Radioactive Substances Series

PARCOM Recommendation 91/4 on Radioactive Discharges

Norway's Report on the Implementation of PARCOM Recommendation 91/4 on radioactive discharges for 2006

OSPAR Commission
2006

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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contents

Introduction

This report has been produced as part of the fourth round of implementation reporting on PARCOM Recommendation 91/4, where Norway was scheduled to report to the meeting of the OSPAR Radioactive Substances Committee in 2006. The report is outlined according to the guidelines. The first section gives general information regarding national legislation, dose limits, discharge limits etc.

Section 2 and 3 give site specific information about each of the two nuclear installations (research reactors) in Norway.

1. General Information

1.1 National legislation/ regulation

Authorisations of nuclear installations are issued on the basis of Act No. 36 of 12 May 2000 on Radiation Protection and Use of Radiation which entered into force 1 July 2000 and Regulation No. 1362 of 21 November 2003 on Radiation Protection and Use of Radiation. With some exceptions, the regulation entered into force 1 January 2004 and replaced former regulations on this field.

Nuclear installations are also regulated in accordance with Act No. 28 of 12 May 1972 concerning Nuclear Energy Activities. This Act was last revised 30 August 2002.

The discharge authorisations require the use of Best Available techniques (BAT)

1.2 Other basis for national legislation/regulation

The Norwegian policy in this field is based on internationally accepted principles for radiation protection from appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).

When issuing authorisations for nuclear installations, Norwegian practice is to focus on BAT, ALARA-principle and the precautionary principle

1.3 Dose constraints/limits for nuclear facilities

The dose limit applied in the current discharge authorisation given to each of the two sites of the Norwegian Institute for Energy Technology is 1 μSv/year for the most exposed members of the general population from liquid discharges. The dose limit for emissions to air is 100 μSv/year whereof iodine isotopes should not contribute more than 10 μSv/year.

1.4 Discharge limits

The current discharge authorisation contains specific warning limits for emissions. When emissions exceed these warning limits or the prognosis shows that the limits may be exceeded during the year, the Norwegian Radiation Protection Authority shall be notified. These warning limits are calculated on the basis of the emissions in recent years and are specific for each radionuclide or groups of radionuclides. The limits are different for emissions to air and water.

1.5 Monitoring programmes of environmental concentrations of radionuclides

The operators of the research reactors are required to carry out environmental monitoring, especially of the recipient of the radioactive emissions and discharges. This requirement is a condition of the discharge Authorisation.

In the discharge authorisations issued by the Norwegian Radiation Protection Authority it is required that the establishment carry out control measurements of their emissions to air and water. These measurements are conducted according to a programme approved by the Norwegian Radiation Protection Authority and the results of the monitoring are reported to NRPA yearly. Further on, the establishment is instructed to conduct yearly recipient surveillance according to a programme approved by NRPA.

In addition to the environmental monitoring programmes carried out by the operator of the nuclear sites, the Norwegian Radiation Protection Authority coordinates national monitoring programmes for radioactive contamination of the marine and terrestrial environments.

The marine monitoring programme was established in 1999. The principal objective of the programme is to document levels, distributions and trends of anthropogenic and naturally occurring radionuclides along the Norwegian coast, in the North Sea, the Norwegian Sea and the Barents Sea, and to make information regarding radioactive contamination available to authorities, the fishing industry, media and the public in general.

1.6 Environmental norms and standard

Action limits for the concentration of Cs-137 and Cs-134 in foodstuffs exists, but in principle they apply in relation to Chernobyl-derived contamination only. Otherwise, the degree of protection of the environment still is based on the protection of human health through the application of dose constraints/limits.

In addition to the traditional protection of human health, the principle that the environment should also be protected has been adopted in the new radiation protection act.

Internationally accepted and agreed criteria for environmental protection are so far lacking, but the NRPA is engaged in activities of the International Union of Radioecology and the ICRP to develop a framework for the protection of the environment from ionising radiation, and this work is expected to contribute to the development of environmental norms and standards.

1.7 National Authority responsible for supervision of discharges

Licensing and supervision of the operation of nuclear sites is carried out by the Norwegian Radiation Protection Authority (NRPA).

1.8 Inspection and surveillance programmes

The sites of the nuclear research reactors are inspected by the NRPA on a regular basis with regard to nuclear safety and radiation protection.

The NRPA collects and analyses samples near the sites and discharge points independently and/or obtains double control samples from the operators monitoring programmes.

1.9 Reporting to national authorities

Liquid discharges and emissions to air of radionuclides and results of the operators' environmental monitoring programmes are reported to the Norwegian Radiation Protection Authority each year.

If discharges exceed the predefined warning levels, the NRPA shall be notified.

1.10 International reporting

Liquid radionuclide discharges from the research reactor sites are reported to OSPAR each year.

2. Institute for Energy Technology, Kjeller

2.1 Site characteristics

2.1.1 Name of site

Institute for Energy Technology (IFE),

Kjeller, Norway

2.1.2 Type of facility

- Research reactor JEEP II, heavy water cooled and moderated.
- Metallurgical Laboratory II, incl. hot cells. (This facility has no liquid waste discharges as from 2000.)
- Medical radioactive isotopes facilities GE Healthcare, Amersham Health AS (production) and Isotope Laboratories (QA and sales).
- Radioactive Waste Treatment Plant for LL-and IL waste.

2.1.3 Year for commissioning/licensing/decommissioning

Reactor commissioning:	1967
Current reactor licence:	expiry date 2009

2.1.4 Location

The mentioned facilities are all situated at the premises of IFE at Kjeller, about 20 km north east of Oslo.

2.1.5 Receiving waters

Liquid effluent is discharged through a designated pipeline to the river Nitelva about 100 km from the sea. The river, having an annual mean flow rate of 5 m3/second, empties into Lake Oyeren where the water is mixed with the water of river Glomma having an annual mean flow rate of 400 m3/second. Glomma River empties into the Oslo Fjord at Fredrikstad City.

2.1.6 Production

The thermal effect of the research reactor JEEP II is 2 MW.

The Radwaste Plant manages liquid and solid LL- and ILW from Norwegian industry, universities, hospitals, etc., as well as from IFE. The annual production of solid waste is about 120 drums (210 litres) which are transported to the combined storage and disposal facility in Himdalen. The liquid waste is either solidified or discharged.

A plant producing radiopharmaceutical products, managed by a private company, GE Healthcare, Amersham Health AS, is operating in close collaboration with IFE. The discharge authorisation for IFE also includes the discharges from this production facility.

2.2 Discharges

The discharge limit is authorised by the Norwegian Radiation Protection Authority (NRPA). It is based on that the annual dose to any member of a critical group of the population along the Nitelva River shall not exceed 1 µSv.

2.2.1 Description of systems

The low level liquid waste originates from the mentioned facilities from where it is transported by special pipelines to the Radwaste Plant. The Plant has a system of large tanks for storage of liquid waste. The plant also has facilities for filtration and purification of the water by ion exchange and evaporation. It is normally not needed to purify the produced liquid waste before discharge in order to comply with the given discharge limit. The shortlived radionuclides are however normally (if no capacity problems) allowed to decay to a great extent before discharge.

Before discharges are authorised by IFE's Health and Safety Department, samples are analysed by this department for all relevant radionuclides, and the amounts to be discharged are compared to the discharge limit.

2.2.3 Nuclide libraries

Canberra standard nuclide library is used for measuring discharges and identifying and measuring emissions of concern for the marine environment.

2.2.4 Annual liquid discharges

SITE	Radio-nuclides	MBq 1999	MBq 2000	MBq 2001	MBq 2002	MBq 2003	MBq 2004
Institute for Energy Technology Kjeller	Cs-137	30	6,7	26	25	22	7,9
	Cs-134	1,9	0,43	2,5	2,3	1,2	0,35
	I-131	1,35E+3	25	107	6,0	15	27
	I-125	182	91	310	350	540	327
	Ce-144	-	-	-	1,6	3,3	1,1
	Gd-153	-	-	-	-	-	-
	Sb-125	-	-	-	-	2,7	0,075
	Ru-103	-	-	-	-	0,14	0,10
	Ru/Rh-106	-	-	-	-	2,0	-
	Ag-110m	-	-	-	1,2	2,1	0,089
	Nb-95	-	-	-	0,17	0,42	-
	Zr-95	-	-	-	0,13	0,14	-
	Zn-65	0,75	0,90	3,8	-	0,27	0,10
	Co-58	-	-	-	-	0,26	-
	Co-60	6,9	8,7	74	60	55	24
	S-35	18,5	142	-	-	-	18,5
	Sr-90	161	6,5	1,23	0,55	0,33	2,6
	Pu-238	-	-	-	0,011	0,002	0,010
	Pu-239,40	0,016	0,17	0,3E-3	0,038	0,034	0,15
	Am-241	-	-	-	0,70	0,0050	0,0027
	H-3	0,85E+5	4,02E+5	15,1E+5	23,6E+5	28,3E+5	2,95E+5
	Total (% of limit)	53	4,5	20	18	17	7,0

The total annual discharge varies, as shown in the table, roughly between 5 and 50 % of the limit, with an average of about 20 % for the years 1999-2004.

Being within the limit of 1 µSv at a location 100 km upstream of the sea, the liquid discharges from IFE are already close to zero with regard to the marine environment.

2.2.5 Emissions to air

There are no emissions to air from the facilities of concern for the marine environment.

Only the shortlived nuclides Ar-41 and I-131 are measurable in the emissions to air. I-131 emissions varied in the range 940 – 2690 MBq per year in the period 1999-2004.

2.2.6 Quality assurance

The Health and Safety Department has a comprehensive quality control and assurance system where all work tasks, including measurement of activity, are described in detail in working instructions and procedures.

To ensure that the discharges are carried out correctly, several control procedures relating to the technical condition of the discharge pipe, procedures to verify that discharges actually reach the discharge point and controls of the water level in the river prior to discharge has been implemented.

2.2.7 Target values

Discharges are related to the discharge limit given by the NRPA mentioned above (see point 2.2.2).

2.3 Environmental impact

2.3.1 Concentrations in environmental samples

The concentrations of ^{137}Cs in Nitelva River water sampled within the monitoring programme (see point 3.3) were below the analytical laboratory's detection limit. The theoretical average river water concentration of discharged ^{137}Cs in 1999-2004 was 0,11 mBq/litre. The water concentration is more than 80 times lower when it empties into the Oslo Fjord. Furthermore, this is more than 5 orders of magnitude lower than the ^{137}Cs concentration of the outflow waters from the Baltic Sea with which it mixed in the Oslo Fjord and Skagerrak.

The detected average concentrations in 2004 of ^{90}Sr in river water was 6,2 mBq/litre, and the theoretical average from IFE's discharges was 0,02 mBq/litre. The corresponding numbers for ^{239,240}Pu were about 0,1 mBq/litre and 1,0E-3 mBq/litre, respectively. These results show that the river water still has major contributions from other sources like the atmospheric bomb test fallout and the Chernobyl fallout.

As a result of discharges in the late sixties and early seventies from a uranium purification plant, an area of about 260 m^2 of the bottom sediments of Nitelva had been contaminated mainly with plutonium. The maximum concentrations, reaching levels of 1-2 MBq/kg, were in 1999 detected at about 20-60 cm depth in the sediments. About 165 m^3 of sediments in which the sum of plutonium and Am-241 concentrations could be higher than 10 kBq/kg were removed early last year, and is now disposed of in the Himdalen Facility for low-level and intermediate-level radioactive waste.

2.3.2 Nuclide libraries

Canberra standard nuclide library is used for all gamma spectrum analysis.

2.3.3 Monitoring programmes

The environmental monitoring programme for Nitelva River is operated by IFE's Health and Safety Department and includes river water, sediment, fish and water plants sampled several times during the year. The programme has been approved by the NRPA.

2.3.4 National target levels

Not developed.

2.3.5 Quality assurance

The Health and Safety Department has a comprehensive quality control and assurance system where all work tasks, including measurement of activity are described in detail in working instructions and procedures. Criteria for non-conformity are also defined in these procedures. The Department is member of IAEAs ALMERA network of Radioanalytical laboratories for analysis of environmental samples.

2.4 Radiation doses to the public

2.4.1 Calculated annual effective dose to local critical group

	1999	2000	2001	2002	2003	2004
Effective dose from limnic (river water) exposure pathways (µSv)	0,l53	0,05	0,20	0,18	0,17	0,07

In the marine environment, the resulting dose to some critical group will be much lower than 1 µSv due to the dilution of more than a factor of 80.

2.4.2 Total exposure

The above table covers all discharges of low level liquid radioactive waste into the river Nitelva from IFE Kjeller over the last 6 years. The calculated effective dose values are theoretical and can thus only be applied to measured discharge values.

2.4.3 Definition of critical group

The critical group is hypothetical and only defined by their food consumption and living habits. The estimation of doses to the group is based on theoretical radionuclide concentrations in the mentioned local river environment, situated 100 km from the sea, calculated from measured discharge values. The doses represent the adult population. It has been established that children, taking their consumption and living habits into account, do not receive doses which deviate significantly from the adults.

2.4.4 Exposure pathways

The calculation of effective dose to the critical group is based on:

- Annual consumption of 20 kg fish from the river, and
- 100 hours/year occupancy on the riverbanks, while
- bathing and boating did not lead to significant contribution to the doses.

2.4.5 Methodology

All modelling of transfer of radionuclides in the environment and resulting doses to critical group are based on the use of the code PC-CREAM (EUR 17791 EN (NRPB-SR296), UK, 1997. The code uses the model described in:

> Simmonds J.R., Lawson G. and Mayall A., *Methodology for assessing radiological consequences of routine releases of radionuclides to the environment*,
>
> European Commission, EUR 15760 EN, ISSN 1018-5593, (1995)

2.4.6 Site-specific factors

No site-specific factors are used except for the, by IFE's Health and Safety Department, determined K_d for ^{60}Co and ^{137}Cs for the actual river sediment. The estimates are otherwise based on default factors from the above reference (point 4.5).

2.4.7 Target dose

The discharge limits defined by the NRPA are based on a limiting effective dose to an individual in the critical group of 1 µSv/year, as mentioned above (point 2).

2.4.8 Quality assurance

There are no measurements involved in the dose assessment except for what is mentioned in 4.6. The calculations have been tested against example calculations from the reference in 4.5.

3. Institute for Energy Technology, Halden

3.1 Site Characteristics

3.1.1 Name of site

Institutt For Energiteknikk

OECD Halden Reactor Project

3.1.2 Type of facility

Halden Boiling Water Reactor (HBWR), heavy water cooled and moderated. HBWR has three main systems, the primary system (heavy water) and two light water heat removal systems where the secondary system is a closed loop system.

3.1.3 Year for commissioning etc.

Commissioning: 1959

Current Licence: expiry date 31/12-2008

3.1.4 Location

HBWR is located in the town of Halden, in the south-eastern part of Norway, close to the Swedish border.

3.1.5 Receiving waters

Liquid effluent is released to the river Tista which discharges into Iddefjord, leading to Skaggerak.

3.1.6 Production

The maximum heat removal capacity is 25 MW. The heat is transferred from the tertiary system to the adjacent paper factory as steam. The primary system operates with a water temperature of 240 ºC, corresponding to an operating pressure of 33,4 bar.

3.2 Discharges

3.2.1 Description of systems

Drainage and delay system

This system is designed for collection and disposal of water. Water is directed to and flows through a 10m^3 delay tank. Activity monitoring is performed continuously on the water leaving the delay tank to the sewage system. In the case of abnormally high water activity, a main outlet valve will close automatically, and the water is collected in the three delay tanks (total volume 30 m^3). If necessary, an additional 80 m^3 of water can be pumped to a pit in the reactor hall, thus providing a storage capacity of 110m^3. This water can then be cycled through a clean-up system with particle filter and ion exchange resin, before release.

Otherwise all appropriate circuits, including the primary system and experimental circuits are equipped with particle filters and ion exchange columns to ensure clean-up as near to the source as possible.

3.2.2 Efficiency of systems

Liquid waste destined for disposal is retained and cleaned, with the help of ion exchange columns and an evaporation tank, to a level considered acceptable for discharge, relative to the applicable discharge limits.

Waste streams destined for discharge are directed through the delay system described above. The water flows to a delay tank that has a constant water level corresponding to 5 m^3. This provides a degree of retention since there is no direct flow-through of water, thus allowing further reduction of activity before discharge, due to both sedimentation and radioactive decay.

3.2.3 Nuclide libraries

Canberra standard nuclide library is used for measuring discharges and identifying and measuring emissions of concern for the marine environment. The standard library has been supplemented with a number of radionuclides which have been identified in discharges through a comprehensive study of peaks which were not identifiable using the standard library.

3.2.4 Annual liquid discharges

Site	Radionuclide	1999 TBq	2000 TBq	2001 TBq	2002 TBq	2003 TBq	2004 TBq
Institutt For Energy Technology Halden Reactor Project	H-3	0,67	0,52	0,24	1,1	0,27	0,54
	Cr-51	$2,4 \cdot 10^{-4}$	$6,1 \cdot 10^{-4}$	$2,9 \cdot 10^{-4}$	$1,5 \cdot 10^{-4}$	$1,3 \cdot 10^{-4}$	$2,1 \cdot 10^{-4}$
	Mn-54	$5,6 \cdot 10^{-6}$	$5,0 \cdot 10^{-6}$	$7,0 \cdot 10^{-6}$	$5,3 \cdot 10^{-7}$	$1,8 \cdot 10^{-7}$	$7,3 \cdot 10^{-7}$
	Mn-56	-	$1,3 \cdot 10^{-5}$	-	-	-	$2,8 \cdot 10^{-6}$
	Co-58	$2,0 \cdot 10^{-5}$	$1,4 \cdot 10^{-5}$	$4,9 \cdot 10^{-5}$	$5,1 \cdot 10^{-6}$	$3,3 \cdot 10^{-6}$	$8,7 \cdot 10^{-6}$
	Fe-59	-	$7,2 \cdot 10^{-8}$	-	$3,2 \cdot 10^{-7}$	-	$7,5 \cdot 10^{-7}$
	Co-60	$3,8 \cdot 10^{-4}$	$5,3 \cdot 10^{-4}$	$4,4 \cdot 10^{-4}$	$8,8 \cdot 10^{-5}$	$6,2 \cdot 10^{-5}$	$6,8 \cdot 10^{-5}$
	Sr-90	-	-	-	-	$3,3 \cdot 10^{-6}$	$2,1 \cdot 10^{-6}$
	Zr-95	$1,4 \cdot 10^{-5}$	$2,1 \cdot 10^{-5}$	$1,6 \cdot 10^{-5}$	$5,4 \cdot 10^{-6}$	$3,3 \cdot 10^{-6}$	$4,9 \cdot 10^{-6}$
	Nb-95	$6,0 \cdot 10^{-5}$	$3,8 \cdot 10^{-5}$	$4,0 \cdot 10^{-5}$	$1,2 \cdot 10^{-5}$	$8,5 \cdot 10^{-6}$	$1,1 \cdot 10^{-5}$
	Ru-103	-	$5,3 \cdot 10^{-7}$	$2,8 \cdot 10^{-6}$	$5,9 \cdot 10^{-7}$	$1,7 \cdot 10^{-7}$	$4,5 \cdot 10^{-7}$
	Ru-106	-	$3,4 \cdot 10^{-5}$	$2,0 \cdot 10^{-9}$	$1,8 \cdot 10^{-7}$	-	-
	Cd-109	-	$3,1 \cdot 10^{-6}$	$4,6 \cdot 10^{-7}$	$3,3 \cdot 10^{-7}$	$1,6 \cdot 10^{-8}$	-
	Ag-110m	-	$3,4 \cdot 10^{-6}$	$4,9 \cdot 10^{-7}$	$5,0 \cdot 10^{-9}$	$1,7 \cdot 10^{-7}$	$1,0 \cdot 10^{-9}$
	Sb-124	-	$1,2 \cdot 10^{-6}$	-	$5,3 \cdot 10^{-7}$	-	-
	Sb-125	$3,9 \cdot 10^{-5}$	$1,2 \cdot 10^{-4}$	$1,3 \cdot 10^{-4}$	$1,8 \cdot 10^{-5}$	$6,0 \cdot 10^{-8}$	$1,9 \cdot 10^{-9}$
	I-131	$6,5 \cdot 10^{-6}$	$4,0 \cdot 10^{-7}$	$4,3 \cdot 10^{-8}$	$9,3 \cdot 10^{-7}$	$3,6 \cdot 10^{-6}$	$6,8 \cdot 10^{-7}$
	Cs-134	$2,9 \cdot 10^{-5}$	$1,5 \cdot 10^{-5}$	$2,0 \cdot 10^{-6}$	$1,8 \cdot 10^{-5}$	$8,8 \cdot 10^{-6}$	$8,0 \cdot 10^{-6}$
	Cs-137	$5,3 \cdot 10^{-4}$	$2,9 \cdot 10^{-4}$	$5,8 \cdot 10^{-5}$	$1,1 \cdot 10^{-4}$	$1,3 \cdot 10^{-4}$	$7,0 \cdot 10^{-5}$
	Ce-144	-	$4,0 \cdot 10^{-6}$	$6,4 \cdot 10^{-6}$	$8,2 \cdot 10^{-7}$	$2,9 \cdot 10^{-7}$	$6,8 \cdot 10^{-7}$
	Ce-141	$8,3 \cdot 10^{-6}$	$1,6 \cdot 10^{-5}$	$1,4 \cdot 10^{-5}$	$5,7 \cdot 10^{-6}$	$3,2 \cdot 10^{-6}$	$1,6 \cdot 10^{-5}$

3.2.5 Quality assurance

The automatic closing function of the main outlet valve on the delay tank which is initiated by abnormally high activity levels is tested along with other vital instrumentation before each reactor start up.

The conductivity of water leaving ion exchange columns is measured continuously in order to follow the ion exchange function of the resin. To further monitor the function of the ion exchange columns, gammaspectrum analysis is performed on samples taken periodically of water entering and leaving the column. A program for mapping the dose rate along the height of columns is also performed to follow the movement of the activity and prevent unexpected release from the column.

Continual logging of all instrument signals is taken care of by the Picasso data collection and presentation system. Live time measurement and historical data is displayed on terminals.

The Project has a comprehensive quality control and assurance system where all work tasks, including measurement of activity, are described in detail in working instructions and procedures.

3.2.6 Target values

Discharges are related primarily to the discharge limits given by the authorities.

In addition to discharge limits which are directly related to resulting doses to the critical group, the authorities have enforced nuclide-specific notification levels. These levels are directly related to previous operational results at the facility. If a notification level should be exceeding, the authorities shall be informed and the reason for the discharge explained. A discharge exceeding notification levels does not constitute a violation of the discharge authorisation but is intended to ensure that the authorities have continuous control of operating conditions at the plant.

Through the authorisation for release of radioactivity, the operator is obliged to limit the discharge to levels as low as reasonably achievable (ALARA) and to consider use of the best available technology (BAT) in order to achieve this. Equipment, methods and routines are continuously evaluated for potential discharge-reducing measures, including measures to enhanced worker awareness of the issue. In any effort to reduce discharges, the resulting discharge-reduction must however be seen in view of doses incurred by occupationally exposed individuals and the economic investment necessary to achieve the reduction. Since the current discharge level and resulting doses to the public are very low, evaluation of possible major new installations often reveal that the doses or investment involved in implementing a measure do not justify the marginal reduction in discharge that it is possible to achieve. The best dividends are often achieved through apparently modest changes to existing equipment or procedures, and in increased worker awareness.

3.3 Environmental Impact

3.3.1 Monitoring programmes

The environmental monitoring program includes:

- Bottom sediment samples from the river Tista at the discharge area, once a year.
- Sediment samples from sandbeaches along the fjord, once a year.
- Fish from Iddefjord once a year.
- Grass from neighbouring farms, twice a year
- Precipitant (rain, snow) from two locations once a fortnight
- Tritium monitoring of urine samples from individuals in the vicinity (approx.50/year).

3.3.2 Concentrations in environmental samples

Samples of sediment from the riverbed at the discharge area contain both natural and anthropogenic radionuclides. There is however very little sedimentation because of the considerable flow and volume of water in the river. Samples of other materials which have been analysed show either none or very low levels of anthropogenic radionuclide. Cs-137 concentration in fish is approximately 1 Bq/kg, a level which does not deviate from concentrations in other areas in Norway.

3.3.3 Nuclide library

Canberra standard nuclide library is used for measuring discharges and identifying and measuring emissions of concern for the marine environment. The standard library has been supplemented with a number of radionuclides which have been identified in discharges through a comprehensive study of peaks which were not identifiable using the standard library.

3.3.4 National target levels

Not developed.

3.3.5 Quality assurance

The Project has a comprehensive quality control and assurance system where all work tasks, including measurement of activity are described in detail in working instructions and procedures. Criteria for non-conformity are also defined in these procedures.

3.4 Radiation doses to the public

3.4.1 Average annual effective dose

	1999	2000	2001	2002	2003	2004
Effective dose from marine exposure pathways (µSv)	0,07	0,08	0,09	0,02	0,01	0,02

3.4.2 Total exposure

The above table covers all release of activity into the river Tista from the facility over the last 6 years. Effective dose values are theoretical and thus can only be applied to measured discharge values.

3.4.3 Definition of critical group

The critical group is hypothetical and only defined by their food consumption and living habits. The estimation of doses to the group is based on theoretical radionuclide concentration in the environment, calculated from measured discharge values. The dose represents an average in a group with an age distribution identical to the age distribution in the Norwegian population. It has been established that children, taking their consumption and living habits into account, do not receive doses which deviate significantly from the average.

3.4.4 Exposure pathways

The calculation of effective dose to the critical group is based on:

Annual consumption of 30kg fish from the fjord

200 hours/year occupancy on the fjord beaches

50 hours/year bathing in the fjord

1000 hours/year of boating on the fjord

3.4.5 Methodology

All modelling of transfer of radionuclides in the environment and resulting doses to critical group are based on:

Simmonds J.R., Lawson G. and Mayall A., *Methodology for assessing radiological consequences of routine releases of radionuclides to the environment*,

European Commission, EUR 15760 EN, ISSN 1018-5593, (1995)

3.4.6 Site-specific factors

No site-specific factors are used. The estimates are based on default factors from the above reference (4.5)

3.4.7 Target dose

Release limits defined by the competent authority are based on a limiting effective dose to an individual in the critical group of 1 µSv/year.

3.4.8 Quality assurance

There are no measurements involved in the dose assessment. The calculations have been tested against example calculations from the reference in 4.5.