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Säteilyturvakeskus
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Key words: environmental radioactivity, nuclear power plants, terrestrial environment, aquatic environment

Abstract

The monitoring of radioactive substances round Finnish nuclear power plants continued in 2002–2004 in accordance with the regular environmental monitoring programmes. Altogether, some 1000 samples are analysed annually from the terrestrial and aquatic environs of the two power plants.

Trace amounts of activation products originating from airborne releases from the local power plants were detected in several air and deposition samples taken from the close vicinities of the power plants. At Loviisa, observations were made in two; at Olkiluoto in three aerosol samples during the reporting period. Except for the naturally occurring beryllium-7, the concentrations of all radionuclides in the air samples were very low; from few microbequerels to few tens of microbequerels per cubic metre. A similar pattern was tenable for the deposition samples as well. The activity concentrations of cobalt-60 of local origin were at their highest 0.3 bequerels per square metre in one sample taken from Loviisa and in one sample taken from Olkiluoto. No traces of local discharge nuclides were detected in foodstuffs, drinking water or garden products. In mushrooms and wild berries picked up in 2004 from the Loviisa area, only Chernobyl-derived caesium isotopes and natural potassium-40 were detected.

Local discharge nuclides were more abundant in the aquatic environment, especially in samples of indicator organisms, sinking matter and sediments, which effectively accumulate radioactive substances. Besides tritium originating from local discharges, the most significant artificial radionuclide in the samples taken from the aquatic environs of the power plants was still caesium-137 originating from the Chernobyl accident (potassium-40 is a naturally occurring radionuclide). Elevated tritium concentrations were more frequent in the water samples from Loviisa. In indicator organisms and sinking matter, the observed concentrations of local discharge nuclides were generally somewhat higher and their distribution range was wider in the sea area off Olkiluoto. However, the concentrations were so low that they do not cause any harmful effects to local

people or wildlife. Small amounts of cobalt-60 originated from the local power plant were detected in sediments at a distance of about 14 km from Olkiluoto.

This Annual Report includes an extensive collection of sampling and analysis methods used in the environmental monitoring of radioactive substances in the vicinities of the nuclear power plants in Finland.

ILUS Erkki, KLEMOLA Seppo, VARTTI Vesa-Pekka, MATTILA Jukka, IKÄHEIMONEN Tarja K. Suomen ydinvoimalaitosten ympäristön säteilyvalvonnan tulokset vuosilta 2002–2004. STUK-A227. Helsinki 2008, 156 s.

Avainsanat: ympäristön radioaktiivisuus, ydinvoimalaitokset, maaympäristö, vesiympäristö

Tiivistelmä

Suomen ydinvoimalaitosten ympäristön säteilyvalvonta jatkui vuosina 2002–2004 säännöllisten tarkkailuohjelmien mukaisesti. Kahden voimalaitospaikan maa- ja vesiympäristöstä otetaan ja analysoidaan yhteensä lähes tuhat näytettä vuodessa.

Pieniä määriä paikallisten voimalaitosten ilmapäästöistä peräisin olevia aktivoitumistuotteita havaittiin useissa lähialueelta otetuissa ilma- ja laskeumanäytteissä. Loviisassa havaintoja tehtiin kahdesta ja Olkiluodossa kolmesta ilmanäytteestä. Luonnon beryllium-7:a lukuun ottamatta kaikkien radioaktiivisten aineiden pitoisuudet olivat erittäin pieniä, muutamasta mikrobequerellistä muutamaan kymmeneen mikrobequerelliin kuutiometrissä ilmaa. Sama tendenssi oli näkyvissä myös laskeumanäytteissä. Paikallisista päästöistä peräisin olevan koboltti-60:n pitoisuudet olivat suurimmillaan alle 0.3 Bq neliömetrillä yhdessä Loviisan ja yhdessä Olkiluodon ympäristöstä raportointijakson aikana otetussa laskeumanäytteessä. Elintarvikkeissa, talousvedessä ja puutarhatuotteissa ei esiintynyt paikallisista päästöistä lähtöisin olevia radioaktiivisia aineita. Loviisan voimalaitoksen ympäristöstä vuonna 2004 kerätyissä sienissä ja luonnonmarjoissa esiintyi vain Tshernobylin onnettomuudesta peräisin olevia cesium-isotooppeja ja luonnon kalium-40:a.

Vesiympäristössä oli runsaammin paikallisista päästöistä peräisin olevia aktivoitumistuotteita; erityisesti ns. indikaattorikasveissa ja -eläimissä, sekä pohjalle laskeutuvassa aineksessa ja pohjasedimenteissä, jotka keräävät tehokkaasti radioaktiivisia aineita. Voimalaitosten päästöistä peräisin olevan tritiumin ohella merkittävin keinotekoinen radioaktiivinen aine voimalaitosten ympäristönäytteissä oli edelleen Tshernobylin onnettomuudesta peräisin oleva cesium-137. Kaikissa näytteissä esiintyvä kalium-40 on luonnon radionuklidi. Kohonneita tritium-pitoisuuksia oli useammin Loviisan ympäristöstä otetuissa merivesinäytteissä. Indikaattoriorganismeissa ja pohjalle laskeutuvassa aineksessa havaittujen paikallisten päästönuklidien pitoisuudet olivat

Olkiluodossa yleensä jonkin verran suuremmat ja niitä havaittiin laajemmalla alueella kuin Loviisassa. Pitoisuudet olivat kuitenkin niin pieniä, ettei niillä ole haitallista vaikutusta ympäristön asukkaille eikä luonnon organismeille. Pieniä määriä koboltti-60:a havaittiin pohjasedimenteissä noin 14 kilometrin etäisyydellä Olkiluodon voimalaitoksesta.

Tämä vuosiraportti sisältää kattavan koosteen ydinvoimalaitosten ympäristön säteilyvalvonnassa käytetyistä näytteenotto- ja analyysimenetelmistä.

Contents

1 Introduction

There are four nuclear power plant (NPP) units in Finland: two pressurised water reactors at Loviisa (rated net electric power of each 488 MW), on the south coast, and two boiling water reactors at Olkiluoto (rated net electric power of each 840 MW) on the west coast of Finland (Fig. 1). The units at Loviisa were commissioned in 1977 and 1980, and those at Olkiluoto in 1978 and 1980.

The surveillance of radioactive substances in the vicinities of the NPPs is carried out under permanent monitoring programmes, in which some 1000 samples are taken annually from the two NPP sites. The aim is to confirm that the discharges from the power plants are within permissible release limits and to monitor their dispersion in the environment. Local circumstances and various spreading directions on land and sea have been taken into account in planning the sampling network.

In order to provide reference data, the programmes commenced one year before the first reactor went into operation. Radioecological background studies were started at Loviisa in 1966 and at Olkiluoto in 1972. Since 1976, the results have been published in the Annual Reports of STUK (Radiation and Nuclear Safety Authority).

This report presents the results of the monitoring programmes in 2002–2004. Apart from annual refuelling and maintenance outages and some brief production breaks, the power plants were in continuous commercial operation throughout the period.

The annual maintenance outages at the Loviisa power plant units were in 2002 from 22 July to 12 October, in 2003 from 2 August to 9 September and in 2004 from 24 July to 26 September. The annual outages at the Olkiluoto plant units were in 2002 from 5 to 27 May, in 2003 from 11 May to 6 June, and in 2004 from 9 May to 3 June.

The annual load factors of the Loviisa power plant units 1 and 2 were 89.3% and 82.2% in 2002, 92.4% and 87.9% in 2003 and 87.1% and 93.8% in 2004, respectively. The load factors for the Olkiluoto power plant units 1 and 2 were 95.3% and 96.6% in 2002, 97.0% and 95.5% in 2003, and 95.1% and 96.1% in 2004, respectively (STUK-B-YTO 224, 233 and 241).

The authors of the present report are responsible for various sections of it. Erkki Ilus undertook the editing of the report and was responsible for planning the monitoring programmes, and he also wrote the chapters on programmes, sampling methods, deposition and terrestrial environment, foodstuffs and aquatic environment. Seppo Klemola was responsible for the gamma-spectrometric analyses and wrote the chapters on gamma spectrometric sample measurements, air, measurements of environmental gamma radiation and the dose estimates.

Tarja K. Ikäheimonen was responsible for pre-treatment of samples and radiochemical analyses with Vesa-Pekka Vartti's assistance, and she also wrote the chapters on pre-treatment of samples and radiochemical analysis methods together with Vesa-Pekka Vartti. Jukka Mattila took on the responsibility of implementing the sampling programmes.

2 Discharge data

Annual airborne and aquatic discharges (Bq) from Loviisa and Olkiluoto nuclear power stations in 2002–2004 are provided below. Only radionuclides with a longer half-life than one week are reported.

Loviisa

	AIRBORNE			AQUATIC		
Nuclide	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
H-3	2.2E+11	2.2E+11	2.2E+11	1.3E+13	1.5E+13	1.7E+13
C-14	3.7E+11	3.2E+11	3.2E+11	-	-	-
Cr-51	9.6E+05	1.9E+06	3.2E+06	-	-	-
Mn-54	1.6E+06	7.6E+05	1.2E+06	5.0E+05	2.5E+06	4.3E+06
Co-58	4.9E+06	5.9E+06	1.0E+07	8.1E+04	5.0E+05	7.5E+06
Fe-59	-	-	2.9E+05	-	-	1.9E+06
Co-60	5.5E+06	2.5E+06	3.6E+06	4.9E+05	1.3E+06	3.1E+08
Sr-89	-	-	-	-	-	-
Sr-90	-	-	-	-	-	-
Zr-95	5.7E+05	1.6E+05	9.5E+05	-	1.0E+06	-
Nb-95	1.6E+06	2.0E+05	1.8E+06	-	-	-
Ag-110m	1.2E+07	8.1E+06	1.4E+07	9.8E+06	9.1E+06	1.9E+08
Te-123m	4.1E+04	-	1.9E+05	-	1.1E+04	-
Sb-124	8.0E+06	6.2E+06	1.4E+07	3.3E+07	2.6E+07	6.5E+07
Sb-125	-	-	-	-	-	1.5E+08
I-131	9.8E+05	3.5E+06	1.1E+07	-	-	-
Cs-134	-	-	-	5.0E+05	2.5E+05	8.0E+06
Cs-137	3.0E+04	2.9E+04	-	4.0E+07	3.5E+07	1.3E+08

Olkiluoto

Nuclide	AIRBORNE 2002	2003	2004	AQUATIC 2002	2003	2004
H-3	3.9E+11	2.8E+11	3.2E+11	1.0E+12	1.1E+12	1.5E+12
C-14	9.5E+11	6.8E+11	8.4E+11	-	-	-
Cr-51	1.2E+07	6.9E+06	1.6E+06	3.4E+07	1.5E+08	7.8E+07
Mn-54	1.7E+06	4.0E+06	2.6E+06	3.5E+07	3.4E+07	4.2E+07
Co-58	3.0E+06	4.4E+06	2.9E+06	4.8E+07	2.7E+07	3.3E+07
Fe-59	2.8E+05	3.2E+05	-	-		4.7E+06
Co-60	1.1E+07	1.6E+07	1.4E+07	4.8E+08	2.8E+08	2.4E+08
Sr-89	4.5E+05	-	-	-	-	-
Sr-90	-	-	-	-	-	-
Zr-95	3.0E+05	-	-	7.3E+06	8.2E+05	4.1E+06
Nb-95	3.7E+05	-	1.9E+05	1.3E+07	5.0E+05	6.7E+06
Sn-113	-	-	-	7.5E+05	-	2.4E+05
Sb-124	9.9E+05	5.6E+05	-	4.0E+05	9.5E+05	5.5E+06
Sb-125	-	-	-	3.5E+06	1.6E+07	2.0E+06
I-131	9.8E+06	1.7E+07	-	3.4E+06	2.7E+05	2.6E+05
Cs-134	-	-	-	1.2E+07	7.3E+06	2.1E+06
Cs-137	-	-	-	1.2E+08	7.6E+07	6.2E+07

3 Monitoring programmes

The environmental monitoring programmes of the Loviisa and Olkiluoto nuclear power plants are revised every five years on the basis of previously obtained experience. The attached programme was taken into use from the beginning of 2003; the programme used in 1998–2002 was given in our previous Annual Report (STUK-A218).

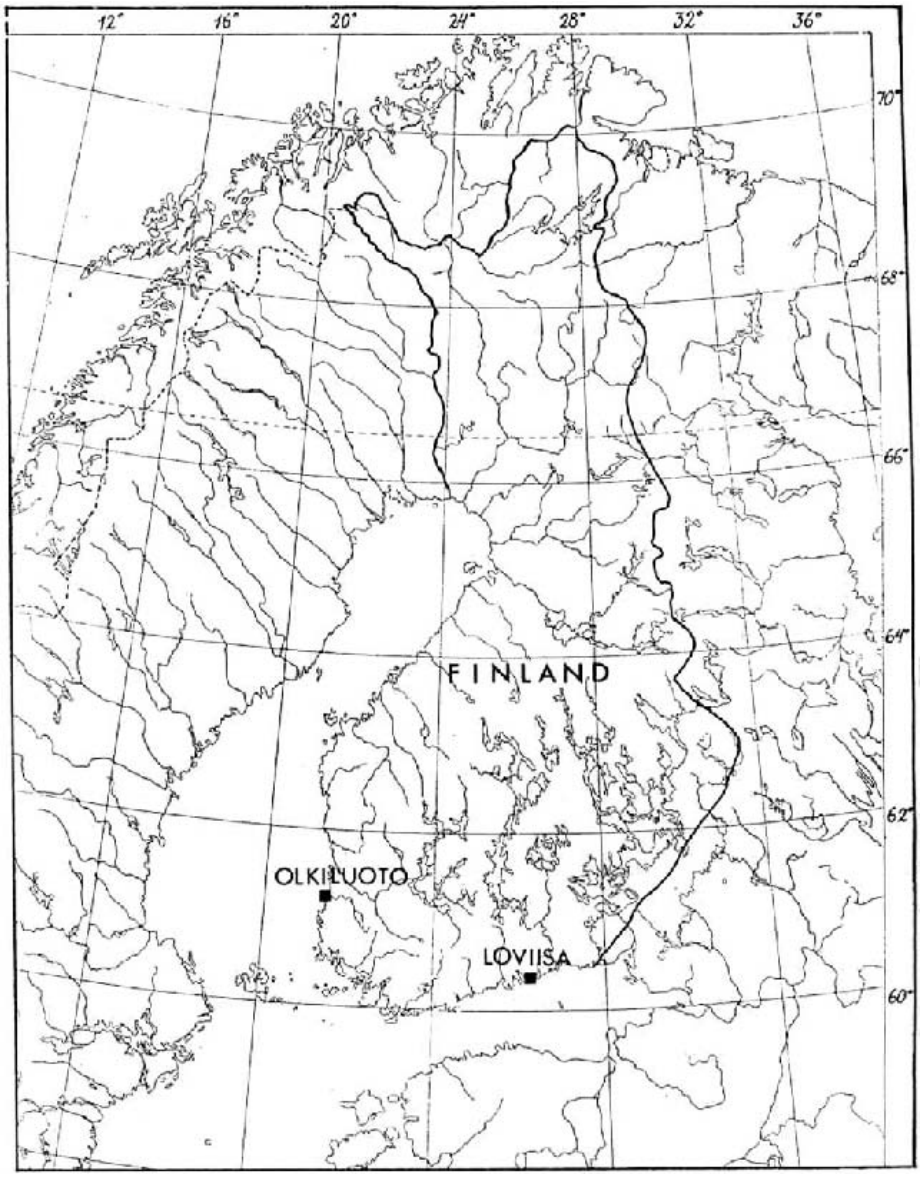

Figure 1. Location of Loviisa and Olkiluoto nuclear power stations.

Programmes for monitoring radionuclides in the environs of Finnish nuclear power plants in 2003 – 2007

Monitoring object	Type of measurements or samples and number of measurements or sampling stations	Measuring or sampling frequency	Analyses and frequencies
1. External radiation	a) Environmental dose rate meters at Loviisa (17) and Olkiluoto (14) at 0 - 10 km from the power plants	Continuous measurement and recording	Dose rate, min., max., mean, analogue plotter charts and/or digital hourly average values
	b) TLD dosemeter stations at Loviisa (10) and Olkiluoto (11) at 0 - 10 km from the power plants	Continuous measurement	Gamma dose, 4 times a year
	d) Supplementary gamma-spectrometric measurements	Once every two years	Gamma spectrum, once every two years
2. Airborne radioactive particles and iodine	a) Air sample collectors at Loviisa (4) and Olkiluoto (4), at 0 - 10 km from the power plants. The collectors can collect airborne radioactive particles and iodine (also iodine in the form of organic compounds)	Continuous collection. Filters replaced twice a month; at one station once a week during refuelling	Gamma emitters, twice a month (once a week)
	b) Supplementary monitoring performed with a portable air sample collector	Once a week during refuelling	Gamma emitters, once a week during refuelling
3. Deposition	Deposition collectors at Loviisa (4) and Olkiluoto (4), at 0 - 10 km from the power plants	Continuous collection	Gamma emitters, and ^{3}H, 4 - 12 times a year; ^{89}Sr and ^{90}Sr, 4 times a year

4. Soil	Soil samples are drawn from the area of assumed maximum deposition to determine the accumulation of long-lived radionuclides	Once every four years	Gamma emitters and ^{90}Sr, vertical distribution
5. Terrestrial wild plants, natural products and game	a) Reindeer lichen from 1 sampling site close to the power plants	Once a year	Gamma emitters, once a year
	b) Hair moss from 1 sampling site at Loviisa and Olkiluoto	Once a year	Gamma emitters, ^{89}Sr and ^{90}Sr, once a year
	c) Pine needles from 1 sampling site close to the power plants	Once a year after the refuelling	Gamma emitters, once a year
	d) Ferns from 1 sampling site close to the power plants	Once a year after the refuelling	Gamma emitters, once a year
	e) Wild berries and mushrooms grown in the vicinities of the power plants	Once every four years simultaneously with the soil sampling	Gamma emitters
6. Grazing grass	Collective sample representing farms producing milk, at 0 - 10 km from the power plants	Twice a growing season	Gamma emitters, twice a growing season
7. Milk	a) Sample representing farms producing milk, at 0-10 km from the power plants	Once a week	^{131}I and gamma emitters, once a month
	b) Sample representing the whole production of the local dairy (at Loviisa at 0 - 40 km distance from the power plant)	Once a week	Gamma emitters, once a month and ^{131}I if needed; ^{89}Sr, ^{90}Sr, 6 times a year
8. Garden produce	a) Lettuce grown at 0 - 10 km from the power plants	Twice a growing season	Gamma emitters, twice a year

	b) Apples grown at Loviisa and black currants grown at Olkiluoto, at 0 - 10 km from the power plants	Once a year	Gamma emitter, once a year
9. Grain	Rye and wheat samples, grown at less than 20 km from the power plants	Once a year	Gamma emitters, once a year; ^{89}Sr and ^{90}Sr, only from wheat
10. Meat	Beef samples from livestock raised at less than 40 km from the power plants. The samples represent the grazing season and the fodder season	Twice a year	Gamma emitters, twice a year
11. Drinking water	Samples of drinking water or raw water from the power plants and from the towns of Loviisa and Rauma	2−4 times a year	Gamma emitters and ^{3}H, 2−4 times a year; ^{89}Sr and ^{90}Sr, twice a year
12. Sea water	Samples from 5 stations in the surrounding sea areas of the power plants	2 - 4 times a year	Gamma emitters, ^{3}H, ^{89}Sr and ^{90}Sr, 2−4 times a year (Sr only from 2 stations)
13. Bottom sediments	a) Sinking matter collected by sediment traps at 4 stations in the surrounding sea areas of the power plants	Continuous collection	Gamma emitters, 4 times a year; ^{238}Pu and ^{239,240}Pu, once a year from 2 stations
	b) Sediment samples are taken from several stations in the surrounding sea areas	Once every four years	Gamma emitters, ^{90}Sr, ^{238}Pu and ^{239,240}Pu, vertical distribution
14. Aquatic indicator organisms	a) Periphyton collected by 1 m^2 sampling plates close to the cooling water outlets of the power plants	Continuous collection during the growing season (May-September)	Gamma emitters, 4 times a growing season

	b) Filamentous green algae from 1 sampling site at Loviisa and Olkiluoto	Once a year	Gamma emitters, once a year
	c) *Fucus vesiculosus* from 5 sampling sites at Loviisa and Olkiluoto	Twice a year	Gamma emitters twice a year; ^{89}Sr, ^{90}Sr, ^{238}Pu and ^{239,240}Pu, from 2 sites once a year
	d) Submerged seed plants *Myriophyllum spicatum* and *Potamogeton pectinatus* from 1 sampling site at Loviisa and Olkiluoto	Once a year	Gamma emitters, once a year
	e) Crustacean *Saduria entomon* at Loviisa and bivalve molluscs *Macoma baltica* + *Mytilus edulis* at Olkiluoto from one sampling site	Once a year	Gamma emitters, once a year; ^{89}Sr and ^{90}Sr, from *Saduria* and *Macoma* once a year
15. Wild fish	Pike, perch, roach and Baltic herring from two sampling areas at Loviisa and Olkiluoto	Twice a year	Gamma emitters, twice a year; ^{89}Sr and ^{90}Sr, one perch and Baltic herring sample once a year
16. Farmed fish	Young salmon and other fish from the fish farm of Loviisa	10 times a farming season	Gamma emitters, 10 times a year
17. Carbon-14	Samples of biota and foodstuffs from 2–3 sites in the vicinities of the power plants and from a reference area	Once a year	^{14}C, once a year
Radioactivity in man is measured annually on about 12 persons living 1–10 km from either power plant.			

The location of the sampling stations, sites and areas are shown in Figs 2–5. Soil and sediment surveys are carried out in both areas every 4 years. In 2002, the sediment survey was conducted at Loviisa and in 2003 at Olkiluoto. The soil survey (combined with that of mushrooms and wild berries) was arranged at Loviisa in 2004. The sampling points and areas used in these surveys are presented in Figs 6–8.

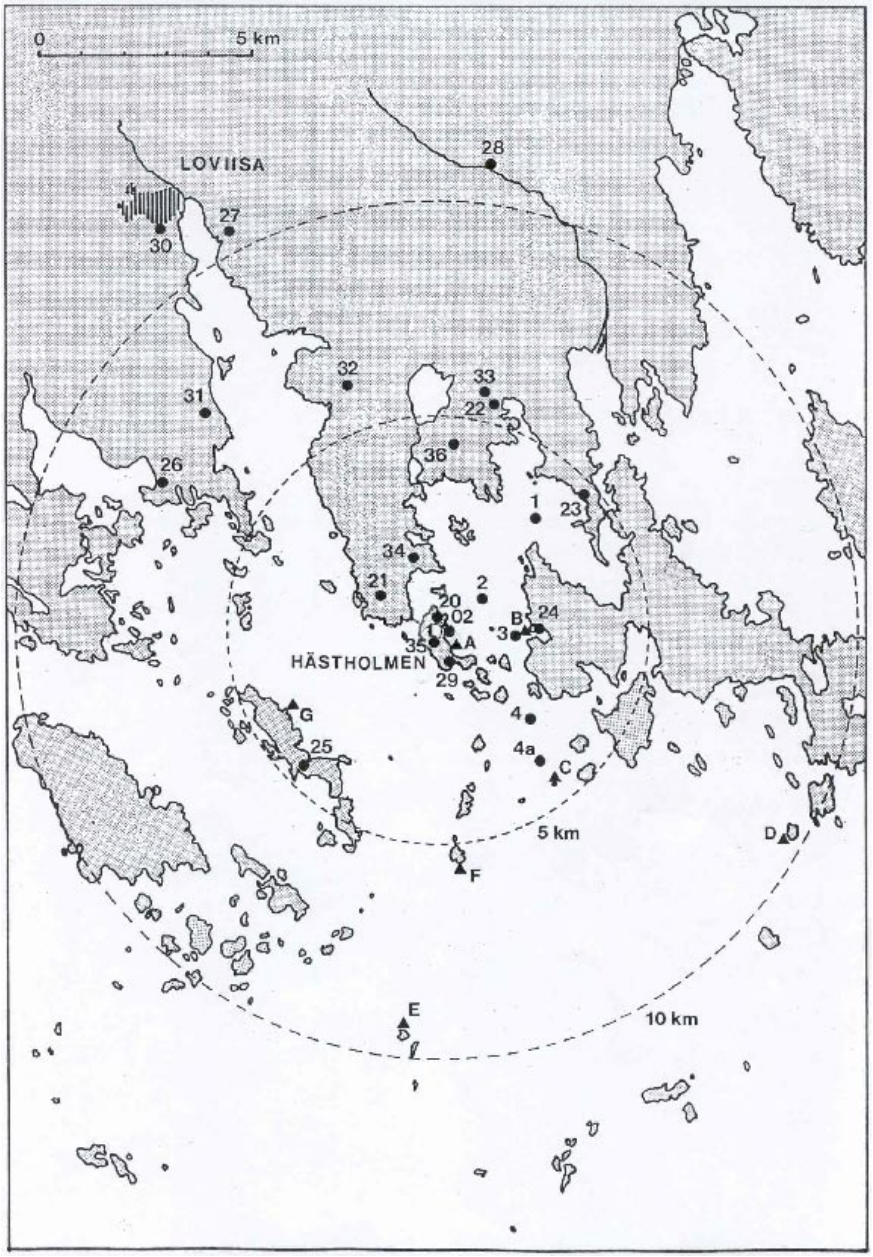

Figure 2. Sampling and measurement stations or sites in Loviisa: 20-29 TLD dosemeters (high pressure ionization chamber measurements until the end of 2002); 34 direct gamma-spectrometric measurements; 21,24, 27, 33 air sample collectors, 33 supplementary air sampling; 20, 24, 27, 33 deposition collectors; 20, 30 drinking water; 22 grazing grass; 33 lettuce; 31 apple; 29 ferns; 32 hair moss; 35 reindeer lichen and pine needles; 02, 1, 2, 4, R1 seawater; 1, 3, 4a, R1 sinking matter; A, B, C, D, E, F, G aquatic indicator organisms. Reference station R1 is located off the map, about 14 km west of the power plant.

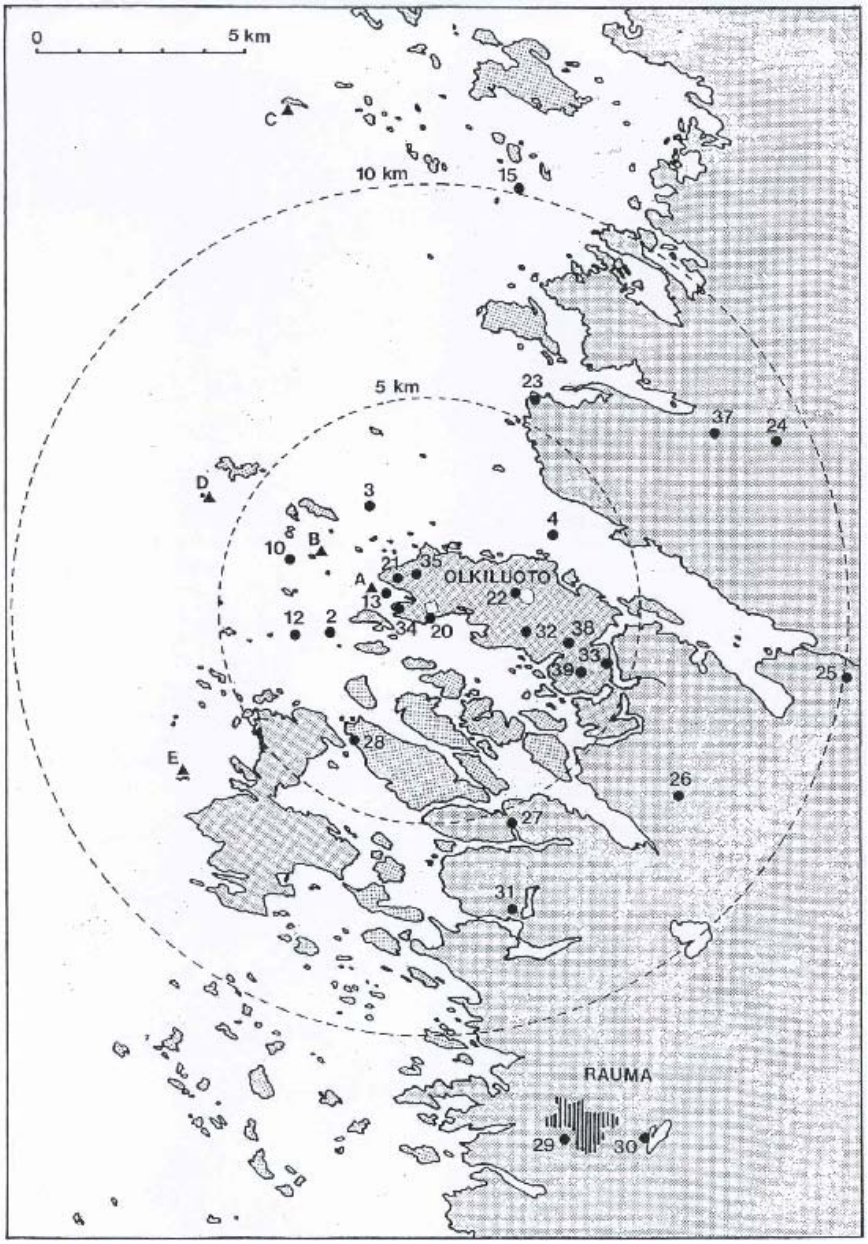

Figure 3. Sampling and measurement stations or sites in Olkiluoto:20-29, 34 TLD dosemeters (high pressure ionization chamber measurements until the end of 2002); 38 direct gamma-spectrometric measurements; 22, 26, 31, 37 air sample collectors; 33 supplementary air sampling; 21, 26, 31, 37 deposition collectors; 22, 30 drinking water; 26 lettuce in 2002; 33 lettuce in 2003 and 2004; 26 black currant; 34 ferns in 2003; 39 ferns in 2004; 32 hair moss; 21 reindeer lichen and pine needles; 35 dumping ground for exempted waste; 2, 3, 10, 13, 15 seawater; 3, 4, 12, 15 sinking matter; A, B, C, D, E aquatic indicator organisms.

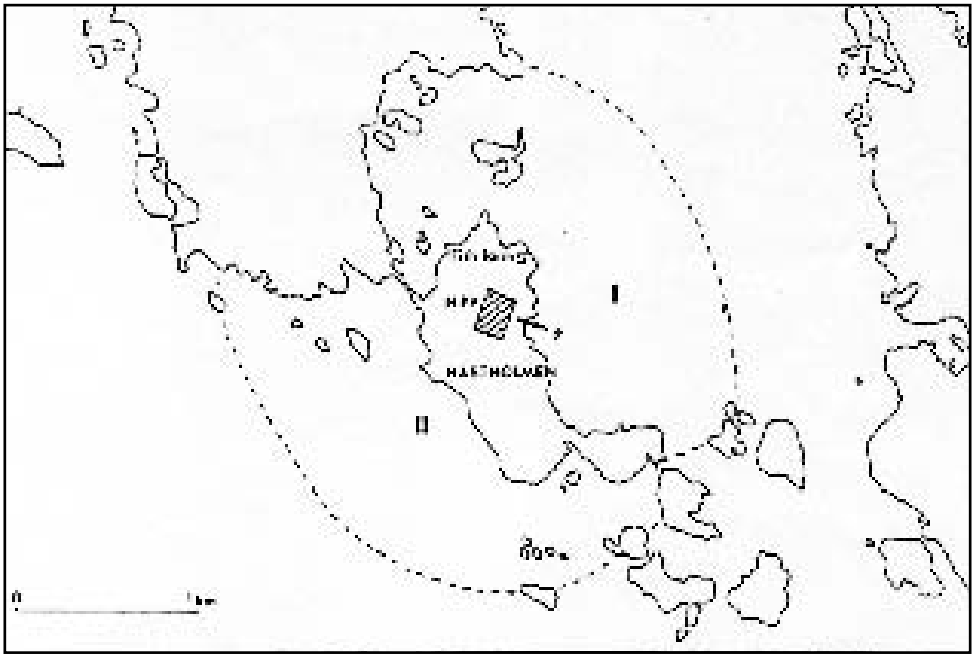

Figure 4. Fishing areas in Loviisa.

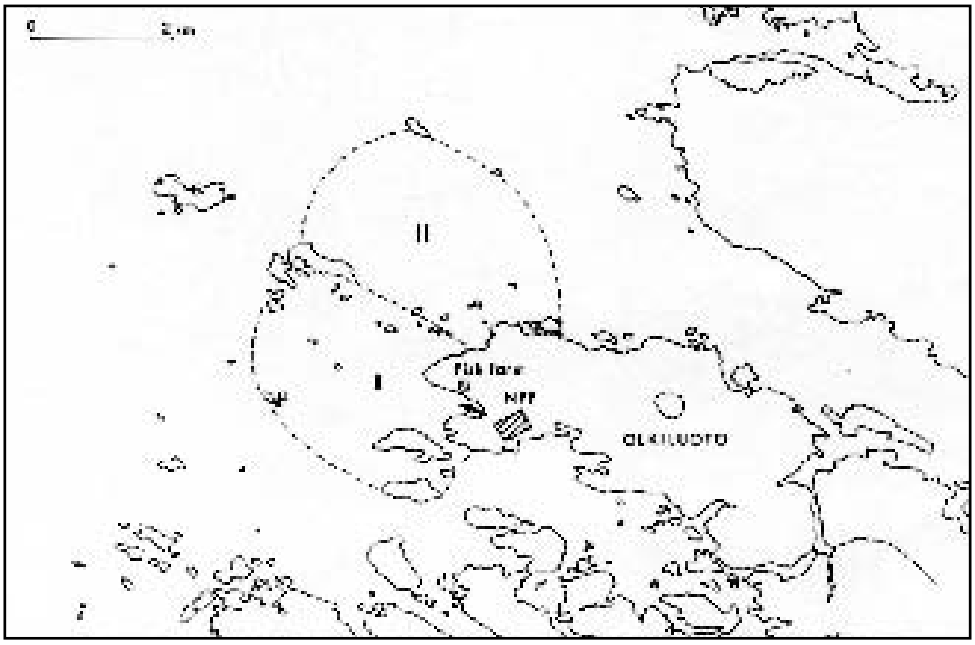

Figure 5. Fishing areas in Olkiluoto.

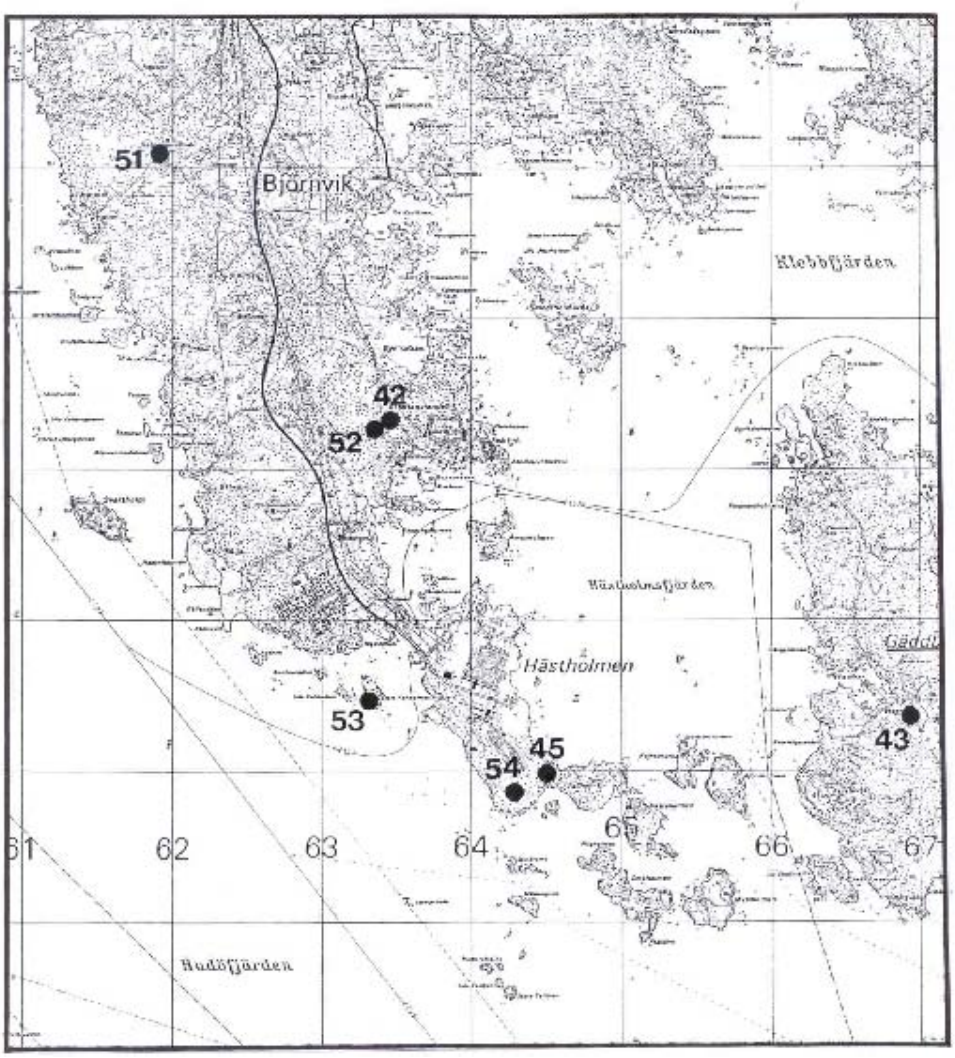

Figure 6. Sampling points and areas in the 2004 survey of soil, mushrooms and wild berries in Loviisa.

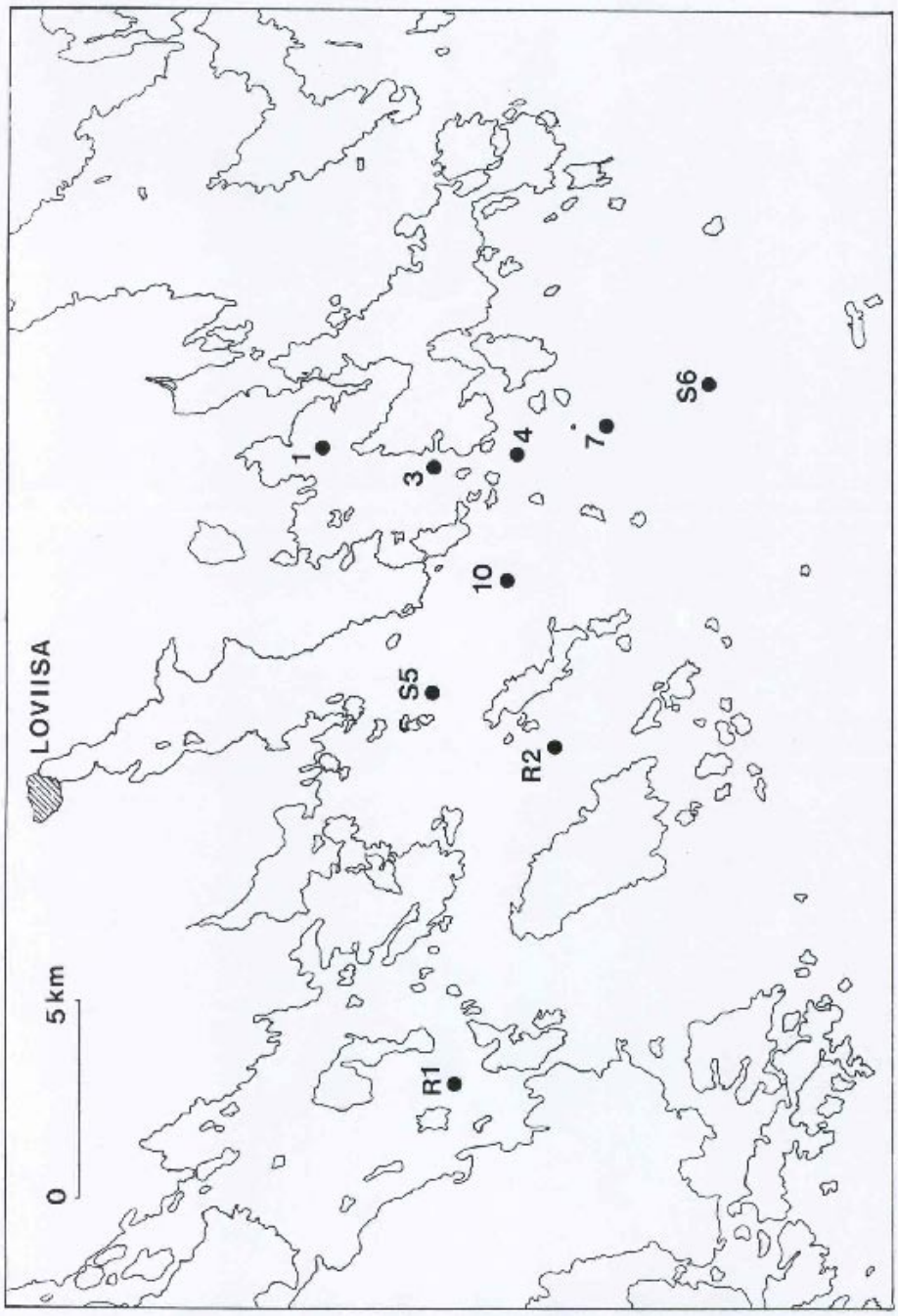

Figure 7. Sampling stations in the 2002 sediment survey in Loviisa.

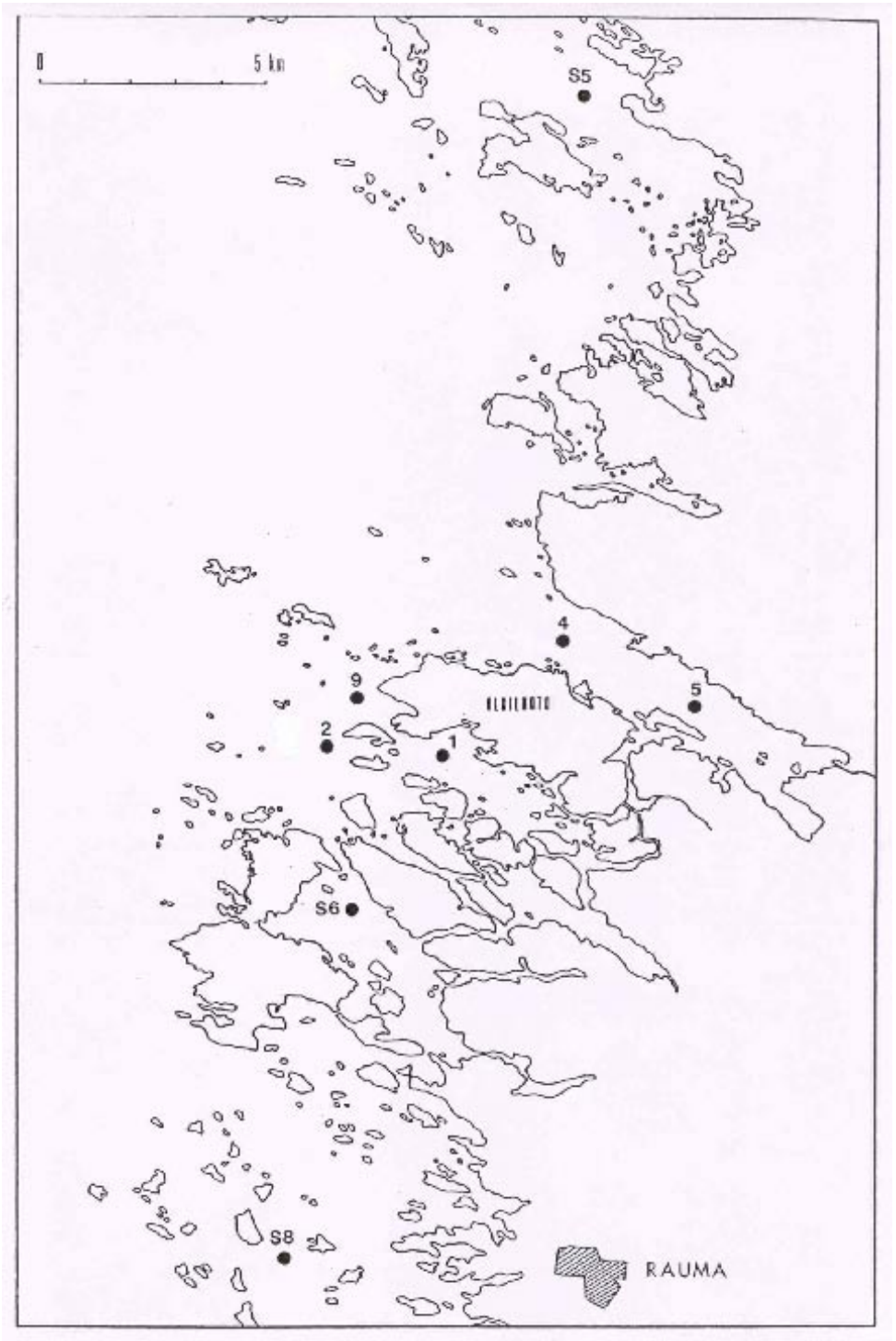

Figure 8. Sampling stations in the 2003 sediment survey in Olkiluoto.

4 Material and methods

The sampling and analysis methods used in the environmental monitoring at Loviisa and Olkiluoto have been briefly described in our previous Annual Reports (STUK-A67, STUK-A79, STUK-A92, STUK-A102, STUK-A121, STUK-A157, STUK-A192, STUK-A205, STUK-A218), but a more comprehensive compilation of the methods is given in this chapter. Detailed descriptions of the sampling, pre-treatment and analysis methods are available in Finnish in the STUK/TKO Handbooks 3.1.2-3.1.6.

The development of an uniform and modern quality system for the whole of STUK began in 1997 and the regulation was completed in 1999. The quality system is based on Total Quality Management (TQM) according to ISO standard 9004 (ISO 9004, 2000). A major step in continuous improvement was reached in 1999 when accreditation was awarded by FINAS (the Finnish Accreditation Service). Accredited fields of testing include tests of radiation safety (i.e., gamma-spectrometric analyses, radiochemical analyses of tritium, radioactive strontium and transuranic elements in the environmental and foodstuff samples) and related environmental sampling.

In order to determine the quality of the sampling and analysis methods, our laboratory has participated in several intercomparisons in recent years, conducted by various organizations, e.g., the International Atomic Energy Agency and its Marine Environment Laboratory, Nordic Nuclear Safety Research, Helsinki Commission, etc. Our results have been consistent with the reference values.

The overall uncertainty of the analysis results includes statistical, calibration and analytical uncertainties expressed as relative error (%) in 1 σ confidence level, but not the uncertainty due to sampling.

Deviations and changes to permanent programmes

During the reporting period, the following deviations from the permanent monitoring programmes or changes to the earlier sampling procedures were registered:

In 2003, ferns *(Polypodium vulgare)* were taken as new terrestrial indicator organisms to the monitoring programmes of Loviisa and Olkiluoto. Samples of ferns are taken once a year from one sampling site in both areas.

In 2003, the sampling areas D and E in Loviisa for *Fucus vesiculosus* were changed to new sampling areas F and G situated closer to the power plant (Fig. 2).

During the reporting period, there were problems to catch sufficient amounts of certain fish samples required for the analysis. In Loviisa, a sufficient

amount of roach was not obtained from either sampling area in 2002 and from Area I in May 2003. Baltic herring was not obtained from either area in September 2003. In Olkiluoto, roach was not obtained from Area II in September 2003 and from Area I in September 2004. Substitute samples for roach were obtained from bream or ide (Tables XXIII and XXIV).

The sediment trap at Station Olkiluoto 4 was not found after the winter collection period 2001-2002 and a new trap was installed at the Station on April 19, 2002.

4.1 Sampling of air

Four high-volume air sample collectors (Fig. 9) are located adjacent to both of the power plants. A schematic drawing of the sampler is given in STUK-A121, Fig. 8. Air samples are collected simultaneously on Whatman glass-fibre filters (GF/A) and activated carbon-loaded glass-fibre filters (Whatman 72) superimposed on each other. The filter area is 0.043 m^2 and the airflow rate is about 60 $m^3\ h^{-1}$, corresponding to a face velocity of 0.4 m s^{-1}. The flow rate is measured by a rotameter. The filters are usually changed twice a month, but during maintenance and refuelling outages of the power plants, filters from the sampler closest to the power plant are changed weekly.

After sampling, the filters are mailed to STUK where they are compressed into disc form (diameter 42 mm, height 3 mm (fibreglass filter) or 10 mm (carbon-loaded filter)) to provide an efficient counting geometry for gamma-spectrometry.

During the maintenance and refuelling outages of the power plants, air monitoring is intensified by a supplementary sampler (Fig. 10) placed near the power plants, in the path of the prevailing wind. A schematic drawing and technical specifications of the sampler are given in STUK-A102, pp. 15-16. Air samples are collected on a glass-fibre filter and in a cartridge filled with activated carbon.

Air is drawn through a circular Whatman GF/A glass-fibre filter (area of 0.0573 m^2) at a velocity of about 140 $m^3\ h^{-1}$, which is measured with a pressure difference meter. Owing to the pressure difference, some of the air passed through the filter also flows through the cartridge filled with 563 cm^3 of activated carbon. Airflow through the cartridge depends on the thickness of the carbon layer, which is selected to ensure that the maximal flow is 12 $m^3\ h^{-1}$ when potassium-iodine impregnated carbon of Sutcliffe Speakman type 207B-1.5KI8-12 is used. The residence time in the carbon bed is then 0.17 s, which is sufficient even for the adsorption of methyl iodine.

Figure 9. Stationary high-volume air samplers located in Loviisa and Olkiluoto.

Figure 10. The supplementary portable high-volume air sampler.

The airflow rate through the carbon is measured, and it can be reduced and totally shut off with a valve. The minimum detectable ^{137}Cs concentration in air is about 1 µBq m^{-3} when the sampling time is 3-4 days and the compressed filter is measured overnight with an efficient semiconductor detector. Shorter sampling and measuring times – 8 h and 1.5 h, respectively – detect a ^{137}Cs concentration of 0.2 mBq m^{-3}.

4.2 Sampling of deposition

Six different types of collectors for dry and wet deposition are used in the environmental monitoring programmes at Loviisa and Olkiluoto.

Large-area collectors are located at Station 20 in Loviisa and at Station 21 in Olkiluoto. Schematic drawings of the large-area collectors with dimensions are given in STUK-A121, Fig. 9. The collectors consist of a round or square sampling funnel (1 m^2) with a sample vessel underneath (Figs. 11 and 12).

Electric warming is used to prevent freezing and for melting the snow deposited in the collector in winter. The sample vessels are changed when full, and always at the end of each month. Before the monthly changing of the sample vessel, the entire area of the sampling funnel is washed carefully to ensure that all dry deposition is included in the sample. The washing fluids consist of diluted nitric acid and distilled water, and are combined with the monthly samples.

The large-area collectors are primarily used for qualitative analyses of deposited material. Because of the lack of a proper windshield, it is possible that dry material is lost from the large and shallow collector funnels during a strong wind, or that water splashes out during a heavy rain.

The “Ritva” collectors are made of stainless steel and are used as basic collectors of deposition at Stations Loviisa 24, 27 and 33 as well as at Stations Olkiluoto 26, 31 and 37 (Fig. 13). The collectors are electrically warmed in winter. A schematic drawing of the collector is given in STUK-A205, Fig 8. The total height of the collector is 135 cm; the diameter of the sampling funnel is 300 mm (area 0.07 m^2) and the height is 300 mm.

The sample vessels are changed at the end of each month. Before the monthly changing of the sample vessel, the sampling funnel is washed carefully to ensure that all dry deposition is included in the sample. The washing fluids consist of diluted nitric acid and distilled water, and are combined with the monthly samples.

Rainwater samples for tritium analysis are collected through the use of three types of collectors. The collector located at Sampling Station Loviisa 33 is shown in Fig. 14, and the type of collectors located at Stations Loviisa 20, Olkiluoto 21 and 26 in Fig. 15. The collectors are equipped with proper

Figure 11. The large area collector for deposition at Loviisa.

Figure 12. The large-area collector for deposition at Olkiluoto.

Figure 13. The "Ritva" collector for deposition. This collector is warmed in winter.

Figure 14. The collector for tritium in rainwater at Loviisa 33.

Figure 15. The collector for tritium in rainwater at Olkiluoto 21.

windshields made of sheet metal. Schematic drawings and the dimensions of the collectors are provided in STUK-A121, Figs. 10a and 10b.

The diameter of the sample vessels used in the collector at Loviisa 33 is 160 mm (area 0.02 m^2), but 250 mm (0.05 m^2) in the collectors located at Loviisa 20, Olkiluoto 21 and 26. The vessels used at Olkiluoto differ in some details from those used at Loviisa 20. At Loviisa, the sample vessels are of stainless steel. The upper part of the vessel is cylindrical with a funnel-formed bottom. The lower part is a removable water back attached to the upper part with hooks. At Olkiluoto, the sample vessel is made of brass, and the lower part is fixed to the upper part and equipped with a spout for pouring the sample into a container bottle.

The sample vessels are emptied in accordance with the amount of precipitation, but in winter if it snows the sample vessels are changed daily, and ice and snow are melted at room temperature before emptying the water into a container bottle. At the end of each month (before the next collection period), the vessels are washed. The sampling period for tritium is one month. The samples collected at Stations Loviisa 20 and Olkiluoto 21 are analysed monthly, but at Stations Loviisa 33 and Olkiluoto 26, the monthly samples are bulked quarterly for analysis.

4.3 Sampling of soil

In the 2004 soil survey at Loviisa, the samples were taken with a TACIT golf-hole drill (Fig. 16). The drill consists of a stainless steel frame with lifting handles and a bottom plate, which is pushed against the ground. Two removable halves of a stainless-steel tube are fitted onto the frame to compose jointly a complete sampling tube with an inner diameter of 105 mm (area 86.59 cm^2). The total length of the tube is 36 cm, but the maximum sampling depth with the TACIT drill is only 22 cm. The halves of the tube are struck synchronously with a rubber-hammer into the soil, the device is twisted half-round by the lifting handles and it is lifted carefully to lie on the ground. The upper half of the tube is pulled out and the soil prop is sectioned into slices using a stainless steel disc.

Three parallel cores were taken at random from an area of 10 x 10 m, and the parallel slices were combined for analysis. The sampling passed off without a hitch and the samples were of good quality.

In the 2004 soil survey at Loviisa, two of the three sampling points (42 and 43) were the same as in 1988, 1992, 1996 and 2000, whereas Sampling Site 45 was new (Fig. 6). The Sampling Sites 42 and 43 were small patches of old open fields or meadows with high grass (the ground has lain fallow for many years). In general, the type of soil was similar to that in 2000 at both sampling sites. There was a thick layer of mould and clay with roots of grass at the surface, and

Figure 16. A TACIT golf-hole drill.

underneath there was clay, which became more rigid as the depth increased. The Sampling Site 45 was a small open place in the forest. Below a thin (4 cm) layer of litter, peat and organic matter, the soil turned to mould mixed with sand and roots and then to clay at a depth of 10 cm.

4.4 Sampling of terrestrial wild plants and natural products

Samples of reindeer lichen are taken by gathering the thalli from a marked area of a uniform lichen matt growing on the rock (Fig. 17). Other plants, needles and residues of soil are removed carefully from the sample before putting the lichens into a plastic bag. The minimum sample size is 0.8 kg fresh weight.

Samples of hair moss are taken by cutting the stalks with scissors from a moss matt so that only the green parts are taken for the sample. Other plants, needles and residues of soil are removed carefully from the sample before putting into a plastic bag. The minimum sample size is 0.8 kg fresh weight or 1.5 kg when Sr is also analysed.

Samples of pine needles are taken by breaking 2-3 branches of middle-sized pines growing in the sampling site. The branches are put into a plastic sack and transported to the laboratory. In the laboratory, the branches are dried overnight at 105 ºC and the dry needles are taken into the sample for analysis. The minimum sample size is 150 g dry weight.

Fern samples are taken by cutting the stalks with scissors near the base. Residues of soil are removed carefully before putting the stalks into a plastic bag. The minimum sample size is 1.2 kg fresh weight.

Mushrooms and berries are picked as for normal household use. Both the caps and stems of mushrooms are taken into the sample. Various species of mushrooms are separated from each other and litter is removed before putting the sample into a plastic bag. The attempt is to gather the samples from an area which is as small and uniform as possible. The minimum sample size is 0.8 kg fresh weight for mushrooms and 1.0 kg for berries.

Figure 17. Sampling of reindeer lichen.

Figure 18. Sampling of grazing grass.

4.5 Sampling of grazing grass

Grazing grass is taken from the pasture by cutting the grass with a scythe or pruning shears (Fig. 18) and put into a plastic sack. Care should be taken that no litter or residues of soil are included. The minimum sample size is 1.0 kg fresh weight.

4.6 Sampling of milk, grain and meat

Milk samples are taken by the personnel of local dairies operating in the regions of the power plants. Cans containing concerning agent are provided to the dairies in advance by STUK. The samples from the farms producing milk at a distance of 0–10 km from the power plants are taken from the tanks of the farmers by the milk truck driver. The samples representing the whole production of the local dairy are taken from collection tanks in the dairy according to standard methods used in sampling of foodstuffs. The quantities of the samples are 6 litres from the 0-10 km area and 4 litres from the entire production of the dairy. The samples are sent immediately as chilled express transportation to STUK.

Grain samples are taken in local grain stores by certified sampling persons with standard methods used in sampling of foodstuffs. Requests of samples with

instructions are sent from STUK to the grain stores once a year. The samples are taken with automatic sampling equipments of the grain stores, 1 kg per farm so that the minimum total amount of the sample is 2 kg.

Meat samples are taken in a central slaughterhouse by the veterinarian on duty according to the requests and instructions sent from STUK twice a year. The samples are taken from cows of varied ages in the same ratio as they are for slaughter. 100-150 g of low-fat meat (diaphragm or neck muscle) from 10-20 animals are taken to obtain the minimum size of the sample, 1.5 kg. The samples are immediately deep-frozen and sent to STUK.

4.7 Sampling of garden products

Lettuce samples are taken from a chosen garden by cutting the plants with scissors from the base (Fig. 19) so that mould is not derived in the sample. The minimum sample size is 1.5 kg fresh weight.

Apple samples are taken from a chosen garden as for normal household use. The minimum sample size is 1.5 kg fresh weight.

Black currant samples are taken from a chosen garden as for normal household use; only the berries (without stems) are collected. The minimum sample size is 1.5 kg fresh weight.

Figure 19. Sampling of lettuce.

4.8 Sampling of drinking water

Samples of drinking water are taken directly from the network of water pipes or from raw water reservoirs. In Loviisa, both the samples from the town of Loviisa and from the power plant are taken directly from tap water. Before taking the sample, 1-2 litres of water are flown into the sample kegs for thorough rinsing, and the water is thrown away. Then the sample of 2 x 15 litres is taken. In Olkiluoto, the samples of drinking water are taken principally from the raw water reservoirs of the town of Rauma and the power plant. The samples are taken with a pail from the surface of the water and then the water is poured through a big funnel into the sample kegs. The kegs are rinsed before sampling as before.

4.9 Sampling of natural waters

In the monitoring programmes of the power plants, water samples are also taken from surface seawater in Loviisa and Olkiluoto (2 x 15 litres), and from a ditch edging a dumping ground for exempted waste in Olkiluoto (20 litres).

The samples from the ditch and those from seawater for analyses of gamma-emitters and strontium are taken with a pail from the surface water and the water is poured through a big funnel into the sample kegs (Fig. 20). Care should be taken that no rubbish from the surface of the water is derived in the sample. Seawater samples for tritium analyses (1 litre) are taken from 1 m depth with a Limnos water sampler (Fig. 21). The sample kegs and bottles are rinsed with local water before taking the samples.

4.10 Sampling of sinking matter

Sinking particulate matter is collected using buoy-carried sediment traps anchored 1 metre above the sediment surface. The collection was initiated at Loviisa in 1974 and at Olkiluoto in 1977. Over the course of time the sampling method has gone through several changes.

At the beginning, the collection was done with single funnel-shaped collection vessels supplemented with changeable sample tubes (volume 50 ml), and attached in pairs at different depths to an anchor rope. This procedure was followed at Loviisa in 1974–1979 and at Olkiluoto in 1977–1980. In the next phase, the sediment traps consisted of four parallel collection vessels of the same type as before (STUK-A102, Fig. 10) fixed quadrically to a plastic core, and anchored 1 metre above the sediment surface. The upper diameter of the collection funnels was 92 mm (collection area of the trap 4 x 66.5 cm^{-2}) at Loviisa and 85 mm (4 x 56.8 cm^{-2}) at Olkiluoto. These kinds of traps were used at Loviisa in 1980–1988 and at Olkiluoto in 1981–1992.

Figure 20. Water sampling with pail and funnel.

Figure 21. Water sampling with Limnos sampler.

In 1989 a new type of sediment trap was taken into use at Loviisa. It consisted of four cylindrical collection vessels made of plexiglass and mounted quadrically in a plastic frame (STUK-A102, Fig. 10). The inside diameter of the cylinders was 92 mm (collection area 4 x 66.5 cm^{-2}) and the height was 300 mm. These traps were used at Loviisa in 1989-2000.

The currently used type of sediment traps consists of three cylinder-formed collection vessels made of plexiglass and mounted in a triangle-shaped frame (Fig. 22 and STUK-A157, Fig. 8). The inside diameter of the cylinders is 92 mm (collection area 3 x 66.5 cm^{-2}) and the height 500 mm; the height/diameter ratio (H/D) thus being 5.43.

The collection vessels (= tubes) are changed four times a year: at the beginning of May, the end of July, the end of August and the beginning of November. The trap is then raised to the surface, the tubes are detached, and clean tubes are set in place. Next the trap is carefully put down again without disturbing the light surface layer of the sediment. The boat is anchored during this work.

The closed collection tubes are subsequently moved in an upright position to the field laboratory, where the clear water is siphoned out from the tubes and the settled material is rinsed with a drop of local seawater from the three parallel tubes into a joint transport vessel, in which the samples are transported to STUK. At STUK, the samples are allowed to stand overnight, and the rest of the clear water is carefully siphoned away. An approximate fresh weight is determined and the samples are deep-frozen in drying bowls. The frozen samples are dried for two days in a freeze-drier and then homogenized and analysed gamma-spectrometrically.

Fig. 23 illustrates the different ways the traps are installed during the open water and winter periods. In winter, a big sign buoy is anchored below the ice at a depth of 4-5 metres. As a result, the drifting of ice does not remove the trap from its permanent position in the spring. During the open water period, the traps are marked with flag buoys.

4.11 Sampling of sediments

Sediment surveys are carried out in both areas every four years. In 2002, the sediment survey was conducted in Loviisa and in 2003 in Olkiluoto (p. 17). At Loviisa, the ordinary sampling stations 1, 3, 4, 7, 10 and R1 have been used in almost all sediment surveys carried out before. Station R2 was used earlier in the 1994 sediment survey and Station S5 in 1998. Station S6 was now sampled for the first time (Fig. 7). At Olkiluoto, the ordinary sampling stations 1, 2, 4 and 9 have also been used in almost all sediment surveys carried out before.

Figure 22. A triangle-shaped sediment trap on deck.

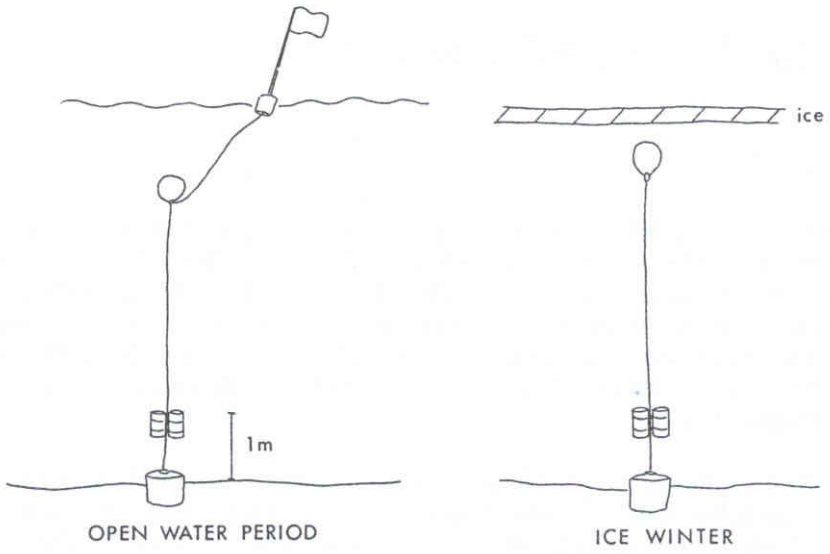

Figure 23. Installation of the sediment trap during the open water and winter periods.

Stations S5, S6 and S8 were included in the sampling programme in 1995 and Station 5 in 1999 (Fig. 8).

Since 1975, the research boat Detektori of STUK has been used in the sediment samplings at Loviisa and Olkiluoto. It is a stable, 9-m-long research boat equipped with an electric winch, hydraulic boom-crane, echo sounder and GPS. Since 1994, the samples have been taken by a Gemini Twin Corer, which is a gravity corer consisting of two parallel coring tubes in a stainless steel body and two lateral rudder closers (Fig. 24). The inner diameter of the coring tubes (Plexiglas) is 80 mm. The total length of the corer is 132 cm and that of the coring tubes 79 cm. The weight of the corer is 33 kg + 2 or 4 additional weights, 7.4 or 10.2 kg each. Before 1994, the ordinary sediment samples were taken by a STUK corer described in Ilus et al., 2000.

The sectioning apparatus of the Gemini Twin Corer consists of a screw-operated extruder piston and a wheel for adjusting the extrusion, a Plexiglas slicing base and slicing ring with centimetre scaling (Figs. 25 and 26). The equipment and the results of its intercomparison tests are presented in Ilus et al., 2000.

The 2002 sediment survey at Loviisa was carried out under ideal weather conditions and the samplings succeeded smoothly. The Gemini corer was used with the additional weights of 2 x 7.4 kg. At Stations R2, S5 and S6, only one core was sectioned and two parallel cores were sectioned at all the other stations. In each case, the first core was sectioned in 1-cm intervals to a depth of 30 cm and the second to a depth of 14-15 cm. The 1-cm-slices were analysed separately for gamma-emitters. Subsequently, the 1-cm slices of the uppermost 10 or 15 centimetres from the second cores were combined into 5 cm bulk samples for Sr, Pu and second gamma analyses (Table XXVIII).

At Stations Loviisa 3, 4, 7, 10, S5 and S6, the type of sediment was black or dark-grey, watery sulphidic mud. The mud was most fluid at the Stations 10 and 3. Although there were at least traces of a thin oxidized surface layer at each station, the sediment smelled of hydrogen sulphide, and usually there was a growth of sulphur bacteria at the surface. Gas hollows were abundant in the sediment cores. At Station R2, the sediment was soft mud-clay with a relatively thin (1.5 cm) oxidized surface layer. At the Stations 1 and R1, the sediment consisted of soft sulphidic clay with a thick brown oxic mud layer at the surface. Larvae of *Chironomus plumosus* were abundantly found down to a depth of 16 cm at Station R1 and to a depth of 22 cm at Station 1, and holes made by them were found to a depth of 30 cm at Station 1.

Good weather also favoured the sediment survey at Olkiluoto in 2003, enabling successful samplings. Due to the more clayey sediments at Olkiluoto, the Gemini corer was used with the heavier additional weights (2 x 10.2 kg).

Figure 24. The Gemini Twin Corer.

Figure 25. Sectioning apparatus of Gemini Twin Corer.

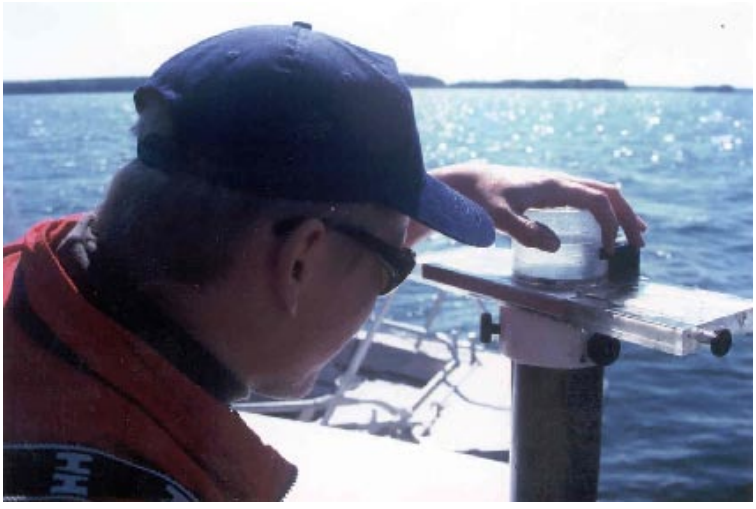

Figure 26. Slicing of a sediment sample with the sectioning apparatus of Gemini Twin corer.

One core was taken at each station and sectioned in 1-cm intervals to a depth of 30 cm. The 1-cm slices were freeze-dried separately, but then combined and homogenized to 5-cm thick bulk samples for analyses. An extra core was taken at Station 2 and the 1-cm slices were analysed separately to a depth of 30 cm (Table XXXI).

At Stations Olkiluoto 2 and 9, the type of sediment was relatively soft sulphidic clay with a relatively thin layer (1-2 cm) of oxidized mud at the surface and a more solid layer of sulphidic clay beneath. At Stations S5, S6 and S8, the sediment was a little more solid sulphidic clay with a 2-cm thick layer of soft mud at the surface. At Stations 1 and 4, the seabed consisted of sulphidic clay, and at Station 5 of grey clay mixed with sand. Oxic conditions prevailed in the surface sediments at each station in Olkiluoto.

4.12 Sampling of aquatic indicator organisms

Periphyton was taken to the monitoring programmes of both power plants from the beginning of 1998. The collection periods are from the beginning of May to the end of June, and after that one month's periods until the end of September (altogether 4 periods a year). Periphyton is collected with large (the total collection area 1 m^2) collection plates (STUK-A205, Fig. 9). The large collection area is necessary to obtain a sufficient amount of periphyton for analysis. The plates are installed with buoys and anchors at a depth of 0.5-1 m close to the cooling water outlets of the power plants. Periphyton is scraped out from the plate into a large collection vessel 4 times a growing season and then transferred to a plastic box in which the chilled samples are transported to STUK. At STUK, the clear water above the sample is siphoned away, the sample is evaporated to dry in 105 ºC and it is homogenized before analysis.

In 1998–2003, periphyton was collected with collection plates made of plywood (Fig. 27). Both sides (0.5 m^2 each) of the plate were used for collection. Since 2004, two parallel collection plates (collection area 4 x 0.25 m^2) made of Plexiglass have been used both in Loviisa and Olkiluoto (Fig. 28).

The samples of filamentous green algae are taken by snorkeling (Fig. 29) and those of the bladder-wrack (*Fucus vesiculosus*), submerged seed plants (*Myriophyllum spicatum and Potamogeton pectinatus*) and the common mussel (*Mytilus edulis*) are taken by means of SCUBA diving (Fig. 30). The samples of the relict crustacean (*Saduria entomon*) are caught by means of bait nets (Fig. 31). The samples of the bivalve mussel *Macoma baltica* are taken with an Ekman-Birge grab (Fig. 32) and a benthos sieve. The minimum sample size is 0.5 kg fresh weight for filamentous green algae, 1.8 kg for bladder-wrack and submerged seed plants and 200 g for *Mytilus*, *Saduria* and *Macoma*.

Figure 27. The periphyton plate used in 1998–2003.

Figure 28. The periphyton plate used since May 2004.

Figure 29. Sampling of filamentous green algae.

Figure 30. Sampling of bladder-wrack.

Figure 31. A bait net for the sampling of *Saduria entomon*.

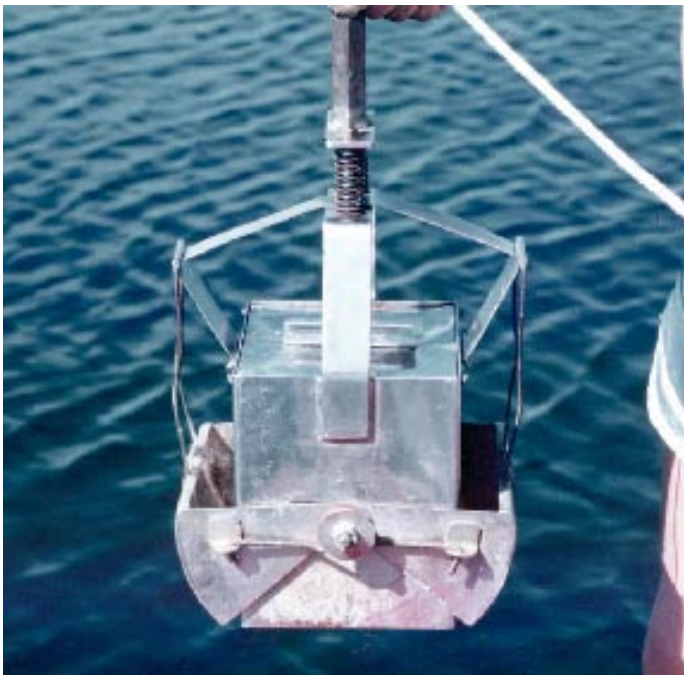

Figure 32. An Ekman-Birge grab.

4.13 Sampling of fish

Samples of wild fish (pike, perch, roach and Baltic herring) are taken with nets of different mesh sizes (Fig. 33). The target sample size is 5 kg, and the minimum 2 kg fresh weight of uncleaned fish. Pikes are scaled and filleted for analysis, but only the heads and entrails are removed from perch, roach (also scaled) and Baltic herring. After cleaning, the samples are frozen and transported to STUK.

4.14 Pre-treatment of samples

Due to low activity levels, the collected samples must be quite large. Only air filter samples are measured as such after pressing them into the measuring geometry. Other samples are concentrated in the laboratory with various pre-treatment methods in order to be suitable for analysis.

Sea water samples are evaporated to smaller volumes and then measured with gamma-spectrometry in Marinelli beakers and afterwards introduced to radiochemical analyses if needed.

Deposition, milk and drinking water samples are evaporated to dryness, and the residue is ashed in 450 °C. After the gamma measurement, the samples are introduced to radiochemical analyses if needed.

Figure 33. Disentangling of fish nets.

Soil samples are dried overnight in 105 °C and then sieved with a 2-mm sieve and homogenized. Sediment and sinking matter samples are freeze-dried and then homogenized with a mortar. The samples or sub-samples are first measured with gamma-spectrometry.

Terrestrial wild plants, natural products, grazing grass, grain, meat, garden products and aquatic indicator organisms are dried overnight in 105 °C and then homogenized with blenders before gamma-spectrometric measurements. Fish samples are dried overnight in 105 °C and then ashed in 450 °C before the measurement.

4.15 Gamma-spectrometric sample measurements

There are altogether 11 low-background high-resolution spectrometer systems for gamma-spectrometric sample measurements in the laboratory. The detectors are placed in cylindrical background shields designed at STUK. 12 – 14 cm thick lead walls are lined inside with cadmium (1 mm) and copper (0.5 mm) to reduce the effect of x-rays. The background count rate is on average 1.4 counts s^{-1}. Long (5000 – 7000 min) background measurements are performed 2 – 3 times per year. Shorter background checks are occasionally performed.

The relative efficiencies of the hyperpure germanium (HPGe) detectors are between 20% and 87%. Energy resolution is between 1.7 and 2.0 keV at 1.33 MeV.

All spectrometers use the energy range of 20 – 2700 keV, and the corresponding conversion gains of multichannel analysers are set to 8192 channels.

Calibrated measuring geometries are two simple cylindrical containers, diameters 42 mm and 74 mm, correspondingly, and a 0.5 litre Marinelli beaker. The filling height of the simple cylindrical beakers is flexible, the maximum of 25 mm corresponding to a volume of 35 ml for a smaller beaker and 105 ml for a larger beaker. To obtain maximum counting efficiency, all the beakers are measured on top of the detector end-cap.

The efficiency calibration of the detectors has been carried out by using separate single-line nuclide standards in water solution or multigamma standard solutions. The following nuclides have been used: ^{40}K, ^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{137}Cs, ^{139}Ce, ^{203}Hg, ^{210}Pb and ^{241}Am. Also, a semi-empirical efficiency calibration method, including sample self-attenuation, can be utilised for cylindrical sample containers including Marinelli beakers and point sources.

The spectra are analysed using the GAMMA-99 computer code developed at STUK. The programme searches peaks, evaluates their area and, after subtracting the background, calculates the activity concentrations for identified nuclides. The varying height and density of the samples and the true coincidence summing are

taken into account in calculating the results. Four parameters affect the peak search routine and peak area calculations: the stiffness of the Compton background of the whole spectrum can be chosen. With a threshold parameter it is possible to choose the minimum size of the peaks accepted for the analysis, and the integration area over the peak both in the peak search and in the final calculation can be chosen separately. The peak search routine and peak area calculations have been tested using IAEA reference spectra. It is also possible to add peaks and remove false ones from the calculations. The energy tolerance in identification is optional, the default value being 1 keV. The optional internal energy calibration performed by the program ensures that the energy calibration is accurate. A graphic printout of every spectrum enables checking the quality of a computer analysis as well as the current status of the spectrometer.

The programme uses the nuclide library, including 106 nuclides and 600 gamma lines with the decay scheme data. The data is updated by reference to R.B. Firestone, Table of Isotopes, 8th edition.

4.16 Radiochemical analysis methods

Radiochemical analyses completed from the samples include tritium (^{3}H), strontium (^{89}Sr, ^{90}Sr) and plutonium (^{238}Pu, $^{239+240}$Pu).

4.16.1 Tritium

Rainwater, drinking water and seawater samples were distilled once or twice (seawater) to purify the samples before the tritium measurements. Tritium was measured from the distilled water samples by liquid scintillation counting. The water sample (9 ml) was mixed thoroughly with the OptiPhase HiSafe2 scintillation cocktail (11 ml) and stored at least for two days in a dark and cool place in order to remove the chemiluminescence from the samples. A low background liquid scintillation counter Quantulus 1220 (PerkinElmer LAS) was employed for the measurements. Measuring times for the samples were 300 min and for the background 1000 min, respectively.

The counter was calibrated with certified tritium standards diluted into distilled tritium-free background water (groundwater, Pori, Vuolle). A reference vial with a tritium standard and a background vial were included in every counting series. The efficiency for tritium was about 20%. The detection limit was set to 4 kBq/l. The overall uncertainty includes uncertainties from counting and pipetting.

4.16.2 Strontium

For most of the samples, pre-purification before final separation of strontium is necessary. The ashed samples were dissolved in nitric or hydrochloric acid. Stable strontium was added to the samples for determination of chemical yield in the analyses. Orthophosphate precipitation was performed for the milk samples. Fusion was done for the deposition and drinking water samples, as well as for the plant samples before strontium was precipitated as oxalate. The soil and sediment samples were leached for three days in a room temperature with hydrochloric acid and water (1:1). The dissolved strontium was first purified with oxalate and carbonate precipitations. The seawater samples were diluted to about 4 litres after the gamma-spectrometric measurements and a part of the impurities were removed with ferric hydroxide leaching.

Strontium was finally separated from the rest of the interfering nuclides with 3 grams of extraction chromatographic resin SrResin (100-150 µm, Eichrom industries) in 8 M HNO_3 media. The elution was done with 0.05 M HNO_3 after washing the resin with 3 M HNO_3. Strontium was precipitated as carbonate with ammonium carbamate ($NH_4CO_2NH_2$). The filtered precipitate was put into the measuring geometry with filter paper, Mylar film and preparate ring.

The sample preparate (including ^{89}Sr, ^{90}Sr and ingrowing ^{90}Y) was counted with a low-background proportional counter for 1000 minutes. After counting, the strontium in the carbonate precipitate was dissolved in HCl and left to wait for ingrowth of ^{90}Y. 10 mg of stable yttrium was added for a carrier. After about 18 days, the ^{90}Y was separated with carbonate-free ammonia as a hydroxide. The supernatant solution was used for chemical yield determination of strontium with an atomic absorption spectrometer. Yttrium hydroxide was dissolved in nitric acid and the yttrium was precipitated as an oxalate with oxalic acid. The preparate was done similarly as earlier, now for an oxalate precipitate. The ^{90}Y -preparate was counted twice (1000 min) with a low-background proportional counter to ensure the purity of the preparate. The chemical yield of yttrium was determined with an EDTA titration. The ^{90}Sr activity was calculated from the measurements of the ingrowth ^{90}Y. The corresponding amount was deducted from the first proportional counter measurement to determine the portion of the ^{89}Sr activity.

The calibrations for ^{89}Sr, ^{90}Sr and ^{90}Y measurements were done by certified standard solutions. The calibrations for ^{89}Sr and ^{90}Sr are very time consuming, and are therefore more seldom performed than those for ^{90}Y. The stability of the proportional counter was followed continuously with the reference beta preparates. Background samples were measured about once a month. The reference and blank samples were analysed at least once a year. The overall

uncertainty estimation includes uncertainties from counting, pipetting, weighing, yield determinations and repeatability. The typical detection limit for ^{90}Sr was 0.02 Bq/sample.

4.16.3 Plutonium

The dried samples (soil, sediment or biota) were leached and wet ashed with concentrated HNO_3 and HCl (and HF is necessary). ^{242}Pu tracer for chemical yield determination of plutonium was added into the samples before wet ashing. After that, the filtered (if necessary) samples were evaporated and dissolved in 8 M HNO_3. To ensure that the oxidation state of plutonium was +4, the samples were warmed with H_2O_2 and $NaNO_2$ was added into the warm samples before the anion exchange.

The anion resin, Dowex 1x4 (50–100 mesh) in nitrate form was added into the 8 M HNO_3 sample solution and mixed with a magnetic stirrer for about one hour. The resin was transferred to an ion chromatography column and the dropped solution was discarded. The column was washed first with 8 M HNO_3 and then with concentrated HCl. Pu was eluted with conc. HCl + 1 M NH_4I solution by reducing it to + 3 oxidation state. The eluate was evaporated to dryness several times with conc. HNO_3 on a hot plate. Electrodeposition was done from a slightly acidic nitric acid solution, within 45 to 90 minutes (current 1.7–1.9 A and voltage 6 to 9 V) with Pt-spiral as an anode and stainless steel disc as a cathode.

Alpha emitting plutonium isotopes (^{238}Pu, $^{239+240}Pu$ and tracer ^{242}Pu) were counted with an alpha spectrometer AlphaAnalyst (Canberra). Typical counting times varied from 4000 to 6000 minutes. The detection limit was about 0.0005 Bq/sample depending on the measuring time and background.

The energy calibration was done using a certified mixed alpha standard preparate and the efficiency calibration was done using a certified standard Am-241 preparate. The quality assurance of the alpha spectrometer was done regularly by a pulse check and background measurements. In addition, blank and reference samples were analysed regularly. ^{242}Pu tracer solution is delivered by a certified standard solution company.

The overall uncertainty covers uncertainty from the activity of the tracer (incl. pipetting) and repeatability of the method.

5 Results and discussion

5.1 Air

The activity concentrations of the gamma-emitting nuclides detected in ground-level air at Loviisa are given in Tables Ia and Ib, and those at Olkiluoto in Tables IIa and IIb. The radionuclide concentrations in the supplementary air samples at Loviisa and Olkiluoto are shown in Tables IIIa and IIIb, respectively.

Chernobyl-derived ^{137}Cs was the dominant artificial radionuclide in surface air in 2002–2004. It was detected in 95% of the samples. The observed concentrations ranged from 0.6 to 12.6 μBq m^{-3} at Loviisa (Fig. 34) and from 0.9 to 52 μBq m^{-3} at Olkiluoto (Fig. 35).

Two filters from Olkiluoto contained about ten times more ^{137}Cs than the annual average. Assuming that the whole caesium activity comes from one particle, the activity of this particles was about 1 Bq.

Nuclides originating from the local power plant were detected in only two samples at Loviisa. One of these contained small amount of ^{110m}Ag, and the other had less than 1 μBq m^{-3} of both ^{58}Co and ^{60}Co. The cobalt observations were made during the maintenance period of the Loviisa plant. The frequency of observations of local discharges was decreased compared to the previous reporting period (STUK-A218).

At Olkiluoto, nuclides of local origin were detected in three filters. Two of these were from the maintenance period of the Olkiluoto plant. All these filters contained small amounts of ^{60}Co. In addition to ^{60}Co, several other power plant originated nuclides were observed in the air as collected with the supplementary sampler in May 2004: ^{51}Cr, ^{54}Mn, ^{59}Fe, ^{57}Co, ^{48}Co, ^{65}Zn and ^{124}Sb. In further studies, this filter was divided into sub-samples until it was found that all these nuclides were in one aerosol particle. The activities of the nuclides in the particle were as follows:

^{51}Cr	0.19 ± 0.06 Bq	(uncertainty 1σ)
^{54}Mn	1.13 ± 0.06	
^{59}Fe	0.20 ± 0.02	
^{57}Co	0.019 ± 0.003	
^{58}Co	6.4 ± 0.3	
^{60}Co	11.8 ± 0.6	
^{65}Zn	0.05 ± 0.1	
^{124}Sb	0.13 ± 0.01	

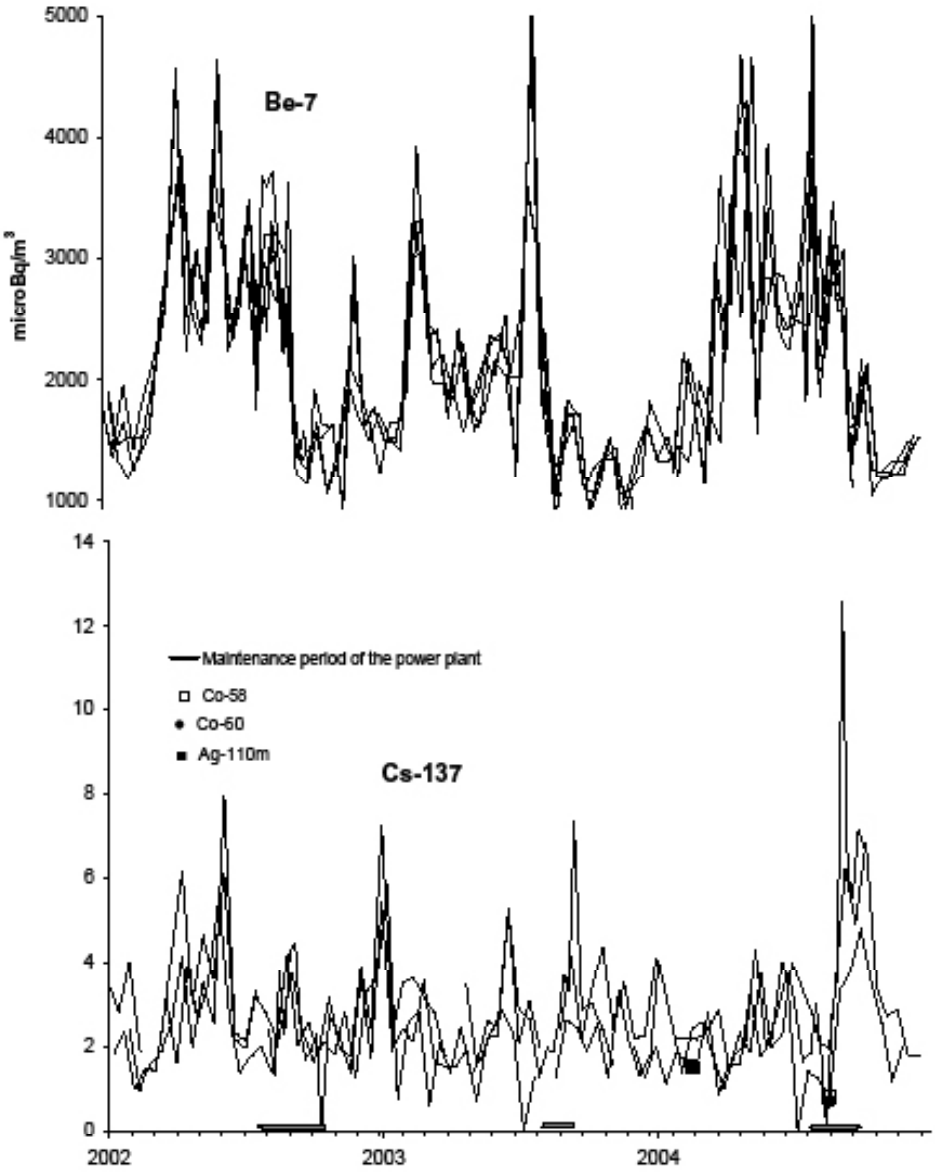

Figure 34. Concentrations of ^{7}Be and artificial nuclides detected in ground-level air ($\mu Bq\ m^{-3}$) at four sampling stations in the vicinity of the Loviisa NPP in 2002–2004.

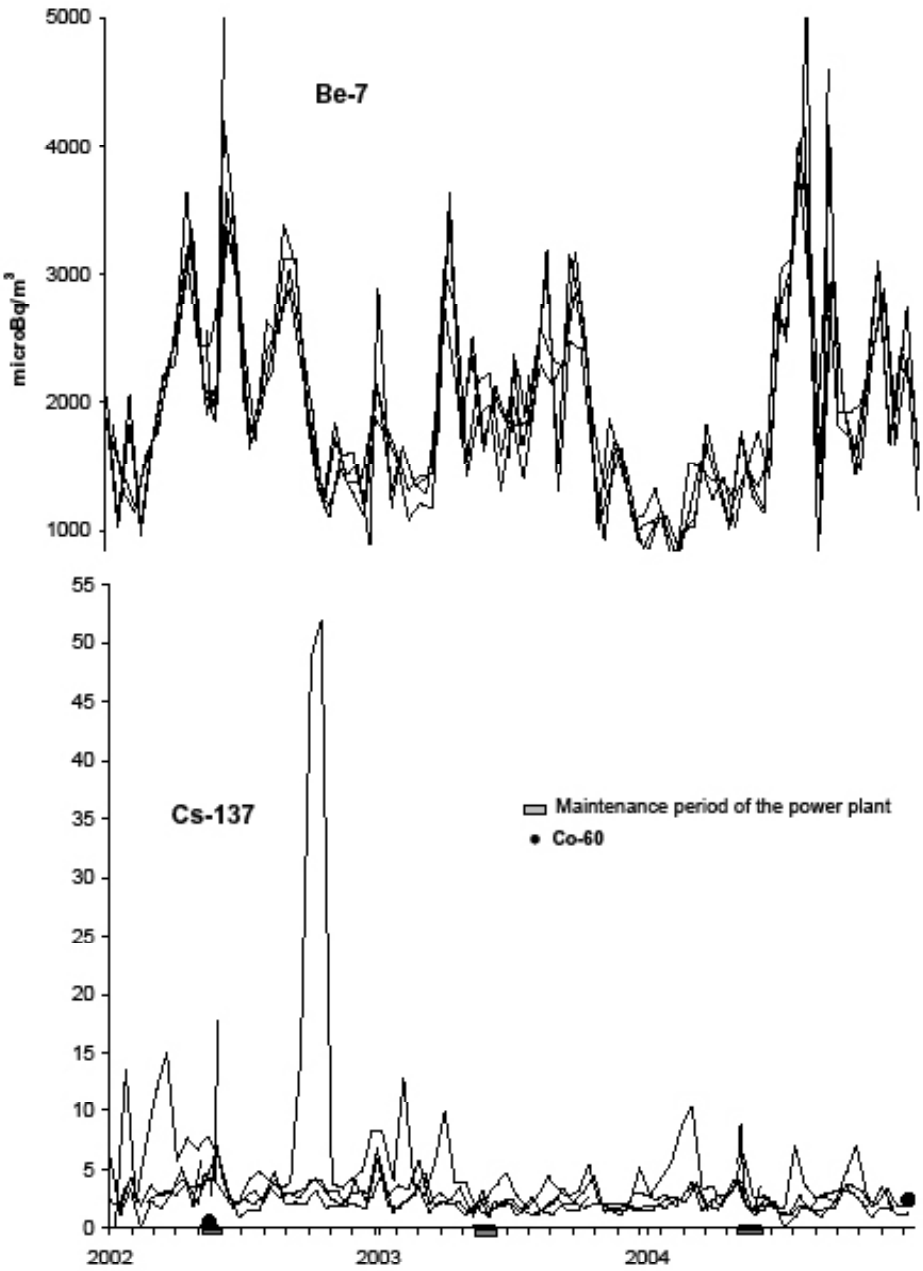

Figure 35. Concentrations of ^{7}Be and artificial nuclides detected in ground-level air (μBq m^{-3}) at four sampling stations in the vicinity of the Olkiluoto NPP in 2002–2004.

5.2 Deposition and terrestrial environment

The activity concentrations of the gamma-emitting radionuclides detected in the samples from the large area collectors of deposition at Stations Loviisa 20 and Olkiluoto 21 are given in Tables IVa and IVb. Chernobyl-derived ^{137}Cs was the dominant artificial radionuclide in the deposition as in the surface air. ^{7}Be is naturally produced by cosmic-ray interactions. The monthly deposits of ^{137}Cs at Loviisa 20 varied between 0.034 and 0.45 Bq m^{-2} and those at Olkiluoto 21 between 0.074 and 0.54 Bq m^{-2}. The quarterly deposits of ^{90}Sr (of far-fallout origin) varied between 0 and 0.21 Bq m^{-2} at Loviisa 20 and 0 and 0.67 Bq m^{-2} at Olkiluoto 21 (Table V).

In 2002 and 2003, trace amounts (max. 0.03 Bq m^{-2}) of ^{60}Co and ^{110m}Ag were detected once or twice a year in deposition samples from the large area collector at Loviisa. In 2004, the detections ^{54}Mn, ^{60}Co and ^{110m}Ag were a little more frequent, and the maximum concentration of ^{110}Ag was 0.09 Bq m^{-2} (Table IVa). These discharge nuclides originated from the local power plant. In analogous samples from Olkiluoto, no traces of local discharges were detected (Table IVb). In general, observations of ^{60}Co in the large area collectors at Loviisa and Olkiluoto since 1977 and 1981, respectively, have decreased considerably in recent years (Figs. 36 and 37).

During the entire monitoring period, ^{60}Co has been detected more often in the deposition samples from the large area collector at Loviisa than at Olkiluoto. The highest number of observations was in both areas in 1996; in 9 monthly samples at Loviisa and in 6 monthly samples at Olkiluoto (Fig. 38). Within each year, the highest number of observations has been in August-September at Loviisa and in May-July at Olkiluoto (Fig. 39), i.e., during the annual maintenance periods of the power plants.

In the quarterly deposits collected with the Ritva collectors at Stations Loviisa 24, 27 and 33, and Olkiluoto 26, 31 and 37, local discharge nuclides were detected once in Olkiluoto (^{54}Mn and ^{60}Co at Olkiluoto 31 in October-December 2002), and once in Loviisa (^{60}Co at Loviisa 24 in January-March 2004). The annual total deposits of ^{137}Cs varied between 1.87 and 4.85 Bq m^{-2} at the Loviisa stations and between 1.65 and 3.91 Bq m^{-2} at the Olkiluoto stations (Tables VIa and VIb). Slightly increased concentrations of tritium were detected in two rainwater samples collected at Station Olkiluoto 21 in May and November 2002 (4.5 and 10 Bq l^{-1}, respectively). All other tritium concentrations in rainwater at Olkiluoto and Loviisa were below the detection limit (4 Bq l^{-1}).

In the soil samples taken from Loviisa in 2004, the peak concentrations of the Chernobyl-derived ^{137}Cs were at the depths of 2-4 or 4–6 cm (Table VII). The highest total amount of ^{137}Cs per square metre was 27 300 Bq m^{-2} at Station Loviisa 43, but the maximum concentration 5 500 Bq kg^{-1} d.w. was in

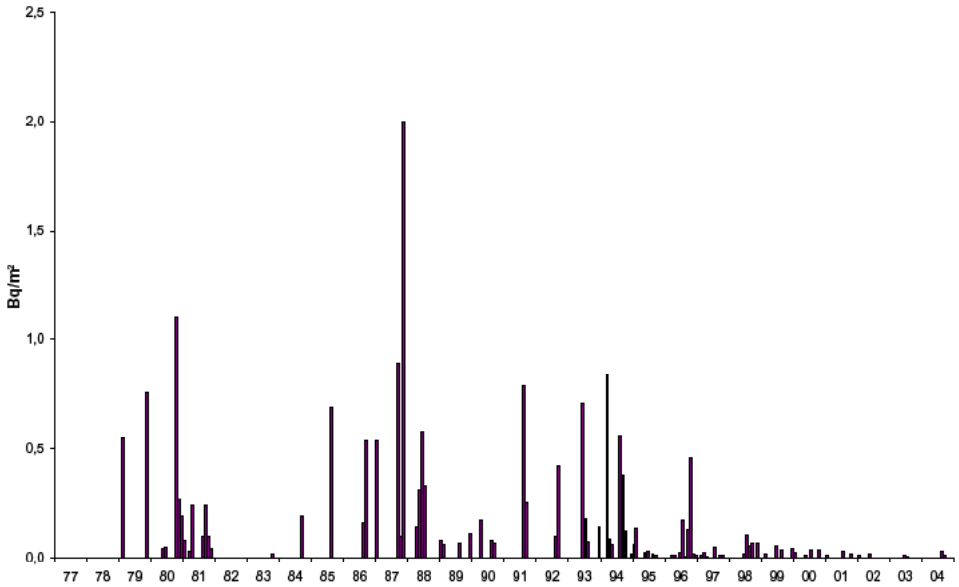

Figure 36. Observations of ^{60}Co in deposition samples at Station Loviisa 20, 1977–2004.

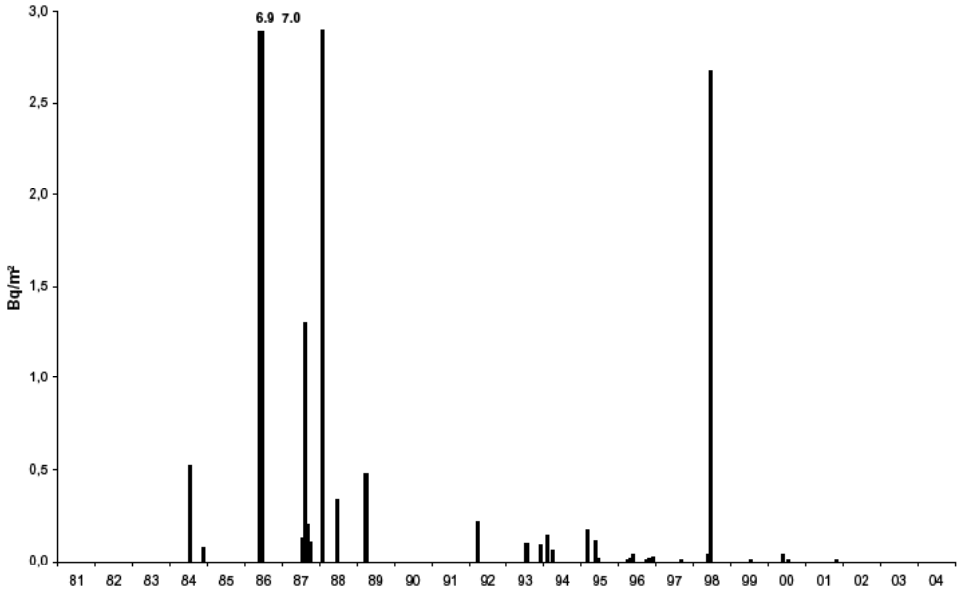

Figure 37. Observations of ^{60}Co in deposition samples at Station Olkiluoto 21, 1981–2004.

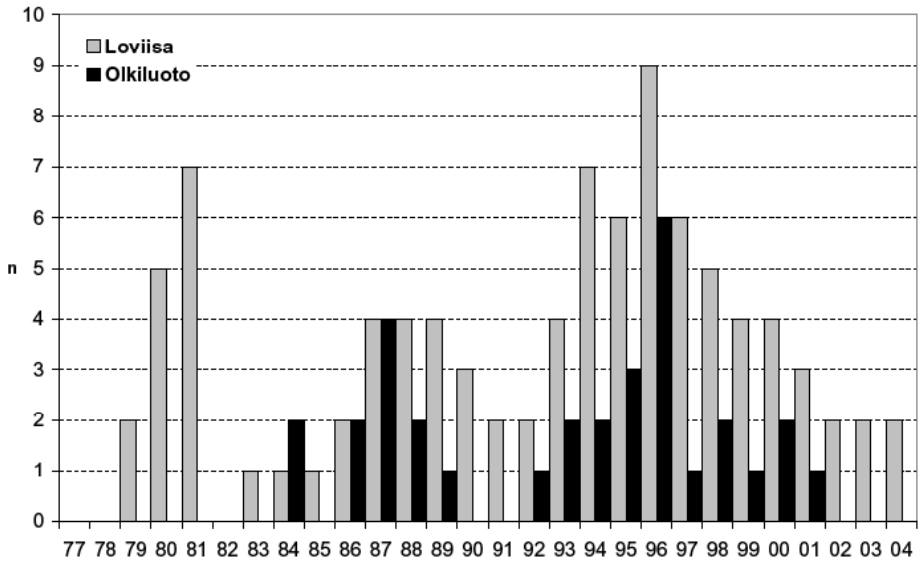

Figure 38. Number of yearly observations of ^{60}Co in deposition samples at Station Loviisa 20, 1977–2004 and Station Olkiluoto 21, 1981–2004.

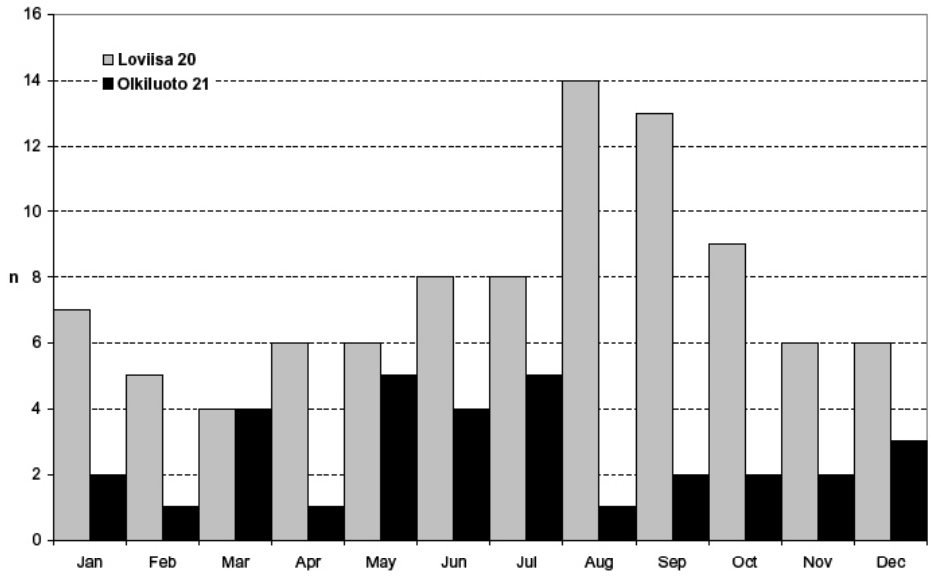

Figure 39. Number of monthly observations of ^{60}Co in deposition samples at Station Loviisa 20, 1977–2004 and Station Olkiluoto 21, 1981–2004.

the 4–6 cm soil layer at Station Loviisa 45. In 2000, the highest total amount of ^{137}Cs was 39 400 Bq m^{-2} at Loviisa 43 (STUK-A218). The large variation in the total amounts is due to the uneven distribution of the Chernobyl fallout on the ground. The maximum concentration of ^{90}Sr was 25 Bq kg^{-1} in the surface soil at Station Loviisa 42. No traces of local discharge nuclides were found in the soil samples.

The activity concentrations of ^{137}Cs in hair moss (Table VIII) were clearly higher in the Loviisa area (530–1200 Bq kg^{-1} d.w.) than in Olkiluoto (210–490 Bq kg^{-1}), as also in all the preceding monitoring periods. The clearly higher concentrations in Loviisa are probably due to the characteristics of the local habitats. In general, the habitats of hair moss in the sampling sites at Loviisa have been more humid than at Olkiluoto. As a whole, the ^{137}Cs concentrations have decreased in both areas in recent years.

The activity concentrations of ^{90}Sr were low in the hair moss samples, as well as those of ^{137}Cs in the grazing grass samples (Table IX) from both areas in 2002–2004 (< 3 Bq kg^{-1} d.w.). No local discharge nuclides were found either in the hair moss or in the grazing grass samples.

Ferns *(Polypodium vulgare)* were taken as new terrestrial indicator organisms to the monitoring programmes in 2003. The first samples taken in 2003 and 2004 indicate that the uptake of caesium is particularly high in ferns (Table X, *cf.* also Ilus 2006). The activity concentrations of ^{137}Cs were 4700 and 7300 Bq kg^{-1} d.w. in the samples from Loviisa and 1250 and 2910 Bq kg^{-1} d.w. in those from Olkiluoto. In reindeer lichen, the ^{137}Cs concentrations varied between 490 and 1510 Bq kg^{-1} d.w. in Loviisa and between 290 and 570 Bq kg^{-1} d.w. in Olkiluoto, and in pine needles the concentrations were still clearly lower (Table X).

Traces of local discharges were found in only one terrestrial indicator sample. A minute amount of ^{60}Co (0.31 Bq kg^{-1} d.w.) was recorded in a reindeer lichen sample taken at Station Olkiluoto 21 in July 2003 (Table X).

The water samples taken from the ditch edging the dumping ground for exempted waste at Olkiluoto contained only small amount of Chernobyl-derived ^{137}Cs (Table XI). No local discharge nuclides were found in the ditchwater.

5.3 Foodstuffs

No traces of local discharge nuclides were detected in any foodstuff sample taken from the surroundings of the Loviisa and Olkiluoto NPPs in 2002–2004. The small amounts of artificial radionuclides detected in the foodstuff samples (^{90}Sr, ^{134}Cs and ^{137}Cs) originated from the Chernobyl accident and the older global fallout caused by the past nuclear weapons tests.

The annual mean concentrations of ^{137}Cs in milk varied between 0.24 and 0.36 Bq l^{-1} in the area surrounding the Loviisa power plant and between 0.45 and 1.15 Bq l^{-1} in the Olkiluoto area (Table XII). The concentrations were slightly higher in the Olkiluoto area as also in the preceding years. In most cases, the ^{137}Cs concentrations in milk from the close vicinity of the Olkiluoto NPP (within 10 km radius of the power plant) were lower than those in the whole production of the local dairy. The annual mean concentrations of ^{90}Sr varied between 0.035 and 0.038 Bq l^{-1} in the Loviisa area and between 0.047 and 0.052 Bq l^{-1} in the Olkiluoto area (Table XIII). In general, the concentrations of ^{137}Cs and ^{90}Sr were at the same level as in the whole country. ^{131}I was not detected in the milk samples at either Loviisa or Olkiluoto.

The contents of ^{90}Sr in drinking water (Tables XIVa and XIVb) were at the same level as in the early 1980s and in the previous years, varying between 6 and 12 Bq m^{-3}. The clear difference between the activity concentrations of ^{137}Cs in the drinking water of the Loviisa NPP (25–60 Bq m^{-3}) compared with those of the Olkiluoto NPP (5–8 Bq m^{-3}) and the town of Rauma (3–8 Bq m^{-3}) is due to the type of soil in the areas of the raw water reservoirs. On the west coast of Finland, the soil is very clayey, which effectively retains caesium in the soil and decreases its concentrations in surface water (STUK-A218). In general, the concentrations of ^{137}Cs in drinking water have continued to decrease in both areas. The water supply of the town of Loviisa is groundwater, which explains the lack of artificial radionuclides. The concentrations of tritium in all the drinking water samples were below the detection limit (4 kBq m^{-3}).

The activity concentrations of ^{90}Sr and ^{137}Cs in cereals were below 1 Bq kg^{-1} d.w. in both areas (Table XV). Among the garden produce, lettuce uptakes caesium more effectively than fruits and berries. In the lettuce samples collected from gardens situated close to the Loviisa and Olkiluoto NPPs, the ^{137}Cs concentrations were 1–7 and 3–11 Bq kg^{-1} d.w., respectively (Table XVI). Black currants from the Olkiluoto area and apples from the Loviisa area contained less than 1.5 Bq kg^{-1} d.w. of ^{137}Cs. The activity concentrations of ^{137}Cs in beef were below 1 Bq kg^{-1} in the vicinity of the Loviisa NPP and below 2 Bq kg^{-1} in the vicinity of Olkiluoto (Table XVII).

A sampling event comprising natural products is arranged every four years in the vicinities of the power plants. In 2004, sampling of mushrooms and wild berries was conducted in the vicinity of Loviisa. Many mushroom species are known to be efficient in accumulating radionuclides (especially caesium) from the environment (Ilus 2006). ^{137}Cs and ^{134}Cs were the only artificial gamma-emitting radionuclides in the mushrooms picked up in 2004 from the Loviisa area. The highest concentrations of ^{137}Cs were in the samples of *Lactarius rufus*, *Boletus variegatus* and Gypsy *(Rozites caperata)*; 2460, 1460 and 1100 Bq kg^{-1}

f.w., respectively (Table XVIII). These mushroom species were proved to belong to the best indicators of caesium also in the Nordic INDOFERN Project (Ilus *op cit.*). The ^{137}Cs concentrations in the most consumed wild berries – blueberry and lingonberry – were 26 and 30 Bq kg^{-1} f.w., respectively.

Fish samples are considered in Chapter 5.4.3.

5.4 Aquatic environment

5.4.1 Seawater

Tritium in seawater originates generally from atmospheric nuclear weapons tests conducted in the Northern Hemisphere during the late 1950s and early 1960s. The levels of fallout ^{3}H have continuously decreased, but tritium is still the most abundant radionuclide in seawater samples. Nevertheless, ^{3}H is also produced in nuclear reactors, and consequently it is the predominant radionuclide both in airborne and liquid discharges from nuclear power plants. It emits low-energy β-particles and therefore does not pose external radiological hazard (Phillips and Easterly 1981).

In Finnish coastal waters, the concentrations of fallout ^{3}H decreased from about 10–15 kBq m^{-3} to less than 4 kBq m^{-3} between the late 1970s and the early 2000s. After that, local discharges have contributed to the values excess of 4 kBq m^{-3} in the Loviisa and Olkiluoto sea areas. In 2002–2004, the maximum concentration of ^{3}H was 94 kBq m^{-3} in the discharge area of the Loviisa power plant (just at the cooling water outlet). At Stations Loviisa 1, 2 and 4, the maximum concentrations were 20, 17 and 13 kBq m^{-3}, while at the reference Station Loviisa R1, the concentrations were below the detection limit 4 kBq m^{-3} (Table XIXa). In the discharge area of the Olkiluoto power plant the maximum concentration was 16 kBq m^{-3} (Table XIXb). Elevated ^{3}H concentrations were more frequent in Loviisa (Fig. 40), which is due both to larger discharges and to the slower exchange of water in the discharge area at Loviisa.

^{40}K is a naturally occurring radionuclide in all environmental samples, ^{137}Cs is mainly originated from the Chernobyl fallout and ^{90}Sr from the global fallout caused by the atmospheric nuclear weapons tests. Due to the short half-life (2.06 years), Chernobyl-derived ^{134}Cs was no longer detected in seawater samples (*cf.* the previous Annual Reports, STUK-A205 and STUK-A218).

In 2004, the mean activity concentration of ^{137}Cs in seawater was 32 (range 24–38 Bq m^{-3}) at Loviisa and 58 (45–69 Bq m^{-3}) at Olkiluoto. Since the Chernobyl accident (1986), the caesium concentrations have decreased more rapidly at Loviisa

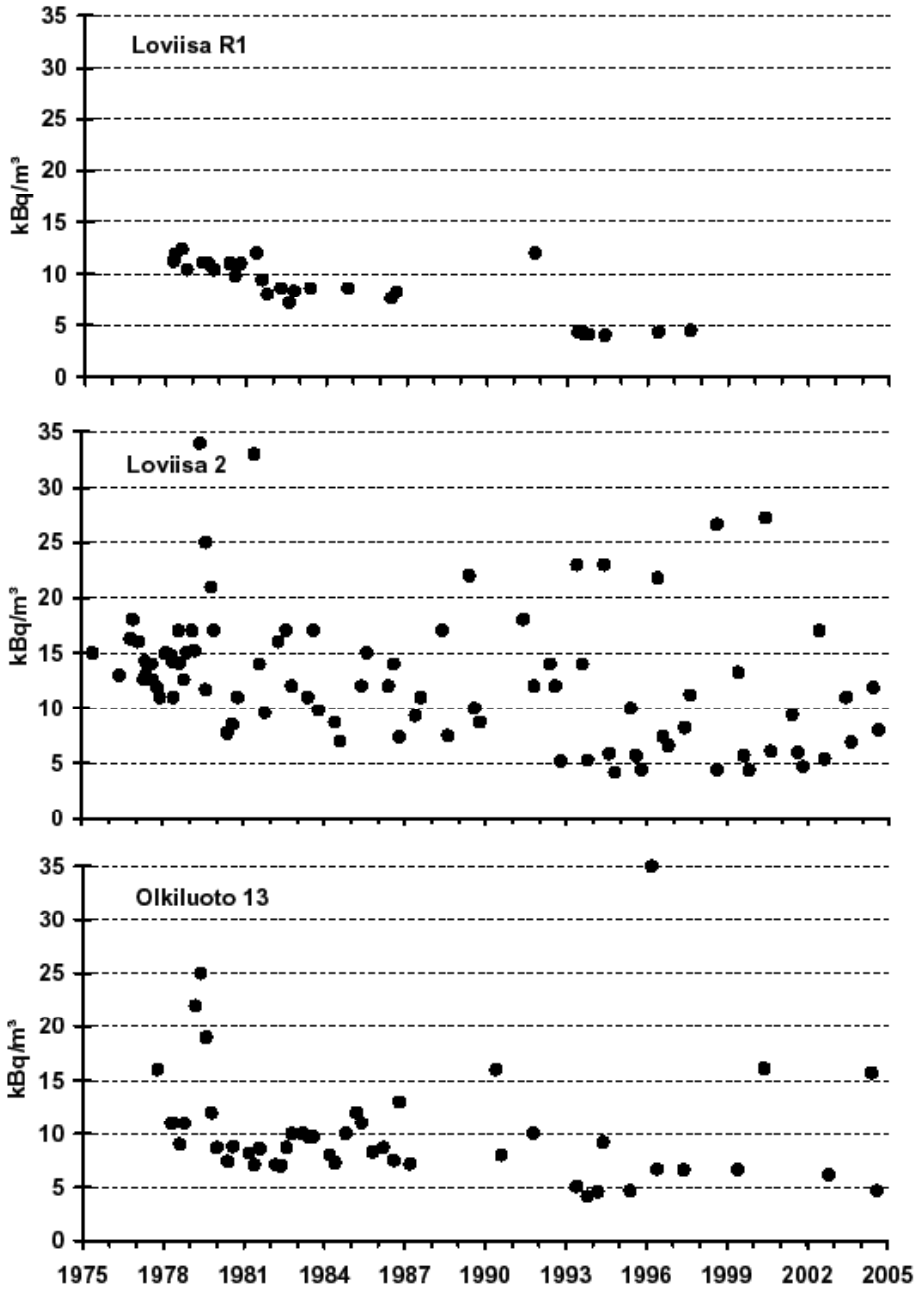

Figure 40. Tritium concentrations in seawater at Stations Loviisa R1, Loviisa 2 and Olkiluoto 13 in 1976–2004 (detection limit 4 kBq m^{-3}).

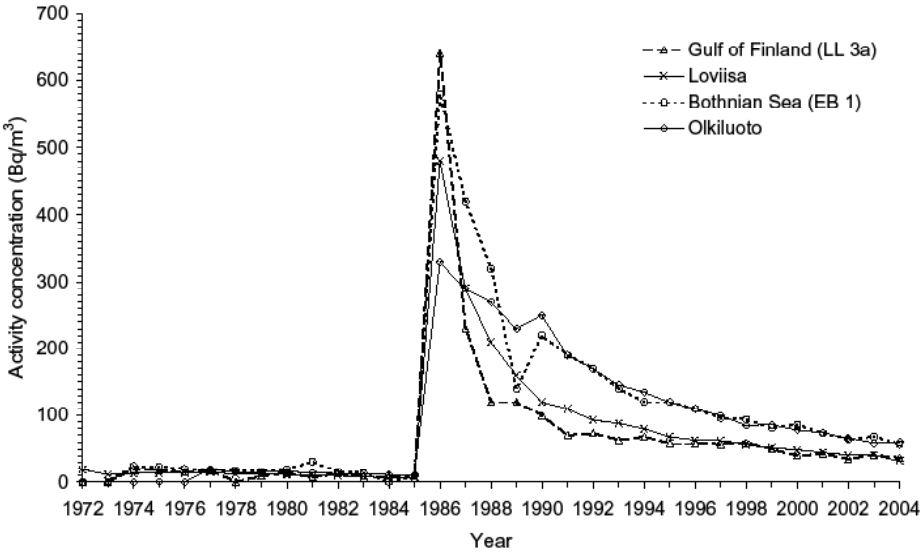

Figure 41. Late-summer mean concentrations of ^{137}Cs in surface sea water at Loviisa and Olkiluoto, and the nearest offshore stations LL3a (Gulf of Finland) and EB 1 (Bothnian Sea) in 1972–2004.

and in the whole Gulf of Finland than at Olkiluoto and in the Bothnian Sea. In Figure 41, Station LL3a represents the open sea off Loviisa and Station EB1 that off Olkiluoto. During 1986–2004, the decrease in ^{137}Cs values has been about 93% at Loviisa and 82% at Olkiluoto (including the physical half-life of ^{137}Cs). The main reason for the varied decreasing rates of caesium is the more effective water exchange between the Gulf of Finland and the Baltic Proper than that between the Bothnian Sea and the Baltic Proper. In the Loviisa area the archipelago also retards the exchange of water more effectively than at Olkiluoto, and consequently the exit rate of caesium from seawater in the discharge area. The ^{90}Sr concentrations in seawater ranged from 8 to 17 Bq m^{-3} at Loviisa and from 7 to 19 Bq m^{-3} at Olkiluoto.

5.4.2 Indicator organisms

The bladder-wrack, *Fucus vesiculosus,* and the filamentous green alga, *Cladophora glomerata,* have been used as aquatic indicator organisms in both areas from the very beginning. The relict crustacean *Saduria entomon* has been used for the same purpose at Loviisa and the bivalve mussels *Mytilus edulis* and *Macoma baltica* at Olkiluoto. Since 1998, periphyton and the submerged seed

plants *Myriophyllum spicatum* and *Potamogeton pectinatus* have been used as new indicator organisms for the monitoring programmes of both power plants. Indicator organisms effectively accumulate radionuclides from water and sediments, thus facilitating the detection of small traces of radionuclides in the environment.

The activity concentrations of Chernobyl-derived caesium in indicator organisms continued to decrease in both areas. However, the caesium concentrations in *Fucus vesiculosus* at Loviisa have decreased more slowly than in the seawater. In 2004, the mean ^{137}Cs concentration in all *Fucus* samples collected at Loviisa was 25 (13–33) Bq kg^{-1} dry wt. and 29 (18–43) Bq kg^{-1} dry wt. at Olkiluoto (Tables XXc and XXIc). As before, there was a clear difference between the caesium values of the innermost and the outer sampling sites at Olkiluoto: the values were higher at the innermost sites. The potential contribution of the thermal effect caused by the cooling water of the power plants on areal differences has been discussed in our previous reports, as has that of low salinity and high turbidity of water in addition to other hydrographic characteristics typical for the discharge areas (STUK-A102, STUK-A121). Nevertheless, the ^{137}Cs discharges from the power plants may also contribute to the concentrations in the vicinity of the discharge outlets.

Periphyton accumulates caesium more effectively than the other indicator organisms used in the monitoring programmes and *Fucus vesiculosus* and the spiked water milfoil, *Myriophyllum spicatum,* seem to be the second best indicators of ^{137}Cs. In 2004, the activity concentrations of ^{137}Cs in periphyton were 24–170 Bq kg^{-1} dry wt. at Loviisa and 126–244 Bq kg^{-1} dry wt. at Olkiluoto. In *Saduria* from Loviisa, the ^{137}Cs concentration was 16 Bq kg^{-1} dry wt., and in *Macoma* from Olkiluoto 11 Bq kg^{-1} dry wt. In *Mytilus* from Olkiluoto the ^{137}Cs concentration was about 3 Bq kg^{-1} dry wt. (Table XXII).

In contrast to the caesium isotopes, ^{90}Sr, ^{238}Pu and ^{239,240}Pu originate mainly from the nuclear weapons tests, and ^{40}K is of natural origin. In 2002–2004, the activity concentrations of ^{90}Sr in *Fucus* ranged from 7 to 11 Bq kg^{-1} dry wt. at Loviisa and from 7 to 17 Bq kg^{-1} at Olkiluoto, and those of ^{239,240}Pu from 0.03 to 0.09 Bq kg^{-1} dry wt. in both areas. ^{238}Pu was detected in one sample; the activity concentration was 0.01 Bq kg^{-1} dry wt. in a *Fucus* sample taken from Olkiluoto C in 2003. In a *Fucus* survey conducted during the early 1980s along the Finnish coast, the mean concentrations of ^{239,240}Pu were 0.26 and 0.15 Bq kg^{-1} dry wt. in the Gulf of Finland and in the Bothnian Sea, respectively (STUK-B-TUTO 14, and 18).

The other radionuclides detected in the indicator organisms originate from local discharges; i.e., ^{51}Cr, ^{54}Mn, ^{58}Co, ^{59}Fe, ^{60}Co, ^{95}Zr, ^{95}Nb, ^{110m}Ag, ^{123m}Te and ^{124}Sb at Loviisa, and ^{54}Mn, ^{58}Co, ^{60}Co and ^{124}Sb at Olkiluoto. ^{51}Cr, ^{59}Fe, ^{95}Zr, ^{95}Nb

and ^{123m}Te were almost exclusively detected in a *Myriophyllum* sample taken at Loviisa in August 2004 (Table XXc).

The most abundantly detected local discharge nuclide in the indicator organisms was ^{60}Co. The highest ^{60}Co concentration, 27 Bq kg^{-1} dry wt., was measured in periphyton samples taken near the cooling water outlets of the power plants; at Loviisa in July 2002 and at Olkiluoto in May–June 2003, i.e., during the maintenance and refuelling outages of the power plants.

Due to the lower discharges, the concentrations of ^{60}Co, ^{54}Mn and ^{58}Co have significantly decreased in *Fucus* in both areas in recent years (Fig. 42). At the inner most Olkiluoto sampling site (A), the mean concentration of ^{60}Co in *Fucus* was 2.3 Bq kg^{-1} dry wt. in 2002–2004, while it was 0.2 Bq kg^{-1} dry wt. at the outer most sampling site (C). At Loviisa, the corresponding mean concentration of ^{60}Co at the inner most sampling site (A) was 1.3 Bq kg^{-1} dry wt., but ^{60}Co was not detected outside Hästholmsfjärden Bay .

During the reporting period, *Myriophyllum* proved by far to be the best indicator organism for all the local discharge nuclides at Loviisa, and periphyton was clearly second best. At Olkiluoto, periphyton seemed to be a slightly better indicator, especially for ^{60}Co. Periphyton has proved to be an excellent indicator organisms for caesium, too, and *Fucus* also seems to accumulate caesium more effectively than the seed plants *Myriophyllum* and *Potamogeton pectinatus*. *Saduria* is a good indicator for ^{110m}Ag and *Mytilus* for ^{60}Co.

5.4.3 Fish

In fish samples caught from Loviisa and Olkiluoto, the caesium concentrations were consistent with those of seawater; the concentrations in all the fish species were generally somewhat higher in Olkiluoto than in Loviisa (Tables XXIII–XXIV). The differences between the fish species were the same as previously: the concentrations were highest in perch and lowest in Baltic herring and roach/bream/ide.

In 2004, the highest ^{137}Cs concentration in perch was 42 Bq kg^{-1} fresh wt. at Olkiluoto and 23 Bq kg^{-1} fresh wt. at Loviisa. The reason for the exceptionally high, but still relatively low value of ^{137}Cs (71 Bq kg^{-1}), detected in the perch sample from Loviisa I in May 2003 is unclear. The activity concentrations of ^{90}Sr, ^{134}Cs and ^{137}Cs in pike and Baltic herring were in both areas at the same level as on the Finnish coast in general (perch and roach are not monitored regularly). Local discharge nuclides (^{60}Co) were detected in three fish samples caught from Olkiluoto in 2002-2004, but the concentrations were very low: < 0.1 Bq kg^{-1} (Table XXIV).

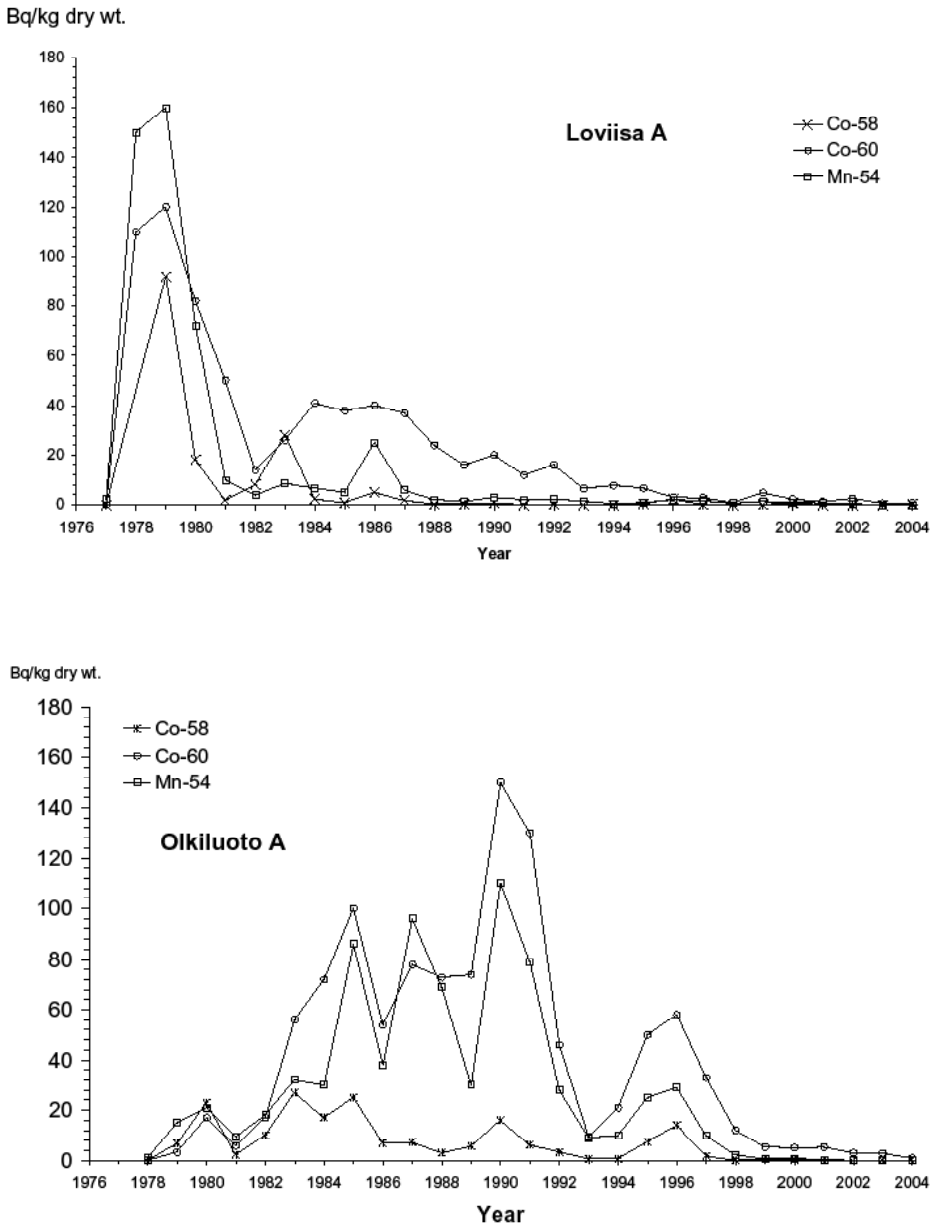

Figure 42. Annual mean concentration of ^{54}Mn, ^{58}Co and ^{60}Co in *Fucus vesiculosus* at sampling stations Loviisa A and Olkiluoto A in 1977–2004.

In the samples of young salmon taken from the fish farm operating in association with the power plant at Loviisa, the activity concentrations of ^{137}Cs were clearly lower than in the free-living fish, and ^{134}Cs was not detected (Tables XXV). The highest ^{137}Cs concentration in farmed fish was 1.2 Bq kg^{-1} fresh wt. It has been stated earlier that the low concentrations are due to the low caesium contents of the feed used in the farm.

5.4.4 Sinking matter

Suspended particulate matter can be considered as a non-living indicator of radionuclides in the aquatic environment, as many radionuclides tend to adsorb to sinking particles. The affinity of caesium to clay particles is well-known, but many other nuclides seem to have a similar tendency as well. Since many problems are involved in sampling of recently settled particles from the surface of the sediment, proper sediment samples are taken in the monitoring programmes only once every 4 years, and the less frequent sampling is replaced by continuous round-the-year collection of sinking matter.

The activity concentrations of ^{137}Cs and ^{134}Cs were clearly higher in sinking matter than in the indicator organisms. This is due to the affinity of caesium to adsorb to particles. In 2004, the mean concentration of ^{137}Cs was 530 (410–630) Bq kg^{-1} dry wt. at Station Loviisa 3 (Hästholmsfjärden), 460 (390–530) Bq kg^{-1} dry wt. at Reference Station Loviisa R1 and 340 (230–410) Bq kg^{-1} dry wt. at Station Olkiluoto 12. (Tables XXVIa -XXVIb). The higher values in the Loviisa area are due to the higher particle content in water there (STUK-A102).

^{54}Mn, ^{58}Co, ^{60}Co and ^{110m}Ag found in the sinking matter samples at Loviisa, and ^{60}Co at Olkiluoto, originated from local discharges. ^{60}Co was detected regularly in sinking matter collected from each station at Olkiluoto and from the two innermost stations (1 and 3) at Loviisa, whereas ^{110m}Ag, ^{54}Mn and ^{58}Co were detected only in a few samples collected at Loviisa 1, 3 and 4a, which are located closest to the power plant. The maximum concentration of ^{60}Co was 78 Bq kg^{-1} dry wt. in a sample collected at Loviisa 3 in July–September 2002. No traces of local discharges were detected at the Loviisa R1 Reference Station, which is located about 14 km west of the Loviisa NPP. However, ^{60}Co was regularly detected at the Olkiluoto 15 Station, located 10 km north of the Olkiluoto NPP. Long-term fluctuations of ^{54}Mn, ^{58}Co and ^{60}Co in sinking matter collected during the open-water periods at the Stations Loviisa 3 and Olkiluoto 2 (Olkiluoto 12 since 1993) are illustrated in Fig. 43. During the last few years, the concentrations have decreased significantly due to the reduced discharges, except for the somewhat higher values at the Loviisa 3 Station in 2002.

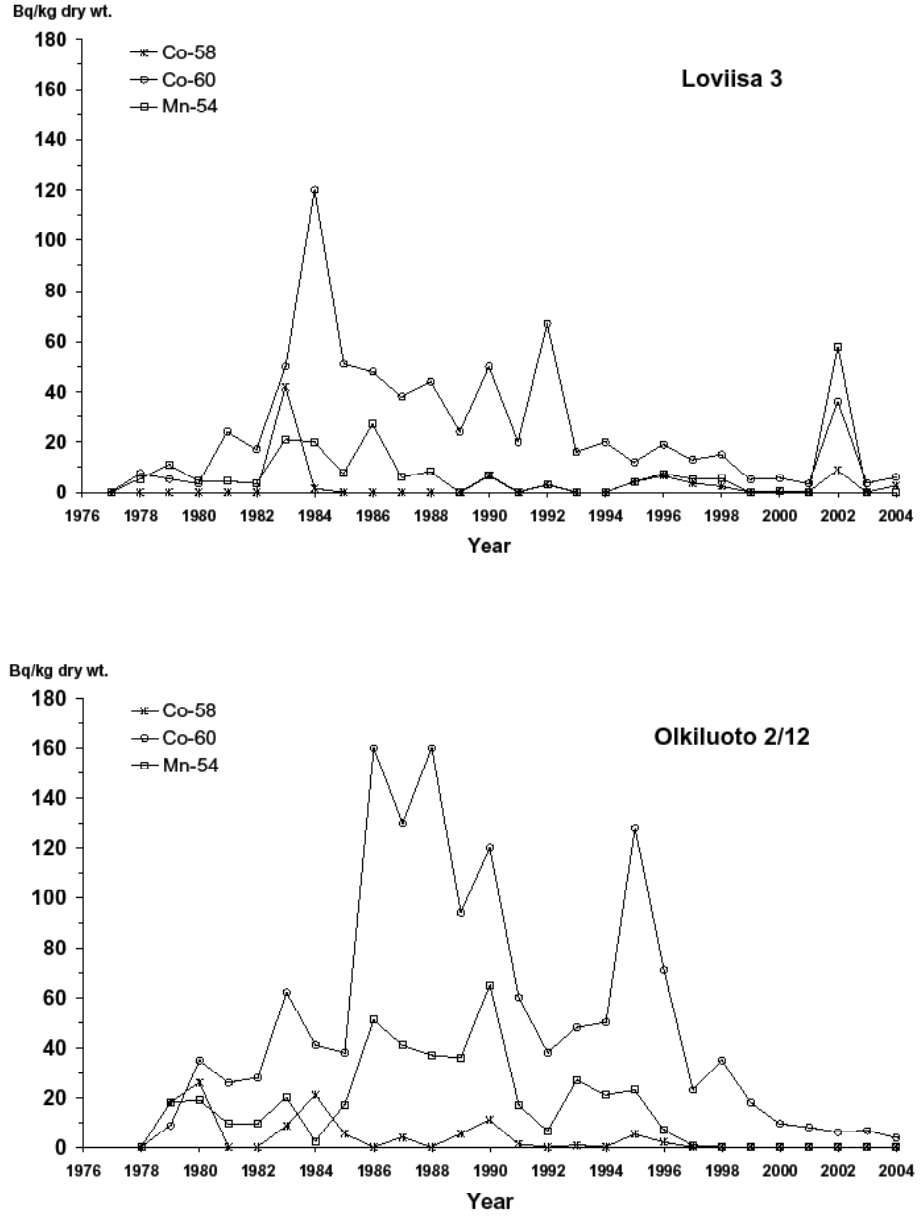

Figure 43. Mean concentrations of ^{54}Mn, ^{58}Co and ^{60}Co in sinking matter at Stations Loviisa 3 and Olkiluoto 2/12 during the open-water periods in 1977–2004.

The activity concentrations of ^{238}Pu and ^{239,240}Pu in sinking mater were 0–0.03 Bq kg^{-1} dry wt. and 0.49–1.1 Bq kg^{-1} dry wt. at Loviisa, and 0–0.13 and 0.9–1.2 Bq kg^{-1} dry wt. at Olkiluoto, respectively (Table XXVII).

5.4.5 Bottom sediments

In addition to ^{40}K (natural) and the fallout nuclides ^{90}Sr, ^{238}Pu and ^{239,240}Pu (principally originating from the nuclear weapons tests), and ^{134}Cs and ^{137}Cs (principally originating from the Chernobyl accident), the sediment samples taken in 2002 and 2003 at Loviisa and Olkiluoto also contained small amounts of ^{60}Co originating from local discharges (Tables XXVIII-XXXI). Furthermore, ^{125}Sb was detected in one sediment sample; 6.7 Bq kg^{-1} dry wt. at a depth of 5–10 cm at Station Loviisa R2.

At Loviisa, the peak values of Chernobyl-derived ^{137}Cs occurred at different depths at different stations according to the sedimentation rate: from a depth of 6–7 cm at Loviisa Station R2 to a depth of 16–17 cm at Station Loviisa S5. The highest peak value, 5590 Bq kg^{-1} dry wt., was at a depth of 13–14 cm at the Station Loviisa 3. Fig. 44 illustrates the vertical distribution of ^{137}Cs in 1-cm slices at this station in 1986–2002. The peak was now at a 1-cm lower depth than four years ago. The peak in the 13–14 cm sediment layer corresponds to a sedimentation rate of about 0.8 mm y^{-1}. The peak in the 16–17 cm layer at Station Loviisa S5 corresponds to a sedimentation rate of about 1 mm y^{-1}.

The highest total amount of ^{137}Cs per square metre was 59 500 Bq m^{-2} at Station R1 and the lowest 19 100 Bq m^{-2} at Station R2. In general, the total amounts had decreased after the previous survey (1998) at all other stations, except at the Stations R1 and S5.

^{60}Co was detected only at three stations in the sediment samples taken from the Loviisa area in 2002. The observations were most abundant at the Station Loviisa 3, while at Loviisa 1, ^{60}Co was detected only in three slices and at Loviisa 7 in one slice (Table XXIXb). During the last few years, the number of ^{60}Co detections has considerably decreased at the stations located outside Hästholmsfjärden Bay. At Station Loviisa 3, the highest activity concentration of ^{60}Co (17.5 Bq kg^{-1} dry wt.) was now found in the 9–10 cm layer, and the deepest observation of ^{60}Co was made in the slice of 16-17 cm. These observations are in good agreement with those made in 1998 (STUK-A205) taking into account the sedimentation rate at the station and the half-life of ^{60}Co (5.3 years).

The customary sediment samples taken at Olkiluoto in 2003 were sectioned in 5-cm slices (Table XXX); only one sediment core taken from Station Olkiluoto 2 was sectioned in 1-cm slices (Table XXXI). The peak values of ^{137}Cs caused by the Chernobyl fallout occurred in the 5–10 cm sediment layer at Stations Olkiluoto

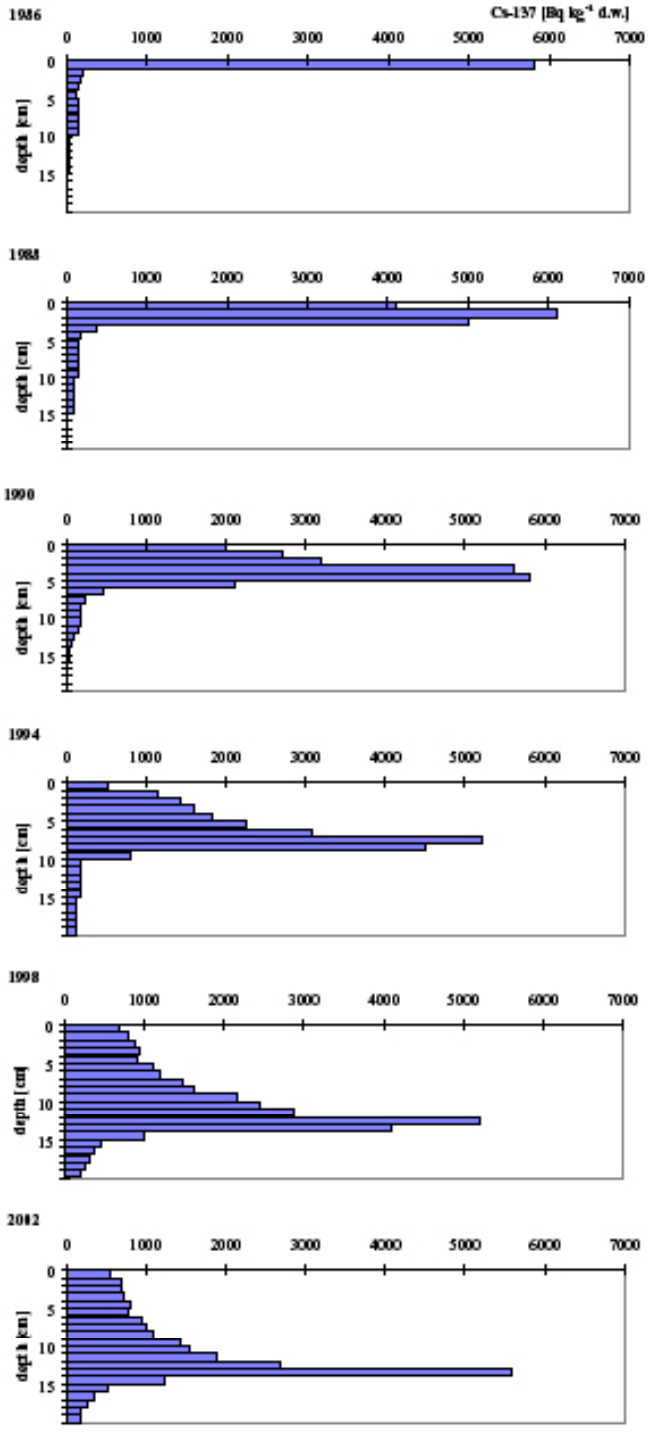

Figure 44. Vertical distribution of ^{137}Cs concentrations at Station Loviisa 3, 1986–2002.

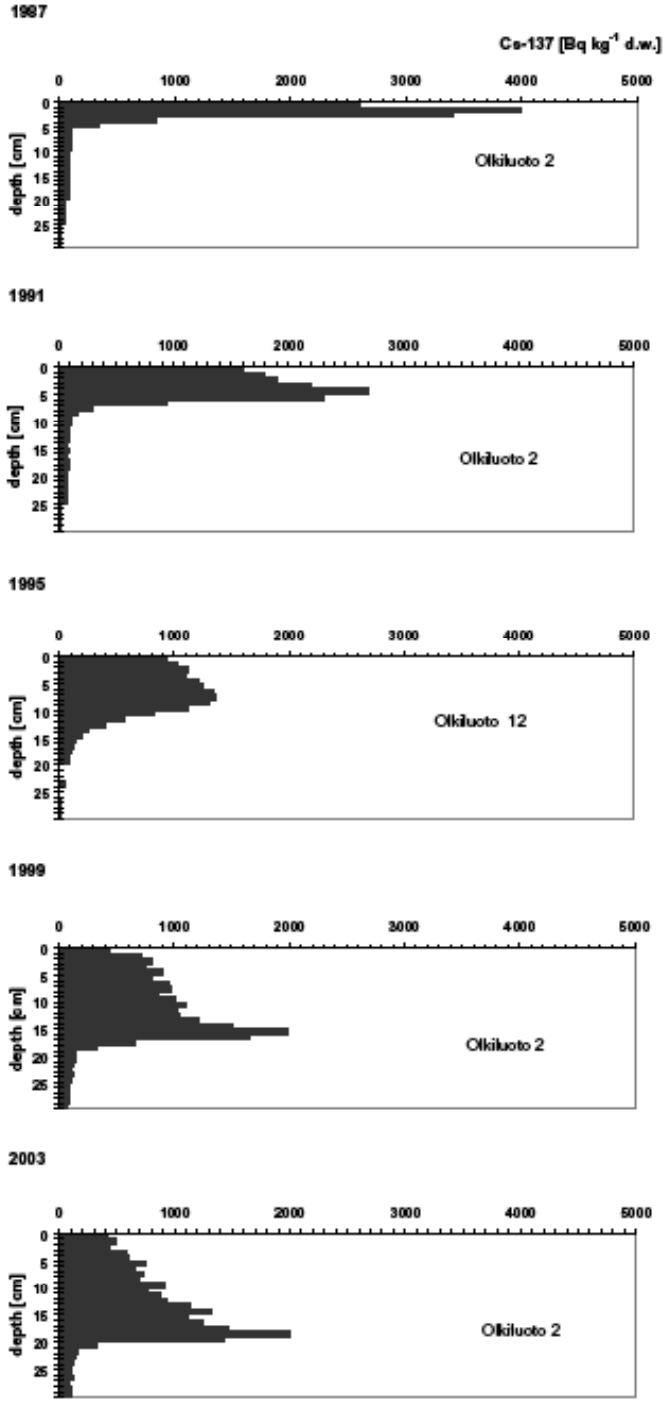

Figure 45. Vertical distribution of ^{137}Cs concentrations at Stations Olkiluoto 2/12, 1987–2003.

S5, S6 and S8, in 10–15 cm at Station Olkiluoto 4 and in 15–20 cm at Station Olkiluoto 9. At the Stations Olkiluoto 1 and 5, the peak was still in the upper most 0–5 cm layer. Fig. 45 illustrates the vertical distribution of ^{137}Cs in the 1-cm slices at the Stations Olkiluoto 2/12 in 1986–2003. In 2003, the highest activity concentration (2000 Bq kg^{-1} dry wt.) was in the 18–19 cm sediment layer, which corresponds to a sedimentation rate of about 1.1 mm y^{-1}.

The highest total amount of ^{137}Cs per m^2 was 47 600 Bq m^{-2} at Station 2 and the lowest 10 700 Bq m^{-2} at Station 5. In general, the total amounts had slightly increased after the previous survey (1999) at Stations 2, 4, 9, S6 and S8, but decreased at Stations 1 and S5.

Small amounts of ^{60}Co were detected in sediments at all the stations studied. The highest activity concentrations observed were 83 Bq kg^{-1} dry wt. in the 7–8 cm layer at Station Olkiluoto 2 and 26 Bq kg^{-1} dry wt. in the 15–20 cm layer at Station Olkiluoto 9, which are located nearest to the power plant. At the most distant sampling stations, Olkiluoto S5 and S8, the highest activity concentrations of ^{60}Co were 2.5 Bq kg^{-1} dry wt. in the 5–10 cm layers. As a whole, the amounts of ^{60}Co in sediments have continued to decrease also in the Olkiluoto area in recent years.

Activity concentrations of ^{90}Sr, ^{238}Pu and ^{239,240}Pu in the surface sediment samples taken from the Loviisa area in 2002 and from the Olkiluoto area in 2003 were 1–5 Bq kg^{-1}, 0–0.110 Bq kg^{-1} and 0.77–2.91 Bq kg^{-1} dry wt., respectively. These values did not diverge from those typical for the Gulf of Finland and Bothnian Sea.

5.5 Measurements of environmental gamma radiation

The results of the measurements made at the dosimeter stations in 2002 are provided in Table XXXII. The values ranged from 0.13 to 0.22 μSv h^{-1} in the Loviisa area and from 0.09 to 0.14 μSv h^{-1} in the Olkiluoto area. Table XXXIII shows the fallout nuclides observed in the spectrometric measurements of the gamma radiation in the open field locations. No fission products were observed during the direct spectroscopic measurements of atmospheric releases.

5.6 Dose estimates based on reported discharge data

The radiation doses to the public from the discharges of the Finnish nuclear power plants were estimated using the VALTO computer model developed at STUK. The calculations are based on the discharge and meteorological data reported to STUK by the power companies. The effective dose commitments in 2002–2004 are summarised below.

		From airborne discharges	From aquatic discharges	Sum
Individual dose (µSv)				
Loviisa	2002	0.039	0.015	0.054
	2003	0.037	0.015	0.052
	2004	0.036	0.19	0.22
Olkiluoto	2002	0.021	0.045	0.066
	2003	0.016	0.027	0.043
	2004	0.014	0.023	0.037
Collective dose				
Loviisa	2002	5.3×10^{-4}	7.1×10^{-6}	5.4×10^{-4}
	2003	6.2×10^{-4}	7.3×10^{-6}	6.3×10^{-4}
	2004	5.6×10^{-4}	1.2×10^{-4}	6.8×10^{-4}
Olkiluoto	2002	2.9×10^{-4}	5.3×10^{-5}	3.4×10^{-4}
	2003	2.7×10^{-4}	3.1×10^{-5}	3.0×10^{-4}
	2004	1.5×10^{-4}	2.7×10^{-5}	1.8×10^{-4}

The collective doses were calculated for the population residing within 80 km of the power plant. The dose estimates do not include ^{14}C releases, which are reported as calculated from energy output figures.

Individual doses to the hypothetical critical group since the beginning of power production by the NPPs are presented in Fig. 44. In 2004, the dose for the critical group at Loviisa increased about fourfold compared with the previous two years. This was mainly due to the aquatic discharges of ^{60}Co, which increased more than two orders of magnitude compared with the year 2000 (cf. Chapter 2).

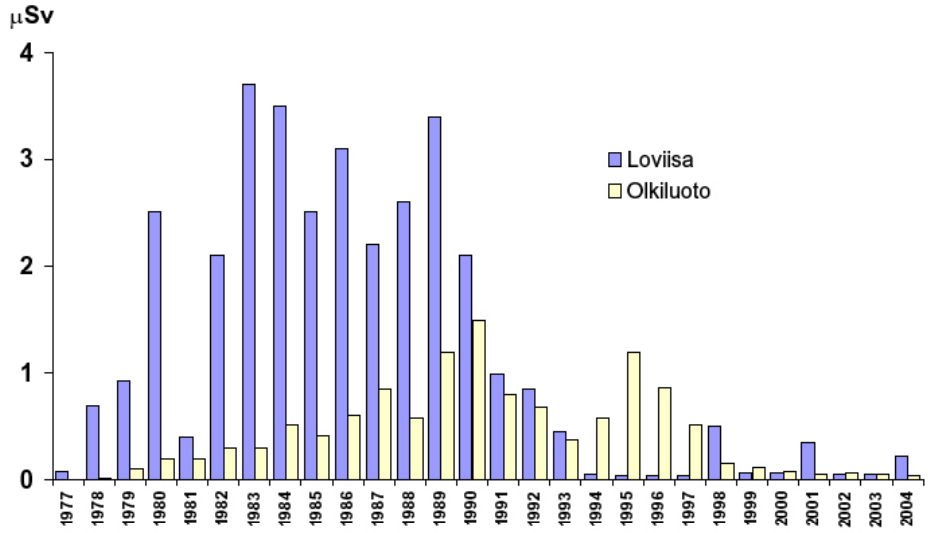

Figure 46. Average doses to critical groups in the vicinities of Finnish NPPs since the beginning of power production.

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Table Ia. The concentration of gamma-emitting nuclides in ground-level air at the Loviisa 21 and Loviisa 27 sampling stations in 2002–2004 (μBq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling period	Loviisa 21				Loviisa 27			
	^{7}Be		^{137}Cs		^{7}Be		^{137}Cs	
28.12.2001 - 8.1.2002	1710	5	2.4	14	1730	5	3.5	11
8.1.2002 - 22.1.2002	1420	3	<		1360	4	2.8	12
22.1.2002 - 5.2.2002	1950	3	2.4	7	1650	5	4.0	12
5.2.2002 - 10.2.2002	1440	3	1.0	15	1250	3	1.9	9
10.2.2002 - 5.3.2002	1770	3	1.5	18	1440	6	<	
5.3.2002 - 19.3.2002	2190	3	1.9	9	2060	3	2.2	9
19.3.2002 - 2.4.2002	2620	3	2.5	7	2580	3	4.2	5
2.4.2002 - 16.4.2002	4600	3	4.2	5	4500	3	6.2	4
16.4.2002 - 30.4.2002	2240	5	2.0	15	2520	4	3.0	10
30.4.2002 - 14.5.2002	3000	5	3.6	16	3100	3	4.6	7
14.5.2002 - 28.5.2002	2650	3	2.6	10	2470	5	3.6	10
28.5.2002 - 11.6.2002	4600	3	8.0	4	4400	3	6.1	4
11.6.2002 - 26.6.2002	2360	3	2.3	7	2230	5	2.2	16
26.6.2002 - 9.7.2002	2700	4	2.2	14	2520	3	2.0	15
9.7.2002 - 23.7.2002	3500	3	3.3	10	3400	3	3.2	9
23.7.2002 - 30.7.2002	2120	5	<		2320	5	2.8	28
30.7.2002 - 6.8.2002	3700	3	2.4	22				
6.8.2002 - 13.8.2002	3600	3	1.3	16	3100	5	2.2	14
13.8.2002 - 20.8.2002	3700	3	3.8	8				
20.8.2002 - 27.8.2002	3200	3	2.3	10	2800	3	4.2	10
27.8.2002 - 3.9.2002	2220	5	4.2	14				
3.9.2002 - 10.9.2002	3600	3	4.5	8	1980	5	2.0	30
10.9.2002 - 17.9.2002	1570	5	2.4	27				
17.9.2002 - 24.9.2002	1370	4	1.7	20	1310	5	2.6	11
24.9.2002 - 1.10.2002	1570	3	1.9	12				
1.10.2002 - 8.10.2002	1190	3	2.3	11	1460	5	1.9	17
8.10.2002 - 15.10.2002	1920	5	<					
15.10.2002 - 29.10.2002	1630	4	2.8	10	1530	4	3.2	6
29.10.2002 - 12.11.2002	1600	3	2.2	13	1630	4	2.0	14
12.11.2002 - 26.11.2002	980	4	1.4	8	940	5	1.8	7
26.11.2002 - 10.12.2002	3000	3	3.7	8	2760	3	3.9	10
10.12.2002 - 23.12.2002	1600	3	1.7	7	1620	3	2.5	7
23.12.2002 - 7.1.2003	1760	3	5.4	6	1770	3	7.2	6
7.1.2003 - 21.1.2003	1500	4	1.9	7	1480	4	2.3	8
21.1.2003 - 4.2.2003	1480	5	2.4	19	1530	6	3.5	19
4.2.2003 - 18.2.2003	1980	4	2.1	11	1900	4	3.7	10
18.2.2003 - 4.3.2003	3300	5	3.6	17	3900	3	3.2	11

< = below the detection limit

Table Ia. Continued.

Sampling period	Loviisa 21				Loviisa 27			
	^{7}Be		^{137}Cs		^{7}Be		^{137}Cs	
4.3.2003 - 18.3.2003	2490	5	1.6	17	2340	5	2.8	12
18.3.2003 - 1.4.2003	2360	3	1.5	16	2400	3	1.8	14
1.4.2003 - 15.4.2003	1840	4	1.5	21	1680	5	<	
15.4.2003 - 29.4.2003	2350	4	1.9	14	2420	3	3.5	9
29.4.2003 - 13.5.2003	1710	5	0.7	28	1830	5	1.6	15
13.5.2003 - 27.5.2003	1920	3	2.2	14	1620	5	2.6	23
27.5.2003 - 10.6.2003	2360	3	2.3	6	2280	3	2.5	7
10.6.2003 - 24.6.2003	2310	3	5.3	4	2370	3	5.3	8
24.6.2003 - 8.7.2003	2060	5	2.9	22	2020	5	2.1	17
8.7.2003 - 22.7.2003	2600	3	2.7	14	2020	5	3.1	28
22.7.2003 - 5.8.2003	4700	3	1.3	16	5200	5	2.0	25
5.8.2003 - 12.8.2003	2280	3	2.0	11	1800	5	<	
12.8.2003 - 19.8.2003	2380	3	1.9	26				
19.8.2003 - 26.8.2003	1800	3	2.5	18	1230	3	2.4	11
26.8.2003 - 2.9.2003	1040	5	3.7	12				
2.9.2003 - 9.9.2003	1440	4	3.3	12	1390	5	4.1	17
9.9.2003 - 16.9.2003	1760	5	7.3	18				
16.9.2003 - 30.9.2003	1700	5	2.9	19	1640	5	2.1	26
30.9.2003 - 14.10.2003	1110	6	3.0	19	1080	4	3.5	9
14.10.2003 - 28.10.2003	1060	5	2.4	13	1270	5	4.4	8
28.10.2003 - 11.11.2003	1340	4	1.6	8	1340	4	2.4	6
11.11.2003 - 25.11.2003	1330	6	<		1440	4	3.5	16
25.11.2003 - 9.12.2003	1030	4	2.0	12	930	5	2.2	11
9.12.2003 - 23.12.2003	1420	3	1.3	11	1270	4	2.3	10
23.12.2003 - 7.1.2004	1640	3	2.0	13	1630	3	4.1	8
7.1.2004 - 20.1.2004	1350	4	1.1	18	1330	5	2.2	14
20.1.2004 - 3.2.2004	1530	3	1.8	7	1440	3	2.2	8
3.2.2004 - 17.2.2004	1200	5	1.7	17	1320	4	2.2	15
17.2.2004 - 2.3.2004	2160	4	1.6	8	1990	5	2.4	16
2.3.2004 - 16.3.2004	1800	4	2.8	6	1730	3	2.9	6
16.3.2004 - 30.3.2004	1460	3	0.8	11	1490	5	1.5	17
30.3.2004 - 13.4.2004	3700	3	1.6	9	3500	3	2.3	7
13.4.2004 - 27.4.2004	2620	3	1.6	15	2510	3	1.9	12
27.4.2004 - 11.5.2004	4700	3	3.3	16	4700	5	3.8	14
11.5.2004 - 25.5.2004	2340	3	1.8	7	2340	5	2.0	14
25.5.2004 - 8.6.2004	2830	5	2.1	12	2880	5	2.2	30
8.6.2004 - 22.6.2004	2840	3	4.0	8	2860	3	4.0	10
22.6.2004 - 6.7.2004	2400	5	3.4	11	2490	4	3.4	9
6.7.2004 - 20.7.2004	2440	3	1.7	7	2450	3	2.7	13

< = below the detection limit

Table Ia. Continued.

Sampling period	Loviisa 21				Loviisa 27			
	^{7}Be		^{137}Cs		^{7}Be		^{137}Cs	
20.7.2004 - 27.7.2004	2800	3	1.8	13	2450	3	2.2	14
27.7.2004 - 3.8.2004	2020	5	3.0	31				
3.8.2004 - 10.8.2004	5300	3	1.8	22	3200	3	2.0	9
10.8.2004 - 17.8.2004	2100	5	<					
17.8.2004 - 24.8.2004	2320	3	2.7	11	2170	5	3.2	23
24.8.2004 - 31.8.2004	2910	3	3.6	11				
31.8.2004 - 7.9.2004	3500	3	13	7	3200	3	6.2	7
7.9.2004 - 14.9.2004	2920	3	6.2	5				
14.9.2004 - 21.9.2004	3100	3	5.6	11	2170	3	4.9	5
21.9.2004 - 28.9.2004	1600	3	7.1	5				
28.9.2004 - 12.10.2004	1640	3	6.7	7	1510	3	6.8	7
12.10.2004 - 26.10.2004	2120	5	3.1	9	2070	3	3.4	6
26.10.2004 - 9.11.2004	1240	4	1.8	14	1200	3	2.7	12
9.11.2004 - 23.11.2004	1230	5	1.3	18	1180	6	2.9	12
23.11.2004 - 7.12.2004	1220	5	1.0	19	1340	3	1.8	19
7.12.2004 - 21.12.2004	1370	6	1.6	19	1490	5	1.8	25
21.12.2004 - 4.1.2005	1520	3	0.6	29	1320	5	<	

< = below the detection limit

Table Ib. The concentration of gamma-emitting nuclides in ground-level air at the Loviisa 33 and Loviisa 24 sampling stations in 2002–2004 (μBq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling period	Loviisa 33				Loviisa 24			
	^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
2.1.2002 - 15.1.2002	1900	4	1.8	15	1840	3	1.1	23
15.1.2002 - 29.1.2002	1460	4	2.4	7	1340	5	2.0	18
29.1.2002 - 12.2.2002	1520	3	1.0	13	1180	5	<	
12.2.2002 - 26.2.2002	1520	4	1.5	9	1350	5	1.6	18
26.2.2002 - 12.3.2002	1590	4	1.4	17	1550	4	1.4	17
12.3.2002 - 26.3.2002	2530	3	3.1	10	2470	3	3.3	11
26.3.2002 - 9.4.2002	3200	3	1.6	17	3100	3	1.3	17
9.4.2002 - 23.4.2002	3900	3	3.9	8	3700	3	3.8	9
23.4.2002 - 7.5.2002	2770	3	2.6	11	2560	3	2.4	11
7.5.2002 - 21.5.2002	2390	3	3.5	11	2300	3	3.1	11
21.5.2002 - 4.6.2002	3800	3	5.6	5	3400	4	7.6	5
4.6.2002 - 18.6.2002	3200	3	2.7	11	3100	3	2.6	12
18.6.2002 - 2.7.2002	2380	3	1.4	21	2340	3	1.1	19
2.7.2002 - 16.7.2002	3200	3	1.8	15	3000	3	2.5	13
16.7.2002 - 30.7.2002	2280	5	2.0	18	2570	3	2.3	8
30.7.2002 - 13.8.2002	3200	3	1.4	27	2960	5	2.9	27
13.8.2002 - 27.8.2002	3200	3	2.6	13	2670	5	3.5	21
27.8.2002 - 10.9.2002	3000	3	3.7	5	2590	5	6.4	8
10.9.2002 - 24.9.2002	1380	5	2.4	11	1230	5	2.7	12
24.9.2002 - 8.10.2002	1270	3	1.7	18	1140	5	1.9	18
8.10.2002 - 22.10.2002	1640	5	2.1	18	1550	5	2.1	11
22.10.2002 - 5.11.2002	1070	5	1.8	14	1060	5	2.8	10
5.11.2002 - 19.11.2002	1410	5	2.8	9	1310	5	1.6	17
19.11.2002 - 3.12.2002	2130	3	1.3	21	1960	3	1.0	21
3.12.2002 - 17.12.2002	1940	5	3.3	12	1690	5	2.6	16
17.12.2002 - 31.12.2002	1650	5	3.6	13	1510	5	2.9	11
31.12.2002 - 14.1.2003	1240	6	5.8	13	1710	6	6.7	15
14.1.2003 - 28.1.2003	1650	5	0.8	24	1500	5	1.1	26
28.1.2003 - 11.2.2003	1650	4	2.5	12	1420	4	2.6	12
11.2.2003 - 25.2.2003	3300	3	2.8	6	2970	3	2.5	6
25.2.2003 - 11.3.2003	3300	3	0.6	17	3100	3	0.7	18
11.3.2003 - 25.3.2003	2100	3	2.1	8	1960	3	2.0	8
25.3.2003 - 8.4.2003	2200	3	1.4	11	1960	3	1.3	12
8.4.2003 - 22.4.2003	1920	5	2.5	22	1840	5	2.0	23
22.4.2003 - 6.5.2003	1570	3	1.3	23	2280	4	1.3	18
6.5.2003 - 20.5.2003	1890	3	1.8	17	1580	5	<	
20.5.2003 - 3.6.2003	2170	3	2.4	12	1740	5	3.4	21
3.6.2003 - 17.6.2003	2040	5	2.9	20	2160	3	4.0	9

< = below the detection limit

Table Ib. Continued.

Sampling period	Loviisa 33				Loviisa 24			
	^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
17.6.2003 - 1.7.2003	2520	3	2.3	7	2030	5	5.3	20
1.7.2003 - 15.7.2003	1210	5	<		1380	3	4.4	15
15.7.2003 - 29.7.2003	3600	3	1.3	20	3600	3	2.1	15
29.7.2003 - 12.8.2003	3100	5	<		3100	5	1.9	29
12.8.2003 - 26.8.2003	1650	5	1.3	24	1790	4	2.3	11
26.8.2003 - 9.9.2003	1040	3	2.6	10	1040	3	4.9	8
9.9.2003 - 23.9.2003	1700	5	2.5	15	1820	3	5.3	8
23.9.2003 - 7.10.2003	1720	3	1.9	9	1710	3	3.9	5
7.10.2003 - 21.10.2003	900	3	2.5	10	860	3	3.3	8
21.10.2003 - 4.11.2003	1270	4	1.3	10	1110	6	1.9	17
4.11.2003 - 18.11.2003	1520	3	3.3	5	1530	3	1.0	15
18.11.2003 - 2.12.2003	1050	6	2.1	12	940	4	1.7	8
2.12.2003 - 16.12.2003	1100	3	1.3	10	1030	3	1.3	13
16.12.2003 - 30.12.2003	1200	4	1.8	14	-		-	
30.12.2003 - 28.1.2004	1820	5	4.1	16	-		-	
28.1.2004 - 10.2.2004	1320	4	1.4	9	1240	5	1.3	24
10.2.2004 - 24.2.2004	2210[1]	3	2.4	7	2220	3	2.0	7
24.2.2004 - 9.3.2004	1780	3	2.6	7	1790	4	2.2	6
9.3.2004 - 23.3.2004	1220	4	1.8	9	1140	5	<	
23.3.2004 - 6.4.2004	2970	3	1.0	20	1880	5	<	
6.4.2004 - 20.4.2004	2400	5	1.8	13	2150	5	1.7	17
20.4.2004 - 4.5.2004	4000	3	2.0	12	4000	5	2.0	22
4.5.2004 - 18.5.2004	4300	4	4.3	9	3800	5	4.2	12
18.5.2004 - 1.6.2004	1550	5	2.0	22	1660	3	1.3	16
1.6.2004 - 15.6.2004	3400	5	2.7	22	4000	3	5.5	7
15.6.2004 - 29.6.2004	2430	3	3.7	5	2610	5	4.6	8
29.6.2004 - 13.7.2004	2240	5	<		2410	4	1.7	19
13.7.2004 - 27.7.2004	2640	3	1.4	11	2870	3	2.3	13
27.7.2004 - 10.8.2004	3600	3	1.3	22	4000	3	3.5	11
10.8.2004 - 24.8.2004	1850	5	0.6	29	2420[2]	3	2.1[2]	14
24.8.2004 - 7.9.2004	2850	3	3.3	9	3200	3	10	5
7.9.2004 - 21.9.2004	2660	3	3.8	8	2680	6	1.8	23
21.9.2004 - 5.10.2004	1340	3	4.8	5	1250	5	8.9	10
5.10.2004 - 19.10.2004	2160	3	3.5	6	2030	5	4.3	14
19.10.2004 - 2.11.2004	1040	5	2.6	13	1250	5	3.0	9
2.11.2004 - 16.11.2004	1200	6	1.2	28	1240	6	<	
16.11.2004 - 1.12.2004	1210	3	2.0	15	1320	4	1.6	15
1.12.2004 - 14.12.2004	1220	5	<		1320	5	1.3	24
14.12.2004 - 28.12.2004	1470	4	1.0	11	1540	5	<	

< = below the detection limit

- = not determined

[1] = in addition ^{110m}Ag: 1.5 (9)

[2] = in addition: ^{58}Co: 0.8 (27), ^{60}Co: 0.7 (26)

Table IIa. The concentration of gamma-emitting nuclides in ground-level air at the Olkiluoto 22 and Olkiluoto 31 sampling stations in 2002–2004 (μBq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling period	Olkiluoto 22				Olkiluoto 31			
	^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
27.12.2001 - 9.1.2002	2030	5	5.9	9	1870	5	2.4	20
9.1.2002 - 23.1.2002	1070	4	1.2	18	1020	3	1.7	13
23.1.2002 - 6.2.2002	2060	3	3.3	13	1830	5	4.3	14
6.2.2002 - 20.2.2002	970	5	<		1050	3	1.9	12
20.2.2002 - 6.3.2002	1670	3	2.3	12	1690	3	3.7	9
6.3.2002 - 20.3.2002	2180	3	1.7	15	2220	3	2.7	9
20.3.2002 - 3.4.2002	2450	3	3.0	9	2290	5	3.2	12
3.4.2002 - 17.4.2002	3600	7	5.1	6	3200	5	4.1	15
17.4.2002 - 2.5.2002	2550	3	1.9	8	2450	3	3.5	5
2.5.2002 - 8.5.2002	1910	5	5.7	20	2440	3	3.7	8
8.5.2002 - 15.5.2002	2100	5	<					
15.5.2002 - 22.5.2002	1990	3	2.7	16	2900	5	4.3	15
22.5.2002 - 29.5.2002	4200	3	7.4	8				
29.5.2002 - 13.6.2002	3600	3	3.8	7	3500	3	3.0	10
13.6.2002 - 26.6.2002	2410	3	2.1	13	2000	5	1.7	30
26.6.2002 - 10.7.2002	1770	5	2.5	23	1710	5	2.5	16
10.7.2002 - 24.7.2002	2390	5	2.0	27	2630	3	3.1	10
24.7.2002 - 7.8.2002	2560	3	2.8	10	2530	3	2.2	13
7.8.2002 - 21.8.2002	2890	5	4.8	9	3000	5	4.1	8
21.8.2002 - 4.9.2002	2310	5	2.0	14	2500	3	2.9	11
4.9.2002 - 18.9.2002	1750	4	2.2	10	1940	5	3.1	18
18.9.2002 - 2.10.2002	1250	3	2.1	11	1170	5	3.3	13
2.10.2002 - 16.10.2002	1850	3	3.2	10	1720	3	4.2	7
16.10.2002 - 30.10.2002	1380	5	1.8	15	1440	4	3.1	7
30.10.2002 - 13.11.2002	1370	6	1.9	12	1510	4	3.2	7
13.11.2002 - 20.11.2002					890	4	2.1	9
20.11.2002 - 28.11.2002	2110	5	2.0	16				
28.11.2002 - 11.12.2002					2890	4	4.0	10
11.12.2002 - 23.12.2002	1310	6	1.7	19	1180	5	2.3	21
23.12.2002 - 8.1.2003	1650	5	6.0	7	1650	5	6.7	6
8.1.2003 - 22.1.2003	1370	4	2.0	14	1350	4	2.7	9
22.1.2003 - 5.2.2003	1290	5	1.6	25	1410	4	3.6	10
5.2.2003 - 19.2.2003	2070	4	2.4	12	1770	5	3.3	15
19.2.2003 - 5.3.2003	3400	4	3.5	7	3600	3	5.7	6
5.3.2003 - 19.3.2003	1830	5	1.4	27	1720	6	2.1	21
19.3.2003 - 2.4.2003	2360	5	2.3	22	2510	4	3.0	9
2.4.2003 - 16.4.2003	1620	5	2.0	10	1690	4	2.3	6
16.4.2003 - 30.4.2003	2130	3	2.2	6	2040	3	3.4	5

< = below the detection limit

Table IIa. Continued.

Sampling period	Olkiluoto 22				Olkiluoto 31			
	^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
30.4.2003 - 14.5.2003	1860	4	1.3	17	1860	3	1.6	14
14.5.2003 - 21.5.2003	2260	3	1.7	15	1820	3	2.5	9
21.5.2003 - 28.5.2003	1670	4	2.1	17				
28.5.2003 - 4.6.2003	1760	3	1.0	31	1870	5	1.7	13
4.6.2003 - 11.6.2003	2200	5	2.2	15				
11.6.2003 - 25.6.2003	2570	3	2.0	7	2290	5	2.0	15
25.6.2003 - 9.7.2003	2340	3	2.4	12	2140	5	2.0	22
9.7.2003 - 23.7.2003	2290	5	1.6	18	2320	3	1.3	17
23.7.2003 - 6.8.2003	3200	3	1.2	10	2860	5	2.6	14
6.8.2003 - 20.8.2003	2400	3	1.6	7	2320	3	1.4	8
20.8.2003 - 3.9.2003	1070	3	2.1	11	1010	4	1.2	25
3.9.2003 - 17.9.2003	1870	5	3.4	14	1340	5	2.0	24
17.9.2003 - 1.10.2003	1570	5	2.3	21	1640	4	2.2	14
1.10.2003 - 15.10.2003	1140	3	1.8	12	1080	4	3.0	8
15.10.2003 - 29.10.2003	860	6	2.0	21	1120	5	4.5	10
29.10.2003 - 12.11.2003	1060	6	2.0	13	1320	5	1.4	13
12.11.2003 - 26.11.2003	1120	4	1.4	9	1030	6	1.6	15
26.11.2003 - 10.12.2003	880	4	2.0	10	750	4	1.5	12
10.12.2003 - 23.12.2003	1530	5	1.5	17	1150	5	3.1	13
23.12.2003 - 7.1.2004	1500	3	1.9	11	1550	3	2.8	9
7.1.2004 - 21.1.2004	1400	4	1.9	8	1240	6	2.4	12
21.1.2004 - 4.2.2004	1380	5	1.8	14	1420	5	2.9	10
4.2.2004 - 18.2.2004	1240	4	2.4	10	1030	5	1.9	25
18.2.2004 - 3.3.2004	1480	3	2.3	11	1520	3	3.2	10
3.3.2004 - 17.3.2004	1770	4	3.9	13	1340	5	3.6	9
17.3.2004 - 31.3.2004	1420	5	2.0	23	1580	4	1.6	19
31.3.2004 - 14.4.2004	3000	4	1.6	12	2770	5	2.9	13
14.4.2004 - 28.4.2004	3100	3	2.9	10	3100	3	2.7	9
28.4.2004 - 12.5.2004	4200	4	3.6	9	4200	3	4.1	6
12.5.2004 - 19.5.2004	2500	3	1.9	17	1570	3	1.7	17
19.5.2004 - 26.5.2004	760	5	1.6	30				
26.5.2004 - 2.6.2004	1930	3	1.5	14	3100	3	1.8	12
2.6.2004 - 9.6.2004	4200	3	2.1	16				
9.6.2004 - 24.6.2004	1930	5	2.6	18	1830	4	2.0	18
24.6.2004 - 7.7.2004	1920	3	1.2	15	1730	3	1.4	28
7.7.2004 - 20.7.2004	1980	5	1.1	18	1470	5	1.1	23
20.7.2004 - 4.8.2004	2360	3	1.9	12	2370	3	2.8	9
4.8.2004 - 18.8.2004	2890	3	1.7	14	2830	3	1.6	8

< = below the detection limit

Table IIa. Continued.

Sampling period			Olkiluoto 22				Olkiluoto 31			
			^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
18.8.2004	-	1.9.2004	1890	4	1.0	20	1680	5	2.8	22
1.9.2004	-	15.9.2004	2740	3	1.8	15	2340	5	3.0	24
15.9.2004	-	29.9.2004	1550	3	3.2	9	1170	5	3.2	16
29.9.2004	-	13.10.2004	2040	5	3.0	13	1460	5	3.7	14
13.10.2004	-	27.10.2004	2040	4	2.2	7	1760	5	3.2	11
27.10.2004	-	10.11.2004	1090	3	0.9	23	1070	4	1.9	12
10.11.2004	-	24.11.2004	1090	3	1.8	15	880	5	3.5	17
24.11.2004	-	8.12.2004	1300	6	1.6	17	1160	4	1.9	13
8.12.2004	-	22.12.2004	1380	6	<		1360	5	<	
22.12.2004	-	5.1.2005	1580	5	0.9	26	1610	4	1.5	18

< = below the detection limit

Table IIb. The concentration of gamma-emitting nuclides in ground-level air at the Olkiluoto 26 and Olkiluoto 37 sampling stations in 2002–2004 (μBq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling period	Olkiluoto 26				Olkiluoto 37			
	^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
2.1.2002 - 16.1.2002	1690	5	<		1830	3	1.0	21
16.1.2002 - 30.1.2002	1440	4	14	5	1300	5	3.6	16
30.1.2002 - 13.2.2002	1200	4	2.2	24	1140	6	<	
13.2.2002 - 27.2.2002	1550	3	7.3	4	1610	3	2.2	7
27.2.2002 - 13.3.2002	1810	4	12	5	1760	3	2.8	9
13.3.2002 - 27.3.2002	2270	5	15	7	2330	5	3.1	14
27.3.2002 - 10.4.2002	2890	3	5.7	6	2660	5	2.8	14
10.4.2002 - 24.4.2002	3400	3	7.6	5	3300	3	3.9	8
24.4.2002 - 8.5.2002	2150	3	6.7	5	2110	3	2.2	10
8.5.2002 - 22.5.2002	1960	5	7.8	10	1860	4	4.7	9
22.5.2002 - 5.6.2002	3400	5	6.2	7	3600	5	6.2	6
5.6.2002 - 19.6.2002	2910	3	2.7	9	2870	5	3.1	20
19.6.2002 - 3.7.2002	1650	5	2.1	15	1740	3	1.0	17
3.7.2002 - 17.7.2002	1930	5	4.1	17	2050	3	1.5	18
17.7.2002 - 31.7.2002	2430	3	4.8	7	2240	5	1.6	15
31.7.2002 - 14.8.2002	3400	3	4.0	5	3100	5	3.5	9
14.8.2002 - 28.8.2002	3100	3	3.4	8	3100	3	2.6	11
28.8.2002 - 11.9.2002	2050	4	3.8	11	1900	5	3.0	15
11.9.2002 - 25.9.2002	1330	3	15	4	1330	3	2.6	11
25.9.2002 - 9.10.2002	1110	5	49	6	1200	3	4.1	7
9.10.2002 - 23.10.2002	1600	4	52	3	1480	5	4.2	9
23.10.2002 - 7.11.2002	1610	4	3.8	8	1290	5	2.4	11
7.11.2002 - 20.11.2002	1180	4	3.4	9	1120	5	2.0	19
20.11.2002 - 4.12.2002	2190	3	4.1	8	1880	5	2.9	17
4.12.2002 - 18.12.2002	1820	5	4.9	20	1750	5	3.2	9
18.12.2002 - 30.12.2002	1600	5	8.3	10	1550	5	2.7	15
30.12.2002 - 15.1.2003	1320	4	8.3	6	1080	4	4.7	7
15.1.2003 - 29.1.2003	1430	5	4.1	4	1210	4	1.4	9
29.1.2003 - 12.2.2003	1440	4	13	9	1170	5	2.2	10
12.2.2003 - 26.2.2003	3000	5	3.7	9	2770	4	2.8	9
26.2.2003 - 13.3.2003	2750	4	2.8	9	2170	4	4.7	22
13.3.2003 - 26.3.2003	1540	5	5.6	13	1430	5	1.9	21
26.3.2003 - 9.4.2003	2160	4	9.9	4	1890	4	2.2	10
9.4.2003 - 23.4.2003	2220	3	3.8	6	1980	3	2.1	7
23.4.2003 - 7.5.2003	1590	3	3.9	5	1320	3	1.2	10
7.5.2003 - 21.5.2003	2040	5	1.9	16	1860	5	1.8	13
21.5.2003 - 4.6.2003	1670	5	2.6	14	1410	5	1.2	31
4.6.2003 - 18.6.2003	2230	4	3.7	7	2050	3	1.8	11

< = below the detection limit

Table IIb. Continued.

Sampling period	Olkiluoto 26				Olkiluoto 37			
	^{7}Be		^{137}Cs		^{57}Be		^{137}Cs	
18.6.2003 - 2.7.2003	3000	3	4.7	8	3200	5	2.5	18
2.7.2003 - 16.7.2003	1530	3	2.8	11	1310	3	1.1	19
16.7.2003 - 30.7.2003	3200	3	1.8	9	2470	5	<	
30.7.2003 - 13.8.2003	2750	3	2.6	8	2420	3	1.1	19
13.8.2003 - 28.8.2003	1870	3	4.4	8	1580	5	2.1	22
28.8.2003 - 10.9.2003	1330	5	3.4	13	930	4	2.5	15
10.9.2003 - 24.9.2003	1720	3	2.7	10	1650	3	1.4	14
24.9.2003 - 8.10.2003	1490	3	3.1	18	1330	3	1.6	14
8.10.2003 - 22.10.2003	1010	4	5.4	5	920	3	2.7	9
22.10.2003 - 5.11.2003	1070	5	2.0	10	860	6	<	
5.11.2003 - 20.11.2003	1100	5	2.1	13	1170	5	1.7	10
20.11.2003 - 3.12.2003	750	4	2.1	11	680	4	1.2	14
3.12.2003 - 17.12.2003	1020	5	2.2	11	990	5	1.8	16
17.12.2003 - 30.12.2003	1030	6	5.1	8	1090	3	1.6	9
30.12.2003 - 28.1.2004	1830	5	2.8	15	1670	5	1.4	17
28.1.2004 - 11.2.2004	1050	4	5.5	6	1020	4	2.7	10
11.2.2004 - 25.2.2004	1770	3	8.7	5	1740	4	2.4	12
25.2.2004 - 10.3.2004	1350	3	10	8	1270	3	4.0	7
10.3.2004 - 24.3.2004	1180	5	3.3	9	1140	5	1.5	16
24.3.2004 - 6.4.2004	2760	5	3.6	10	2830	5	2.5	10
6.4.2004 - 21.4.2004	2560	3	2.4	5	2480	3	1.9	8
21.4.2004 - 5.5.2004	4000	5	3.2	12	3900	3	4.0	7
5.5.2004 - 19.5.2004	3300	3	6.3	5	2880	5	3.9	13
19.5.2004 - 2.6.2004	1530	3	2.6	7	1190	5	1.1	21
2.6.2004 - 16.6.2004	3000	4	2.7	6	2960	3	1.6	8
16.6.2004 - 30.6.2004	1950	3	2.0	11	1990	3	2.3	9
30.6.2004 - 14.7.2004	1640	4	1.6	15	1440	5	<	
14.7.2004 - 28.7.2004	2210	3	7.0	6	2120	3	0.9	30
28.7.2004 - 11.8.2004	3100	3	3.6	5	3100	3	1.9	12
11.8.2004 - 25.8.2004	1710	4	2.6	9	1670	3	1.4	18
25.8.2004 - 7.9.2004	2420	3	2.7	10	2290	3	1.6	16
7.9.2004 - 22.9.2004	2110	6	2.2	20	2130	5	1.8	15
22.9.2004 - 6.10.2004	1060	5	4.8	14	1160	5	3.7	13
6.10.2004 - 20.10.2004	2330	3	7.0	9	1980	5	2.6	16
20.10.2004 - 4.11.2004	1400	4	2.6	9	1350	3	1.8	15
4.11.2004 - 17.11.2004	1010	4	2.0	13	850	6	<	
17.11.2004 - 1.12.2004	1030	5	3.3	17	950	6	2.3	20
1.12.2004 - 15.12.2004	1340	6	1.9	21	1400	6	1.1	27
15.12.2004 29.12.2004	1750	4	1.8	8	1550[1]	5	1.3[1]	24

< = below the detection limit [1] = in addition ^{60}Co: 2.4 (11)

Table IIIa. The concentration of gamma-emitting radionuclides in supplementary samples of ground-level air at the Loviisa 33 sampling station in 2002–2004 (μBq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling period			^{7}Be		^{137}Cs	
2002						
16.7.2002	-	22.7.2002	3000	5	2.41	7
22.7.2002	-	29.7.2002	1750	3	1.30	9
29.7.2002	-	5.8.2002	3000	3	1.76	7
5.8.2002	-	12.8.2002	2400	5	0.81	25
12.8.2002	-	19.8.2002	3300	3	2.86	5
19.8.2002	-	26.8.2002	2770	3	2.18	6
26.8.2002	-	2.9.2002	2400	3	4.4	4
2.9.2002	-	9.9.2002	2640	3	2.83	9
9.9.2002	-	16.9.2002	1590	3	1.69	11
2003						
28.7.2003	-	4.8.2003	4700	3	1.23	9
4.8.2003	-	11.8.2003	2200	3	2.47	6
11.8.2003	-	28.8.2003	1770	3	1.40	18
28.8.2003	-	25.8.2003	1650	5	1.61	15
25.8.2003	-	1.9.2003	830	3	2.27	6
1.9.2003	-	8.9.2003	1050	3	3.7	9
2004						
19.7.2004	-	26.7.2004	2890	3	1.62	7
26.7.2004	-	2.8.2004	1830	5	1.47	19
2.8.2004	-	9.8.2004	4500	3	1.69	7
9.8.2004	-	16.8.2004	2100	3	2.03	6
16.8.2004	-	23.8.2004	2080	3	1.83	10
23.8.2004	-	30.8.2004	2360	3	1.90	7
30.8.2004	-	6.9.2004	3100	3	5.0	4
6.9.2004	-	13.9.2004	2570	3	5.6	6
13.9.2004	-	20.9.2004	2570	3	8.1	4
20.9.2004	-	27.9.2004	1610	3	7.4	5
27.9.2004	-	1.10.2004	1110	3	8.0	5

Table IIIb. The concentration of gamma-emitting radionuclides in supplementary samples of ground-level air at the Olkiluoto 33 sampling station in 2002–2004 (μBq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling period		^{7}Be		^{60}Co		^{137}Cs	
2002							
2.5.2002	6.5.2002	2550	3	<		2.88	7
6.5.2002	13.5.2002	1980	5	<		4.6	8
13.5.2002	20.5.2002	2040	3	0.55	15	4.3	5
20.5.2002	27.5.2002	4200	3	<		4.1	5
27.5.2002	30.5.2002	5900	3	<		17.8	4
2003							
8.5.2003	12.5.2003	1570	3	<		0.98	20
12.5.2003	19.5.2003	2380	5	<		1.68	15
19.5.2003	26.5.2003	2200	3	<		3.2	7
26.5.2003	2.6.2003	1890	5	<		2.28	14
2.6.2003	5.6.2003	2210	5	<		<	
2004							
3.5.2004	6.5.2004	4200	3	<		5.6	5
6.5.2004	10.5.2004	5800	3	<		8.8	4
10.5.2004	17.5.2004	2740	3	<		2.48	7
17.5.2004	24.5.2004[1]	1480	3	<		1.56	14
24.5.2004	31.5.2004	1330	3	<		1.82	6
31.5.2004	7.6.2004	4600	3	<		3.5	4

< = below the detection limit

[1] = in addition ^{51}Cr, ^{54}Mn, ^{59}Fe, ^{57}Co, ^{58}Co, ^{60}Co, ^{65}Zn, ^{124}Sb, activities, see text.

Table IVa. Monthly deposits of gamma-emitting nuclides at the Loviisa 20 sampling station (Bq m^{-2}) in 2002–2004. Area of the collector is 1 m^2. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Month	^{7}Be		^{54}Mn		^{60}Co		^{110m}Ag		^{137}Cs	
2002										
January	73	3	0		0.010	17	0.031	9	0.258	3
February	62	3	0		0		0		0.237	5
March	34	3	0		0		0		0.170	5
April	20.0	5	0		0		0		0.106	7
May	34	5	0		0.020	19	0		0.400	5
June	97	5	0		0		0		0.252	5
July	103	3	0		0		0		0.203	3
August	6.1	4	0		0		0		0.110	6
September	15.2	3	0		0		0		0.103	4
October	41	3	0		0		0		0.127	5
November	30	3	0		0		0		0.126	4
December	18.9	3	0		0		0		0.138	4
Annual total									2.23	
2003										
January	53	3	0		0		0		0.195	3
February	6.7	3	0		0		0		0.034	12
March	12.0	3	0		0		0		0.065	8
April	24.3	5	0		0		0		0.163	8
May	85	3	0		0		0		0.189	4
June	140	3	0		0.011	15	0.022	12	0.45	3
July	78	3	0		0.009	17	0		0.174	4
August	93	3	0		0		0		0.116	4
September	44	5	0		0		0		0.100	9
October	52	3	0		0		0		0.100	4
November	56	3	0		0		0		0.068	5
December	65	3	0		0		0		0.113	7
Annual total									1.77	
2004										
January	15.7	3	0		0		0		0.053	6
February	35	3	0		0		0		0.088	6
March	42	3	0		0		0		0.097	4
April	25.9	3	0		0		0		0.089	4
May	64	3	0		0.017	16	0		0.32	4
June	133	3	0		0.034	11	0		0.35	4
July	132	3	0		0		0		0.149	5
August	171	3	0		0.029	14	0.086	15	0.207	5
September[a]	144	3	0.006	30	0.010	16	0.026	14	0.103	4
October	76	5	0		0		0		0.094	13
November	56	5	0		0		0.062	14	0.088	13
December	32	3	0		0		0		0.114	6
Annual total									1.75	

0 = below the detection limit

[a] = in addition ^{124}Sb 0.011 Bq/m^2 ± 30%

Table IVb. Monthly deposits of gamma-emitting nuclides at the Olkiluoto 21 sampling station (Bq m^{-2}) in 2002–2004. Area of the collector is 1 m^2. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Month	^{7}Be		^{137}Cs	
2002				
January	65	5	0.172	6
February	54	3	0.173	5
March	29.1	3	0.123	6
April	10.0	3	0.132	4
May	61	3	0.54	3
June	115	3	0.44	3
July	149	3	0.46	3
August	24.4	3	0.165	6
September	45	3	0.287	3
October	22.2	3	0.244	4
November	58	3	0.125	4
December	12.4	3	0.113	4
Annual total			2.97	
2003				
January	47	3	0.144	4
February	10.6	4	0.105	6
March	25.0	3	0.161	5
April	15.1	5	0.144	10
May	151	5	0.243	5
June	64	3	0.35	3
July	21.4	3	0.206	3
August	94	3	0.33	4
September	36	3	0.231	3
October	46	3	0.184	5
November	58	3	0.117	4
December	36	3	0.162	6
Annual total			2.38	
2004				
January	36	3	0.089	4
February	33	3	0.106	7
March	23.9	3	0.099	4
April	16.5	5	0.081	9
May	67	5	0.41	5
June	66	3	0.287	3
July	89	5	1.70	5
August	98	3	0.281	4
September	92	3	0.289	3
October	43	5	0.074	14
November	43	3	0.125	4
December	44	3	0.108	6
Annual total			3.65	

Table V. Quarterly deposits of ^{90}Sr at the Loviisa 20 and Olkiluoto 21 sampling stations (Bq m^{-2}) in 2002–2004. Area of the collector is 1 m^2. The uncertainties (1σ) include statistical, calibration and analytical uncertainty.

	Loviisa 20		Olkiluoto 21	
2002				
Jan - Mar	0		0	
Apr - Jun	0		0.030	8
Jun - Sep	0.080	21	0.043	7
Sep - Dec	0.030	9	0.120	6
2003				
Jan - Mar	0		0	
Apr - Jun	0.041	8	0	
Jul - Sep	0.053	16	0.051	10
Oct - Dec	0		0.080	6
2004				
Jan - Mar	0		0	
Apr - Jun	0.120	15	0.050	25
Jul - Sep	0.210	14	0.67	20
Oct - Dec	0.055	20	0.220	20

0 = below the detection limit of 0.03 Bq m^{-2}

Table VIa. Quarterly deposits of gamma-emitting nuclides at the Loviisa sampling stations (Bq m^{-2}) in 2002–2004. Area of the collector is 0.07 m^2. The uncertainties (1σ) include both statistical and calibration uncertainty.

	^{7}Be		^{60}Co	^{137}Cs	
2002					
Loviisa 24					
Jan - Mar	118	4	0	0.94	8
Apr - Jun	186	3	0	1.42	4
Jul - Sep	102	5	0	1.32	9
Oct - Dec	101	4	0	0.91	8
			Annual total	**4.59**	
Loviisa 33					
Jan - Mar	171	3	0	0.58	6
Apr - Jun	242	5	0	0.79	9
Jul - Sep	105	7	0	0.39	30
Oct - Dec	107	3	0	0.50	8
			Annual total	**2.26**	
Loviisa 27					
Jan - Mar	160	3	0	0.55	8
Mar - Jun	275	5	0	0.97	8
Jun - Oct	142	4	0	0.81	12
Oct - Dec	105	4	0	0.38	14
			Annual total	**2.71**	
2003					
Loviisa 24					
Jan - Mar	42	8	0	0.88	16
Apr - Jun	300	3	0	1.29	4
Jul - Sep	196	4	0	1.17	6
Sep - Dec	183	4	0	1.51	7
			Annual total	**4.85**	
Loviisa 33					
Jan - Mar	65	4	0	0.21	21
Apr - Jun	460	3	0	0.91	5
Jul - Sep	259	5	0	0.68	14
Oct - Dec	211	5	0	0.36	20
			Annual total	**2.16**	
Loviisa 27					
Jan - Mar	59	7	0	0.61	17
Apr - Jun	510	5	0	1.46	6
Jul - Sep	219	5	0	0	
Oct - Dec	218	3	0	0.30	11
			Annual total	**2.37**	

0 = below the detection limit

Table VIa. Continued.

			^{7}Be		^{60}Co		^{137}Cs	
2004								
Loviisa 24								
Jan	-	Mar	105	4	0.266	17	0.32	16
Apr	-	Jun	330	3	0		1.46	7
Jul	-	Sep	440	3	0		1.43	4
Oct	-	Dec	136	4	0		1.02	9
					Annual total		**4.23**	
Loviisa 33								
Jan	-	Mar	141	4	0		0.34	21
Apr	-	Jun	152	5	0		0.52	11
Jul	-	Sep	520	3	0		0.53	12
Oct	-	Dec	208	3	0		0.48	14
					Annual total		**1.87**	
Loviisa 27								
Jan	-	Mar	117	4	0		0	
Apr	-	Jun	300	5	0		1.01	10
Jul	-	Sep	550	3	0		1.03	7
Oct	-	Dec	213	5	0		0.82	15
					Annual total		**2.86**	

0 = below the detection limit

Table VIb. Quarterly deposits of gamma-emitting nuclides at the Olkiluoto sampling stations (Bq m^{-2}) in 2002–2004. Area of the collector is 0.07 m^2. The uncertainties (1σ) include both statistical and calibration uncertainty.

	^{7}Be	^{54}Mn	^{60}Co	^{137}Cs
2002				
Olkiluoto 31				
Jan - Mar	142 4	0	0	0.64 10
Apr - Jun	229 5	0	0	0.99 9
Jul - Sep	202 3	0	0	0.71 6
Oct - Dec	74 4	0.57 11	0.229 18	0.31 17
			Annual total	**2.65**
Olkiluoto 26				
Jan - Mar	179 3	0	0	0.45 15
Apr - Jun	273 5	0	0	1.17 9
Jul - Sep	234 4	0	0	1.15 7
Oct - Dec	98 3	0	0	1.14 5
			Annual total	**3.91**
Olkiluoto 37				
Jan - Mar	134 4	0	0	0.41 15
Apr - Jun	251 3	0	0	0.76 5
Jul - Sep	262 3	0	0	1.30 5
Oct - Dec	80 4	0	0	0.20 26
			Annual total	**2.67**
2003				
Olkiluoto 31				
Jan - Mar	68 4	0	0	0.54 6
Apr - Jun	231 3	0	0	0.82 8
Jul - Sep	108 5	0	0	0.30 21
Oct , Dec	125 6	0	0	0
			Annual total	**1.66**
Olkiluoto 26				
Jan - Mar	83 6	0	0	0.34 17
Apr - Jun	277 3	0	0	0.75 6
Jul - Sep	146 3	0	0	0.51 12
Oct - Dec	195 4	0	0	0.36 25
			Annual total	**1.96**
Olkiluoto 37				
Jan - Mar	65 5	0	0	0.25 28
Apr - Jun	204 5	0	0	0.38 26
Jul - Sep	133 4	0	0	0.40 12
Oct - Dec	148 5	0	0	0.62 21
			Annual total	**1.65**

0 = below the detection limit

Table VIb. Continued.

	^{7}Be		^{54}Mn	^{60}Co	^{137}Cs	
2004						
Olkiluoto 31						
Jan - Mar	79	7	0	0	0	
Apr - Jun	181	3	0	0	0.73	8
Jul - Sep	274	5	0	0	0.68	10
Oct , Dec	121	5	0	0	0.51	16
				Annual total	**1.92**	
Olkiluoto 26						
Jan - Mar	98	4	0	0	0.54	14
Apr - Jun	166	4	0	0	0.74	9
Jul - Sep	320	3	0	0	0.58	7
Oct - Dec	188	5	0	0	0.41	13
				Annual total	**2.27**	
Olkiluoto 37						
Jan - Mar	70	6	0	0	0.30	29
Apr - Jun	194	3	0	0	1.02	7
Jul - Sep	340	3	0	0	0.70	9
Oct - Dec	164	4	0	0	0.29	21
				Annual total	**2.31**	

0 = below the detection limit

Table VII. The amounts of ^{90}Sr and gamma-emitting nuclides in soil samples taken from the vicinity of the Loviisa nuclear power station in 2004 (Bq kg^{-1} dry weight). The relative uncertainties (1σ) include both statistical and calibration uncertainty.

Station	Sampling depth cm	^{40}K		^{90}Sr		^{134}Cs		^{137}Cs	
Loviisa 42									
	0-2	510	5	25.3	5	1.89	14	990	4
	2-4	740	8	14.3	5	2.67	18	1370	3
	4-6	890	4	8.2	5	0		360	4
	6-8	840	4	-		0		75	5
	8-10	1010	8	-		0		24.3	4
	10-20,5	900	3	-		0		4.0	3
						Total Bq m^{-2}			18600
Loviisa 43									
	0-2	590	5	3.5	6	1.97	19	790	4
	2-4	660	5	2.28	6	0		820	4
	4-6	660	5	1.96	6	1.36	17	720	4
	6-8	670	5	-		0.71	29	640	4
	8-10	680	5	-		0.71	18	440	4
	10-21	690	5	-		0		32	4
						Total Bq m^{-2}			27300
Loviisa 45									
	0-2	740	16	3.3	6	0		340	4
	2-4	0		5.1	6	4.8	15	1880	4
	4-6	174	8	9.5	6	10.9	13	5500	4
	6-8	610	5	-		4.5	11	2160	4
	8-10	340	6	-		1.83	26	620	4
	10-21	660	4	-		0		41	4
						Total Bq m^{-2}			23500

0 = below the detection limit
- = not analysed

Table VIII. ^{90}Sr and gamma-emitting nuclides in hair moss at Loviisa and Olkiluoto in 2002–2004 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

	^{7}Be		^{40}K		^{90}Sr		^{134}Cs		^{137}Cs	
Loviisa 32										
21.5.2002	241	5	259	6	-		4.3	4	1230	5
25.9.2002	156	4	330	4	2.27	6	1.53	8	530	4
25.9.2003	294	5	350	6	1.65	6	1.60	7	840	5
20.9.2004	580	4	299	5	2.19	5	1.79	10	1110	4
Olkiluoto 32										
3.6.2002	171	5	267	5	-		1.19	11	340	4
1.10.2002	273	4	275	5	1.65	6	1.60	10	490	5
21.7.2003	46	8	171	6	1.40	5	0		208	4
26.7.2004	174	5	168	5	1.25	6	0.61	14	244	4

- = not analysed
0 = below the detection limit

Table IX. Gamma-emitting nuclides in grazing grass in a zone extending 10 km from the Loviisa and Olkiluoto power plants in 2002–2004 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

	^{7}Be		^{40}K		^{137}Cs	
Loviisa 22						
2.7.2002	60	6	780	5	1.75	12
15.8.2002	37	8	910	4	0.97	22
3.7.2003	32	7	800	5	1.83	10
7.8.2003	72	5	600	5	0.79	17
8.7.2004	66	5	800	4	1.68	13
12.8.2004	148	5	560	5	2.59	7
Olkiluoto						
5.6.2002	6.7	12	880	5	0.97	13
14.8.2002	37	7	960	5	1.43	13
11.6.2003	38	6	890	4	2.17	10
28.8.2003	41	5	780	5	1.91	8
22.6.2004	28.7	6	670	5	0.69	17
25.8.2004	74	5	940	5	1.24	11

Table X. Gamma-emitting nuclides in pine needle, fern and lichen samples at Loviisa and Olkiluoto in 2002–2004 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Date	Dry matter %	^{7}Be		^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
Pine needles											
Loviisa 35											
4.9.2002	45.8	26.8	9	150	6	0		0.71	15	226	5
4.9.2003	44.7	28.8	9	161	5	0		0		218	4
2.9.2004	37.9	83	5	137	5	0		0		182	4
Olkiluoto 21											
27.6.2002	46.5	35	6	120	5	0		0		25.8	4
18.6.2003	56.3	30	6	100	5	0		0		60	4
22.6.2004	54.3	35	7	107	5	0		0.37	20	207	4
Fern											
Loviisa 29											
5.8.2003	47.7	34	11	590	5	0		12.5	3	4700	5
24.8.2004	28.4	0		450	4	0		13.6	3	7300	4
Olkiluoto 34/39											
11.12.2003	33.2	108	5	460	4	0		6.4	3	2910	4
18.8.2004	28.3	19.8	16	480	4	0		2.04	11	1250	4
Reindeer lichen											
Loviisa 35											
16.8.2002	72.1	126	5	43	6	0		1.70	8	490	4
7.8.2003	70.0	123	5	31	7	0		3.8	7	1510	5
12.8.2004	52.3	268	4	47	5	0		0		600	4
Olkiluoto 21											
24.7.2002	25.6	213	4	41	7	0		0.82	16	288	4
22.7.2003	87.0	91	5	29.2	6	0.31	11	0.67	7	310	4
14.7.2004	86.8	163	5	44	7	0		0.77	9	570	3

0 = below the detection limit

Table XI. Gamma-emitting radionuclides in the water of the ditch around the dumping ground for exempted waste at Olkiluoto in 2002–2004 (Bq m^{-3}). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Date	^{40}K		^{137}Cs	
7.5.2002	570	6	2.86	10
26.22.2002	1000	6	2.91	21
11.6.2003	890	4	2.17	10
7.11.2003	670	6	2.23	19
10.11.2004	33	16	3.9	12

Table XII. ^{137}Cs in monthly milk samples (Bq l^{-1}) from the Loviisa and Olkiluoto areas in 2002–2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

		Loviisa				Olkiluoto			
		Within a 10 km radius of the power nuclear plant		Whole production of the local dairy		Within a 10 km radius of the power nuclear plant		Whole production of the local dairy	
		^{137}Cs		^{137}Cs		^{137}Cs		^{137}Cs	
2002	Jan	0.228	6	0.167	9	0.277	8	1.08	3
	Feb	0.186	7	0.31	6	0.164	8	0.94	5
	Mar	0.205	8	0.35	6	0.288	5	0.97	5
	Apr	0.229	8	0.30	7	0.36	4	1.01	5
	May	0.201	7	0.34	5	0.42	5	0.86	5
	Jun	0.251	6	0.235	7	0.66	6	1.05	3
	Jul	0.43	5	0.281	6	0.57	4	0.83	6
	Aug	0.47	6	0.64	4	0.31	5	0.88	5
	Sep	0.50	5	0.46	4	0.31	5	1.40	3
	Oct	0.274	7	0.34	6	0.59	6	0.96	4
	Nov	0.257	6	0.49	6	0.93	5	1.08	5
	Dec	0.37	5	0.225	9	0.54	5	0.98	5
	Mean	0.300		0.345		0.452		1.00	
2003	Jan	0.243	8	0.226	8	0.35	7	1.09	3
	Feb	0.186	8	0.211	7	0.40	6	0.95	6
	Mar	0.255	8	0.30	7	0.37	4	1.05	5
	Apr	0.34	5	0.42	5	0.31	5	1.42	4
	May	0.31	4	0.279	8	0.238	7	0.86	5
	Jun	1.20	3	0.32	7	0.252	6	1.13	5
	Jul	0.102	7	0.246	5	0.37	5	1.16	5
	Aug	0.243	5	0.34	5	0.45	6	1.34	4
	Sep	0.65	5	0.295	7	0.93	5	0.97	4
	Oct	0.36	5	0.219	8	0.76	5	1.72	5
	Nov	0.261	7	0.291	4	0.60	6	1.03	5
	Dec	0.214	8	0.216	6	0.49	5	1.09	5
	Mean	0.364		0.280		0.460		1.15	
2004	Jan	0.207	5	0.181	9	0.48	7	1.28	3
	Feb	0.246	8	0.201	8	0.155	8	1.20	4
	Mar	0.193	5	0.199	8	1.39	5	0.198	5
	Apr	0.253	5	0.138	6	0.70	5	0.81	5
	May	0.157	5	0.216	5	0.32	4	0.92	4
	Jun	0.49	6	0.230	6	0.51	3	0.87	3
	Jul	0.159	9	0.194	9	0.41	7	0.79	3
	Aug	0.49	5	0.242	7	0.31	6	0.96	3
	Sep	0.190	9	0.208	7	0.46	6	0.88	6
	Oct	0.167	9	0.153	10	0.30	7	0.93	5
	Nov	0.173	10	0.169	5	6.6	3	0.82	4
	Dec	0.204	10	0.73	4	0.49	8	0.98	4
	Mean	0.244		0.238		1.01		0.887	

Table XIII. ^{90}Sr in bi-monthly milk samples (Bq l^{-1}) from the Loviisa and Olkiluoto areas (whole production of the local dairy) in 2002–2004. Relative uncertainties (1σ) include both statistical, calibration and analytical uncertainty.

			Loviisa		Olkiluoto	
2002						
Jan	-	Feb	0.044	7	0.049	7
Mar	-	Apr	0.024	7	0.047	7
May	-	Jun	0.035	7	0.052	7
Jul	-	Aug	0.036	10	0.058	8
Sep	-	Oct	0.040	6	0.060	6
Nov	-	Dec	0.041	7	0.046	6
Mean			0.037		0.052	
2003						
Jan	-	Feb	0.035	6	0.048	6
Mar	-	Apr	0.048	6	0.056	6
May	-	Jun	0.035	6	0.054	6
Jul	-	Aug	0.035	6	0.052	6
Sep	-	Oct	0.035	6	0.047	6
Nov	-	Dec	0.039	6	0.046	6
Mean			0.038		0.051	
2004						
Jan	-	Feb	0.038	6	0.047	6
Mar	-	Apr	0.032	7	0.041	7
May	-	Jun	0.033	7	0.049	7
Jul	-	Aug	0.035	7	0.049	7
Sep	-	Oct	0.037	7	0.044	6
Nov	-	Dec	0.033	7	0.051	6
Mean			0.035		0.047	6

Table XIVa. ^{90}Sr and gamma-emitting radionuclides (Bq m^{-3}) in drinking water sampled in the waterworks serving the Loviisa power plant and Town of Loviisa in 2002–2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Date	^{40}K		^{90}Sr		^{137}Cs	
Town Loviisa						
1.3.2002	167	9	-		0	
31.5.2002	131	7	0		0	
30.8.2002	79	14	-		0	
29.11.2002	156	9	0		0	
28.2.2003	199	5	-		0	
28.5.2003	151	6	-		0	
29.8.2003	57	16	-		0	
28.11.2003	80	7	0		0	
27.2.2004	100	8	-		0	
31.5.2004	91	7	-		0	
31.8.2004	70	9	-		0	
30.11.2004	102	7	0		0	
Loviisa power plant						
1.3.2002	78	6	-		51	3
31.5.2002	64	16	6.2	5	25.3	6
30.8.2002	88	7	-		54	4
29.11.2002	52	18	8.9	6	34	6
28.2.2003	90	11	-		57	5
28.5.2003	80	9	7.8	6	40	5
29.8.2003	88	9	-		60	5
28.11.2003	73	6	8.9	5	41	4
27.2.2004	87	8	-		49	4
31.5.2004	67	11	7.7	5	32	5
31.8.2004	61	17	-		38	6
30.11.2004	63	9	7.0	6	32	3

0 = below the detection limit
- = not analysed

Table XIVb. ^{90}Sr and gamma-emitting radionuclides (Bq m^{-3}) in drinking water sampled in the waterworks serving the Olkiluoto power plant and the town of Rauma in 2002–2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Date	^{40}K		^{90}Sr		^{137}Cs	
Town of Rauma						
3.1.2002	121	7	9.1	6	8.1	7
17.4.2002	96	8	-		3.8	8
3.7.2002	87	6	7.0	5	5.6	5
2.10.2002	125	7	-		4.3	10
12.2.2003	162	9	9.8	5	6.4	10
9.4.2003	169	8	-		5.4	11
7.7.2003	108	10	8.4	6	7.6	8
1.10.2003	169	5	-		5.6	7
7.1.2004	163	7	12.2	5	3.3	12
7.4.2004	156	5	-		3.2	10
6.7.2004	100	12	9.3	5	6.5	11
29.9.2004	190	6	-		6.6	5
Olkiluoto power plant						
3.1.2002	83	12	9.1	6	6.6	9
18.4.2002	97	8	-		4.7	10
3.7.2002	110	10	7.8	5	6.5	10
2.10.2002	109	11	-		7.2	9
8.1.2003	138	8	10.4	5	6.0	10
9.4.2003	140	7	-		7.8	8
7.7.2003	90	8	7.2	6	6.2	8
1.10.2003	133	6	-		6.7	5
7.1.2004	111	12	8.4	5	6.3	12
8.4.2004	104	12	-		6.4	11
6.7.2004	104	7	-		5.9	6
29.9.2004	97	12	-		7.6	10

- = not analysed

Table XV. ^{90}Sr and gamma-emitting radionuclides in cereals in the vicinity of Loviisa and Olkiluoto in 2002–2004 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

	Dry matter %	^{40}K		^{90}Sr		^{137}Cs	
Loviisa							
2002							
Rye	64.9	180	3	-		0.65	5
Wheat	54.2	154	3	0.210	7	0.73	6
2003							
Rye	91.3	175	5	-		0.31	7
Wheat	91.4	145	5	0.31	11	0.35	9
2004							
Rye	87.5	163	5	-		0.268	14
Wheat	88.5	141	5	0.110	8	0.287	12
Olkiluoto							
2002							
Rye	87.8	171	4	-		0.33	8
Wheat	88.4	159	4	0.220	7	0.31	8
2003							
Rye	89.2	171	3	-		0.282	5
Wheat	90.7	141	4	0.64	11	0.225	7
2004							
Rye	89.9	194	4	-		<	
Wheat	89.5	135	5	0.200	6	0.135	18

- = not analysed
< = below the detection limit

Table XVI. Gamma-emitting radionuclides in lettuce, apple and black currant in the Loviisa and Olkiluoto areas in 2002–2004 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

	Dry matter %	^{7}Be		^{40}K		^{137}Cs	
Lettuce							
Loviisa 33							
2.7.2002	6.2	72	6	1620	3	1.96	11
15.8.2002	6.5	24.8	6	2050	4	2.38	6
3.7.2003	4.4	35	12	2470	5	1.61	25
14.8.2003	6.1	53	7	1830	3	6.7	6
8.7.2004	7.6	133	6	1470	5	1.94	14
12.8.2004	7.3	176	6	1410	5	3.2	9
Olkiluoto 26							
17.7.2002	5.6	28.8	11	1550	5	3.1	12
4.9.2002	7.2	74	7	1500	5	4.2	9
24.7.2003	8.2	24.8	10	1940	4	10.6	6
22.8.2003	3.9	56	8	1690	5	7.5	7
15.7.2004	3.6	22.0	20	2240	5	6.3	10
20.8.2004	4.9	66	7	1800	5	5.4	8
Apple							
Loviisa 31							
4.9.2002	11.5	0.65	26	370	4	0.46	7
18.9.2003	13.4	2.58	9	340	3	1.31	5
20.9.2004	14.3	8.1	5	340	4	0.40	7
Black currant							
Olkiluoto 26							
30.7.2002	15.8	7.2	7	570	4	1.47	5
20.8.2003	18.2	4.6	7	530	4	1.49	5
17.8.2004	17.5	4.3	19	500	5	1.41	8

Table XVII. Gamma-emitting radionuclides in beef in the Loviisa and Olkiluoto areas in 2002–2004 (Bq kg^{-1} fresh weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

	Loviisa				Olkiluoto			
	^{40}K		^{137}Cs		^{40}K		^{137}Cs	
2002								
spring	90	4	0.91	3	80	5	0.74	6
autumn	92	5	0.55	7	73	4	1.46	5
2003								
spring	-		-		-		-	
autumn	85	5	0.50	6	89	4	0.42	3
2004								
spring	85	4	0.61	3	92	4	0.65	3
autumn	72	3	0.194	7	82	3	1.70	4

- = not analysed

Table XVIII. The amounts of gamma-emitting radionuclides in mushrooms and wild berries taken from the vicinity of the Loviisa nuclear power plant in 2004 (Bq kg^{-1} fresh weight). For sampling sites see Fig. 6. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Sampling area	Date	^{40}K		^{134}Cs		^{137}Cs	
Ramaria *Ramaria flava*	54	24.8.	87	6	0		22.6	4
Horn of plenty *Craterellus cornucopioides*	52	25.8.	141	4	0.61	19	450	4
Sheep Polyporus *Caloporus ovinus*	52	25.8.	81	5	0		58	4
Gypsy *Rozites caperata*	54	24.8.	89	6	1.79	11	1100	5
Boletus *Boletus variegatus*	54	24.8.	56	5	2.76	7	1460	4
Orange-cap boletus *Leccinum versipelle*	52	25.8.	72	7	0		27.6	5
Russula *Russula decolorans*	54	24.8.	95	6	1.48	9	670	5
Red-brown lacteous agaric *Lactarius rufus*	54	24.8.	91	5	4.6	3	2460	3
Lingonberry *Vaccinium vitis-idaea*	51	24.8.	26.0	5	0		30	4
Blueberry *Vaccinium myrtillus*	54	24.8.	19.6	5	0		25.7	4
Rowanberry *Sorbus aucuparia*	53	27.8.	79	4	0		6.6	5

0 = below the detection limit

Table XIXa. ^{3}H, ^{90}Sr and gamma-emitting radionuclides (Bq m^{-3}) in sea water samples at Loviisa in 2002–2004. Relative uncertaintainties (1σ) include both statistical and calibration uncertainty.

Sampling station	Date	Salinity ‰	^{3}H		^{40}K		^{90}Sr*		^{137}Cs	
02	7.3.2002	4.80	0		1720	3	11.0	6	41	4
	16.5.2002	3.72	5300	15	1340	5	12.3	5	32	6
	8.8.2002	4.18	94000	6	1610	5	11.6	6	43	5
	9.10.2002	5.05	0		1960	5	15.5	5	44	5
	27.3.2003	4.70	6300	13	1840	5	10.3	5	45	5
	16.5.2003	4.20	10000	13	1810	5	10.5	5	40	5
	4.8.2003	4.30	0		1600	5	9.8	5	37	6
	15.10.2003	5.30	0		1970	5	11.5	5	44	6
	18.3.2004	4.09	7900	16	1610	4	10.2	5	36	6
	11.5.2004	3.77	10000	10	1560	4	11.3	5	35	6
	12.8.2004	3.98	4300	17	1480	4	10.7	5	34	6
	6.10.2004	3.87	0		1480	5	10.3	5	37	5
1	16.5.2002	3.54	20000	6	1450	5	-		37	6
	9.8.2002	4.08	7400	12	1520	6	-		42	6
	9.10.2002	4.75	4600	16	1720	5	-		41	6
	16.5.2003	4.00	9400	14	1740	5	-		41	6
	4.8.2003	4.10	6700	12	1460	5	-		45	6
	15.10.2003	5.20	4500	17	1970	5	-		45	6
	11.5.2004	3.44	9000	10	1320	5	-		25	5
	12.8.2004	3.77	9800	10	1600	4	-		38	5
	6.10.2004	4.11	0		1650	5	-		34	6
2	16.5.2002	3.63	17000	7	1360	5	-		35	5
	7.8.2002	4.04	5400	15	1350	5	-		40	6
	9.10.2002	4.89	0		1780	5	-		41	5
	16.5.2003	4.30	11000	13	1660	5	-		36	6
	4.8.2003	4.30	6900	12	1640	4	-		44	5
	15.10.2003	5.20	0		1990	5	-		41	6
	11.5.2004	3.56	11900	10	1310	5	-		28	5
	12.8.2004	3.80	8000	11	1330	5	-		33	5
	6.10.2004	4.05	0		1470	5	-		35	6
4	17.5.2002	3.84	9700	10	1510	5	-		38	5
	7.8.2002	3.58	4100	15	1420	6	-		39	6
	9.10.2002	4.96	0		1980	5	-		47	5
	15.5.2003	4.50	13000	12	1860	4	-		43	5
	4.8.2003	4.20	0		1550	5	-		37	6
	15.10.2003	5.00	0		1900	6	-		38	6
	11.5.2004	3.69	0		1530	5	-		34	6
	12.8.2004	3.94	6500	13	1440	5	-		29	6
	6.10.2004	3.88	0		1440	5	-		32	6

0 = below the detection limit 4000 Bq
- = not analysed
* = analytical error included

Table XIXa. Continued.

Sampling station	Date	Salinity ‰	^{3}H		^{40}K		^{90}Sr*		^{137}Cs	
R1	16.5.2002	3.47	0		1330	5	12.5	5	28	6
	5.8.2002	4.36	0		1640	5	9.9	6	41	6
	10.10.2002	4.83	0		1760	5	17.1	16	39	6
	14.5.2003	4.50	0		1800	5	11.5	5	37	5
	5.8.2003	4.50	0		1740	4	11.1	5	44	6
	15.10.2003	5.50	0		2380	4	12.2	5	48	5
	14.5.2004	2.57	0		1130	4	9.9	5	24	5
	10.8.2004	3.30	0		1200	5	8.1	5	26	5
	5.10.2004	4.63	0		2010	4	10.9	5	38	6

0 = below the detection limit 4000 Bq
- = not analysed
* = analytical error included

Table XIXb. ^{3}H, ^{90}Sr and gamma-emitting radionuclides (Bq m^{-3}) in sea water samples at Olkiluoto in 2002–2004. Relative uncertaintainties (1σ) include both statistical and calibration uncertainty.

Sampling station	Date	Salinity ‰	^{3}H		^{40}K		^{90}Sr*		^{137}Cs	
13	12.3.2002	5.26	0		2060	4	11.9	7	57	4
	12.5.2002	5.22	0		2020	5	15.2	5	64	5
	12.8.2002	5.49	0		1970	5	10.7	7	67	5
	26.9.2002	5.57	6200	12	2070	5	12.2	5	61	5
	14.4.2003	5.43	0		1980	5	10.7	5	61	6
	6.5.2003	5.20	0		2170	5	9.0	5	64	5
	22.7.2003	5.50	0		2000	6	18.9	15	59	5
	6.11.2003	5.63	0		2160	5	11.3	5	62	5
	16.3.2004	5.70	0		2010	5	8.1	6	53	5
	28.4.2004	5.49	15700	7	2110	5	11.8	5	61	5
	13.7.2004	5.50	4700	16	1930	5	10.6	11	56	5
	10.11.2004	5.74	0		2140	5	12.6	5	54	5
10	12.5.2002	5.38	0		1890	5	-		57	6
	12.8.2002	5.52	0		2030	5	-		67	5
	26.9.2002	5.57	0		2130	5	-		70	5
	6.5.2003	5.30	0		2330	4	-		65	5
	22.7.2003	5.40	0		2050	5	-		62	5
	6.11.2003	5.62	0		2260	4	-		76	5
	28.4.2004	5.43	0		2100	5	-		61	5
	13.7.2004	5.58	0		2070	4	-		56	5
	10.11.2004	5.79	0		2280	4	-		56	5

0 = below the detection limit 4000 Bq
- = not analysed
* = analytical error included

Table XIXb. Continued.

Sampling station	Date	Salinity ‰	^{3}H	^{40}K		^{90}Sr*		^{137}Cs	
2	12.5.2002	5.40	0	1990	6	-		57	5
	12.8.2002	5.54	0	2030	6	-		65	5
	26.9.2002	5.57	0	2020	5	-		65	5
	6.5.2003	5.30	0	1980	5	-		59	5
	22.7.2003	5.50	0	2110	5	-		61	5
	6.11.2003	5.62	0	1980	5	-		62	6
	28.4.2004	5.51	0	2330	4	-		67	5
	13.7.2004	5.58	0	2120	4	-		60	5
	10.11.2004	5.78	0	2140	5	-		55	5
3	12.5.2002	5.34	0	2000	5	-		63	5
	12.8.2002	5.50	0	2090	5	-		69	6
	26.9.2002	5.49	0	1930	5	-		63	6
	6.5.2003	5.30	0	1990	5	-		60	6
	22.7.2003	5.40	0	1990	5	-		57	5
	6.11.2003	5.63	0	2090	5	-		58	6
	28.4.2004	5.42	0	2200	4	-		58	5
	13.7.2004	5.55	0	2140	4	-		58	5
	10.11.2004	5.75	0	2190	5	-		58	5
15	12.5.2002	4.39	0	1680	5	14.5	5	53	6
	12.8.2002	5.29	0	1970	5	11.0	7	64	5
	26.9.2002	5.50	0	2010	5	12.3	5	66	5
	7.5.2003	5.00	0	1960	5	7.4	5	59	5
	22.7.2003	5.40	0	1970	6	15.5	15	58	5
	5.11.2003	5.63	0	2200	5	10.5	5	61	5
	27.4.2004	5.19	0	1780	5	11.9	5	45	5
	13.7.2004	5.50	0	2420	4	14.3	11	69	5
	9.11.2004	5.70	0	2240	5	11.0	5	56	5

0 = below the detection limit 4000 Bq
- = not analysed
* = analytical error included

Table XXa. ^{90}Sr, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in aquatic plants in the sampling areas A-E at Loviisa in 2002. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date	^{40}K		^{54}Mn		^{58}Co		^{60}Co		^{90}Sr		^{110m}Ag		^{124}Sb		^{134}Cs		^{137}Cs		^{238}Pu	$^{239,240}Pu$	
Periphyton																						
Loviisa A	24.4. - 1.7.	540	5	1.29	25	0		3.8	6	-		0		0		0		266	3	-	-	
	1.7. - 1.8.	570	5	1.14	24	7.2	7	27.2	3	-		30	6	7.0	12	0		134	4	-	-	
	1.8. - 23.8.	440	6	3.4	23	4.1	20	7.5	10	-		9.5	16	3.5	21	0		190	3	-	-	
	23.8. - 25.9.[a]	770	4	3.5	8	13.0	4	18.2	3	-		6.2	4	7.0	5	0		72	3	-	-	
Cladophora glomerata																						
Loviisa A	4.7.	1380	5	0		0		0		-		0		0		0		18.0	5	-	-	
Fucus vesiculosus																						
Loviisa A	15.5.	770	5	0.79	13	0		3.9	4	-		0.61	7	0		0.205	17	52	5	-	-	
	8.8.	710	5	0		0		1.32	6	9.5	5	0.41	20	0.19	24	0		33	4	0	0.062	14
Loviisa B	15.5.	780	5	0.50	25	0		3.3	5	-		0		0		0.228	29	53	5	-	-	
	9.8.	620	5	0		0		1.04	8	-		0.72	10	0		0		26.4	5	-	-	
Loviisa C	17.5.	840	5	0		0		0		-		0		0		0		40	5	-	-	
	9.8.	770	5	0		0		0		-		0		0		0		34	5	-	-	
Loviisa D	14.5.	750	5	0		0		0		-		0		0		0		45	4	-	-	
	7.8.	790	5	0		0		0		-		0		0		0		36	5	-	-	
Loviisa E	14.5.	760	5	0		0		0		-		0		0		0		37	5	-	-	
	7.8.	700	5	0		0		0		7.1	5	0		0		0		29.7	5	0	0.074	16
Myriophyllum spicatum																						
Loviisa A	8.8.[b]	540	5	4.0	8	6.5	6	8.8	4	-		22.5	5	6.8	5	0		52	5	-	-	
Potamogeton pectinatus																						
Loviisa A	9.8.	470	5	0.41	26	0.68	16	1.55	8	-		1.18	8	0.36	23	0		4.6	6	-	-	

0 = below the detection limit
- = not analysed

[a] = in addition: ^{95}Zr: 1.79 (18)
[b] = in addition: ^{95}Zr: 0.98 (23), ^{123m}Te:0.47 (18)

Table XXb. ^{90}Sr, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in aquatic plants in the sampling areas A-G at Loviisa in 2003. Relative uncertainties (1σ) include both statistical and calibration uncertainty

Species	Date	^{40}K	^{54}Mn	^{58}Co	^{60}Co	^{90}Sr	^{110m}Ag	^{124}Sb	^{137}Cs	^{238}Pu	$^{239,240}Pu$
Periphyton											
Loviisa A	13.5. - 3.7.	400 11	0	0	0	-	0	0	153 4	-	-
	3.7. - 30.7.	820 5	0	0	2.97 18	-	0	0	229 5	-	-
	30.7. - 4.9.	237 6	1.43 18	3.9 9	5.0 6	-	5.3 5	5.3 7	26.5 5	-	-
	4.9. - 25.9.	590 5	0	2.76 23	8.4 9	-	4.7 14	0	185 5	-	-
Cladophora glomerata											
Loviisa A	3.7.	550 5	0	0	0	-	0	0	15.9 4	-	-
Fucus vesiculosus											
Loviisa A	23.5.	850 5	0	0	0.61 10	-	0	0	46 4	-	-
	6.8.	760 5	0	0	0.49 11	9.6 5	0	0	32 4	0	0.08 14
Loviisa B	23.5.	680 5	0	0	0.69 8	-	0.48 12	0	37 4	-	-
	6.8.	730 5	0	0	0.52 15	-	0	0	25.7 5	-	-
Loviisa C	22.5.	710 5	0	0	0	-	0	0	33 5	-	-
	5.8.	650 4	0	0	0	-	0	0	27.1 4	-	-
Loviisa F	22.5.	760 4	0	0	0	-	0	0	33 4	-	-
	5.8.	650 5	0	0	0	-	0	0	25.1 5	-	-
Loviisa G	22.5.	830 4	0	0	0	-	0	0	40 4	-	-
	5.8.	860 5	0	0	0	9.1 5	0	0	37 5	0	0.09 12
Myriophyllum spicatum											
Loviisa A	6.8.	520 5	0	0	0.97 19	-	0	0	29.8 5	-	-
Potamogeton pectinatus											
Loviisa A	7.8.	690 5	0.275 25	0	0.50 11	-	0.242 16	0	13.7 5	-	-

0 = below the detection limit
- = not analysed

Table XXc. ^{90}Sr, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in aquatic plants in the sampling areas A-G at Loviisa in 2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date	^{40}K		^{54}Mn		^{58}Co		^{60}Co		^{90}Sr		^{110m}Ag		^{124}Sb		^{137}Cs		^{238}Pu		$^{239,240}Pu$	
Periphyton																					
Loviisa A	7.5. - 29.6.	750	4	0		0		0.69	22	-		0.90	27	0		81	3	-		-	
	29.6. - 6.8.	450	6	3.5	17	9.5	9	5.8	9	-		15.1	7	19.3	6	37	6	-		-	
	6.8. - 2.9.	1260	4	0.88	24	4.7	9	6.0	6	-		8.6	8	4.8	8	23.9	4	-		-	
	2.9. - 6.10.	630	5	1.73	27	13.8	7	20.3	4	-		6.1	13	11.8	6	170	3	-		-	
Cladophora glomerata																					
Loviisa A	1.7.	48	6	0		0		0		-		0		0		9.9	5	-		-	
Fucus vesiculosus																					
Loviisa A	14.5.	440	4	0		0		0.42	13	-		0.65	13	0		25.9	4	-		-	
	26.8.	310	5	0		0.71	7	0.89	5	11.0	7	2.69	5	0.91	7	13.1	4	0		0.027	17
Loviisa B	13.5.	550	4	0		0.49	16	0		-		0		0		33	4	-		-	
	26.8.	330	4	0.139	28	0.56	9	0.54	6	-		2.36	4	0.51	11	12.8	4	-		-	
Loviisa C	12.5.	760	5	0		0		0		-		0		0		31	4	-		-	
	26.8.	700	5	0		0		0		-		0		0		23.7	4	-		-	
Loviisa F	12.5.	740	5	0		0		0		-		0		0		26.3	5	-		-	
	26.8.	720	4	0		0		0		-		0		0		23.1	4	-		-	
Loviisa G	13.5.	760	4	0		0		0		-		0		0		33	5	-		-	
	26.8.	740	4	0		0		0		10.6	7	0		0		26.7	4	0		0.05	13
Myriophyllum spicatum																					
Loviisa A	26.8.[a]	570	5	3.3	8	19.7	5	19.1	5	-		19.1	5	20.1	5	27.1	4	-		-	
Potamogeton pectinatus																					
Loviisa A	26.8.	800	4	0.37	26	0.62	14	0.88	9	-		1.51	8	0.90	12	4.1	5	-		-	

0 = below the detection limit

- = not analysed

[a] = in addition: ^{51}Cr: 7.9 (18), ^{59}Fe: 2.32 (19), ^{95}Zr: 1.65 (17), ^{95}Nb: 5.1 (6), ^{123m}Te: 1.01 (12)

Table XXIa. ^{90}Sr, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in aquatic plants in the sampling areas A-E at Olkiluoto in 2002. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date	^{40}K	^{54}Mn	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$
Periphyton									
Olkiluoto A[a]	19.4. - 26.6.	590 6	0	18.3 7	-	0	330 5	-	-
	26.6. - 23.7.	296 7	0	5.8 12	-	0	138 4	-	-
	23.7. - 28.8.	630 6	0	5.6 11	-	0	94 3	-	-
	28.8. - 17.9.	370 6	0	5.5 9	-	0	73 3	-	-
Cladophora glomerata									
Olkiluoto A	24.7.	990 5	0	1.83 11	-	0	48 5	-	-
Fucus vesiculosus									
Olkiluoto A	8.5.	860 5	0	3.1 5	-	0.251 25	53 5	-	-
	27.8.	730 5	0	2.82 5	7.9 5	0	39 5	0	0.088 14
Olkiluoto B	8.5.	770 5	0	3.1 4	-	0	50 4	-	-
	28.8.	590 5	0.36 26	2.80 5	-	0	34 5	-	-
Olkiluoto C	6.5.	640 5	0	0	-	0	32 5	-	-
	29.8.	480 5	0	0.14 18	6.5 5	0.117 23	22.8 4	0	0.031 25
Olkiluoto D	7.5.	700 5	0	0.36 8	-	0.167 15	35 4	-	-
	29.8.	530 5	0	0.55 12	-	0	26.1 5	-	-
Olkiluoto E	7.5.	590 5	0	0.40 4	-	0	32 4	-	-
	28.8.	620 4	0	0.51 14	-	0	32 4	-	-
Myriophyllum spicatum									
Olkiluoto A	29.8.	700 5	0.99 16	4.3 5	-	0	15.5 5	-	-
Potamogeton pectinatus									
Olkiluoto A	27.8.	540 5	0	1.48 5	-	0	7.0 5	-	-

0 = below the detection limit

- = not analysed

[a] = just in front of the cooling water outlet

Table XXIb. ^{90}Sr, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in aquatic plants in the sampling areas A-E at Olkiluoto in 2003. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date	^{40}K		^{54}Mn		^{58}Co		^{60}Co		^{90}Sr		^{124}Sb		^{137}Cs		^{238}Pu		$^{239,240}Pu$	
Periphyton																			
Olkiluoto A[a]	6.5. - 18.6.	680	5	3.3	11	2.66	14	26.6	3	-		0		380	3	-		-	
	18.6. - 24.7.	600	7	0		0		5.9	26	-		0		136	5	-		-	
	24.7. - 22.8.	198	6	0		0		1.01	17	-		0		37	3	-		-	
	22.8. - 3.10.	440	5	0		0		4.8	6	-		0		168	4	-		-	
Cladophora glomerata																			
Olkiluoto A	23.7.	990	4	0		0		1.24	19	-		0		25.9	5	-		-	
	20.8.	2880	5	0		0		1.40	11	-		0		21.8	4				
Fucus vesiculosus																			
Olkiluoto A	9.5.	750	5	0		0		2.67	6	-		0		44	5	-		-	
	20.8.	690	4	0		0		3.2	4	16.5	6	0		37	4	0		0.07	13
Olkiluoto B	7.5.	650	5	0		0		2.54	5	-		0		36	5	-		-	
	20.8.	590	5	0		0		1.77	6	-		0.229	25	35	5	-		-	
Olkiluoto C	8.5.	640	5	0		0		0.34	18	-		0		31	4	-		-	
	21.8.	700	5	0		0		0.24	14	10.9	5	0		28.9	4	0.010	33	0.06	14
Olkiluoto D	8.5.	610	5	0		0		0.48	19	-		0		27.6	5	-		-	
	21.8.	580	5	0		0		0		-		0		22.5	4	-		-	
Olkiluoto E	8.5.	690	4	0		0		0.60	20	-		0		34	5	-		-	
	21.8.	670	5	0		0		0.32	14	-		0		22.6	4	-		-	
Myriophyllum spicatum																			
Olkiluoto A	21.8.	620	5	1.35	20	0		10.6	4	-		0		33	5	-		-	
Potamogeton pectinatus						0													
Olkiluoto A	21.8.	440	5	0				1.65	9	-		0		6.6	6	-		-	

0 = below the detection limit
- = not analysed
[a] = just in front of the cooling water outlet

Table XXIc. ^{90}Sr, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in aquatic plants in the sampling areas A-E at Olkiluoto in 2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date	^{40}K	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$
Periphyton								
Olkiluoto A[a]	29.4. - 22.6.	610 5	11.7 5	-	0	244 3	-	-
	22.6. - 14.7.	620 4	5.6 5	-	0	199 3	-	-
	14.7. - 19.8.	550 6	20.8 4	-	0	128 5	-	-
	19.8. - 16.9.	540 5	1.91 25	-	0	126 3	-	-
Cladophora glomerata								
Olkiluoto A	14.7.	1160 4	0	0	0	34 5	-	-
Fucus vesiculosus								
Olkiluoto A	11.5.	760 5	0	-	0	43 4	-	-
	19.8.	550 4	1.83 4	10.4 6	0	29.6 4	0	0.033 17
Olkiluoto B	11.5.	740 5	1.28 5	-	0	43 5	-	-
	19.8.	340 5	0.85 4	-	0	18.0 4	-	-
Olkiluoto C	11.5.	760 5	0.28 15	-	0	31 5	-	-
	18.8.	540 5	0.12 21	8.8 6	0.080 26	21.6 4	0	0.040 17
Olkiluoto D	12.5.	620 5	0.29 18	-	0	26.4 5	-	-
	18.8.	730 4	0	-	0	27.6 4	-	-
Olkiluoto E	12.5.	660 5	0.24 11	-	0	29.7 5	-	-
	19.8.	640 5	0.18 22	-	0	23.9 4	-	-
Myriophyllum spicatum								
Olkiluoto A	19.8.	286 4	1.45 8	-	0	26.3 4	-	-
Potamogeton pectinatus								
Olkiluoto A	19.8.	370 5	0.75 7	-	0	9.3 5	-	-

0 = below the detection limit
- = not analysed
[a] = just in front of the cooling water outlet

Table XXII. The concentrations of ^{90}Sr and gamma-emitting nuclides (Bq kg^{-1} dry weight) in a benthic crustacean at Loviisa and two benthic bivalve mussels at Olkiluoto in 2002–2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species **Date**	**^{40}K**	**^{60}Co**	**^{90}Sr***	**^{110m}Ag**	**^{137}Cs**
Saduria entomon					
Loviisa 3					
15.5.-6.6.2002	235 6	0	14.3 5	2.83 12	19.6 4
15.5.-13.6.2003	266 5	0	13.0 8	1.78 20	22.0 5
7.5.-14.5.2004	232 5	0	14.1 5	0.97 13	16.2 5
Macoma baltica					
Olkiluoto 9					
23.7.2002	62 6	0.58 14	15.3 6	0	11.1 5
22. - 23.7.2003	78 5	0.46 13	15.0 6	0	10.9 5
17.8.2004	71 8	0	18.4 6	0	10.9 4
Mytilus edulis					
Olkiluoto A					
24.7.2002	46 6	3.6 4	-	0	3.8 6
23.7.2003	40 7	2.74 5	-	0	2.56 7
14.7.2004	58 8	1.03 12	-	0	2.90 8

0 = below the detection limit
- = not analysed

Table XXIII. Gamma-emitting radionuclides and ^{90}Sr in edible parts of fish caught in the vicinity of the Loviisa power plant in 2002–2004 (Bq kg^{-1} fresh weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date			^{40}K		^{90}Sr*		^{134}Cs		^{137}Cs	
Perch[a]											
Perca fluviatilis											
Area I											
2002	1.5.	-	31.5.	100	5	-		0		25.5	3
	1.9.	-	30.9.	113	6	1.09	16	0		20.4	5
2003	1.5.	-	31.5.	151	5	-		0.136	22	71	5
	1.9.	-	30.9.	123	4	0.55	6	0		21.8	4
2004	6.5.	-	28.5.	78	4	-		0		15.0	4
	4.8.	-	12.8.	102	6	0.44	7	0		18.5	5
Area II											
2002	1.5.	-	31.5.	107	3	-		0.102	18	25.0	3
	1.9.	-	30.9.	117	3	-		0		20.3	3
2003	1.5.	-	31.5.	97	4	-		0		22.7	4
	1.9.	-	30.9.	109	3	-		0		20.9	4
2004	5.5.	-	13.5.	91	8	-		0		22.7	5
	4.8.	-	5.8.	110	4	-		0		23.3	3
Pike[b]											
Esox lucius											
Area I											
2002	1.5.	-	31.5.	113	3	-		0.066	15	14.7	4
	1.9.	-	30.9.	120	3	-		0		10.9	4
2003	1.5.	-	31.5.	120	3	-		0		11.3	4
	1.9.	-	30.9.	110	5	-		0		13.9	5
2004	6.5.	-	28.5.	111	3	-		0		15.1	4
	4.8.	-	5.8.	130	4	-		0		17.9	4
Area II											
2002	1.5.	-	31.5.	103	5	-		0.084	18	23.7	5
	1.9.	-	30.9.	126	4	-		0		10.7	4
2003	1.5.	-	31.5.	121	3	-		0.041	12	13.0	3
	1.9.	-	30.9.	119	3	-		0		11.1	4
2004	5.5.	-	13.5.	110	4	-		0		6.4	3
	5.8.	-	5.8.	118	4	-		0		13.6	3

[a] flesh and bones analysed
[b] only flesh analysed
* = analytical error included
0 = below the detection limit
- = not analysed

Table XXIII. Continued.

Species Date				^{40}K		^{90}Sr*		^{134}Cs	^{137}Cs	
Baltic herring[a]										
Clupea harengus membras										
Area I										
2002	1.5.	-	31.5.	94	4	-		0	4.9	4
	1.9.	-	30.9.	107	5	0.180	16	0	5.6	5
2003	1.5.	-	31.5.	102	5	-		0	5.9	5
2004	6.5.	-	28.5.	118	4	-		0	6.2	3
	22.9.	-	2.11.	113	5	0.043	8	0	6.0	5
Area II										
2002	1.5.	-	31.5.	104	4	-		0	5.7	5
	1.9.	-	30.9.	116	4	-		0	6.3	5
2003	1.5.	-	31.5.	128	4	-		0	7.6	5
2004	5.5.	-	13.5.	107	4	-		0	6.8	3
	22.9.	-	2.11.	103	4	-		0	6.4	3
Roach[a]										
Rutilus rutilus										
Area I										
2003	1.9.	-	30.9.	98	4	-		0	4.9	4
2004	6.5.	-	28.5.	107	4	-		0	6.8	3
	6.8.	-	31.8.	102	4	-		0	4.8	3
Area II										
2003	1.5.	-	31.5.	97	4	-		0	5.1	4
	1.9.	-	30.9.	101	3	-		0	4.5	3
2004	5.5.	-	13.5.	93	6	-		0	4.4	5
	5.8.	-	12.8.	88	3	-		0	3.7	4

[a] flesh and bones analysed
[b] only flesh analysed
* = analytical error included
0 = below the detection limit
- = not analysed

Table XXIII. Continued.

Species Date				^{40}K		^{90}Sr*	^{134}Cs	^{137}Cs	
Bream[a]									
Abramis brama									
Area I									
2002	1.5.	-	31.5.	95	6	-	0	3.8	5
	10.10.	-	11.10.	106	6	-	0	4.9	5
2003	1.5.	-	31.5.	92	6	-	0	5.9	5
Area II									
2002	1.5.	-	31.5.	95	4	-	0	4.8	5
	1.9.	-	30.9.	101	4	-	0	5.4	5
Ide[a]									
Leuciscus idus									
Area II									
2002	1.5.	-	31.5.	101	4	-	0	7.8	4

[a] flesh and bones analysed
[b] only flesh analysed
* = analytical error included
0 = below the detection limit
- = not analysed

Table XXIV. Gamma-emitting radionuclides and ^{90}Sr in edible parts of fish caught in the vicinity of the Olkiluoto power plant in 2002–2004 (Bq kg^{-1} fresh weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Species	Date			^{40}K		^{60}Co		^{90}Sr*		^{134}Cs		^{137}Cs	
Perch[a]													
Perca fluviatilis													
Area I													
2002	2.5.	-	22.5.	102	6	0		-		0		32	5
	9.9.	-	15.10.	108	4	0		0.46	7	0		29.7	4
2003	8.5.	-	16.5.	103	4	0		-		0		35	4
	1.9.	-	17.9.	106	4	0		0.44	7	0		36	3
2004	12.5.	-	1.6.	87	4	0		-		0		29.2	4
	9.9.	-	18.10.	94	4	0		0.53	7	0		36	3
Area II													
2002	2.5.	-	22.5.	95	4	0		-		0		34	4
	10.9.	-	21.10.	114	3	0		-		0.011	13	28.3	3
2003	16.5.	-	2.6.	106	6	0		-		0		26.1	5
	1.9.	-	22.9.	107	4	0.090	9	-		0.079	13	39	3
2004	16.5.	-	1.6.	92	3	0		-		0		26.3	3
	9.9.	-	18.10.	109	4	0		-		0		42	4
Pike[b]													
Esox lucius													
Area I													
2002	2.5.	-	22.5.	108	4	0		-		0.073	18	23.3	4
	9.9.	-	15.10.	124	4	0		-		0		19.3	4
2003	8.5.	-	16.5.	109	3	0		-		0.099	13	35	4
	1.9.	-	17.9.	145	4	0		-		0.050	18	24.7	4
2004	12.5.	-	1.6.	88	3	0		-		0		14.6	4
	9.9.	-	18.10.	112	3	0		-		0		21.4	4
Area II													
2002	2.5.	-	22.5.	115	3	0		-		0.093	16	26.6	4
	10.9.	-	21.10.	118	5	0		-		0		17.3	5
2003	16.5.	-	2.6.	136	4	0		-		0.088	19	24.6	4
	1.9.	-	22.9.	140	4	0		-		0		29.5	4
2004	5.5.	-	1.6.	139	3	0		-		0		24.6	4
	9.9.	-	18.10.	108	5	0		-		0		16.6	5

[a] flesh and bones analysed
[b] only flesh analysed
* = analytical error included
0 = below the detection limit
- = not analysed

Table XXIV. Continued.

Species Date				^{40}K		^{60}Co		^{90}Sr*		^{134}Cs		^{137}Cs	
Baltic herring[a]													
Clupea harengus membras													
Area I													
2002	2.5.	-	22.5.	113	4	0.077	10	-		0.032	25	8.7	3
	9.9.	-	15.10.	114	5	0		0.073	7	0		10.5	5
2003	8.5.	-	16.5.	137	4	0		-		0		10.6	4
	1.9.	-	17.9.	120	5	0		0.045	11	0		10.6	5
2004	12.5.	-	1.6.	110	5	0		-		0		7.5	5
	9.9.	-	18.10.	118	5	0		0.052	8	0		11.6	5
Area II													
2002	2.5.	-	22.5.	108	3	0		-		0		8.0	4
	10.9.	-	21.10.	114	5	0		-		0		9.9	5
2003	16.5.	-	2.6.	117	4	0		-		0.029	22	9.4	3
	1.9.	-	22.9.	116	4	0		-		0		10.4	3
2004	5.5.	-	1.6.	120	5	0		-		0		9.0	5
	9.9.	-	18.10.	113	5	0		-		0		9.1	5
Roach[a]													
Rutilus rutilus													
Area I													
2002	2.5.	-	22.5.	89	6	0		-		0		6.4	5
	9.9.	-	15.10.	106	3	0		-		0		7.6	3
2003	8.5.	-	16.5.	101	6	0		-		0		7.8	5
	1.9.	-	17.9.	100	3	0		-		0		7.1	3
2004	12.5.	-	1.6.	93	6	0		-		0		7.1	5
Area II													
2002	2.5.	-	22.5.	107	4	0		-		0		8.0	5
	10.9.	-	21.10.	106	4	0		-		0		7.2	4
2003	16.5.	-	2.6.	98	3	0		-		0		7.4	4
2004	16.5.	-	1.6.	88	4	0		-		0		7.2	3
	9.9.	-	18.10.	103	4	0		-		0		7.3	5

[a] flesh and bones analysed
[b] only flesh analysed
* = analytical error included
0 = below the detection limit
- = not analysed

Table XXIV. Continued.

Species Date	^{40}K	^{60}Co	^{90}Sr*	^{134}Cs	^{137}Cs
Bream[a]					
Abramis brama					
Area II					
2004 9.9. - 18.10.	85 6	0	-	0	5.3 5
Ide[a]					
Leucicus idus					
Area II					
2003 1.9. - 22.9.	106 6	0.087 7	-	0	7.1 5

[a] flesh and bones analysed
[b] only flesh analysed
* = analytical error included
0 = below the detection limit
- = not analysed

Table XXV. Gamma-emitting radionuclides in young salmon from the Loviisa Fish Farm in 2002–2004 (Bq kg^{-1} fresh weight). Relative uncertainties include (1σ) both statistical and calibration uncertainty.

Species	Date	^{40}K		^{137}Cs	
Oncorhynchus mykiss	7.1.2002	103	4	0.271	20
Oncorhynchus mykiss	5.2.2002	110	4	0.285	17
Oncorhynchus mykiss	5.3.2002	103	4	0.166	13
Oncorhynchus mykiss	21.3.2002	100	4	0.30	10
Oncorhynchus mykiss	2.4.2002	114	4	0.300	10
Oncorhynchus mykiss	6.5.2002	112	5	0.34	9
Oncorhynchus mykiss	5.11.2002	100	4	0.41	14
Oncorhynchus mykiss	4.12.2002	105	4	0.46	13
Oncorhynchus mykiss	9.1.2003	101	4	0.30	17
Oncorhynchus mykiss	4.2.2003	96	5	0.226	19
Oncorhynchus mykiss	4.3.2003	99	5	1.35	6
Oncorhynchus mykiss	27.3.2003	102	5	0.146	23
Coregonus lavaretus	1.4.2003	103	4	0.73	9
Oncorhynchus mykiss	6.5.2003	113	5	0.33	13
Oncorhynchus mykiss	12.11.2003	96	4	0.37	14
Oncorhynchus mykiss	2.12.2003	98	4	0.297	14
Oncorhynchus mykiss	8.1.2004	102	5	0.52	10
Oncorhynchus mykiss	3.2.2004	116	4	0.280	20
Oncorhynchus mykiss	2.3.2004	101	4	0.38	14
Oncorhynchus mykiss	18.3.2004	112	5	0.289	12
Oncorhynchus mykiss	6.4.2004	93	5	0.174	21
Salmo salar	10.5.2004	108	4	0.48	14
Salmo salar	10.12.2004	114	4	0.40	15

Table XXVIa. Gamma-emitting radionuclides in sinking matter (Bq kg^{-1} dry weight) in the vicinity of Loviisa nuclear power plant in 2002–2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K	^{54}Mn	^{58}Co	^{60}Co	^{110m}Ag	^{134}Cs	^{137}Cs
Loviisa 1	8								
31.10.2001 - 25.4.2002		23.3	790 4	0	0	6.5 6	4.2 15	2.95 12	760 4
25.4.2002 - 2.7.2002		17.2	750 5	0	0	0	0	2.44 21	690 3
2.7.2002 - 3.9.2002		17.4	710 5	0	0	3.3 13	0	2.25 28	620 3
3.9.2002 - 19.11.2002		10.6	780 5	1.15 29	1.63 28	6.7 5	2.89 19	2.22 13	690 3
19.11.2002 - 13.5.2003		7.3	620 5	0	0	2.84 15	0	0	460 4
13.5.2003 - 1.7.2003		7.3	770 4	0	0	2.50 14	0	1.97 19	510 3
1.7.2003 - 2.9.2003		6.6	670 6	0	0	17.5 7	0	0	490 3
2.9.2003 - 14.11.2003		16.3	890 4	0	0	4.0 9	2.70 18	0	760 4
14.11.2003 - 22.4.2004		12.4	710 5	0	0	22.1 16	0	0	630 3
22.4.2004 - 29.6.2004		11.6	680 4	0	0	3.4 13	0	0	460 3
29.6.2004 - 31.8.2004		11.6	630 6	7.6 13	6.5 15	11.0 7	3.0 25	0	410 5
31.8.2004 - 22.11.2004		25	760 3	0	0	2.24 10	5.5 10	0	620 3

0 = below the detection limit

Table XXVIa. Continued.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K		^{54}Mn		^{58}Co		^{60}Co		^{110m}Ag		^{134}Cs		^{137}Cs	
Loviisa 3	17															
30.10.2001 - 25.4.2002		24.8	820	4	1.63	16	2.84	19	18.7	3	12.9	5	3.0	7	770	3
25.4.2002 - 2.7.2002		10.5	570	7	0		0		0		0		0		420	5
2.7.2002 - 4.9.2002		7.4	720	6	166	3	22.1	8	78	3	0		0		530	3
4.9.2002 - 19.11.2002[a]		9.6	700	5	6.5	9	5.0	14	29.3	4	3.9	20	1.48	25	600	33
19.11.2002 - 13.5.2003		12.9	630	5	0		0		7.0	5	0		1.01	28	520	3
13.5.2003 - 1.7.2003		7.8	330	6	0		0		0		0		0		139	4
1.7.2003 - 2.9.2003		6.0	670	6	0		0		5.8	11	0		0		370	3
2.9.2003 - 14.11.2003		8.6	580	5	0		0		5.4	8	0		1.70	18	450	3
14.11.2003 - 22.4.2004		11.1	730	5	0		0		3.6	11	0		0		650	3
22.4.2004 - 29.6.2004		10.3	510	5	0		0		2.28	13	0		0		253	3
29.6.2004 - 31.8.2004[b]		6.3	610	6	0		5.3	19	8.8	8	4.3	17	0		370	3
31.8.2004 - 30.11.2004		9.3	680	5	0		2.47	19	7.3	6	6.0	15	0		480	3

0 = below the detection limit

[a] in addition: ^{95}Zr: 3.9 (24)

[b] in addition: ^{124}Sb: 5.9 (24)

Table XXVIa. Continued.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K	^{54}Mn	^{58}Co	^{60}Co	^{110m}Ag	^{134}Cs	^{137}Cs
Loviisa 4A	27								
29.10.2001 - 26.4.2002		31.3	770 5	0	0	2.09 15	0	1.89 23	750 3
26.4.2002 - 4.7.2002		9.5	530 6	12.0 9	0	10.9 7	0	0	380 3
4.7.2002 - 4.9.2002		5.1	600 7	0	0	0	0	0	490 3
4.9.2002 - 19.11.2002		10.7	660 5	0	0	2.31 16	0	0	590 4
19.11.2002 - 15.5.2003		9.7	680 5	0	0	0	0	0	540 3
15.5.2003 - 1.7.2003		9.3	400 5	0	0	0	0	0	92 4
1.7.2003 - 2.9.2003		5.6	530 4	0	0	0	0	0	188 3
2.9.2003 - 14.11.2003		7.4	510 6	0	0	0	0	0	293 3
14.11.2003 - 22.4.2004		12.3	670 5	0	0	0	0	0	510 4
22.4.2004 - 29.6.2004		9.8	370 6	0	0	0	0	0	160 3
29.6.2004 - 31.8.2004		6.6	490 7	0	0	0	0	0	284 3
31.8.2004 - 30.11.2004		11.9	580 7	0	0	0	0	0	410 5

0 = below the detection limit

Table XXVIa. Continued.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K	^{54}Mn	^{58}Co	^{60}Co	^{110m}Ag	^{134}Cs	^{137}Cs
Loviisa R1	13								
31.10.2001 - 25.4.2002		24.0	880 5	0	0	0	0	2.96 14	650 3
25.4.2002 - 2.7.2002		44.5	900 5	0	0	0	0	0	570 3
2.7.2002 - 3.9.2002		36.4	1010 4	0	0	0	0	1.82 24	550 3
3.9.2002 - 19.11.2002		26.0	890 6	0	0	0	0	2.20 22	560 5
19.11.2002 - 14.5.2003		5.3	720 6	0	0	0	0	0	500 3
14.5.2003 - 1.7.2003		19.0	660 5	0	0	0	0	1.47 26	340 3
1.7.2003 - 2.9.2003		24.4	1110 4	0	0	0	0	1.58 24	560 4
2.9.2003 - 13.11.2003		21.4	960 4	0	0	0	0	1.28 13	530 3
13.11.2003 - 23.4.2004		10.3	850 5	0	0	0	0	0	530 3
23.4.2004 - 29.6.2004		18.4	780 5	0	0	0	0	0	390 3
29.6.2004 - 31.8.2004		20.8	810 6	0	0	0	0	0	410 5
31.8.2004 - 22.11.2004			860 5	0	0	0	0		500 3

0 = below the detection limit

Table XXVIb. Gamma-emitting radionuclides in sinking matter (Bq kg^{-1} dry weight) in the vicinity of Olkiluoto nuclear power plant in 2002–2004. Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
Olkiluoto 12	15									
6.11.2001 - 17.4.2002		136.3	770	5	7.0	5	2.33	16	510	3
17.4.2002 - 25.6.2002		15.1	730	4	4.8	12	0		390	3
25.6.2002 - 27.8.2002		7.9	620	6	8.2	9	0		400	3
27.8.2002 - 26.11.2002		25.7	670	5	4.9	10	1.49	26	450	3
26.11.2002 - 8.5.2003		34.7	620	5	6.3	5	1.19	30	400	3
8.5.2003 - 18.6.2003		8.4	830	6	5.8	16	0		440	5
18.6.2003 - 19.8.2003		7.6	660	5	3.8	13	0		390	3
19.8.2003 - 5.11.2003		34.4	700	5	10.2	6	0		410	3
5.11.2003 - 28.4.2004		79.7	760	6	4.2	11	0		410	5
28.4.2004 - 22.6.2004		13.4	670	5	6.4	7	1.93	20	400	3
22.6.2004 - 17.8.2004		14.4	820	5	2.15	9	0		227	3
17.8.2004 - 10.11.2004		39.7	640	4	2.92	7	0		340	3

0 = below the detection limit

Table XXVIb. Continued.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
Olkiluoto 3	13									
6.11.2001 - 19.4.2002		193.5	770	4	4.8	8	1.79	19	410	3
19.4.2002 - 25.6.2002		16.8	580	5	5.0	10	1.68	22	330	3
25.6.2002 - 27.8.2002		5.1	570	7	6.0	15	0		320	3
27.8.2002 - 26.11.2002		57.5	750	5	6.7	6	1.22	24	430	3
26.11.2002 - 8.5.2003		44.0	700	5	4.0	6	1.27	20	400	3
8.5.2003 - 18.6.2003		16.1	720	5	4.1	9	0		380	3
18.6.2003 - 19.8.2003		10.3	640	5	4.8	11	0		350	3
19.8.2003 - 5.11.2003		96.7	730	5	4.3	8	1.32	27	410	3
5.11.2003 - 28.4.2004		133.6	730	5	4.3	5	1.09	19	420	3
28.4.2004 - 22.6.2004		22.9	620	5	6.8	8	0		340	3
22.6.2004 - 17.8.2004		10.4	640	5	5.6	10	0		320	3
17.8.2004 - 10.11.2004		107.5	650	6	4.5	10	0		320	5

0 = below the detection limit

Table XXVIb. Continued.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
Olkiluoto 4	8									
19.4.2002 - 25.6.2002		19.1	670	5	4.9	6	2.03	16	410	3
25.6.2002 - 27.8.2002		10.0	690	5	8.4	4	1.53	14	410	3
27.8.2002 - 27.11.2002		30.3	740	5	7.8	6	1.69	22	470	3
27.11.2002 - 7.5.2003		10.0	590	5	2.40	15	0		283	3
7.5.2003 - 17.6.2003		14.3	640	5	4.3	16	0		370	4
17.6.2003 - 19.8.2003		12.2	660	5	5.2	10	0		400	3
19.8.2003 - 5.11.2003		19.3	670	7	6.7	13	0		390	5
5.11.2003 - 28.4.2004		60.9	700	4	2.96	7	0		410	3
28.4.2004 - 22.6.2004		25.5	740	4	5.5	9	0		400	3
22.6.2004 - 17.8.2004		15.9	710	5	4.4	8	0		420	3
17.8.2004 - 9.11.2004		27.7	670	3	3.8	6	0		370	3

0 = below the detection limit

Table XXVIb. Continued.

Sampling station Sampling period	Sampling depth m	Dry weight g	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
Olkiluoto 15	11									
6.11.2001 - 17.4.2002		147.9	730	5	1.46	15	1.60	21	460	3
17.4.2002 - 25.6.2002		15.8	620	4	0		1.32	24	380	4
25.6.2002 - 27.8.2002		19.1	720	4	2.65	9	1.70	13	430	4
27.8.2002 - 27.11.2002		46.5	710	5	1.58	20	1.75	26	440	3
27.11.2002 - 7.5.2003		14.9	630	5	0		0		350	3
7.5.2003 - 17.6.2003		12.4	780	5	5.7	8	0		420	4
17.6.2003 - 19.8.2003		15.6	750	5	1.70	16	0		450	3
19.8.2003 - 5.11.2003		59.8	760	5	6.2	7	1.24	27	420	3
5.11.2003 - 27.4.2004		79.8	760	4	4.6	8	0		430	4
27.4.2004 - 22.6.2004		21.8	770	4	0		0		390	3
22.6.2004 - 17.8.2004		21.3	750	5	0		0		400	3
17.8.2004 - 9.11.2004		41.9	750	5	2.26	16	0		390	3

0 = below the detection limit

Table XXVII. The concentrations of ^{238}Pu and $^{239,240}Pu$ (Bq kg^{-1} dry weight) in combined sinking matter samples in the vicinities of Loviisa and Olkiluoto nuclear power plants in 2002–2004. Relative uncertainties (1σ) include statistical and calibration uncertainty.

Sampling station Sampling period	^{238}Pu		$^{239,240}Pu$	
Loviisa 3				
30.10.2001–19.11.2002	0.029	25	1.10	7
19.11.2002–14.11.2003	0		0.72	10
14.11.2003–30.11.2004	0		0.92	7
Loviisa R1				
31.10.2001–19.11.2002	0.031	24	0.61	8
19.11.2002–13.11.2003	0		0.55	8
13.11.2003–22.11.2004	0.022	37	0.49	8
Olkiluoto 12				
6.11.2001–26.11.2002	0.042	21	1.09	6
26.11.2002–5.11.2003	0		0.92	8
5.11.2003–10.11.2004	0.13	15	1.21	7
Olkiluoto 15				
6.11.2001–27.11.2002	0.027	24	1.24	6
27.11.2002–5.11.2003	0.040	25	1.20	7
5.11.2003–9.11.2004	0.043	25	1.04	7

0 = below the detection limit

Table XXVIII. Vertical distribution of ^{90}Sr, ^{238}Pu, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) in uppermost 5-cm slices of bottom sediments at Loviisa in 2002. Relative uncertainties (1σ) include both statistical and calibration uncertainty. The samples were taken by Gemini Twin Corer.

Sampling station (depth) slice (cm)	Dry matter %	^{40}K	^{60}Co	^{90}Sr*	^{125}Sb	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$
Loviisa 1 (7.1 m)									
0-5	10.7	850 4	2.71 15	1.66 7	0	2.54 21	800 4	0.052 28	2.08 7
5-10	14.9	820 5	4.1 12	2.35 5	0	2.79 22	930 4	0.078 20	2.17 6
10-15	18.2	860 5		-	0	3.4 17	770 4	-	-
Loviisa 3 (16.7 m)									
0-5	10.0	800 7	5.0 16	4.2 7	0	0	670 5	0.040 36	1.18 8
5-10	11.9	830 5	11.2 5	2.13 8	0	5.1 13	1150 3	0.056 27	1.60 7
10-15	13.7	770 5	9.3 7	-	0	9.9 8	2650 3	0.059 26	2.39 7
Loviisa 4 (22.7 m)									
0-5	8.47	700 7	0	2.99 7	0	-	690 5	0.062 25	1.97 5
5-10	9.03	730 5	0	5.3 10	0	4.2 17	1000 4	0.048 32	1.59 4
10-15	13.4	750 5	0	-	0	8.4 13	2160 4	0.110 21	2.91 7
Loviisa 7 (31.8 m)									
0-5	7.63	700 7	0	-	0	2.38 21	700 3	0.062 25	1.29 8
5-10	9.39	770 5	0	-	0	4.9 14	1140 3	0.048 32	1.81 7
10-15	15.5	800 4	0	-	0	3.5 13	1080 4	-	-
Loviisa 10 (23.4 m)									
0-5	8.09	760 5	0	2.66 7	0	3.8 13	740 3	0	1.07 10
5-10	10.2	710 5	0	5.1 6	0	5.6 15	1150 3	0.041 31	1.45 7
10-15	13.5	840 5	0	-	0	11.4 8	2910 3	-	-

0 = below the detection limit
- = not analysed
* = analytical error included

Table XXVIII. Continued.

Sampling station (depth) slice (cm)	Dry matter %	^{40}K	^{60}Co	^{90}Sr*	^{125}Sb	^{134}Cs	^{137}Cs	^{238}Pu	^{239,240}Pu
Loviisa R1 (12 m)									
0-5	15.7	980 5	0	1.01 8	0	3.3 15	710 3	0	0.77 10
5-10	22.9	950 5	0	1.6 7	0	3.7 17	870 3	0	0.92 9
Loviisa R2 (16 m)									
0-5	10.8	750 5	0	-	0	3.8 14	1000 3	-	-
5-10	17.0	880 5	0	-	6.7 26	3.9 17	1000 3	-	-
Loviisa S5 (17.1 m)									
0-5	7.93	760 5	0	-	0	3.8 17	750 3	-	-
5-10	11.4	840 5	0	-	0	4.3 14	1080 3	-	-
10-15	13.4	800 5	0	-	0	6.4 12	1830 3	-	-
Loviisa S6 (35.6 m)									
0-5	8.22	710 5	0	-	0	2.61 27	790 3	-	-
5-10	12.5	760 5	0	-	0	5.8 12	1640 3	-	-

0 = below the detection limit
- = not analysed
* = analytical error included

Table XXIXa. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by Gemini Twin Corer at the station Loviisa 1 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 7.1 m

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
I core									
0-1	6.5	660	6	0		3.8	20	650	3
1-2	10.3	880	7	0		0		760	4
2-3	12.1	820	6	0		0		800	3
3-4	12.8	940	5	3.8	19	3.3	21	810	3
4-5	13.6	810	6	0		4.6	25	820	5
5-6	14.2	810	5	0		4.6	17	850	3
6-7	12.5	910	5	10.8	11	0		820	4
7-8	15.3	820	7	0		0		840	5
8-9	15.3	820	8	0		0		870	5
9-10	15.6	910	4	0		4.5	20	1070	3
10-11	17.1	860	5	0		4.4	20	1210	4
11-12	17.3	870	5	2.69	13	0		1120	3
12-13	18.1	840	5	0		0		780	4
13-14	18.9	960	4	0		0		590	3
14-15	19.3	850	5	0		0		420	5
15-16	19.6	970	6	0		0		280	5
16-17	19.8	930	6	0		0		210	3
17-18	21.1	840	7	0		0		139	5
18-19	21.1	940	5	0		0		89	5
19-20	20.8	820	6	0		0		64	5
20-21	20.9	860	5	0		0		41	6
21-22	21.9	880	5	0		0		22.5	6
22-23	22.4	950	4	0		0		14.4	7
23-24	22.6	840	7	0		0		10.9	11
24-25	22.6	830	5	0		0		10.2	7
25-26	22.7	920	4	0		0		8.3	10
26-27	22.0	880	5	0		0		10.0	9
27-28	21.5	910	5	0		0		10.8	7
28-29	22.1	780	7	0		0		13.8	11
29-30	22.6	910	5	0		0		9.7	9
total amount								23800	Bq m^{-2}

Table XXIXa. Continued.

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
II core									
0-1	6.23	690	11	0		0		730	5
1-2	10.2	820	6	0		0		800	3
2-3	11.7	770	6	0		4.4	26	800	5
3-4	12.6	730	6	0		0		750	4
4-5	13.9	830	6	0		0		740	5
5-6	14.2	840	4	0		2.7	22	780	4
6-7	15.1	840	5	2.21	18	2.7	18	830	4
7-8	15.5	970	4	0		0		910	3
8-9	15.8	800	6	0		0		970	4
9-10	16.0	860	7	0		0		1080	5
10-11	17.5	840	8	0		0		1160	5
11-12	18.0	740	6	0		5.6	22	760	4
12-13	18.6	880	5	0		0		490	5
13-14	19.0	880	4	0		0		340	3

0 = below the detection limit

Table XXIXb. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by Gemini Twin Corer at the station Loviisa 3 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 16.7 m.

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
I core									
0-1	6.20	780	9	0		0		550	5
1-2	9.43	840	5	0	16	0		690	3
2-3	11.9	820	6	12.0	9	4.8	25	680	3
3-4	12.1	810	5	3.3	15	0		730	3
4-5	12.8	800	5	6.7	11	3.3	21	800	3
5-6	12.2	840	8	7.3	17	0		770	5
6-7	11.2	800	5	8.9	8	4.8	20	940	3
7-8	10.7	760	6	4.5	15	0		1020	3
8-9	12.1	640	6	13.0	11	0		1080	4
9-10	13.1	910	4	17.5	6	4.6	15	1440	3
10-11	11.4	730	6	10.1	12	6.7	19	1530	4
11-12	13.5	760	8	14.1	11	6.7	19	1900	5
12-13	13.6	810	5	8.5	7	11.9	7	2690	3
13-14	14.4	770	5	7.7	9	18.6	8	5590	3
14-15	15.4	760	5	5.0	17	4.5	21	1220	4
15-16	16.3	810	6	0		0		510	4
16-17	17.4	940	4	2.73	21	0		360	3
17-18	16.3	800	6	0		0		255	5
18-19	16.1	810	8	0		0		196	5
19-20	15.9	890	4	0		0		183	4
20-21	16.3	820	5	0		0		153	5
21-22	16.3	840	5	0		0		131	5
22-23	16.5	720	8	0		0		130	5
23-24	16.7	950	4	0		0		89	4
24-25	19.4	920	3	0		0		42	4
25-26	19.4	810	5	0		0		28	5
26-27	18.7	750	8	0		0		17.5	11
27-28	19.6	840	5	0		0		12.6	9
28-29	19.8	873	4	0		0		7.6	12
29-30	24.4	850	5	0		0		6.3	16
total amount								37800 Bq m^{-2}	

Table XXIXb. Continued.

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
II core									
0-1	6.57	790	6	4.0	21	0		600	3
1-2	9.5	810	7	0		0		670	3
2-3	11.8	690	8	0		0		660	3
3-4	12.4	780	11	0		0		710	5
4-5	11.9	920	7	0		0		770	4
5-6	12.2	790	9	6.5	26	0		800	4
6-7	12.6	800	8	7.6	22	0		830	5
7-8	12.1	750	7	7.1	15	0		980	3
8-9	12.2	700	7	7.5	17	0		1250	3
9-10	13.6	780	9	14.8	16	0		1390	5
10-11	11.8	680	8	7.6	19	0		1600	36
11-12	13.6	800	7	0		8.0	16	2170	3
12-13	13.4	910	11	0		0		2460	5
13-14	13.9	720	9	0		14.8	16	4400	4
14-15	15.3	930	6	0		14.8	20	1750	3

0 = below the detection limit

Table XXIXc. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by Gemini Twin Corer at the station Loviisa 4 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 22.7 m.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
I core							
0-1	5.61	820	5	0		640	3
1-2	8.62	780	7	0		690	5
2-3	8.45	590	6	0		590	4
3-4	10.16	770	5	3.4	18	730	4
4-5	10.60	780	10	0		700	5
5-6	9.50	750	7	0		820	5
6-7	9.12	840	5	0		810	3
7-8	8.62	810	6	0		990	3
8-9	8.94	730	6	0		1110	3
9-10	11.02	770	5	4.9	24	1540	3
10-11	13.23	730	8	0		1520	5
11-12	13.38	710	8	0		1640	5
12-13	13.39	780	5	8.3	13	2170	3
13-14	13.84	890	5	11.1	13	2720	3
14-15	14.38	810	6	13.6	12	3280	4
15-16	15.52	900	4	0		3590	3
16-17	16.64	840	5	7.1	19	1820	4
17-18	16.75	710	8	0		630	5
18-19	15.95	800	6	0		420	4
19-20	16.29	820	5	0		310	3
20-21	16.72	810	5	0		229	3
21-22	16.94	830	5	0		202	3
22-23	17.54	780	5	0		162	3
23-24	17.41	810	5	0		134	5
24-25	18.20	940	4	0		117	4
25-26	19.19	740	6	0		117	5
26-27	19.08	810	5	0		127	5
27-28	18.49	750	5	0		121	5
28-29	18.89	890	4	0		122	4
29-30	19.25	900	4	0		123	4
total amount						42800 Bq m^{-2}	

Table XXIXc. Continued.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
II core							
0-1	5.89	690	7	0		660	3
1-2	8.41	600	10	0		620	5
2-3	8.19	770	6	0		740	3
3-4	10.02	690	6	0		770	3
4-5	10.47	750	7	0		710	5
5-6	9.31	670	10	0		750	5
6-7	8.75	870	5	0		880	3
7-8	6.83	680	7	0		940	3
8-9	7.84	700	7	0		1070	3
9-10	9.79	740	7	0		1380	4
10-11	12.26	850	8	0		1460	5
11-12	13.01	940	5	6.8	14	1690	3
12-13	13.53	780	6	4.9	24	2010	3
13-14	13.58	730	6	9.4	14	2420	3
14-15	13.68	750	5	10.2	13	2870	3

0 = below the detection limit

Table XXIXd. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by Gemini Twin Corer at the station Loviisa 7 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 31.8 m.

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
I core									
0-1	5.91	600	12	0		0		580	5
1-2	5.61	1000	6	0		0		600	4
2-3	8.65	670	7	0		0		720	5
3-4	8.55	710	6	0		0		710	3
4-5	9.82	770	6	0		0		760	3
5-6	8.30	660	8	0		5.4	27	780	5
6-7	8.35	730	6	0		0		850	3
7-8	6.99	690	6	0		0		860	3
8-9	10.90	730	7	0		7.5	17	1120	5
9-10	12.44	780	5	1.5	26	6.0	13	1500	4
10-11	12.84	780	5	0		6.1	11	1860	3
11-12	14.56	840	6	0		6.2	20	1750	4
12-13	16.29	810	5	0		5.0	18	1310	3
13-14	16.73	780	5	0		2.4	24	560	3
14-15	17.47	920	4	0		0		230	4
15-16	18.17	820	6	0		0		186	4
16-17	19.40	840	4	0		0		147	4
17-18	19.33	810	5	0		0		130	5
18-19	19.38	860	5	0		0		119	3
19-20	20.20	810	5	0		0		109	3
20-21	19.62	840	5	0		0		105	3
21-22	18.88	860	5	0		0		101	5
22-23	19.50	900	4	0		0		94	4
23-24	19.54	830	5	0		0		92	5
24-25	21.08	930	4	0		0		86	4
25-26	23.01	910	4	0		0		68	4
26-27	22.34	860	5	0		0		48	4
27-28	23.08	940	4	0		0		31	5
28-29	23.82	910	5	0		0		19.2	7
29-30	26.24	880	5	0		0		8.2	12
total amount								21800 Bq m^{-2}	

Table XXIXd. Continued.

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
II core									
0-1	4.59	660	13	0		0		540	4
1-2	7.86	840	8	0		0		710	4
2-3	6.61	650	12	0		0		570	5
3-4	8.35	810	13	0		0		660	5
4-5	9.15	910	9	0		0		700	5
5-6	8.40	760	10	0		0		710	5
6-7	8.46	840	5	0		0		820	3
7-8	8.94	690	8	0		0		850	4
8-9	5.76	800	8	0		0		810	3
9-10	11.00	750	9	0		0		1100	5
10-11	11.86	830	7	0		0		1500	3
11-12	13.82	720	6	0		7.4	18	1810	4
12-13	15.93	570	5	0		0		930	4
13-14	17.57	900	4	0		0		370	3
14-15	18.26	790	7	0		0		202	5

0 = below the detection limit

Table XXIXe. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by GeminiTwin Corer at the station Loviisa 10 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 23.4 m.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
I core							
0-1	4.01	780	12	0		450	5
1-2	9.24	720	13	0		550	5
2-3	9.42	800	7	0		710	3
3-4	10.69	740	7	0		780	3
4-5	9.63	790	7	0		800	4
5-6	9.24	930	9	0		820	5
6-7	8.99	940	5	5.4	22	910	3
7-8	10.43	740	7	0		1080	4
8-9	11.63	800	6	4.8	17	1310	3
9-10	11.33	810	6	4.4	18	1460	3
10-11	11.93	870	8	0		1650	5
11-12	12.79	890	5	7.6	17	2000	3
12-13	14.68	800	6	9.6	14	2560	4
13-14	14.53	750	6	14.6	12	3300	3
14-15	15.92	840	5	18.9	6	4700	3
15-16	17.63	840	7	0		540	5
16-17	19.22	840	5	0		330	4
17-18	16.89	880	5	0		260	5
18-19	16.64	830	5	0		230	3
19-20	16.55	750	8	0		160	5
20-21	15.71	820	5	0		166	3
21-22	15.81	800	5	0		136	3
22-23	16.69	720	6	0		114	5
23-24	16.56	770	7	0		103	6
24-25	14.67	830	5	0		117	3
25-26	15.87	790	5	0		110	3
26-27	17.83	820	5	0		106	3
27-28	15.73	840	5	0		98	4
28-29	14.89	780	5	0		101	3
29-30	13.95	720	5	0		98	3
total amount						38100 Bq m^{-2}	

Table XXIXe. Continued.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
II core							
0-1	4.45	860	14	0		500	6
1-2	8.45	640	10	0		700	3
2-3	9.38	800	8	0		680	3
3-4	10.46	740	14	0		680	6
4-5	9.49	670	9	0		810	3
5-6	8.97	690	11	0		780	5
6-7	9.23	630	9	0		990	3
7-8	10.19	720	7	0		1070	3
8-9	10.09	710	10	0		1220	5
9-10	11.42	750	7	0		1290	4
10-11	10.20	730	8	9.7	23	1610	3
11-12	11.06	800	9	0		1700	5
12-13	13.74	740	9	6.0	23	2080	5
13-14	14.67	780	5	10.7	9	3000	3
14-15	16.09	820	5	12.0	15	3600	3

0 = below the detection limit

Table XXIXf. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by GeminiTwin Corer at the station Loviisa R1 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 12.0 m.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
I core							
0-1	7.10	920	6	0		590	3
1-2	15.50	820	6	0		630	3
2-3	18.51	880	6	0		640	3
3-4	20.30	1020	5	2.5	26	660	3
4-5	20.65	950	6	0		660	5
5-6	21.71	840	7	0		680	5
6-7	22.17	1010	4	2.7	24	760	3
7-8	23.66	1000	5	0		870	3
8-9	23.33	930	6	0		910	3
9-10	23.66	940	5	0		960	3
10-11	23.84	920	5	0		1110	3
11-12	24.64	1010	5	3.8	20	1210	3
12-13	24.96	890	6	0		1440	3
13-14	24.60	980	5	8.5	14	1740	3
14-15	25.83	960	6	0		1820	3
15-16	26.53	930	8	7.6	28	1930	5
16-17	26.65	970	8	0		920	5
17-18	26.30	900	6	0		430	4
18-19	26.54	860	6	0		310	5
19-20	26.55	980	5	0		229	4
20-21	25.95	970	5	0		203	3
21-22	25.85	910	6	0		185	3
22-23	25.82	950	5	0		176	3
23-24	26.69	900	5	0		152	3
24-25	27.93	1010	5	0		123	4
25-26	26.98	880	6	0		128	5
26-27	28.19	1020	6	0		68	6
27-28	28.44	910	5	0		49	5
28-29	26.89	930	5	0		38	5
29-30	28.08	920	5	0		17.2	8
total amount						59500 Bq m^{-2}	

Table XXIXf. Continued.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
II core							
0-1	7.56	880	7	0		590	3
1-2	14.26	950	7	0		610	5
2-3	18.27	950	6	0		680	3
3-4	19.77	970	6	0		660	3
4-5	21.10	890	9	0		650	5
5-6	21.51	910	6	0		680	4
6-7	22.15	910	6	0		740	5
7-8	23.54	990	5	0		840	3
8-9	22.96	980	5	4.3	19	910	3
9-10	23.04	960	6	4.4	22	930	3
10-11	23.71	890	6	3.8	29	980	5
11-12	24.73	980	5	0		1080	3
12-13	25.87	980	5	5.3	17	1420	3
13-14	28.96	970	5	5.0	18	1640	3
14-15	26.44	840	8	6.6	25	1660	5

0 = below the detection limit

Table XXIXg. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by GeminiTwin Corer at the station Loviisa R2 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 16.0 m.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs
0-1	5.37	710	6	3.5	25	700
1-2	11.43	810	6	0		890
2-3	12.59	860	8	0		1010
3-4	13.46	940	4	0		1040
4-5	14.14	780	6	4.7	27	1230
5-6	15.08	750	7	5.0	26	1340
6-7	16.21	860	6	0		1370
7-8	16.99	850	7	0		1160
8-9	17.96	800	6	0		620
9-10	18.65	900	7	0		320
10-11	21.09	930	6	0		163
11-12	22.40	860	9	0		75
12-13	22.63	840	6	0		51
13-14	22.77	930	5	0		42
14-15	23.24	1030	5	0		26
15-16	23.93	910	6	0		14.6
16-17	23.82	850	6	0		15.7
17-18	23.42	1000	5	0		17.1
18-19	23.82	880	9	0		10.4
19-20	23.91	930	6	0		13.2
20-21	24.67	930	5	0		13.3
21-22	24.38	880	6	0		11.7
22-23	24.96	940	5	0		7.5
23-24	26.15	880	6	0		5.0
24-25	28.34	780	8	0		0
25-26	28.15	860	6	0		0
26-27	26.67	170	12	0		0
27-28	29.62	960	5	0		0
28-29	33.33	900	5	0		0
29-30	32.83	810	5	0		0
total amount						19100 Bq m^{-2}

0 = below the detection limit

Table XXIXh. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by GeminiTwin Corer at the station Loviisa S5 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 17.1 m.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
0-1	2.37	600	16	0		430	4
1-2	8.84	660	9	0		710	3
2-3	8.33	620	11	0		640	5
3-4	11.22	850	8	0		760	5
4-5	11.03	760	8	0		770	3
5-6	12.09	750	7	0		860	3
6-7	12.78	950	8	0		920	5
7-8	9.79	830	7	0		950	3
8-9	10.31	830	9	0		1010	5
9-10	11.76	850	7	0		1400	3
10-11	12.60	780	8	0		1410	3
11-12	11.45	850	7	0		1450	3
12-13	12.87	920	7	0		1680	3
13-14	14.92	990	5	0		2000	3
14-15	15.22	890	7	8.8	16	2390	4
15-16	15.72	770	10	0		2840	5
16-17	17.14	920	7	17.4	17	5100	4
17-18	17.12	860	7	0		1420	5
18-19	18.23	1010	5	0		430	4
19-20	18.14	800	6	0		320	3
20-21	17.57	760	7	0		238	3
21-22	16.98	740	10	0		173	6
22-23	17.42	880	6	0		147	4
23-24	15.18	790	8	0		126	6
24-25	15.71	790	6	0		135	4
25-26	17.02	880	6	0		127	4
26-27	17.22	860	7	0		129	6
27-28	16.42	870	6	0		108	5
28-29	17.02	880	6	0		69	4
29-30	18.39	760	10	0		39	10
total amount						49600 Bq m^{-2}	

0 = below the detection limit

Table XXIXi. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by GeminiTwin Corer at the station Loviisa S6 in 2002 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty. Depth 35.6 m.

Slice (cm)	Dry matter %	^{40}K		^{134}Cs		^{137}Cs	
0-1	4.79	610	8	0		570	3
1-2	6.51	850	6	0		610	4
2-3	9.73	630	11	0		670	5
3-4	10.07	730	7	0		760	3
4-5	9.83	650	8	0		900	3
5-6	10.77	650	10	0		1060	5
6-7	12.01	880	5	5.9	16	1520	3
7-8	12.78	900	6	0		1630	3
8-9	13.40	800	7	0		1860	3
9-10	13.76	770	8	0		1970	5
10-11	15.40	800	8	0		1640	5
11-12	16.56	830	8	0		940	4
12-13	17.07	860	6	0		470	3
13-14	18.17	930	6	0		212	4
14-15	19.00	920	6	0		162	4
15-16	20.45	820	6	0		144	4
16-17	21.04	870	6	0		122	4
17-18	21.42	830	7	0		114	6
18-19	18.49	840	9	0		97	7
19-20	18.28	810	6	0		117	4
20-21	19.03	920	7	0		105	6
21-22	17.90	780	6	0		97	4
22-23	16.59	810	7	0		93	6
23-24	18.51	940	6	0		98	4
24-25	19.65	880	6	0		89	4
25-26	22.63	830	9	0		84	7
26-27	23.30	840	6	0		83	6
27-28	23.40	850	6	0		74	5
28-29	24.76	930	6	0		40	8
29-30	24.71	890	6	0		10.8	10
total amount						26000 Bq m^{-2}	

0 = below the detection limit

Table XXX. Vertical distribution of ^{90}Sr, ^{238}Pu, $^{239,240}Pu$ and gamma-emitting radionuclides (Bq kg^{-1} dry weight) and total amounts of ^{137}Cs (Bq m^{-2}) in bottom sediments at Olkiluoto in 2003. Relative uncertainties (1σ) include both statistical and calibration uncertainty. The samples were taken by Gemini Twin Corer.

Sampling station (depth) slice (cm)	Dry matter %	^{40}K		^{60}Co		^{90}Sr*		^{134}Cs		^{137}Cs		^{238}Pu		$^{239,240}Pu$	
Olkiluoto 1 (6.5 m)															
0-5	20	790	4	9.2	6	-		0		390	3	-		-	
5-10	31	820	6	5.1	13	-		0		259	5	-		-	
10-15	30	920	5	0		-		0		84	3	-		-	
15-20	29	780	5	0		-		0		24.0	4	-		-	
20-25	27	840	4	0		-		0		9.0	9	-		-	
25-30	29	900	4	0		-		0		3.1	14	-		-	
total amount										12500 Bq m^{-2}					
Olkiluoto 2 (14 m)															
0-5	14	730	5	9.1	6	3.5	7	1.88	25	550	3	0.061	15	1.22	6
5-10	19	810	5	39.8	3	5.6	6	2.47	16	750	3	0.079	14	1.54	6
10-15	22	700	7	20.0	7	-		0		880	5	-		-	
15-20	22	740	5	15.9	7	-		0		1460	4	-		-	
20-25	21	770	5	3.8	8	-		0		171	3	-		-	
25-30	24	740	5	0		-		0		103	5	-		-	
total amount										47600 Bq m^{-2}					
Olkiluoto 4 (8.9 m)															
0-5	16	780	4	5.7	8	-		0		480	3	-		-	
5-10	23	810	5	8.8	5	-		1.64	20	700	3	-		-	
10-15	25	730	5	5.5	11	-		0		800	4	-		-	
15-20	27	660	6	0		-		0		190	5	-		-	
20-25	26	790	4	0		-		0		84	4	-		-	
25-30	28	830	5	0		-		0		41	3	-		-	
total amount										32000 Bq m^{-2}					

0 = below the detection limit
- = not analysed
* = analytical error included

Table XXX. Continued..

Sampling station (depth) slice (cm)	Dry matter %	^{40}K		^{60}Co		^{90}Sr*		^{134}Cs		^{137}Cs		^{238}Pu		^{239,240}Pu	
Olkiluoto 5 (5.2 m)															
0-5	24	700	5	2.84	10	-		1.44	23	320	3	-		-	
5-10	33	680	4	0		-		0		192	4	-		-	
10-15	29	760	4	0		-		0		35	4	-		-	
15-20	31	740	6	0		-		0		7.9	7	-		-	
20-25	33	790	4	0		-		0		1.60	24	-		-	
25-30	33	790	5	0		-		0		1.65	15	-		-	
total amount										10700 Bq m^{-2}					
Olkiluoto 9 (9.9 m)															
0-5	14	940	5	79	4	1.83	7	0		620	4	0.110	20	1.25	8
5-10	18	680	5	14.6	7	3.2	6	0		620	4	0.055	17	1.67	6
10-15	19	810	4	18.7	5	-		2.35	21	710	3	-		-	
15-20	23	800	4	26.2	3	-		2.32	19	890	3	-		-	
20-25	25	740	4	9.4	7	-		0		610	4	-		-	
25-30	25	750	5	0		-		0		133	3	-		-	
total amount										45000 Bq m^{-2}					
Olkiluoto S5 (7.5 m)															
0-5	18	800	6	0		3.8	6	0		430	5	0.058	16	1.69	5
5-10	26	740	5	2.54	12	2.10	6	1.91	15	500	3	0.068	15	2.08	5
10-15	32	760	6	0		-		0		320	5	-		-	
15-20	38	770	4	0		-		0		37	5	-		-	
20-25	40	830	4	0		-		0		3.8	11	-		-	
25-30	37	990	4	0		-		0		0		-		-	
total amount										21500 Bq m^{-2}					

0 = below the detection limit
- = not analysed

* = analytical error included

Table XXX. Continued..

Sampling station (depth) slice (cm)	Dry matter %	^{40}K		^{60}Co		^{90}Sr*		^{134}Cs	^{137}Cs		^{238}Pu		^{239,240}Pu	
Olkiluoto S6 (6.4 m)														
0-5	15	780	7	0		-		0	400	5	-		-	
5-10	19	1000	5	2.88	18	-		0	540	4	-		-	
10-15	21	850	4	2.03	15	-		0	500	3	-		-	
15-20	23	840	6	0		-		0	380	5	-		-	
20-25	26	740	4	0		-		0	93	4	-		-	
25-30	25	750	7	0		-		0	19.9	8	-		-	
total amount									21400 Bq m^{-2}					
Olkiluoto S8 (12.7 m)														
0-5	16	830	5	0		3.7	6	2.58	630	3	0.066	16	1.84	6
5-10	21	770	4	2.50	22	2.83	6	0	770	4	0.072	16	2.30	5
10-15	22	750	4	0		-		0	710	4	-		-	
15-20	24	800	4	0		-		0	175	4	-		-	
20-25	26	740	5	0		-		0	59	5	-		-	
25-30	29	860	5	0		-		0	12.5	5	-		-	
total amount									27000 Bq m^{-2}					

0 = below the detection limit
- = not analysed
* = analytical error included

Table XXXI. Vertical distribution of gamma-emitting radionuclides in 1 cm slices of surficial bottom sediments taken by GeminiTwin Corer at the station Olkiluoto 2 in 2003 (Bq kg^{-1} dry weight). Relative uncertainties (1σ) include both statistical and calibration uncertainty.

Slice (cm)	Dry matter %	^{40}K		^{60}Co		^{134}Cs		^{137}Cs	
0-1	2	670	8	6.5	27	0		420	3
1-2	11	740	6	0		0		490	4
2-3	17	770	8	0		0		440	5
3-4	17	730	5	10.0	8	0		590	3
4-5	19	780	5	10.8	6	2.77	17	610	3
5-6	16	930	5	6.7	12	0		750	4
6-7	18	700	8	5.8	18	0		650	5
7-8	14	750	5	83	4	1.78	23	740	3
8-9	13	720	5	9.1	11	0		690	4
9-10	19	930	5	19.4	6	0		910	4
10-11	21	830	4	16.1	6	0		760	3
11-12	22	740	5	14.6	5	3.4	17	870	3
12-13	22	770	5	19.0	4	2.36	18	940	3
13-14	24	840	5	34	4	2.40	23	1140	4
14-15	24	850	5	12.8	7	1.94	22	1320	4
15-16	23	740	7	13.5	9	0		1120	5
16-17	22	740	4	11.0	6	3.3	16	1250	3
17-18	19	720	5	16.0	6	4.8	16	1470	3
18-19	18	770	5	13.1	5	4.0	11	2000	3
19-20	22	730	7	7.0	14	0		1430	5
20-21	22	710	5	5.3	10	0		330	3
21-22	23	740	7	0		0		161	5
22-23	22	720	5	4.0	11	0		143	3
23-24	24	780	4	0		0		118	4
24-25	22	770	5	1.71	18	0		109	3
25-26	22	670	5	0		0		101	3
26-27	25	950	5	0		0		122	5
27-28	23	750	4	0		0		92	4
28-29	23	760	5	0		0		99	3
29-30	25	700	5	0		0		103	3
total amount								47600 Bq m^{-2}	

0 = below the detection limit

Table XXXII. High pressure ionization chamber measurements of environmental dose rates in the vicinity of Loviisa and Olkiluoto nuclear power plants in 2002.

Loviisa Station	μSv h^{-1}	Olkiluoto Station	μSv h^{-1}
20	0.16	20	0.09
21	0.18	21	0.13
22	0.17	22	0.12
23	0.19	23	0.14
24	0.14	24	0.14
25	0.13	25	0.10
26	0.14	26	0.10
27	0.19	27	0.11
28	0.17	28	0.13
29	0.22	29	0.13
		34	0.10

Table XXXIII. Direct spectroscopic measurements of source activity on open fields near the nuclear power plants in 2002–2004 (kBq m^{-2}).

	^{137}Cs
Loviisa 34	
2002	6.1
2004	18
Olkiluoto 38	
2003	1.7

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