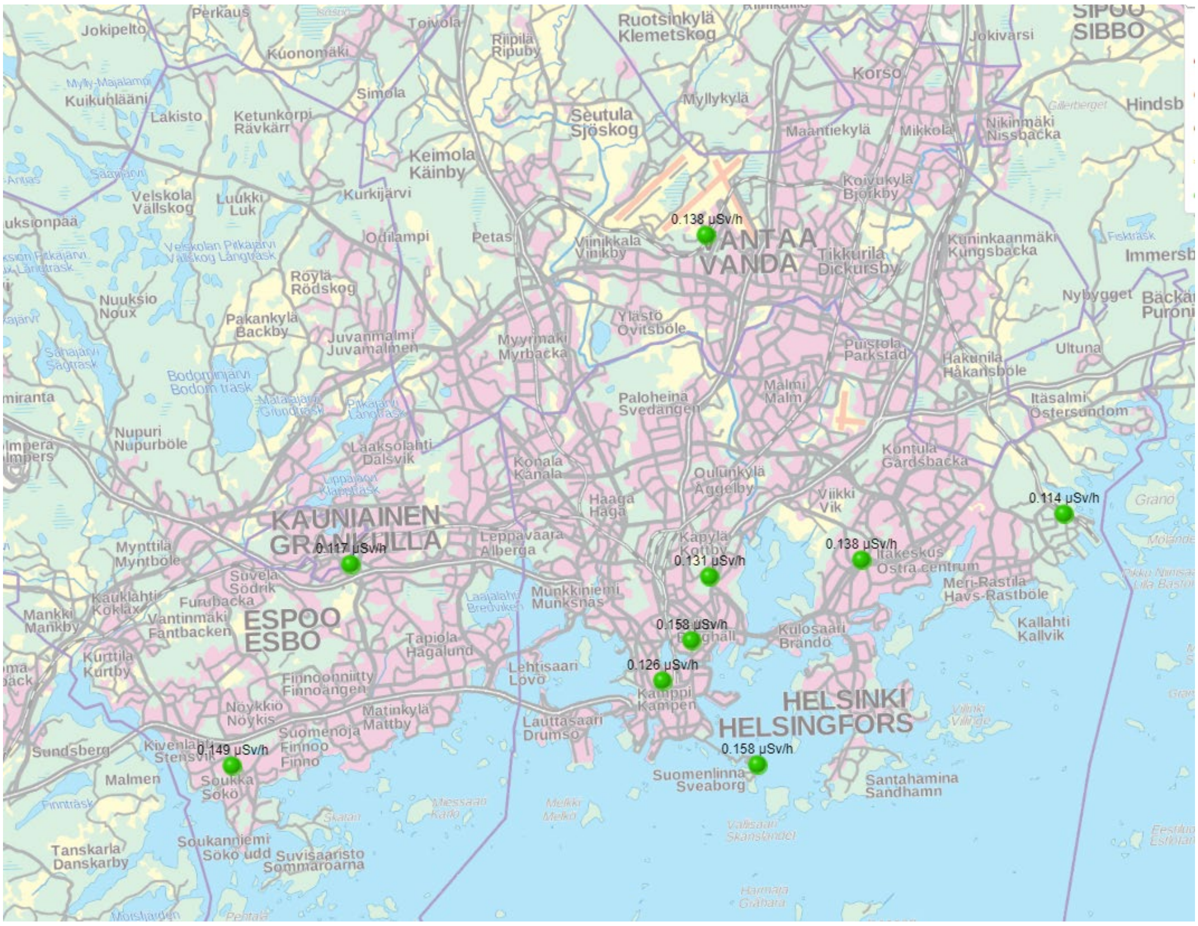

Figure 2. Monitoring locations of the telemetric network in Helsinki

5.3 AIR

5.3.1 STUK air samplers collecting particulate matter and/or iodine

STUK operates eight sampling stations for nationwide monitoring of airborne radioactive substances which are shown on the Table III and Fig. 3 below. Sampling is performed using specially designed samplers which filter large amounts of air. Airborne radioactive substances are deposited on glass fibre filters; charcoal filters are used for gaseous effluents such as iodine. Samplers are manually operated except one fully automated station located at the STUK headquarters in Vantaa. This automatic station filters radioactive substances from the air, changes the filter, prepares the filter for on-site high-resolution gamma ray analysis, performs the measurement and sends the data to automatic analysis. The results are reported on web pages after review.

All air sampling stations are equipped with $LaBr_3$ spectrometric detectors operating with a 10-minute integration time. The spectrometers operate in the same way as the spectrometer connected to an

[7] www.112.fi

external dose rate monitoring station. The detection level depends on different parameters. The detection limit in the laboratory measurement of the collected samples for ^{131}I is around 1 µBq/m^3 for a measurement of 48 hours.

Table III. STUK air samplers and typical detection limits for laboratory measurement of the samples

Site	Flow rate (m^3/h)	Sampling frequency (wk-1)	Typical detection limit (microBq/m^3)			Sampling with on-line monitor
			Cs-134	Cs-137	I-131	
Helsinki / Vantaa*	550	7	1,8	1,8	1,5	yes
Kotka	900	1	0,1	0,1	0,2	yes
Imatra	150	2	0,4	0,4	0,7	yes
Kuopio	150	1	0,4	0,4	0,7	yes
Kajaani	900	1	0,1	0,1	0,2	yes
Rovaniemi	900	1	0,1	0,1	0,2	yes
Sodankylä	150	2	0,4	0,4	0,7	yes
Ivalo	150	2	0,4	0,4	0,7	yes

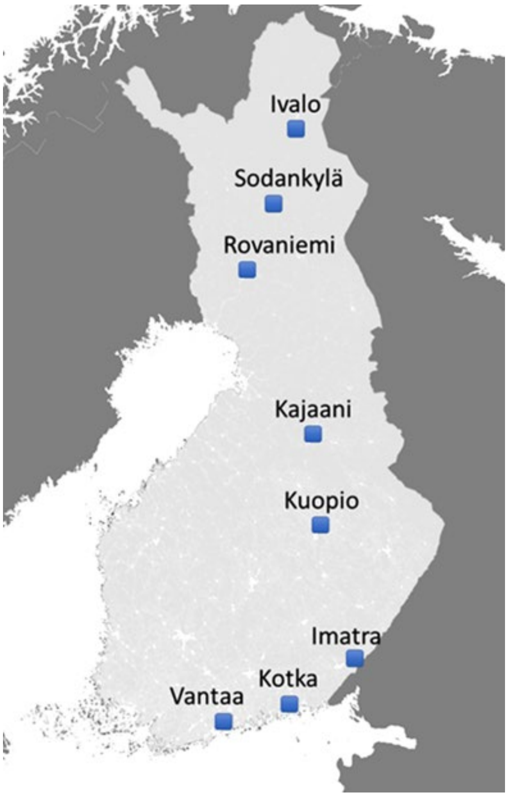

Figure 3. Atmospheric sampling locations (STUK)

Data is transferred continuously to STUK via the government TETRA network and analysed automatically for total counts and the presence of artificial radionuclides. Typical detection limit for I-131 is 3-6 Bq/m³ (direct measurement of the filter being collected) for a 10-minute measurement. Sampler performance parameters are also sent.

All gamma emitting radionuclides are monitored. If anomalous nuclides are detected, the sample can be further analyzed using direct alpha and beta spectroscopy or via radiochemical methods. Particle analysis can be performed if non-homogenous distribution is observed.

Kotka, Kajaani and Rovaniemi are equipped with Snow White air samplers (~900 m^3/h), whereas Imatra, Kuopio, Sodankylä and Ivalo are equipped with Hunter air samplers (~150 m^3/h). The automatic air sampler located at the STUK headquarters is called Cinderella (~500 m^3/h). All air samplers are manufactured by the Finnish company Senya Ltd. The filter on the Hunter sampler is changed twice a week (Monday and Thursday), the filter on the Snow White sampler once a week and the one on the Cinderella sampler once a day.

The glass fibre filters are sent to STUK laboratory by post. They are measured with a high-resolution gamma spectrometer. Nuclide specific minimum detectable concentrations (µBq/m^3) depend on the filtered air volume, the activity of other radionuclides in the sample, the measuring time and decay time before the measurement, detection efficiency and the shielding of the detector. Detection limits are typically a billion times smaller than the concentrations that may lead to protective action being taken.

Continuous operation of the detectors and samplers is assured through a preventative maintenance program, continuous monitoring of equipment performance parameters which are transmitted to central database at 10-minute intervals, and direct observations (check list based) by the station operators. The maintenance program consists of scheduled station visits every two years, during which the pump, sampler and electronics are checked. Preventive maintenance includes regular replacement of air pump ball bearings and clean-up. Samplers are calibrated for air flow measurements.

The quality of gamma spectroscopic analysis is assured by STUK laboratory quality assurance and control procedures.

5.3.2 FMI air samplers monitoring gross beta activity of ground level air

The Finnish Meteorological Institute (FMI) has been monitoring gross beta activity of aerosol particles since 1959. In addition to radiological monitoring the results have been used in meteorological and air quality studies. Currently, weekly aerosol samples are collected at ten stations (Fig. 4), using filter sampling.

Figure 4. Atmospheric sampling locations (FMI)

Weekly samples are obtained from the instruments monitoring continuously aerosol-bound beta activity in the air. Filters are changed every Monday at 06 UTC. The sampling equipment uses two rectangular paper or glass fibre filters with a filtering area of 120 x 140 mm. The weekly air sample volumes are 800 m^3 and 4000 m^3 for paper and glass fibre filters, respectively. The filter material of daily filters is glass fibre (Munktell MGA; Ø 24 cm). The samplers collect particles with an aerodynamic diameter less than 10-15 µm depending on the wind speed. The air flow is measured with a rota meter.

The gross beta activity content of the filters is measured five days after the end of sampling when the short-lived radon (Rn-222) progeny have decayed to Pb-210 and the thoron (Rn-220) progeny have decayed to stable Pb-208. Therefore, the measured gross beta activity consists of Pb-210 and possible artificial beta emitters. The measurements are carried out with an automatic large-area proportional alpha/beta counter. The detector system consists of five gas flow proportional counters with a 250 x 250 mm window, an alpha, a beta and an anticoincidence detector above the filter and a beta and an anticoincidence detector beneath the filter. The flow gas is P-10, a mixture of argon (90 %) and methane (10 %). The filters are attached to holders which are carried one by one beneath the upper detector assembly with the exposed side of the filter facing the alpha detector. The sample identification is read from a bar code attached to the sample holder. Next, the lower detector assembly moves upwards, so that the filter is slightly pressed between both counter assemblies. Pulses from the detectors are counted and the movements of the sample changer are controlled by a computer.

The counting efficiency for alpha particles (^{210}Po) is 42 % and for beta particles (^{210}Bi) 76 %. Each filter type has its own background sample (an unexposed filter), which is measured at least twice per measuring sequence. Similarly, three reference samples (^{242}Pu, ^{90}Sr and ^{55}Fe) are measured at least once per measuring sequence to monitor the stability of the instrument.

The measured net count rates are divided with counting efficiencies and sampled air volumes to obtain total beta activity concentrations. The data is stored on PCs.

5.4 DRY/WET ATMOSPHERIC DEPOSITION

Radioactive substances can be deposited into the environment as dry deposition or with rain as wet deposition. The results of the analyses of the deposition samples as Becquerel per unit area form a basis for transfer studies of the deposited radionuclides both in terrestrial and aquatic environments.

Deposition samples are collected continuously at eight sites, which are the same sites as for STUK air sampling (Fig. 5). The samplers are made of stainless steel with a surface area of 0.07 m^2. The deposition samplers do not separate wet and dry deposition. To facilitate sampling in wintertime, the sampler has a light heating resistor that melts the snow and ice accumulated in the funnel, ensuring its inclusion in the sample.

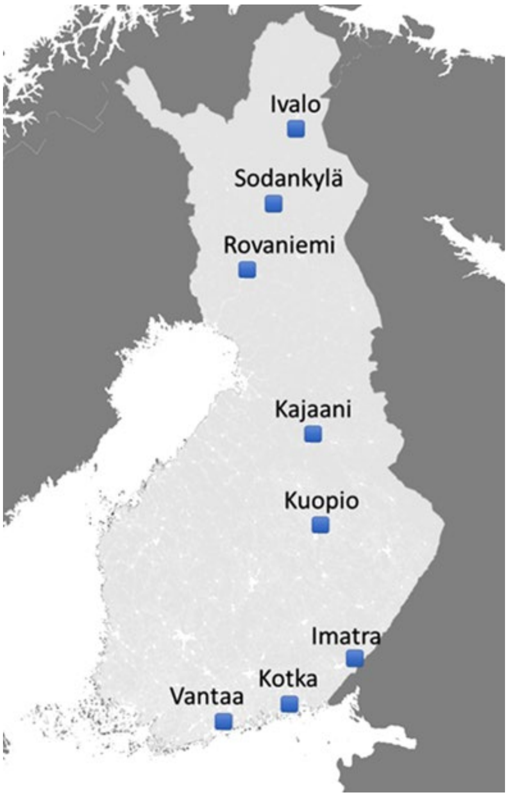

Figure 5. Atmospheric deposition monitoring locations

The usual sampling period is one month. Gamma-emitting nuclides are analysed from a combined quarterly sample and Sr-90 from a combined annual sample. Known amounts of inactive Sr and Cs tracers are added to the samples. After acidification with nitric acid, the samples are concentrated by evaporating them under infrared thermal lamps. The residues are ashed. The ashed samples are analysed for artificial gamma-emitting radionuclides with gamma spectrometers. Strontium is separated by an extraction chromatographic method, and thereafter Sr-90 is determined via its progeny nuclide Y-90, which is measured with a low background liquid scintillation counter.

In addition, tritium (H-3) concentrations in rainwater samples are determined from two stations (Vantaa and Rovaniemi). The samples are distilled and then measured with a liquid scintillation counter.

For emergency purposes STUK has one sampler which separates wet and dry deposition from each other. Its collection area is 0.5 m^2. It is located at the STUK headquarters in Vantaa.

5.5 OTHER ATMOSPHERIC MONITORING CAPABILITIES

FMI has a capability to carry out soundings of radioactivity in the upper atmosphere. A dose rate meter connected to a radiosonde is carried with a weather balloon up to a height of 30-35 km. Dose rate readings on different altitudes, together with meteorological observations (temperature, pressure, humidity, wind direction and speed), are transmitted via radio to a ground station. These soundings are not done on routine basis, but the FMI maintains capability to initiate them in the event of an emergency.

5.6 WATER

5.6.1 Surface waters

Samples of surface waters are taken once a year either in spring or autumn from the mouths of four major rivers in Finland (Kymijoki, Kokemäenjoki, Oulujoki and Kemijoki) (Fig. 6). The sample amount is about 30 litres. In the laboratory, known amounts of Sr and Cs tracers are added to the samples, and they are acidified with nitric acid. The samples are concentrated by evaporating them under infrared thermal lamps, after which the dry residues are ashed. From the ashed samples, Cs-137 and all other gamma emitting radionuclides are analysed using gamma spectrometry. Strontium is separated by extraction chromatography and Sr-90 is measured with a liquid scintillation counter.

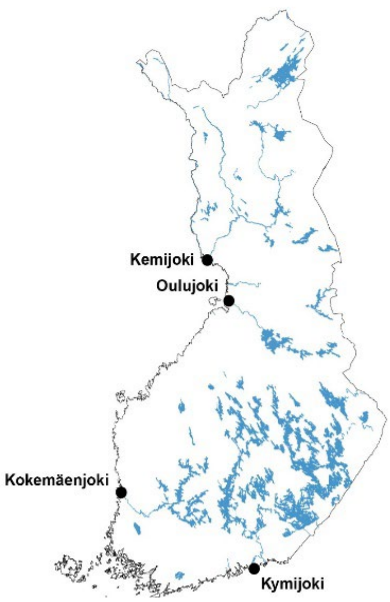

Figure 6. Surface water sampling locations

5.6.2 Ground water and drinking water

Drinking water samples are collected once a year from tap water in Oulu, Rovaniemi, Tampere, Turku and Vantaa (Fig. 7). The sample amount is about 20 litres. First, a subsample is taken from the samples for H-3 analysis. Known amounts of Sr and Cs tracers are added to the rest of the samples, which are then acidified with nitric acid. The samples are concentrated by evaporating them under infrared thermal lamps and by ashing the dry residues. Gamma-emitting radionuclides are analysed with gamma spectrometers on the ashed samples. Strontium is separated by an extraction chromatography, after which Sr-90 is measured with a liquid scintillation spectrometer. The samples for H-3 analysis are distilled until dry to remove any impurities. H-3 is determined by measuring the distilled samples with a liquid scintillation counter.

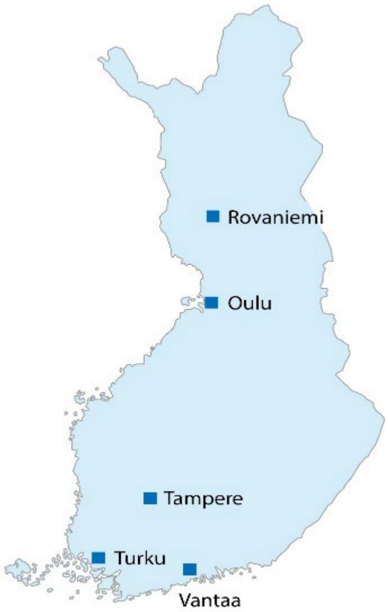

Figure 7. Domestic water monitoring locations

5.7 SOIL, SEDIMENTS AND SEWAGE SLUDGE

The Finnish programme includes monitoring of soil or lake/river sediments only in the vicinity of the Olkiluoto and Loviisa nuclear sites.

Sewage sludge samples at the Viikinmäki wastewater treatment plant in Helsinki (Fig. 8) are collected twice a year from undigested sludge and from dewatered sludge. These samples are collected in March and October; both sample types are collected on the same day.

Sludge samples are analysed for gamma-emitting radionuclides without pre-treatment. In order to detect short-lived nuclides, the measurement is carried out as soon as possible after the sample has arrived at the laboratory. The percentage of the dry material present in the samples is determined after the gamma measurement.

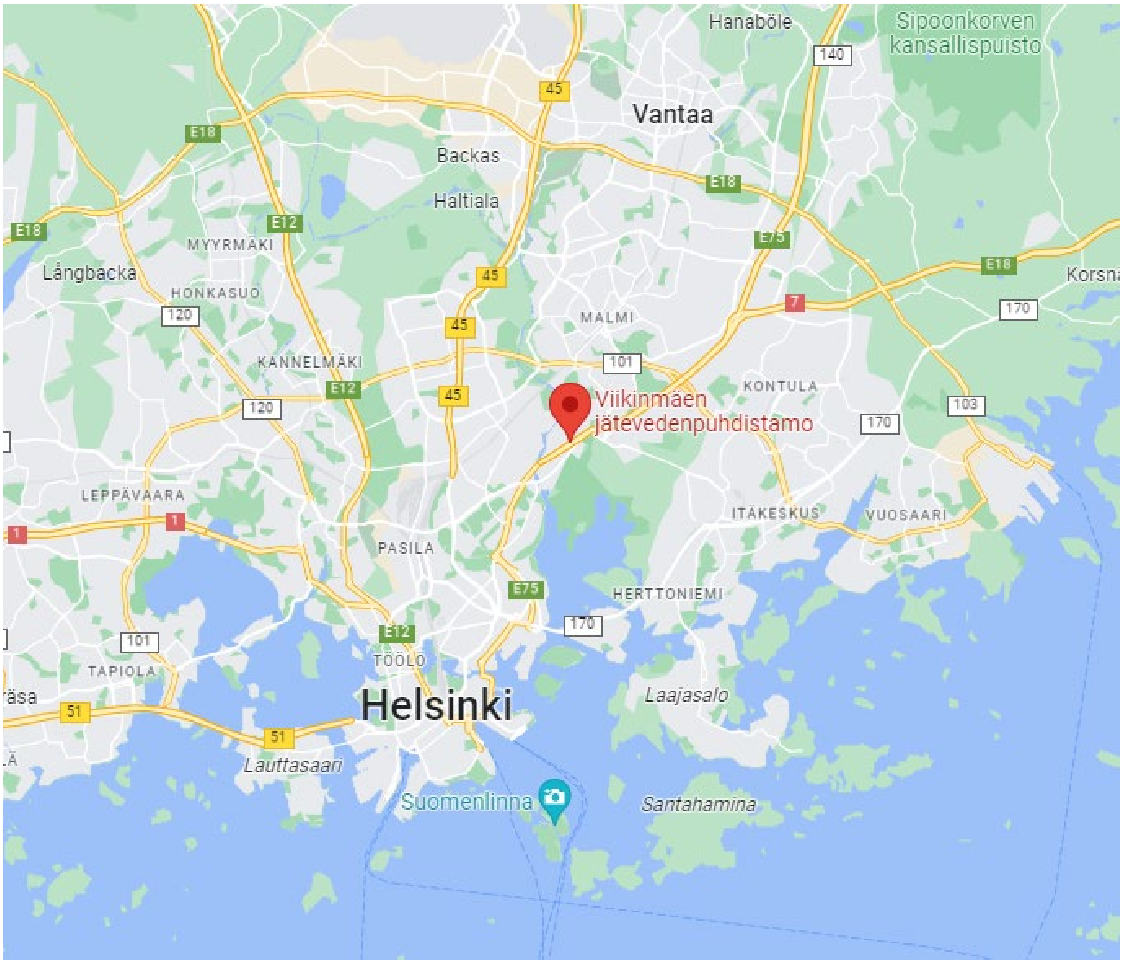

Figure 8. Sewage sludge sampling location in Helsinki

5.8 MARINE ENVIRONMENT

Recommendation 26/3 of HELCOM defines the programme for monitoring the occurrence, transport and amounts of radionuclides in the Baltic Sea. The Finnish contribution consists of about 100 annual samples of seawater, bottom sediments, fish and other biota, the analysis of radioactive substances and the reporting of the results to the HELCOM database.

Samples are taken once per year from nine sampling points for seawater, five points for sediment (sediment cores to depth of about 30 cm, sliced to 2 cm slices, about 15 samples per sampling point) and six points for biota (Fig. 9). Nearest sampling points to Helsinki are Tvärminne near Hanko (herring, pike) and Loviisa (herring, pike, bladder wrack (*Fucus vesiculosus*) and *Saduria entomon*).

Sea water samples are analysed for gamma-emitting radionuclides, Sr-90 and tritium (H-3). Sediments are analysed for gamma-emitting nuclides, and biota for gamma-emitting nuclides and Sr-90.

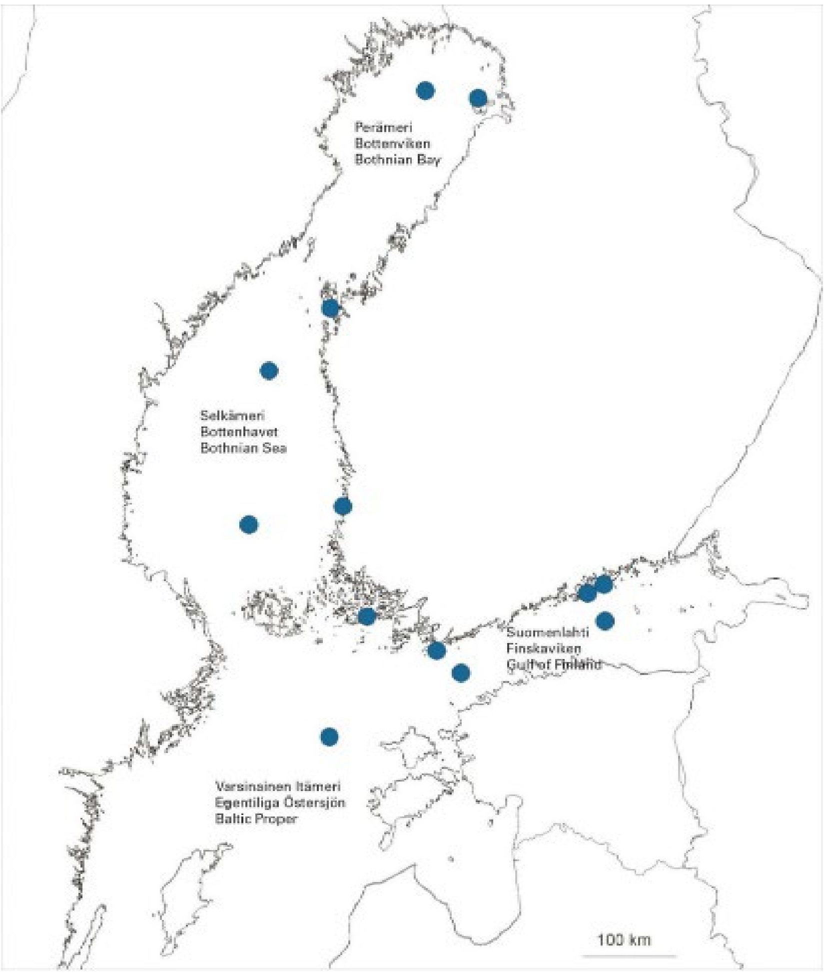

Figure 9. HELCOM marine sampling locations (Finnish contribution)

5.9 FOODSTUFFS AND FEEDING STUFF

5.9.1 Milk

Milk samples come from dairies which have been selected to provide a comprehensive picture of the levels of radioactive substances in milk produced in Finland. In addition, the dairies have been selected so that the Chernobyl fallout in the areas differ from each other. The samples are collected from dairies in Joensuu, Jyväskylä, Oulu, Riihimäki and Seinäjoki (Fig. 10).

Milk samples are collected on a weekly basis and bulked together to compose a monthly sample. Bulking of the weekly samples is performed either by the dairies or in the STUK laboratory. The samples are frozen and delivered to STUK. The monthly samples are evaporated under infrared thermal lamps and ashed before the analysis. Cs-137 and K-40 activity concentrations are determined by gamma spectrometric measurements.

After gamma spectrometric analysis, the monthly samples are combined to make quarterly samples. These quarterly samples are used for Sr-90 analyses. Strontium is separated by extraction chromatography and after this Sr-90 is determined with a liquid scintillation counter.

Figure 10. Milk sampling locations

5.9.2 Mixed diet

Mixed diet samples are collected once a year from three different sites (Helsinki, Tampere and Rovaniemi) (Fig. 11). Sampling is done in the autumn. Sampling sites are institutional kitchens in hospitals. Food and drink samples are collected separately. Food samples are collected for seven days; one food sample consist of all the meals of a day. Drinks are collected only once a week for one day.

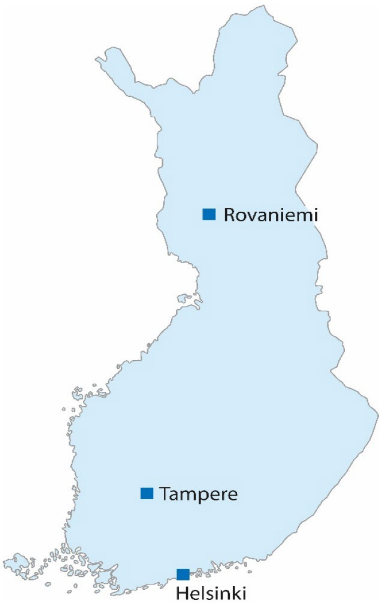

Figure 11. Mixed diet sampling locations

The food samples collected during a day are combined into one sample, which is dried and homogenised. The Cs-137 activity of the daily samples is determined by gamma spectrometric measurements. After Cs-137 has been determined, the samples are ashed and combined into weekly samples for Sr-90 analysis. Strontium is separated from the samples by extraction chromatography, after which Sr-90 is determined with a liquid scintillation counter.

The drinks collected during a day are evaporated under infrared thermal lamps and ashed. Cs-137 activity concentration is determined by gamma spectrometric measurement from the ashed drink samples. Strontium is separated from the samples by extraction chromatography method, after which Sr-90 is determined with a liquid scintillation counter.

5.9.3 Foodstuffs

Wild game, wild mushrooms and freshwater fish are collected each year, wild berries once in five years.

The foodstuffs on the market are acquired from grocery shops once a year in three locations: Helsinki, Tampere and Rovaniemi. The foodstuffs are acquired in the autumn. The samples are pre-treated at STUK and their Cs-137 activity content is determined from gamma spectrometric measurements.

5.9.4 Feeding stuffs

Animal feed is not included in the regular radioactivity monitoring program. The competent authority is the Finnish Food Authority.

5.10 EMERGENCY MONITORING

5.10.1 General

Monitoring of radioactivity in the environment in the event of an emergency is mainly carried out by STUK. STUK's regular staff is nominated into positions in STUK's emergency organization. Currently, the group responsible for the laboratory work in emergencies consist of about 28 persons (lab technicians, physicists and radiochemists). The group responsible for field measurements has 39 persons available. In addition, the FMI can intensify air monitoring and the Defence Forces can carry out radiation monitoring by their CBRN units. Local military reserve organisations have also been trained to monitor radiation.

5.10.2 STUK field monitoring teams

STUK has trained its staff to carry out field monitoring. The teams have the following equipment at their disposal:

- dose rate and contamination meters (dose rate operation range up to 10 Sv/h, alpha/beta probes);
- radiation surveillance backpacks (dose rate and in-situ measurement; $LaBr_3$ gamma spectrometer (6LiF:ZnS(Ag) neutron detector);
- portable air samplers;
- portable HPGe detectors (dose rate and *in-situ* measurement, high resolution gamma spectrometry;
- personal protective equipment.

At its headquarters STUK has a field monitoring support facility 'Reachback' (Fig. 12), which receives the data from the field teams in real time. The 'Reachback' facility can provide quick expert analysis and support to the field teams.

Figure 12. 'Reachback' environmental monitoring support facility at STUK

5.10.3 Mobile laboratories

STUK operates two mobile laboratories:

- Surveillance vehicle Härkä, equipped with
    - direct gamma spectrometry for detection,
    - identification and mapping detectors (NaI(Tl)),
    - Geiger-Muller tube for high dose rate measurements,
    - real time data & voice communication capability to Reachback.
- Mobile monitoring laboratory Sonni2, equipped with
    - ambient gamma dose rate measurement equipment,
    - direct gamma spectrometry for detection,
    - identification and mapping detectors (large NaI detectors & HPGe-detectors),
    - two air sampling systems with flowmeters,
    - sample measurements (HPGe detector),
    - alpha-beta spectroscopy equipment (without chemical treatments),
    - data management systems with GPS positioning for transferring data to a database with real time availability at STUK.

The laboratories are on stand-by at the STUK headquarters. Altogether 15 staff members have been trained to operate the equipment.

5.10.4 Voluntary radiation measurement teams

STUK, in co-operation with the National Defence Training Association of Finland (MPK) and the National Emergency Supply Agency (NESA), has trained and equipped voluntary radiation monitoring teams to support STUK and other authorities. The voluntary teams strengthen Finland's national radiation monitoring capability. The teams are equipped with the following:

- Personal alarming dosimeters
- Dose rate survey meters
- Surface contamination monitors
- Alpha/beta counters for smear samples
- Lightweight, transportable portal monitors
- Portable spectrometers for radionuclide detection and identification (backpack; real time data transfer to Reachback)
- Portable air samplers

Additional information is available on the STUK website[8].

5.10.5 Other capabilities

Local Rescue Services have containers with handheld dose rate meters, portal monitors and protective equipment stationed in Loviisa and Pori. In addition, military capabilities can be requested through an official request for assistance. Legislative and contractual arrangements are in place for requesting such assistance.

5.11 INFORMATION FOR THE GENERAL PUBLIC

The public in Finland is informed about environmental radioactivity in both normal and emergency situations. There is information transmitted on-line, in real time, as well in the form of periodic reports.

All monitoring results are made available to the public on stuk.fi webpages. The data is published automatically or after manual verification.

STUK webpages show real time dose rate monitoring network data via an interactive map. Station specific data is displayed as hourly average dose rates. The data from year 2013 onwards can be accessed via a map interface. Dose rate monitoring data with ten minutes time resolution is downloadable from an open data portal. Selected dose rate monitoring results are also published on national broadcast corporation (YLE) teletext pages.

STUK web pages show nuclide specific airborne concentration data from all eight national monitoring stations including the station situated in the capital region. The data can be downloaded from an open data portal. The data is updated automatically after laboratory measurement results of the air filters have been reviewed.

STUK webpages also show the data from monitoring of fallout, surface and household water, mixed diet, milk, and wastewater sludge. The pages are updated manually when new sample analysis results become available.

In addition to the analytical monitoring data, information on the associated sampling and analytical procedures is provided. STUK publishes all the data from national monitoring as yearly monitoring reports[9] in Finnish, Swedish and English.

[8] https://stuk.fi/en/the-voluntary-radiation-measurement-team-strengthens-finland-s-measurement-capacity

[9] https://www.julkari.fi/handle/10024/146787

6 LABORATORIES PARTICIPATING IN ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES IN HELSINKI

6.1 STUK Measurement and Analysis Laboratory

STUK has a new radiological laboratory, which can handle both environmental and radioactive discharge samples in physically separated work areas. The laboratory is authorised and recognised by the regulatory authority for performing these analyses. It is ISO 17025 accredited, performs its activities both under routine and emergency circumstances, and participates in the IAEA ALMERA network. It takes part in the radiological monitoring programmes within the country (air, water, soil, vegetation, food and industrial) for all the activities involved (sampling, sample preparation, measurement, analysis and reporting).

STUK has implemented QA/QC procedures for the laboratory. The equipment is calibrated, tested and verified according to requirements. Calibration standards used are traceable to (inter)national standards. Uncertainties affecting the results are identified, analysed and reported. STUK organises internal and external audits and participates regularly in intercomparison exercises.

The laboratory uses the NAMIT software, developed at STUK, for managing orders, samples, measurements and measurement results. The NAMIT software has a web-based user interface. All incoming samples are recorded in the system. The system prints barcode labels that are attached to the sample containers. After that the system monitors and guides the sample through the measurement processes and records all relevant analytical data related to it.

The following analytical procedures are applied:

- Deposition, surface water, household water: Sr and Cs tracers are added. The samples are acidified and concentrated by evaporating and the residues are ashed. From the ashed samples, ^{137}Cs is analysed using gamma spectrometry. For strontium analysis, strontium is separated by extraction chromatography.
- Rainwater samples are distilled and then measured for their tritium content.
- Sodium azide is added for preserving milk samples. Milk samples are concentrated by evaporating and the residues are ashed. Cs-137 and Sr-90 are determined from the ashed samples.
- Cs-137 of the dried daily food samples is determined by gamma spectrometric measurement. After Cs-137 has been determined, the samples are ashed and combined into weekly samples for Sr-90 analysis. Strontium is separated from the samples by extraction chromatography.
- Sludge samples are analysed for gamma-emitting radionuclides without pre-treatment. The percentage of the dry material present in the samples is determined after measurement. Tritium and Sr-90 are measured with the low background scintillation counters (Quantulus^{TM}).

The following measurement devices are available in the laboratory:

- Four low background liquid scintillation counters (Quantulus^{TM}, PerkinElmer)
- 15 HPGe detectors. Reference sources/standards covering the energy range 10–1836 keV are used for energy and efficiency calibrations and resolution measurement for the HPGe detectors (NPL reference sources).

Samples are stored in cool and dark place before the pre-treatment process. Dried and ashed samples are stored at room temperature.

6.2 FMI Radiological Laboratory

The Finnish Meteorological Institute radiological laboratory has five gas flow proportional counters used for the measurement of alpha/beta activities on aerosol samples collected with air samplers. The laboratory counting room is located in a pool of water in order to reduce background radiation (Fig. 13). Laboratory staff consists of one-part time radiochemist, one part-time lab technician and one part-time field engineer.

QA/QC procedures have been implemented at the FMI laboratory, although it is not formally accredited. The equipment are calibrated, tested and verified according to requirements; calibration standards used are traceable to (inter)national standards. Uncertainties affecting the results are identified, analysed and reported. Internal and external audits are being organised by the laboratory, but it does not participate regularly in intercomparison exercises.

Figure 13. FMI radiological laboratory facility inside a water pool

7 VERIFICATIONS

7.1 INTRODUCTION

Verifications were carried out in accordance with the agreed programme (Annex 1). This chapter summarises the verifications carried out the by the verification team. The team has assessed the monitoring arrangements based on their own expertise and comparison with similar arrangements in other Member States.

The outcome of the verification is expressed as follows:

- A '*Recommendation*' is made when there is a clear need for improvement in implementing Art. 35. These are included in the main conclusions of the verification. The Commission requests a report on the implementation of the recommendations – lacking implementation of a recommendation can lead to a reverification.
- A '*Suggestion*' is made when the verification team identifies an action, which would further improve the quality of the monitoring.

In addition, the team may '*commend'* particularly good arrangements, which could serve as a best practice indicator for the other EU Member States.

7.2 MONITORING PROGRAMME

The verification team verified the structure of the environmental radioactivity monitoring programme in Finland, and Helsinki in particular, including both automatic and laboratory-based monitoring (Chapter 5).

The team notes that the current programme is sufficient to cover the relevant environmental monitoring and there are sufficient resources for carrying out monitoring in the event of an emergency. Capacities for monitoring radioactivity in food samples exist in several laboratories, but these may not be sufficient in a large-scale food contamination situation.

Results of the monitoring programme are made available to the public on-line and in annual reports in Finnish, Swedish and English.

> *The verification team suggests that STUK reviews the food sample measurement capacity situation in co-operation with other relevant authorities.*
>
> *The verification team commends the practise of annual reporting also in English.*

7.1 RADIATION AND NUCLEAR SAFETY AUTHORITY

7.1.1 Automatic radiation monitoring network

The verification team verified the structure of the automatic radiation monitoring network (ULJAS) in Finland. The system contains altogether 255 monitoring stations, 30 of which are equipped with spectroscopic $LaBr_3$-detectors (USVA subnetwork). Electrical back-up is provided for 72 hours. Five stations are located in the Helsinki region, two of them equipped with $LaBr_3$-detectors. The network data is collected at two server facilities (Finnish government central database and FMI) and exchanged internationally through the EURDEP system.

The verification team verified the web interface of the automatic radiation monitoring network and one monitoring station of the network in Helsinki (Kumpula) (Fig. 15). The interface is very advanced in presenting spectral radiation data (waterfall display, Fig. 14).

The ULJAS station is equipped with a local display and a rain sensor. Data are transferred via the Government data network (VIRVE).

The verification team noted that the radiation dose rate data from the radiation monitoring networks surrounding the Olkiluoto and Loviisa NPPs are not provided to the EURDEP system.

The verification team suggests including data from the Finnish NPP monitoring networks in the EURDEP data files, in agreement with the nuclear site operators.

The verification team commends the advanced data display features of the USVA interface.

Figure 14. USVA-network waterfall display of radiation spectra with GPS positioning

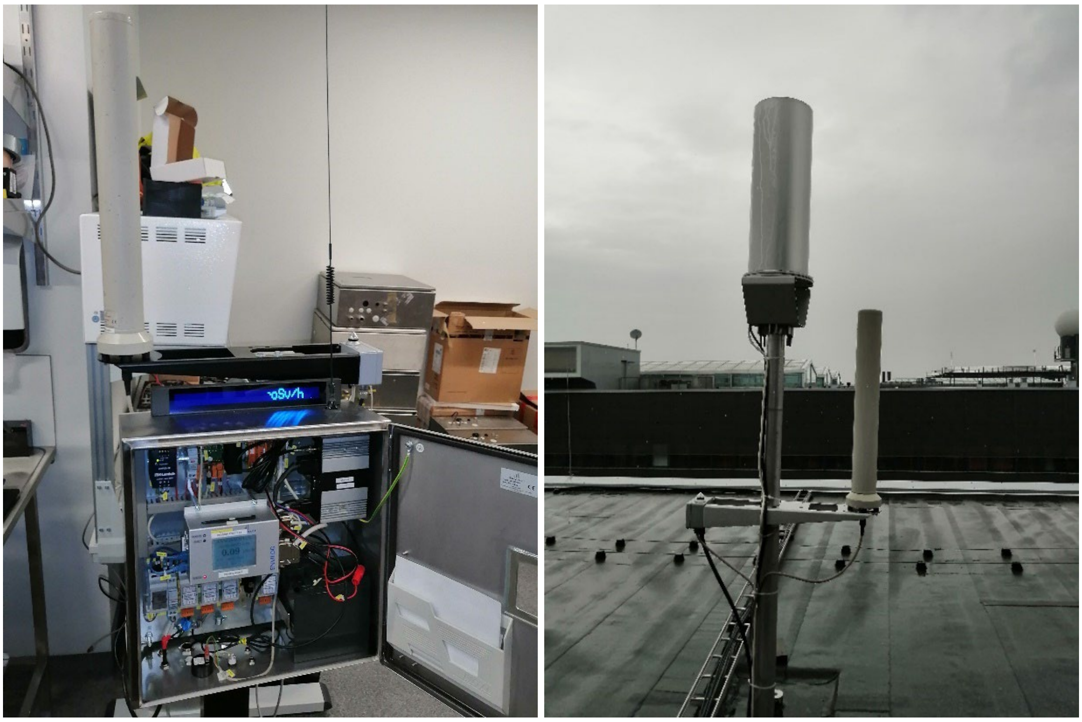

Figure 15. Automatic ambient radiation monitor electronics unit and detectors

7.1.2 Radiological laboratory

The verification team verified the facilities and equipment of the STUK radiological laboratory[10]. The laboratory is new and has sufficient rooms for sample preparation, chemical treatment, counting and storage. No staff or equipment shortages were reported to the verification team. The laboratory is ISO 17025 accredited since 1999. The facility is physically separated in two areas: one for handling environmental and one for handling discharge monitoring samples. There are large rooms for sample preparation (drying, ashing, evaporation, radiochemical separation) and storage (room temperature and cold). Sample management is done using the NAMIT-software, which issues the sample QR-code labels at sample receipt.

The main laboratory counting equipment are located in four low background counting rooms (two for gamma and two for alpha/beta). They comprise the following:

- HPGe-detectors for gamma spectroscopy (18, both Canberra and Ortec), hybrid LN_2-electrical cooling (Fig. 16)
- Alpha-counting system for air filters using PIPS detectors
- Liquid scintillation counters (6, Quantulus 1220 (4), HIDEX 300 SL (1, not operational), Quantulus GCT 6220 (1, not operational)) (Fig. 17)
- Alpha spectrometer Canberra Alpha Analyst (3)
- Inductive-coupled mass spectrometer (ICP-MS Thermo Scientific iCAP Q) for U- Th- and Sr-analysis of NORM samples

Detector calibrations are based on traceable activity standards. EFFTRAN software is used for sample geometry or density corrections. The laboratory participates regularly in intercomparison exercises and proficiency tests.

No remarks.

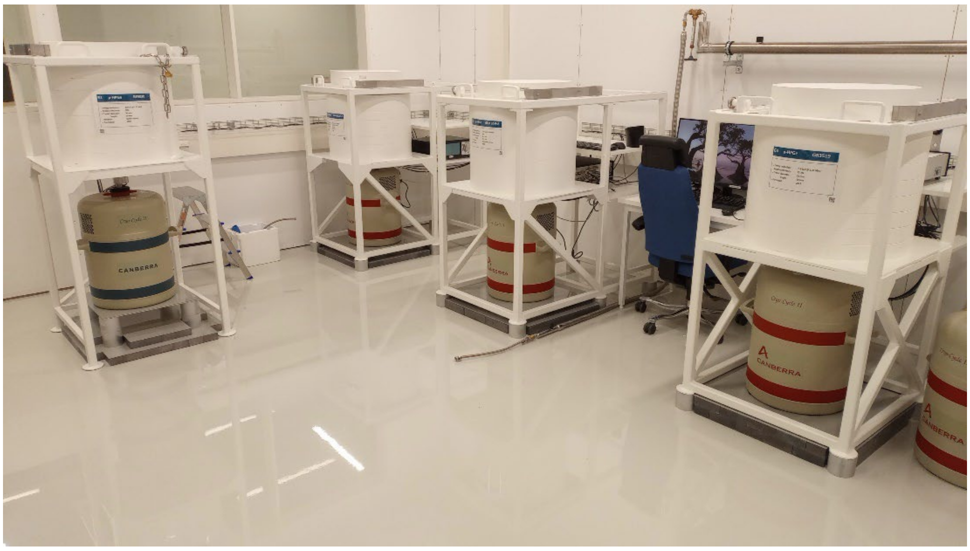

Figure 16. HPGe-detectors at the STUK laboratory counting room

[10] Jokiniemenkatu 28, 01380 Vantaa

Figure 17. Liquid scintillation counters at the STUK laboratory

7.1.3 Air sampling

STUK carries out continuous air sampling on eight locations in Finland. The samples arrive to STUK from the stations by mail with a sampling record form. The particulate sample filters are cut into rectangular sections, stacked and placed into a beaker. The activated charcoal for the gas samples is poured into a Marinelli beaker.

The verification team verified the automatic air monitoring system 'Cinderella' located at the top floor of the STUK office in Vantaa (figure 18). This device has a 5x3 filter cassette, which is changed by a robotic arm. The individual filters are then cut and measured by a HPGe-detector (after 24-hour decay time). The 'Cinderella' does not have the capability for sampling gaseous iodine, but a manual sampler can be used for that purpose in the case of an emergency.

No remarks.

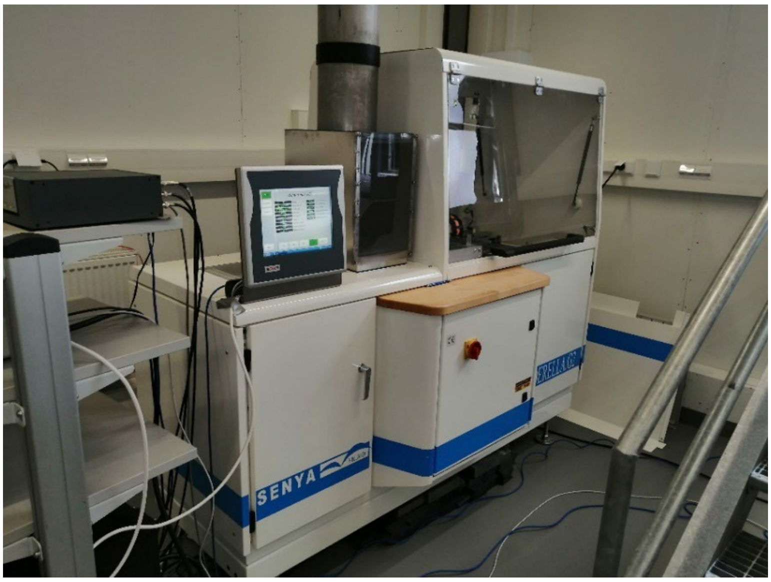

Figure 18. Automatic air radioactivity analysis system 'Cinderella' at STUK

7.1.4 Atmospheric deposition sampling

STUK carries out atmospheric deposition sampling on eight locations in Finland. The verification team verified the sampling equipment located on the roof of the STUK office in Vantaa. The equipment consists of the following:

- Deposition collector 'Ritva' (0.07 m^3 collection area) (Fig. 19). Three monthly samples are combined in a quarterly sample. These are analysed using gamma spectrometry.
- Tritium sampler (monthly sample) (Fig. 19). Each sample is analysed separately.
- Automatic dry/wet atmospheric deposition collector 'Pirkko' (0.5 m^3 collection area) (Fig. 20). This device automatically detects precipitation and separates dry and wet deposition. The sampling period is one month.

The systems are heated for melting snow and ice.

No remarks.

Figure 19. Atmospheric deposition collector 'Ritva' (left) and tritium sampler (right) at STUK

Figure 20. Automatic dry/wet atmospheric deposition collector 'Pirkko' at STUK

7.1.5 Emergency monitoring system

In the event of an emergency STUK coordinates a monitoring system, which consist of the following elements:

- Local monitoring by the Rescue Departments
- Mobile monitoring laboratories Sonni2 and Härkä
- Voluntary radiation monitoring teams
- STUK mobile monitoring teams
- Reachback expert support facility

There are 39 members of STUK staff trained for mobile monitoring. In addition, there is a system for mobilising trained voluntary measurement teams for carrying out emergency radiation monitoring.

The verification team verified the Reachback-facility (Fig. 12), which is located at the STUK office in Vantaa. The facility is very well equipped for providing support to field monitoring units and for providing information to the STUK emergency response centre.

The verification team commends the implementation of the Reachback facility for supporting field measurements.

The verification team commends the development of the voluntary radioactivity monitoring teams in Finland.

7.1.6 Mobile monitoring equipment

The verification team verified the STUK mobile radiological laboratory 'Sonni2' (Fig. 21). The laboratory is built in a 4x4 van. Its monitoring equipment includes two large NaI detectors for radiation mapping, an electrically cooled HPGe-detector for sample measurements, an air sampling system, and a weather monitoring unit. The laboratory has an electrical generator and a satellite positioning system; it is operated by a crew of four experts.

In addition, the verification team verified the following mobile (portable) monitoring equipment available at the STUK office in Vantaa (Fig. 22):

- Mobile NaI detector with GPS (Environics)
- Monitoring back bag 'Vasikka' (Gamma and neutron monitoring with GPS)
- Portable air sampler Lilliput (paper and charcoal filter, flowmeter with a pre-set timer)
- Radiation survey meter Canberra Colibri (gamma dose rate, surface contamination and neutron dose rate)
- Personnel dosimeters
- Portable HPGe-detector (Ortec)

The verification team was informed, that similar equipment is in storage for the use by the voluntary radiation monitoring teams in the event of an emergency. The STUK mobile monitoring equipment can be deployed anywhere in Finland.

No remarks.

Figure 21. STUK mobile laboratory 'Sonni2'

Figure 22. STUK mobile radiation monitoring equipment

7.2 FINNISH METEOROLOGICAL INSTITUTE

7.2.1 Fixed monitoring equipment

The verification team visited the Finnish Meteorological Institute[11], which operates under the Ministry of Transport and Aviation. It operates ten aerosol monitoring stations (Fig. 4), which monitor radioactivity in air on continuous basis. Each sampler has one pump, a 3-way valve and two filters, which operate on a 4-hour cycle to allow decay of short-lived nuclides before direct filter counting (Fig. 23). Real time data are transferred to the FMI server.

The weekly collected air filter samples (20 filters) are sent to the FMI for analysis by an automatic alpha/beta analyser. The analyser dates from 1989 and is still operational. Currently, there is no back-up system for this unique instrument. The performance of the analyser and the analytical results are closely followed by the operators. There are also two HPGe-detectors (only one was operational) for Be-7 measurement of the air filters. Monitoring results are transmitted to STUK, which includes them in the regular programme data flow. FMI does not report radioactivity results on its own website or make announcements to the public. The results are, however, published in scientific publications.

The verification team was informed, that the FMI also maintains two monitoring stations, which can carry out soundings of upper atmosphere radioactivity using radiosondes. Soundings are not part of the regular programme but can be carried out in the event of an emergency.

FMI radioactivity laboratory staff consists of one expert, sampling station managers and technicians. In addition, there is one university student working on the programme. No staff shortages were reported. The FMI radioactivity laboratory is not accredited.

The verification team suggests that the FMI considers training additional experts for radioactivity monitoring to maintain sufficient staff competence in the future.

The verification team suggests acquisition of a back-up for the alpha/beta analyser currently in use.

The verification team commends the FMI capability to carry out soundings of upper atmosphere radioactivity.

Figure 23. Alternating pumps of the FMI air monitoring system

[11] Erik Palménin aukio 1, 00560 Helsinki

7.3 HELSINKI CITY RESCUE DEPARTMENT

7.3.1 First responders' monitoring equipment

The verification team visited the Helsinki City Rescue Department[12] and verified the radiation monitoring capabilities of the first responder teams.

First responders (firemen) have personal dosimeters and basic capability to measure radiation dose rates. If needed, they can also be equipped with a neutron dose monitor and a nuclide identification device. The procedure is to contact STUK for expert advice as soon as a radiation concern has been identified.

The department has the following mobile monitoring equipment (Fig. 24):

[redacted]

- [redacted]

The monitoring equipment can be deployed anywhere in the Helsinki region with the first rescue unit on the accident scene.

[redacted]

In addition, there is no radiation source which could be used for training of the staff in identifying nuclides.

> [redacted]
>
> *The verification team suggests acquisition of a few sealed small multinuclide radiation sources for training purposes.*

Figure 24. Radiation monitoring equipment of the Helsinki City Rescue Department

12 [redacted]

8 CONCLUSIONS

All planned verification activities were completed successfully. The information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, proved very useful.

The information provided and the verification findings lead to the following observations:

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out monitoring of levels of radioactivity in air, water and soil in Helsinki and in its vicinity are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.

(2) The verification activities that were performed demonstrated that the facilities necessary to carry out monitoring of levels of radioactivity in air, water and soil in Helsinki and in its vicinity in the event of a radiological emergency are adequate. The Commission could verify the availability of a representative part of these facilities.

(3) A few technical suggestions are formulated. Notwithstanding these remarks, the verified parts of the monitoring system for environmental radioactivity in place is in conformity with the provisions laid down under the Article 35 of the Euratom Treaty.

(4) The verification summary is presented in the 'Main Conclusions' document that is addressed to the Finnish competent authority through the Permanent Representative of Finland to the European Union.

(5) The Commission services kindly request the Finnish authorities to submit a report on any significant changes in the set-up of the monitoring arrangements. Based on this report the Commission will consider the need for a follow-up verification.

(6) The verification team acknowledges the excellent co-operation it received from all persons involved in the activities it performed.

ANNEX 1

VERIFICATION PROGRAMME

EURATOM ARTICLE 35 VERIFICATION IN FINLAND

(HELSINKI CAPITAL REGION)

28 – 30 AUGUST 2023

Monday 28 August

14:00 **Radiation and Nuclear Safety Authority (STUK)**
(Jokiniemenkuja 1, 01370 Vantaa)
- Verification team arrival at STUK

14:30 **Verifications at the Helsinki City Rescue Department**
([redacted])
- First responders' radiation monitoring equipment

Tuesday 29 August

09:30 **Opening meeting at the Radiation and Nuclear Safety Authority (STUK)**
(Jokiniemenkuja 1, 01370 Vantaa)
- Welcome and introduction
- European Commission Art. 35 verification activities and programme of the verification mission
- Discussion on the past verifications in Finland by the Commission
- General presentation of STUK
- General presentation of department of measurements and environmental monitoring
- Other presentations
- Verification planning

10:30 **Overview of radioactivity monitoring arrangements in Finland and in the Helsinki region**
- Dose and dose rate monitoring
- Air sampling
- Dry/wet deposition sampling
- Soil sampling
- Water sampling
- Food stuff and feeding stuff sampling
- Marine monitoring
- Mobile monitoring systems
- Emergency monitoring systems
- Public information arrangements
- R&D activities and studies

14:00 **Verifications of STUK fixed and mobile monitoring systems**
(*Jokiniemenkuja 1, 01370 Vantaa*)

- Automatic dose rate monitors and early warning system
- Air samplers
- Mobile equipment
- Other

15:30 **Verification of STUK laboratory facilities**
(Jokiniemenkuja 1, 01370 Vantaa)

- Radiological laboratory

<u>Wednesday 30 August</u>

09:30 **Verifications at the Finnish Meteorological Institute**
(Erik Palménin aukio 1, 00560 Helsinki)

- Air sampling equipment
- USVA station

13:00 **Review of Finland data in the Commission Art. 35 database**

15:00 **Closing meeting at STUK**
(Jokiniemenkuja 1, 01370 Vantaa)