EUROPEAN COMMISSION
DIRECTORATE-GENERAL ENVIRONMENT
Directorate C - Nuclear safety and civil protection
**ENV.C.1 - Environmental monitoring and inspection**

# TECHNICAL REPORT

## VERIFICATIONS MADE UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

## CAITHNESS, SCOTLAND (U.K.)

**15 to 18 March 1999**

**Reference: UK-99/1**

# VERIFICATIONS MADE UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

FACILITIES: Installations for monitoring and controlling radioactive discharges and for surveillance of the environment in the North of Scotland during normal operations of the UKAEA Dounreay nuclear site.

SITE: Caithness District, Scotland (UK).

DATE: 15 to 18 March 1999.

REFERENCE: UK-99/1.

INSPECTORS: A. Janssens (Head of team)
S. Vadé
S. Van der Stricht
H. Puchta

DATE OF REPORT: 15th of September 1999, final report agreed upon with the UK authorities on the 29th of May 2000.

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# TECHNICAL REPORT

## 1. ABBREVIATIONS AND DEFINITIONS

| | |
|---|---|
| AEFD | Agriculture, Environment and Fisheries Department (Scottish Office) |
| CDF | Central Database Facility |
| CEFAS | Centre for Environment, Fisheries and Aquaculture Science |
| DETR | Department of the Environment, Transport and the Regions |
| DFR | Dounreay Fast Reactor |
| DMTR | Dounreay Material Test Reactor |
| DTI | Department of Trade and Industry |
| EMS | Environmental Monitoring System |
| FCA | Fuel Cycle Area |
| FEPA | Food and Environment Protection Act (1985) |
| HMIPI | Her Majesty's Industrial Pollution Inspectorate |
| HSE | Health and Safety Executive |
| ILW | Intermediate Level Waste |
| LLLETP | Low Level Liquid Effluent Treatment Plant |
| LLW | Low Level Waste |
| MAFF | Ministry of Agriculture, Fisheries and Food |
| NAMAS | National Measurement Accreditation Service |
| NII | Nuclear Installations Inspectorate |
| NRPB | National Radiological Protection Board |
| PCM | Plutonium Contaminated Material |
| PFR | Prototype Fast Reactor |
| RIFE | Radioactivity in food and the environment (report) |
| RIMNET | Radiation Incident Monitoring Network |
| SEPA | Scottish Environment Protection Agency |
| TID | Technical Implementation Document |
| UKAEA | United Kingdom Atomic Energy Authority |
| WRACS | Waste Receipt Assay Characterisation and Supercompaction facility |

## 2. INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State shall establish facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the basic safety standards [1].

Article 35 also gives the European Commission the right of access to such facilities in order that it may verify their operation and efficiency.

For the European Commission, the Directorate-General for Environment, Nuclear Safety and Civil Protection (DG XI) is responsible for undertaking these verifications.

For the purpose of such a review, a verification team from DG XI visited the United Kingdom Atomic Energy Authority (UKAEA) Dounreay Nuclear Establishment. The visit also included meetings with The Scottish Office, the Scottish Environment Protection Agency (SEPA) and the National Radiological Protection Board (NRPB). Details of the programme are given under section 4.3 below.

The present report contains the results of the verification team's review of relevant aspects of the environmental surveillance at and around the Dounreay site. The purpose of the review is to provide independent verification of the adequacy of monitoring facilities for:

- discharges of radioactivity into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant exposure pathways.

With due consideration to the scope of the verification mission, to the variety and extension of the different facilities on the Dounreay site and taking into account the relatively short time available for the execution of the programme, it was agreed that emphasis would be put on:

- the monitoring facilities for gaseous discharges and, more in particular, for the Fuel Cycle Area (FCA) main stack,
- the environmental monitoring programme,
- the effluent laboratories and the environmental laboratories,
- UKAEA's monitoring programme for radioactive particles in the marine environment.

The present report is also based on information collected from documents referred to under section 4.2 and from discussions with various persons met during the visit, as listed under section 4.4 below.

## 3. BACKGROUND

In 1997 and 1998, a series of issues have focused attention on the Dounreay nuclear complex. Following an incident in May 1998 which left the Fuel Cycle Area on the site without its normal electricity supplies for 16 hours, the UK competent authorities brought forward a planned audit of the management of safety at Dounreay. In August 1998 the Health and Safety Executive (HSE) and the Scottish Environment Protection Agency (SEPA) released their report "Safety Audit at Dounreay" [ref. 1]. The safety audit was the last of a series of actions that showed the safety culture at Dounreay to be unsatisfactory but also demonstrated the steps the UK competent authorities plan to correct the situation. The Audit required UKAEA to produce a plan for remedial measures to be implemented. The UKAEA response 'Dounreay – The Way Ahead' proposed remedial measures appropriate to each of the recommendations.

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[1] At the time of the verification, Directive 80/836/Euratom was in force. This directive has been replaced by Directive 96/29/Euratom, which should be implemented in national legislation by May 2000.

The HSE/SEPA report mainly relates to issues pertaining to overall management, safety culture and waste management. It is not primarily concerned with monitoring of radioactive effluents or with levels of radioactivity in the environment.

The Euratom Treaty does not confer to the Commission a right to intervene on matters related to plant safety.

However, a number of issues and related HSE/SEPA recommendations are specifically within the remit of the Commission, in particular recommendations made with respect to the management of radiological protection, to radioactive waste discharge monitoring facilities, environmental monitoring systems and various waste facilities and their management. The relevant HSE/SEPA recommendations are listed in annex 1.

Analysis of the HSE/SEPA report strongly indicates that the implementation of the ALARA (as low as reasonably achievable) principle, one of the pillars of the Basic Safety Standards, has been left wanting for some years. The report also confirms an earlier Enforcement Notice served by SEPA (in 1998) that stack emissions were not as low as reasonably practicable [ref. 28]. A second Enforcement Notice (also in 1998) required UKAEA to validate its records of FCA atmospheric discharges for the period January 1993 to March 1998 and to provide corrected records as necessary [ref. 29].

The HSE/SEPA report, with respect to environmental monitoring, recommends that development and improvement of the monitoring strategy for radioactive fragments in the marine environment around Dounreay be continued. Emphasis is put on intertidal areas where there is public access. An NRPB report (December 1998) underlines this recommendation [ref. 3]. The NRPB report was issued in the framework of the precautionary fishing ban around Dounreay (Emergency Order under the Food and Environment Protection Act 1985, made by the Scottish Office Health Minister on October 29th 1997), and proposes that the fishing ban be maintained.

The HSE/SEPA report, concerning the various waste facilities at Dounreay, recommends UKAEA to develop a strategic plan for handling, treatment, storage and disposal of all radioactive wastes on site, and to integrate the strategy with plans for decommissioning [2]. Especially the intermediate level radioactive waste deposits in the so-called Shaft and Wet Silo are of immediate concern. The Shaft is a long-standing issue of repeated public concern, generating parliamentary questions both at national level and in the European Parliament. UKAEA has proposed, and the Government has accepted a strategy for the Shaft and Wet Silo.

From 10th to 14th May 1993, a verification was performed under the terms of Article 35 of the Euratom Treaty at the facilities for monitoring the level of radioactivity in the air, water and soil in the area around Dounreay. The verification team acted within the framework set by the 1993 Protocol agreed between the UK authorities and the European Commission. The verification focused on environmental monitoring stations, sampling procedures and analytical methods. The on-site waste disposal facilities were not within the scope of the verification activities. The team's verification report concluded at that time that the objectives were met and that the verification results were satisfactory.

It results from the HSE/SEPA safety audit that the situation may have considerably degraded since then.

The Commission, having taken due notice of the safety audit report; having decided that a series of facts presented in the said report are within its remit; recognising the potential public interest in the safety audit report and its implications; finding it necessary to thoroughly inform itself about remedial

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2 A first draft of an integrated decommissioning strategy has been produced for the regulators. A final version is scheduled for publication in September 2000.

actions taken; wanting to perform a comprehensive review to assess the current status of environmental monitoring facilities and practices at Dounreay and in the North of Scotland; decided to announce its intention to conduct a second Article 35 verification in Caithness.

## 4. PREPARATION AND CONDUCT OF THE VERIFICATION

### 4.1 Preamble

The Commission's decision to request the conduct of a second Article 35 verification was forwarded to the UK competent authorities in November 1998. In its request the Commission notified and justified that, in the framework of the relevant safety audit recommendations, it intended to extend its Article 35 verification activities somewhat beyond the scope established in the Protocol. On a voluntary basis, the UK authorities proposed a verification programme covering almost all matters in which the Commission had expressed special interest, in particular with regard to on-site waste disposal facilities, including the Dounreay Shaft. The UK authorities underlined that this offer had been made in the interest of open government, acknowledging potential public interest and, in this context, the need for Commission officials to be well informed.

### 4.2 Documents

In order to facilitate the work of the verification team, a package of information was supplied in advance by the Scottish Office. SEPA, NRPB and UKAEA provided additional documentation during the visit. Further documentation was received in the weeks following the verification visit. The documentation received is listed in annex 2.

### 4.3 Programme of the visit

The verifications were carried out in accordance with the programme agreed between the Commission and the Scottish Office. The programme provided for an information meeting (half a day) at the Scottish Office premises at Edinburgh, a visit of SEPA's headquarters at Stirling (half a day) and a visit of the NRPB laboratory at Glasgow (half a day).

At Dounreay, the programme also provided for an information meeting (half a day) with UKAEA representatives. During this meeting, UKAEA made presentations on the following topics:

- the FCA power supply loss on 07 May 1998,
- the presence of radioactive particles in the marine environment around Dounreay,
- the Dounreay Shaft,
- the history of the Prototype Fast Reactor (PFR) since 1993.

The verification team visited two new waste treatment plants currently being built and commissioned at Dounreay, the Low Level Liquid Effluent Treatment Plant (LLLETP) and the Waste Receipt Assay Characterisation and Supercompaction facility (WRACS) respectively. A visit was also paid to two waste storage facilities, the low-level waste Pits and the intermediate-level waste Shaft.

A programme overview is provided in annex 3 to this report.

### 4.4 Representatives of the Scottish authorities, the NRPB and the operator

During the visit the following representatives of the national authorities, the operator and other parties involved were met:

The Scottish Office:

| | |
|---|---|
| S. Hampson | AEFD, Head of Environment Group |
| Ms B. Campbell | AEFD, Head of Environment Protection Unit |
| Dr I. Hall | AEFD, Environment Protection Unit, Air Quality and Radioactive Waste |
| J. Halley | AEFD, Environment Protection Unit, Radioactive Waste |
| S. Rooke | AEFD, Head of Food Safety Unit |

SEPA:

| | |
|---|---|
| A. Paton | Chief Executive |
| Ms P. Henton | Director of Environmental Strategy |
| Dr G. Hunter | Head of Policy Co-ordination (Radioactive Substances) |
| T. Inglis | West Divisional Manager, North Region |
| P. Orr | Specialist - Radioactive Substances |
| H. Fearn | Specialist - Radioactive Substances |

NRPB:

| | |
|---|---|
| Miss F. Fry | Assessments Division Head (Environmental and Physical Sciences) |
| P. Escott | Head of NRPB, Scotland |
| Dr M. Davidson | Quality Assurance and Control |
| D. Welham | Head of Radiochemistry, NRPB, Scotland |

UKAEA:

| | |
|---|---|
| Dr R. Nelson | Director, Dounreay |
| Dr G. Owen | Head of Safety and Environment, Dounreay Division |
| J. Simson | Safety and Environment Group, Environmental Programme Manager |
| S. McWhirter | Strategic and Environmental Projects Group, Senior Projects Manager |
| P. Poulton | Decommissioning Project Group, Senior Project Manager, PFR |
| G. Sinclair | Waste Management Group, Waste Operations Manager |
| N. Sinclair | Waste Management Group, Waste Operations Manager, Environment |
| I. Clark | Waste Management Group, Facility Manager, Environment & Services |
| M. Brown | Nuclear Services Group, Manager Chemistry Support Group |
| D.J. Lord | Safety and Environment Group, Environment Compliance Manager |
| A. McDonald | Nuclear Services Group, Manager of the Marshall Laboratory - D2670 |
| B. Hughes | AEA Technology, Health Physics Services |
| C. Stewart | Nuclear Services Group, Assistant Manager, Environmental and Bioassay |

The verification team acknowledges the co-operation that was received from all the individuals mentioned above and from support staff. The verification team also notes the quality and comprehensiveness of all presentations made and documentation provided.

## 5. THE SCOTTISH ENVIRONMENT PROTECTION AGENCY

### 5.1 Introduction

Since the last Article 35 verification visit carried out in 1993, the regulatory regime in Scotland has changed. In 1993, the regulatory body was Her Majesty's Industrial Pollution Inspectorate (HMIPI) which was part of The Scottish Office. In 1995 the Scottish Environment Protection Agency (SEPA)

was established under the Environment Act 1995 (EA 95). SEPA is a non-departmental public body that became operational on 1 April 1996 and was formed from a large number of predecessor bodies regulating environmental pollution and waste management of all types, not only radioactive substances. This merger gave SEPA additional strength by bringing together many specialisms and permitting the regulation of radioactive substances to be carried out in an integrated fashion within the constraints of the legislative and policy framework set by government.

SEPA's main duty is to protect the environment by controlling pollution to land, air and water in Scotland. This includes radioactive substances: regulating the use and disposal of radioactive substances, holding the national register for the use and disposal of radioactive substances, controlling discharges of radioactive waste from nuclear installations, managing the UK Radiation Incident Monitoring Network (RIMNET) in Scotland.

In its function as regulator SEPA issues authorisations of radioactive discharge to nuclear operators, including UKAEA. A condition of the authorisations issued is that there must be a satisfactory environmental monitoring programme undertaken by the operator (see section 5.2, regulation of radioactive discharges and section 9, environmental monitoring programme).

SEPA is also responsible for the monitoring of radioactivity in the environment. The environmental monitoring programme undertaken by SEPA is a unified programme from which the combined exposure pathways resulting from radioactive substances in the environment and foodstuffs [3] are considered together. Contractors selected after competitive tender undertake SEPA's independent monitoring. Contracts currently are signed for three years and contain requirements with regard to expected quality assurance and quality control. Presently the NRPB holds the contract. The results from the programme, in collaboration with the Ministry of Agriculture Fisheries and Food (MAFF), are made available to the public in an appropriate form, the annual Radioactivity in Food and the Environment (RIFE) Report [ref. 4].

## 5.2 Regulation of radioactive discharges

In the United Kingdom, the legal framework for the protection of the population and the environment against exposure arising from radioactivity discharges is based on the Radioactive Substances Act 1960 (RSA 60); amended by the Environmental Protection Act 1990 (EPA 90); and consolidated under the Radioactive Substances Act 1993 (RSA 93) as amended by the Environment Act 1995 (EA 95).

The disposal of radioactive waste from nuclear establishments in Scotland is permitted, subject to limitations and conditions set out in Certificates of Authorisation granted by SEPA under RSA 93 (as amended). The Certificates of Authorisation determine the conditions and limits for the amount of radioactive substances discharged in solid, liquid or gaseous form from each licensed site. The limits are expressed both as gross alpha and beta values and as nuclide-specific values that may be discharged over specific periods of time. Standard conditions with respect to record keeping, the use of best practicable means to reduce the activity in all the waste discharged, and the means of discharge are included in all SEPA authorisations. Also included are provisions for monitoring programmes, including environmental monitoring and analysis. Failure to comply with these authorisations is an offence under Section 32 of the Act.

Current authorisations for the disposal of liquid and gaseous waste were granted to UKAEA in 1989 (and varied in 1992 and 1993) and for solid radioactive waste in 1972. There is also a 1971 authorisation that allows solid radioactive waste to be recovered from Dounreay to any other UKAEA site or a licensed site occupied by British Nuclear Fuels Limited. Authorisations are currently subject

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[3] SEPA monitors radioactivity in the foodchain on behalf of the Scottish Office.

to 5-year review. The UKAEA applied in October 1993 to the Chief Inspector, HMIPI, under RSA 93, to continue to dispose of gaseous, liquid and solid radioactive wastes from its premises at Dounreay. The application was subject to public consultations (1995/96 and 1997/98) and was sent to the relevant local authorities and made available (as of 1 June 1996) for inspection at SEPA's North Regional Head Office. The subsequent revised Certificates of Authorisation which SEPA is minded to grant were forwarded in October, 1998, to the Secretary of State for Scotland for consultation prior to issue.

SEPA believes that the Certificates of Authorisation that it is minded to grant are more appropriate, transparent and effective in controlling the disposal of radioactive waste than the ones they replace [ref. 10].

The current authorisation limits, pending the ratification and implementation of the new Certificates of Authorisation, are given in annex 4 to this report.

## 5.3 Visit to SEPA Headquarters at Stirling

### 5.3.1 Radiation Incident Monitoring Network (RIMNET)

The RIMNET system in the North of Scotland includes 15 on-line gamma dose rate monitors linked to the Central Database Facility (CDF) in London. For the South of Scotland RIMNET provides 14 monitors. Nation-wide RIMNET is run by the Department of the Environment, Transport and the Regions (DETR).

The RIMNET monitors are Geiger-Müller detectors (type Müllard ZP/1221/01) with a measuring range between 10 nGy and 3 mGy per hour and a sensitivity of 16 cps per μGy/h.

Each monitor operates continuously and measures the gamma dose rate (μGy/h) in air. The dose rate readings include the intrinsic background, cosmic radiation and the terrestrial gamma dose rate. The measurements are polled every hour and are transmitted to the CDF where they are analysed and stored. CDF transfers data and analysis results back to SEPA in real-time.

### 5.3.2 Radioactivity in food and the environment report (RIFE)

In April 1996, SEPA took over the responsibility of collecting and storing the relevant data for Scotland from the Scottish Office. The Scottish Office retained the responsibility for certain generic monitoring carried out for Article 35 of the Euratom Treaty, however the collecting and storing of these data is carried out by SEPA on behalf of the Scottish Office.

Until the 1st April 1997 there were three contractors carrying out monitoring and analysis under contract to SEPA: (a) NRPB – undertook liquid effluent monitoring and environmental monitoring around nuclear sites, in addition to monitoring around landfill sites; (b) MAFF/CEFAS – undertook marine and drycloth monitoring; and (c) Westlakes – undertook what is currently termed the freshwater monitoring around nuclear sites. CEFAS provided SEPA with results in both electronic and hardcopy format. NRPB and Westlakes provided the results in hardcopy format only. All monitoring data were entered into and stored within an inherited statistical package (from the Scottish Office, called SAS) at SEPA's head office in Stirling.

Since the second quarter of 1997, when the NRPB became SEPA's contractor for all radioactive monitoring, the data transmitted by the former are stored in dedicated spreadsheets at the latter's head office. NRPB transmits data to SEPA on paper throughout the year and, when the yearly programme has been completed, electronically. The electronic data are used for the RIFE report. In addition SEPA has a management tool (within the spreadsheets) to control the completeness and timeliness of the sampling programmes and their corresponding analyses. The NRPB notifies SEPA about any unusual findings.

5.3.3 Verification activities

The team verified the consistency between the data as published in the RIFE-3 report (data pertaining to 1997, published 1998), SEPA's environmental programme, NRPB results and source data from the annual AEA Technology report 'Radioactive waste discharges from UKAEA establishments during 1997 and associated monitoring results' [ref. 5]. A series of spot checks were performed.

5.3.4 Verification findings and recommendations

Table 5.1(a) of RIFE-3 (page 86), for sludge (sediment) samples taken at the location 'Oigins Geo' near Dounreay, mentions only one sample having been taken. This contrasts with SEPA's requirement to sample the medium at quarterly intervals. Only one SEPA staff member is in charge of the environmental data spreadsheets. Unfortunately, this person was absent during the verification at Stirling. Other staff members are only partially acquainted with the system and this lack of expertise hampered the progress of the verification team's audit and the discrepancy could not be satisfactorily explained. SEPA provided clarification after the verification visit by stating that the NRPB had taken the three remaining samples as required by contract and had carried out analysis, the results of which had been forwarded to SEPA. SEPA in turn had transmitted the data to CEFAS who were to prepare the RIFE-3 report. The data were however not incorporated in the published results.

Environmental data pre-dating the second quarter of 1997, as well as being held at the contractors' offices, are held by SEPA within the SAS spreadsheet package. The accessibility of historical data is essential with respect to the follow-up of trends, inter alia. Currently SEPA is considering if it should change record keeping from spreadsheet to database format and if this transition is implemented, if it should then contain historical data.

In general, the verification team had the impression that SEPA lacks thoroughness with respect to quality assurance and control on environmental data transmitted by NRPB and UKAEA. Environmental data received are apparently not subjected to in-depth verifications upon receipt or prior to publication.

- *The verification team recommends SEPA to ensure permanent availability of competence in the handling of the environmental data management system.*
- *The verification team, while encouraging the transition from a spreadsheet to a database format, recommends SEPA to include historical data in its environmental data management system.*
- *The verification team recommends SEPA to review its internal quality assurance and control on environmental data transmitted by its contractor or nuclear operators.*

## 5.4 Visit to the NRPB laboratories at Glasgow

5.4.1 Introduction

The NRPB was created in 1970. Its function is to give advice, to conduct research, and to provide technical services in the field of protection against both ionising and non-ionising radiation. Since 1977, government has required NRPB to give advice on the acceptability to and application in the UK of standards recommended by international or inter-governmental bodies.

NRPB has radioanalytical facilities at its Scottish Centre (Glasgow). This laboratory analyses, in its function as SEPA's contractor, environmental samples collected in the framework of nuclear installations surveillance as well as samples taken for the environmental monitoring in Scotland at large, including dietary samples. The samples taken for the surveillance of nuclear installations is

part of SEPA's independent (check) monitoring programme. Results obtained are used to validate the environmental monitoring data provided by nuclear operators and to carry out an independent estimate of the doses to the general public from radioactivity in the environment.

The laboratory received NAMAS accreditation in 1995, renewed after reassessment in 1998 for a period of five years.

The analysis carried out as part of SEPA's check monitoring programme pertains to duplicate effluent samples, and a variety of samples for the marine and terrestrial environment. Details are given in annex 5. NRPB Glasgow, as contractor, implements SEPA's check monitoring programme around Dounreay.

#### 5.4.2 Verification activities

The verification team inspected the laboratory's equipment, audited a number of sample data sheets and sample reports (bundle of results for each sample), checked data processing and consistency.

Sampling activities as performed by NRPB were not subject to verification as such.

#### 5.4.3 Verification findings and recommendations

The laboratory is well equipped for radiochemical preparation and for radionuclide analysis. State-of-the-art equipment is available and particular attention is given to background reduction, especially for liquid scintillation counting (H-3 and C-14). Quality assurance comprises controlled documentation, annual audits, yearly proficiency testing of all staff members and intercomparison exercises. Data processing and archiving is carried out electronically (CD-ROM archive). Any manual calculations are however checked by a second person. Samples are stored for a period of 6 months.

It was noted that lower limits of detection (LLD) are frequently well below those required by SEPA. Significant results (above the LLD) but below customer's requirement are not necessarily reported but are brought to the attention of and discussed with SEPA during statutory meetings.

There were no particular observations and the verification team was satisfied about the efficiency of the analytical methods used, data management, data transmission and archiving.

*The observations made by the verification team do not give rise to a specific recommendation.*

# 6. DESCRIPTION OF THE DOUNREAY SITE

## 6.1 General information

UKAEA Dounreay is situated along the coast of the Atlantic Ocean, in the Caithness district (extreme north-eastern part of Scotland), at about 300 km north of Edinburgh. UKAEA Dounreay lies 15 km to the west of the town of Thurso (population approximately 9200) and 40 km to the north-west of the town of Wick (population approximately 8700). The Caithness district covers an area of 1776 km$^2$ and is sparsely populated (approximately 26700 inhabitants). The nearby Orkney Islands have a population of about 19500.

Only 20% of the land within an 80 km radius around site is fit for agricultural use other than rough pasture. Farming mainly consists of sheep and beef cattle. There is a small amount of inshore fishing near Dounreay for salmon, crabs and lobster and some winkle gathering. The main fishing activity taking place in areas that are far more distant.

As already mentioned in section 3 of this report, a precautionary fishing ban has been established around Dounreay (Emergency Order under the Food and Environment Protection Act 1985, made by the Scottish Office Health Minister on October 29th 1997). See also section 12 of this report.

## 6.2 History and succinct description of the site

### 6.2.1 UKAEA operations

Dounreay is a nuclear site owned by UKAEA and licensed by the Nuclear Installation Inspectorate (NII) of the Health and Safety Executive (HSE). Construction of the facility began in 1955 primarily to pursue the UK Government policy objective to develop fast reactor technology. As the industry has matured, UKAEA's role and activities have changed. This has resulted in the closure of the three reactors operated by UKAEA at Dounreay. The Dounreay Materials Test Reactor (DMTR) was shut down in 1969, the Dounreay Fast Reactor (DFR) in 1977 and finally, the Prototype Fast Reactor (PFR) in 1994. All DMTR fuel has been removed and reprocessed and DMTR is now in a care and maintenance regime. DFR is in the process of being decommissioned, but a substantial number of the breeder assemblies are still in the reactor awaiting removal, with shipping to Sellafield (BNFL) for reprocessing as the preferred disposal route. As for PFR, all used fuel and breeder assemblies have been removed from the reactor vessel itself, but some fuel remains in facilities in the PFR building.

Dounreay retains chemical reprocessing plants for both fast reactor and thermal reactor fuels, together with a fuel fabrication plant and a uranium and thorium recovery plant. Both reprocessing plants are out of service. The thermal reactor plant will be decommissioned. The fast reactor plant has a faulty dissolver and its future is under consideration; if the dissolver were replaced it would be able to reprocess remaining PFR fuel and a limited amount of remnant commercially contracted and other work. No new reprocessing contracts will be undertaken. Currently all the process plants are prohibited from operating under a direction issued by the NII during 1998.

The Dounreay site includes two facilities previously authorised for the disposal of intermediate and low-level radioactive wastes (ILW and LLW): these are, respectively, the Shaft and the Low Level Waste Pits. The LLW Pits continue in use but have now been almost completely filled and LLW is being stored pending final disposal. UKAEA is reviewing future management options for solid LLW. This includes consideration of the option of constructing a new LLW disposal facility to contain future LLW arisings from Dounreay and decommissioning works. The site also includes a facility known as the Wet Silo, in which ILW is stored underwater. The Shaft was the scene of a chemical explosion in 1977. Although the disposal authorisation remains in force, the use of the Shaft for disposal of radioactive waste was progressively reduced since 1971 (when the Silo came into service) and halted completely following the 1977 explosion. In 1998, the UK Government announced its decision that UKAEA implement a programme to retrieve the ILW from the Shaft and from the Wet Silo.

The principal undertaking at Dounreay is the management of nuclear liabilities including the decommissioning of the existing plants.

### 6.2.2 AEA Technology operations

AEA Technology is a tenant on the Dounreay nuclear licensed site. AEA Technology operates, amongst others, a waste treatment plant (the Sodium Disposal Facility). This plant is intended to treat, on a commercial basis, a substantial quantity of radioactive sodium from a German fast reactor. AEA Technology stopped processing the sodium after SEPA issued a Prohibition Notice in May 1997 [ref.27], because "... the continuing operation of the sodium disposal facility involves an imminent risk of pollution of the environment and harm to human health and that the matters that give rise to the said risks are the inadequate determination of the activity of any radionuclides or groups of

radionuclides present in the waste at the time of disposal." and "As a result the company is not controlling radioactivity being discharged to the environment."

6.2.3 The Dounreay Shaft

The Dounreay Shaft was originally excavated in 1956 as a route for removing spoil from the construction of the liquid effluent discharge tunnel to sea. The Shaft is 4.6 m in diameter and 65 m deep. At its base there is a 33 m long connecting tunnel between the Shaft and the main tunnel. The main tunnel contains the pipes used to discharge the trade and low level radioactive effluent from the site. There is a 2.4 m thick concrete plug in the connecting tunnel 20 m away from the Shaft (see annex 8, figures 1 and 2).

UKAEA used the Shaft for disposal of solid waste between 1959 and 1971 when the Wet Silo came into service as an ILW store. The Shaft was used until 1977 for items that were too large for the Wet Silo when an explosion in the Shaft led to cessation of input of material (see annex 8, figure 3).

There is uncertainty over the contents of the Shaft, but it is believed to contain equipment contaminated with radioactive material and sodium, chemicals, natural uranium fuel, radioactive sources, incinerator ash, filters, gloveboxes, sludges, clothing etc. There is approximately 700 $m^3$ of waste in the Shaft and an 8 m depth of water covers this. The disposals to the Shaft took place in accordance with an authorisation under the Atomic Energy Act 1954 and subsequently the Radioactive Substances Act 1960. The UK authorities consider that the Shaft does not meet current standards for an ILW disposal facility.

The authorisation requires that water be pumped from the Shaft so that the water level does not rise above sea level and stays several metres below groundwater level. The intention is to cause a depression cone thus directing the groundwater flow towards rather than away from the Shaft and hence contain contamination.

Investigations (1989) by a remotely operated vehicle to the seaward side of the plug, found the plug to be in good condition and did not find evidence of radioactive leaks. Although low levels of radioactivity were observed throughout the tunnel, there was only activity above this background near the discharge chamber.

UKAEA's plan, accepted by UK Government, is to retrieve the waste from the Shaft and process it to a form suitable for eventual disposal in an ILW repository. UKAEA has commissioned a number of studies into possible waste retrieval and conditioning methods. Also commissioned are further hydrogeological studies near the Shaft to underpin future work on developing potential methods of waste retrieval.

## 7. DISCHARGES TO THE ENVIRONMENT AND THEIR MONITORING

### 7.1 Operator's Compliance Monitoring

UKAEA are required as a condition of their authorisations issued under RSA 93 to monitor and report on the levels of certain named radionuclides in all of the waste discharged. At Dounreay liquid and gaseous waste disposals are made to the environment, solid wastes are retained on site.

The current authorisation limits, pending the ratification and implementation of the new Certificates of Authorisation, are given in annex 4 to this report.

UKAEA's radiochemical laboratories, where effluent samples are analysed, achieved ISO9001 accreditation in 1994 and are working towards achieving the more stringent UKAS accreditation in

2000.

## 7.2 Liquid Radioactive Waste

Low-level liquid wastes are generally analysed and sentenced at the originating plant before being dispatched to the sea discharge tanks. Low level liquid radioactive waste is discharged (after sampling and analysis) from one of two sea discharge tanks to the Atlantic Ocean via a pipeline ending 600 m beyond high water mark at a depth of 24 m. Prior to discharge the relevant sea tank is sampled (the "A" sample) to confirm that the tank's contents can be discharged to sea within the confines of the limits set in SEPA's Authorisation. The discharge then proceeds (during high water to allow maximum dispersion) and is proportionally sampled, the "B" sample. The "B" samples are used to prepare a weekly bulk sample, prorata to the volume discharged (1 ml per $m^3$ sent to sea). Monthly samples are prepared by bulking one litre of each weekly sample, for four or five weeks. The analysis results of the monthly bulk sample are reported to SEPA. Samples of effluent are obtained by SEPA (bimonthly) for independent analysis by SEPA's contractor (NRPB).

The present discharge tanks are old and will cease operations when replaced by the new Low Level Liquid Effluent Treatment Plant (LLLETP), currently under construction. It is expected that commissioning the LLLETP will be completed in the year 2000.

## 7.3 Gaseous Radioactive Waste

The discharge of gaseous waste is undertaken from a number of stacks on the Dounreay site (see annex 7, figure 8).

### 7.3.1 Fuel Cycle Area Main Stack

The FCA main stack is 60 metres high and has an air flow rate of 4.4E+05 $m^3/h$. An isokinetic on-line monitoring system is installed on the stack, providing measurements of the concentration of alpha and beta activity on particulates as well as I-131 activity. The air extracted from the different parts of the FCA is homogenised before delivery to the stack. Exhaust air is extracted from the stack at half-height at a rate of 37 l/min for feeding to the sampling stations. The flow rate of the feed is monitored continuously and triggers alarms when dropping below pre-set levels. An additional sampling station is fitted in a container located at the outside of the stack. This position allows for minimal pipe length and therefore improves the transmission of particulates. Continuous sampling is performed through one aerosol filter and two sets of tritium bubblers serially connected via a high-temperature oxidiser. Gaseous iodine is collected at the extraction duct sampling stations by charcoal granulate filters. Iodine filters are protected from particulates by an upstream aerosol filter. Aerosol filters are exchanged daily, iodine filters weekly.

In 1998, SEPA issued two Enforcement Notices about the main stack [ref. 28 and 29]. The first concerns the presence of radioactive particulate matter in the FCA ventilation duct, stating that "the lack of any effective means to reduce the atmospheric release of this particulate matter is in SEPA's opinion a failure to comply with [...] the Certificate of Authorisation for the disposal of radioactive waste". The second was issued after a notification from UKAEA that between 1996 and 1998 erroneous discharge values had been reported. The second notice states, *inter alia*, that UKAEA has to "critically validate records of gaseous radioactivity discharged from the FCA for the period January 1993 to March 1998 and provide corrected records as necessary". Investigations have, in the meantime, revealed that the procedures in force at that time did not ensure adequate entry of calibration geometry data into the analysis computer. The under-reporting of activity discharged during this period was up to a factor of ten for some nuclide categories, though this amounted to less

than 1% of the total radioactivity discharged. Procedures were modified as remedial action and corrected discharge values were reported to SEPA since.

On 7 May 1998, at 20H20, an incident occurred in which a mechanical digger damaged an 11 kV electrical cable, cutting power supplies to the FCA resulting in the loss of forced ventilation due to the failure of the twin stack fans. The activity monitors and samplers present in the FCA main stack did however remain on-line due to power initially supplied by a set of stand-by batteries, later replaced by power supplied by a petrol driven generator. Because neither fans were operating, the FCA main stack flow rate (normally about 6.5 m/s) fell to approximately 0.5 m/s, sustained by natural convection. Power supplies were restored on 8 May at 12H50. Monitoring of the FCA main stack discharge point thus continued without interruption during the FCA loss of electrical supplies on 7/8 May 1998. During the period in which power was lost, the prevailing weather conditions were: steady wind direction from 210° ± 20° with speeds varying between 5 and 10 m/s and no rainfall. Survey teams as well as a mobile monitoring station were dispatched on 8 May to check the environs of the site for possible contamination (see annex 7, figure 7). Environmental samples were taken (grass) and analysed. On 10 May, the NII performed an independent survey of the north-east corner of site. The surveys did not yield unusual levels of radioactivity anywhere and the NII concluded that no activity was released to the environment as a result of the power loss.

#### 7.3.2 PFR and DFR

Both reactors have been shut down and are undergoing decommissioning. The monitoring arrangements have not changed since the last verification. Following an inspection by SEPA, UKAEA intends to review the current monitoring arrangements. Upgrading of the monitoring regime, in line with that carried out for the main FCA stack, may be envisaged.

#### 7.3.3 Minor Sources

A number of minor stacks are grouped together as either 'west minor sources' (3 stacks) or 'east minor sources' (9 stacks). The monitoring arrangements for these minor stacks are not included in the current authorisations. Following an inspection by SEPA, UKAEA have implemented a monitoring regime for the minor stacks which has been included in the draft revised authorisation that awaits the decision of the Scottish Ministers. Further reviews of the monitoring arrangements are being carried out.

## 8. VERIFICATION OF FACILITIES DISCHARGING TO THE ENVIRONMENT

### 8.1 Introduction

The verification team decided to focus its activities on those discharge points that, since 1993, had been subject to modification, thus avoiding unnecessary duplication of satisfactory verification activities as performed that year. Taking into account recent events with respect to the FCA main stack (as per specific HSE/SEPA Safety Audit report recommendations and SEPA's relevant Enforcement Notices), it was decided that comparatively more attention would be paid to this stack, its monitoring equipment and sampling procedures. The following facilities were not subject to verification: DFR, PFR and the liquid effluent discharge tanks at the Low Active Effluent Collection and Disposal Plant (building D1211).

Also, having in mind the 1993 conclusions and recommendations, the team paid special attention to data management and quality assurance and control at the effluent laboratories.

The competent authorities invited the verification team to visit the Low Level Liquid Effluent

Treatment Plant (LLLETP, under construction) and the Waste Receipt Assay Characterisation and Supercompaction facility (WRACS, being commissioned) in order to inspect the monitoring provisions already in place or under construction.

## 8.2 Liquid radioactive waste

### 8.2.1 Effluent laboratories – verification activities

The verification team visited the effluent laboratories and checked the existence and comprehensiveness of analytical procedures, of documentation on quality assurance programmes and of filing systems.

### 8.2.2 Effluent laboratories – verification findings and recommendations

The procedures cover sample taking and preparation, analytical methodology, statistical tests to verify the plausibility of results as well as subsequent actions in case of divergence and, finally, training of staff. Procedure revisions are well documented, provide traceability and their distribution is clearly defined (acknowledgement of receipt). Calibration and maintenance of online monitoring devices and analytical equipment are adequately documented. Data transmission between the lab and the discharge data accountancy and reporting team is adequately regulated. Activity release data are subject to periodical verification (recalculation).

The verification team notes that, since its 1993 Art.35 verification, the internal quality assurance and control at the effluent laboratories has improved significantly. Sample management, analytical procedures and record keeping revealed no departure from standards. Data management is consistent and adequate archiving of results obtained is in place. Maintenance and calibration procedures with respect to analytical measurement devices and monitoring equipment are well organised.

*The observations made by the verification team do not give rise to a specific recommendation.*

### 8.2.3 LLLETP – verification activities

The verification team was invited by the UK authorities to visit the LLLETP in order to inspect the monitoring provisions already in place or under construction.

### 8.2.4 LLLETP – verification findings and recommendations

The LLLETP is a modern plant provided with an automated sampling system, facilities to adjust the pH of the effluents before discharge and a control system that will automatically abort sea discharge when authorisation limits are transgressed. Noteworthy is the design of the two discharge tanks: the heels of the tanks are conical and thus allow sludge collected at the bottom of the tanks to be extracted and subsequently sent to a sludge treatment facility. The sludge treatment facility will then process these arisings into solid waste, which is anticipated to be of low-level type. In this manner, the amount of activity discharged to the Atlantic Ocean is expected to be further reduced.

*The observations made by the verification team do not give rise to a specific recommendation.*

## 8.3 Gaseous radioactive waste

### 8.3.1 Fuel Cycle Area Main Stack – verification activities

The verification team inspected the monitoring provisions for the FCA main stack, and in particular

the additional sampling station fitted since the 1993 verification.

The team visited the effluent laboratory where it:

- Checked the existence and comprehensiveness of analytical procedures, of documentation on quality assurance programmes and of filing systems.
- Verified the 'Controlled Method CSG/CM/19-issue 2', applicable to actinide separation and preparation, and 'Controlled Method CSG/CM/39', applicable to Sr-90 analysis.
- Observed ongoing sample analyses.
- Audited data management procedures.
- Performed a full data consistency audit for one officially reported total alpha discharge.

The team verified the status of implementation of SEPA's Enforcement Notice [ref. 29] by checking the amended procedures and verifying the validity of the amended gaseous discharge data.

The team also visited the health physics department in order to verify the procedures and quality assurance programmes as applicable to FCA main stack filters.

### 8.3.2 Fuel Cycle Area Main Stack – verification findings and recommendations

The air from the fabrication, reprocessing and processing plants is extracted via a spine duct to the FCA main stack. There is a north and south duct, each with its own fan feeding into the stack. At the time of the 1993 Article 35 verification, monitoring arrangements were provided at both the north and south duct close to the entry to the main stack. These monitoring arrangements have since been improved by UKAEA to ensure isokinetic sampling. The new sampling station, providing additional monitoring capacity, was inspected without giving rise to particular remarks. The FCA main stack monitoring provisions are adequate.

Kr-85 emission is not measured but calculated on the basis of the extent of the ongoing fuel reprocessing activities. As currently all reprocessing activities have been halted, the K-85 discharge is virtually zero.

C-14 is not monitored. The UK authorities do not deem the monitoring of C-14 necessary as PFR as well as DFR fuel, when reprocessed, do not liberate significant amounts of this radionuclide.

The methodology (procedure) for actinide separation and preparation is laid down in the document 'Controlled Method CSG/CM/19-issue2'. Aerosol filters are measured upon retrieval and then stored in a dedicated cabinet with 14 compartments (one per filter). The compartments are labelled Monday to Sunday covering a period of two weeks. After a dwell time of 7 days the filters are retrieved from the cabinet and subjected to total alpha and total beta analysis to assess activity discharged. The results are stored on a dedicated spreadsheet. An additional total gamma measurement is performed for internal purposes. All aerosol filters collected during a calendar month are leached for 8 hours and the leach obtained (approximately one litre) is deemed to contain all the activity present on the filters. The filters are then individually checked for activity remnants and if present leached a second time for 24 hours. When satisfied that leaching is complete all the leach collected is measured by gamma spectrometry. Results obtained are stored in the spreadsheet. Subsequently Sr-90 and actinides are extracted from the leach by ion exchange resins, the process being checked on its efficiency by simultaneous tracer extraction. The actinides with their Pu-236 tracer are deposited on an alpha tray by electrodeposition and then measured by alpha spectrometry. Finally, the alpha tray is leached to allow Pu-241 to be measured by scintillation counting.

Verification of the 'Controlled Method CSG/CM/19-issue2' as well as the 'Controlled Method CSG/CM/39' did not yield any particular comment on the part of the verification team.

The data consistency audit on the official alpha discharge report to SEPA was completed to satisfaction.

The verification team notes that, since its 1993 Art.35 verification, the internal quality assurance and control at the effluent laboratories and health physics department has improved significantly. Sample management, analytical procedures and record keeping revealed no departure from standards. Data management is consistent and adequate archiving of results obtained is in place. Maintenance and calibration procedures with respect to analytical measurement devices and monitoring equipment are well organised.

With respect to SEPA's Enforcement Notice the verification team satisfactorily checked the amended procedure and the modified discharge values. The team notes that, at the time the events occurred, the quality assurance programme in place was not sufficiently robust to provide timely detection of the anomaly. The anomaly was revealed by chance after a laboratory staff replacement, not through adequate quality control and assurance programmes. The team also notes that appropriate remedial action to ensure proper measurements has been taken since.

*The verification team recommends that SEPA endeavours to ensure that failures in quality assurance and control programmes are timely detected.*

8.3.3 PFR and DFR

Both reactors have been shut down and are undergoing decommissioning. The monitoring arrangements have not changed since the last verification. The facilities were not submitted to verification.

8.3.4 Minor Sources

The verification team designated 3 minor sources for verification, the Marshall Laboratory, the Sodium Disposal Facility and WRACS. Presently there are no individual discharge limits foreseen for the minor stacks. The revised authorisation for gaseous releases (see section 5.2) will, if entered into force, provide discharge limits for the minor stacks. Following the FCA main stack power supply failure in 1998, UKAEA started a programme to provide each individual stack with its own back-up power generator. The operator pointed out some of these new generators to the verification team during the site visit.

Marshall Laboratory – verification findings and recommendations

The Marshall Laboratory stack is 24 metres high and has an air flow rate of 7E+04 $m^3/h$. Four separate ventilation systems feed into the stack. The discharged activity carried by particulates collected in the four parts of the plant is monitored separately for each of the four lines. Conditions for isokinetic sampling are fulfilled. The pumps in the sampling systems are checked daily, a failure of the pumps triggers local acoustic and visual alarms.

One part of the plant contains six hot-cells. One hot-cell is supposed to be clean and is separated from the others. However, in 1998 a transfer of activity from the contaminated cells to the clean cell was discovered. It is planned to fit filters into the exhaust air duct of the clean cell to control the situation. The air extracted from the cells is sent to a bypass (sampling line 20D2) for sampling on filters that are exchanged daily. The filters are measured for total alpha and total beta activity after a seven-day period, thus allowing for the decay of natural radionuclides (radon progeny). The bypass has provisions for continuous beta monitoring but not for alpha monitoring. The reason for the absence of alpha monitoring has been explained as being due to background problems caused by radon emanating from the thorium fuel handled in the hot-cells. A monitor capable of separating this background had been purchased but UKAEA found it to be faulty on delivery and was awaiting repair by the manufacturer at the time of the verification visit. The monitor has now been repaired and is currently under evaluation. Initial results suggest a satisfactory performance.

The filters on the three remaining parts of the plant are exchanged twice a week. The filters are analysed for total alpha and total beta on the day of exchange and after seven-day decay period, the results of the latter being used for discharge accountancy purposes.

AEA Technology, acting as contractor, performs the analysis of the filters and results are reported to UKAEA. The detectors used for the analysis are checked daily using Sr-90 and Pu-239 sources. The results of these calibration tests are systematically documented and archived at arm length from the analyst operating the detection system

The monthly and annual sums of activity discharged are reported to SEPA.

*The verification team recommends UKAEA to implement adequate alpha monitoring for gaseous effluents from the Marshall Laboratories.*

Sodium Disposal Facility – verification findings and recommendations

The Sodium Disposal Facility, operated by AEA Technology is currently closed down under a SEPA Prohibition Notice issued in 1997 [ref. 27] because of inadequate monitoring and control of gaseous effluents (tritium in particular). The facility is designed to reprocess sodium coolant from a German fast reactor.

The verification team, after having paid a visit to the plant to verify the existing effluent monitoring provisions, considers SEPA's Prohibition Notice to be justified.

*The observations made by the verification team do not give rise to a specific recommendation.*

WRACS – verification findings and recommendations

The WRACS stack is 12 metres high and is part of the 'east minor sources' group. Air is extracted from the cell housing the compactor and the ISO container filling area. Before delivery at the stack, the extracted air is filtered through HEPA filters. Conditions for isokinetic sampling are fulfilled. A sampling point is provided for continuous alpha and beta particulate radioactivity monitoring. The sampling point is fitted in a container outside the stack and consists of a paper filter that will be weekly exchanged and analysed. The bypass line feeding the sampling point is wrapped in an isolation mantle and a heating system provides isotherm sampling conditions. A guaranteed non-interruptible power supply feeds the system's air pump.

The verification team noted that the gaseous effluent monitoring facilities for WRACS are in line with modern standards.

*The observations made by the verification team do not give rise to a specific recommendation.*

## 9. THE ENVIRONMENTAL MONITORING PROGRAMME

### 9.1 UKAEA

There are two approved routes for discharge from the site into the environment, both of which contain equipment to monitor and record discharge levels: liquid effluent discharged via the low-level liquid effluent sea discharge tanks into the Atlantic Ocean and gaseous effluents discharged via stacks to the atmosphere. Solid wastes are retained on site. One of the conditions of the authorisation to discharge radioactive wastes is that a monitoring programme must be carried out to determine the effects of these discharges on the environment. This programme is known as the Statutory Environmental

Monitoring Programme and is carried out by the operator with the objective to demonstrate that the allowed discharges continue to have a minimal effect on the most exposed members of the critical group and are below the public dose limit of 1 mSv; to provide reassurance that permitted discharges continue to be estimated correctly and to allow the early recognition of unusual discharges to the environment. The statutory programme includes levels of radioactivity in the environment for which immediate notification of the regulator is compulsory.

The environmental monitoring programme focuses on two main areas, terrestrial and marine monitoring, with the objective of quantifying potential doses to individuals. This is undertaken through the direct measurement of dose rates and through the analysis of environmental samples (see annex 7, figures 4 to 6).

Terrestrial monitoring involves the direct measurement of dose rates in specified locations close to and remote from the Dounreay site. Thermo-luminescent dosemeters (TLDs) are also positioned at 15 points on the Dounreay perimeter fence and at 8 offsite locations to provide more extensive dose rate information in the area. For assessment purposes, the area around Dounreay is divided into two zones. The area within a radius of 4 km is designated as the inner zone and the area outwith this radius, the outer zone. Four air and rainwater sampling stations are situated within a 4 km radius from site. The terrestrial monitoring also involves the analysis of environmental samples from a range of sources including grass, soil, sheep faeces, goats' milk etc., the results of which are reported monthly to SEPA.

The marine monitoring programme generally comprises the direct measurement of dose rates in specific locations along the foreshore, including material deposited in the tidal zone, to the east and west of the Dounreay site. Locations within 4 km of the pipeline outlet are monitored weekly, those at a greater distance on a monthly basis. Dose rates from known areas of contamination on the foreshore, adjacent to the Dounreay site, are also recorded. Marine sampling of winkles, salmon, round fish, flat fish, crabs, lobsters and whelks is undertaken. Analysis of soil samples, collected from an area used to dry salmon nets from a local fishery, is also carried out. The results are regularly reported to SEPA.

The statutory environmental monitoring programme is further detailed in annex 6A to this report.

Besides the statutory environmental monitoring programme, UKAEA also runs an Environmental Monitoring System (EMS) consisting of a number of remote monitoring stations within a few kilometres from site (annex 6B). These monitors continuously measure airborne $\gamma$, $\beta$ and iodine activity and form part of the site's emergency response capacity. The EMS sends its measurement results back to site every 10 minutes by radio transmitter.

Finally, UKAEA performs additional monitoring addressing the activities associated with specific operations and facilities, e.g. drycloths programmes, road surveys and the survey of public transport vehicles.

## 9.2 SEPA

In addition to the statutory environmental monitoring programmes imposed on the producers of radioactive waste, SEPA has a number of other programmes in place. These are described as general check monitoring and are carried out independently of the nuclear site operator. Check monitoring does not necessarily duplicate the operator's statutory programme. The intention is to provide an independent check of environmental monitoring carried out by the operator and to test its adequacy, to provide independent environmental data that can be used to estimate the impact on the environment and public health and, to provide an indication of trends in levels of contamination in key media so as to confirm the level of control of authorised discharges to the environment. The current programme covers three areas: discharge, marine and terrestrial monitoring. The discharge monitoring

programme is designed to audit the sampling and analysis undertaken by UKAEA within the statutory effluent monitoring programme. The marine monitoring programme covers an area of shoreline from Castletown harbour to Sandside Bay and includes monitoring of seafood landed at Scrabster from vessels fishing offshore near Dounreay. The terrestrial monitoring programme provides an independent check on levels within the principally affected foodstuffs and regularly includes foodstuffs that particularly accumulate radioactivity (i.e. sheep thyroids). SEPA's monitoring programme around Dounreay is detailed in annex 5 and annex 7, figures 1 to 3.

SEPA also undertakes a programme of freshwater monitoring and radioactivity in foodstuffs remote from nuclear sites.

Nearly all check monitoring in Scotland is managed by SEPA, and is carried out under contract by the NRPB.

### 9.3 AEA Technology

AEA Technology, a tenant on the site, acts as contractor to UKAEA in the environmental monitoring programme. AEA Technology is contracted to collect the environmental samples and to prepare the draft yearly environmental monitoring report [ref. 5], which is then reviewed by a UKAEA Safety Working Party. All environmental samples collected are, however, analysed by UKAEA's environmental laboratories. UKAEA, once satisfied with the validity of the data, transfers them to SEPA.

### 9.4 Aerial survey

During 1998 UKAEA commissioned an aerial radiological survey of the land outside the Dounreay site to extend and complement the existing environmental monitoring programme and to obtain a more comprehensive understanding of the radiological distribution within the Dounreay area. The main objectives of the survey were to measure the radiological background levels in the area, to confirm that the routine environmental surveys carried out are representative and to identify the presence of any radiological anomalies to enable further survey work to be carried out. Aerial survey techniques are well established and have been used successfully in establishing the radiological footprint of areas around nuclear establishments. AEA Technology undertook the survey in conjunction with Sanders GSL and Exploranium Ltd of Canada.

The principal objective of the survey was to establish the distribution and levels of manmade radionuclides of Cs-137, Am-241 and Co-60. In addition, information on the distribution of natural nuclides of potassium, uranium (through Bi-214) and thorium (through Tl-208) was also obtained.

The survey area was roughly rectangular with dimensions of 16 km by 8 km (see annex 7, figure 9). The 16 km side lies on the coastline with Dounreay placed centrally and the 8 km side running inland. The survey employed a gamma spectrometer utilising a 32 litre sodium iodide detector mounted within a helicopter. Flying height was 90 metres along flight lines spaced at 50 m within 2 km of site and spaced at 100 m further afield, amounting to a total of 1682 line km flown. The aircraft was positioned using a global positioning system providing positional accuracy to ± 5 m.

For calibration purposes, a flat field was chosen from which 132 soil samples were taken (to a depth of 20 cm) for the analysis of K, U, Th and Cs-137. The sensitivity of the system was determined by hovering over the field at different altitudes. The calibration curves were obtained from the results of sample analysis and field radiation measurements. Measurements above sea determined background due to cosmic radiation, radon decay products in the air and the radioactivity of the aircraft and its equipment.

AEA Technology found the concentrations of K, U and Th to be at levels expected from the naturally occurring radioactivity in the rock and soil types covered by the survey.

AEA Technology did not record measurable concentrations of Am-241 or Co-60, and concludes that there are no indications that there had been significant release of contamination from Dounreay.

In some areas, AEA Technology found levels of Cs-137 above the general background of 30-50 Bq/kg, notably the valley of the Forss Water where a value of 397 Bq/kg was recorded. Other areas with levels between 70 and 150 Bq/kg were noted along the coastline between Dounreay and Krosskirk, adjacent to the south and east boundaries of the site and on poor, uncultivated ground at Brims, Stemster and Shebster. All levels of Cs-137 activity are well below the Generalised Derived Limit of 1000 Bq/kg. With the exception of the Caesium activity along the coastline and immediately adjacent to the south and east of the site, the activity levels are, from their distribution, almost certainly due to contamination from nuclear weapons testing and the Chernobyl fallout. The activity levels are similar to those found in other areas of the country with a similar pattern of rainfall.

It is AEA Technology's opinion that the elevated levels on the Forss Water arise from the deposition of radioactive Caesium from weapons testing and the Chernobyl accident, leached out of the peat uplands of the Forss catchment area; that the features along the coastline (with a maximum of 130 Bq/kg recorded) are probably due to marine site discharges, via a sea to land transfer mechanism; and that elevated levels to the south and east of site (with a maximum of 125 Bq/kg recorded) are probably arising from atmospheric site discharges.

AEA Technology concludes that the activity levels are consistent with known levels previously established through the environmental sampling programme and are well below levels which represent significant risks to people or to the environment.

## 10. VERIFICATION OF THE ENVIRONMENTAL MONITORING PROGRAMME

### 10.1 UKAEA environmental laboratories

Environmental samples are collected by AEA Technology and analysed by UKAEA.

Since the 1993 Art.35 verification, the statutory environmental monitoring programme has not been modified. It is however worth mentioning that there is no commercial production of cows' milk in the Caithness district. Grass sampling compensates to the absence of dairy herds.

The verification team visited the environmental laboratories and checked the existence and comprehensiveness of the analytical procedures and of documentation on quality assurance programmes. Several documents were reviewed and several records were examined.

Sample management is well organised, a weekly procedure is in place to check the arrival of samples against statutory requirements; samples are identified on receipt with labels carrying the relevant SEPA sample codes; sample details are then entered in a dedicated spreadsheet. Daily control measurements using check samples are performed on all detectors. Calibration procedures are documented. Analytical results are verified and countersigned before data are entered in the spreadsheets. In order to avoid clerical errors, and prior to data transmission to AEA Technology, all sample data and their analytical results are entered in an identical spreadsheet on a secured PC. Errors are highlighted by automated comparison between both files. Since October 1997, data transmission to AEA Technology is performed electronically and AEA Technology's files updated automatically.

The verification team notes that, since its 1993 Art.35 verification, the internal quality assurance and control at the environmental laboratories has improved significantly. Sample management, analytical procedures and record keeping revealed no departure from standards. Data management is consistent and adequate archiving of results obtained is in place. Maintenance and calibration procedures with respect to analytical measurement devices and monitoring equipment are well organised.

*The observations made by the verification team do not give rise to a specific recommendation.*

## 10.2 SEPA

Since the 1993 Art.35 verification, the monitoring programme has not been modified except for the discontinuation of dry cloth monitoring decided in 1997. SEPA is of the view that as dry cloths provide limited quantitative information, they are not particularly useful as part of the check monitoring programme. SEPA is currently evaluating whether medium velocity air samplers should replace dry cloths monitoring.

*The verification team recommends SEPA to consider the installation of independent medium velocity air samplers.*

## 10.3 AEA Technology

As contractor to UKAEA, AEA Technology carries out the Statutory Environmental Monitoring Programme agreed between SEPA and UKAEA. Collected samples are delivered to UKAEA's environmental labs for radiological analysis. Sample data and respective analytical results are stored electronically. Data are transmitted by UKAEA to SEPA as required in the authorisation. Again as contractors to UKAEA, AEA Technology has prepared, since 1997, the yearly reports on the environmental monitoring programmes in and around Dounreay. These reports, after review by UKAEA, are made public [ref. 5].

### 10.3.1 Environmental monitoring – terrestrial

The flow rate of the air samplers is 100 $m^3/h$ and each sampler houses a 400 $cm^2$ filter paper. The operator checks air sampler functionality at weekly intervals and exchanges the filter papers monthly. Air samplers are paired with rain collectors and other minor instruments, together forming a monitoring station. Monitoring stations are supplied with electricity from the nearest building connected to the grid. Rain collectors and minor instruments are protected by a housing and secured by padlocks.

The verification team designated the air sampler located at Shebster Water Treatment Works for inspection. At Shebster the air sampler was not working when the verification team arrived, its power supply being switched off. The operator told the verification team that the device had been checked the week before the verification visit without encountering any problems. Subsequently the team paid a visit to the sampler located at Reay Golf Club and found the device functioning properly.

*The verification team recommends UKAEA to fit the monitoring stations with guaranteed power supply systems and to implement an early warning system in case of system failure.*

### 10.3.2 Environmental monitoring – marine

The verification team noted that the amount of samples collected with respect to lobster, salmon and whelks for the year 1998 has been insufficient thus affecting the availability of Sr-90 data.

Consequently, UKAEA's statutory environmental monitoring programme could not fully comply with SEPA's regulatory requirements.

*The verification team recommends UKAEA that in future either sample collection would proceed until such quantities are gathered that allow for a full implementation of the environmental monitoring programme or, where a sample type is not available in sufficient quantity, that this be reported and documented.*

10.3.3 Environmental monitoring – beaches

The verification team visited the Dounreay foreshore where UKAEA demonstrated its foreshore monitoring programme. A monitoring programme is implemented to search and locate radioactive particles in this area. The foreshore is fenced off and not accessible to the public.

The verification team also visited Sandside Bay where UKAEA demonstrated the use of its Groundhog detection system, developed by AEA Technology. The system is set up to detect the presence of Cs-137 with estimated detection limits of about 7E+04 Bq at a depth of 50 mm, rising to 6.5E+05 Bq at a depth of 200 mm. Groundhog is linked into geo-positioning satellites. Measured activity and positional data are recorded and analysed afterwards by computer at Dounreay. Therefore not immediately obvious particles, if present, can only be located and retrieved after acquired data have been analysed. A man on foot carries the system and so coverage of the beach is slow. Routine surveys of part of the strandline of Sandside bay, which is located 2 km west of Dounreay, are carried out at weekly intervals. In addition to the strandline surveys, the remaining part of the beach is progressively monitored, with the objective of covering the full area of beach over a period of a year.

Recently a vehicle-based Groundhog system with multiple (and larger) detectors has been developed. The use of a vehicle will significantly improve beach coverage and frequency of surveys. The vehicle also carries all necessary electronic devices to analyse the acquired data in real-time. The operational availability of this vehicle is imminent. A more extensive programme of beach monitoring has been initiated and has been included in SEPA's draft revised authorisation.

The verification team notes the presence of multilingual notices erected around Sandside Bay, informing the public of the possible occurrence of radioactive particles on the said beach.

*The verification team endorses the frequency and extent of beach monitoring SEPA is requesting in the new authorisations. In conjunction with the use of the vehicle-mounted Groundhog, these will ensure an appropriate monitoring programme of public beaches in the area around Dounreay.*

10.3.4 Environmental monitoring – data reporting

Since 1997, the carrying out of UKAEA's statutory environmental monitoring programme has been contracted to AEA Technology. The analysis of samples taken remains UKAEA's responsibility. The contract includes preparing the report of environmental data submitted by UKAEA to SEPA as well as drafting the Dounreay yearly environmental report for issue after approval by the UKAEA Safety Working Party [ref. 5]. Previously, such yearly reports were published by UKAEA [refs. 6 to 9]. In order to comply with its task AEA Technology staff has developed a spreadsheet-type PC application. All data collected are stored on one PC connected to UKAEA owned network thus allowing UKAEA to check all data prepared by AEA Technology. Reports to SEPA and data published in the yearly report emanate from this PC after review by UKAEA.

The verification team performed a spot check on environmental data as published in AEA Technology's 1997 Dounreay report. The team wanted to verify the traceability of data reported, more in particular with respect to analytical results for crab samples. AEA Technology's PC

application centralising Dounreay environmental data was used as starting point. The verification exercise could not be performed to satisfaction because the summarised results as published could not, within the time available for verification, be linked to the original data of the individual samples [4]. AEA Technology staff explained that the failure to establish the link was due to teething troubles of the PC application, 1997 being considered as a transitional period where electronic data transmission systems between UKAEA environmental labs and AEA Technology had to be put in place. Also, the 1998 data set if similarly queried, would not pose such problems because automated electronic data transmission has since been fully implemented.

*The verification team recommends UKAEA to implement means of controlling the quality and validity of the environmental data as published by AEA Technology.*

## 11. WASTE DISPOSAL FACILITIES

### 11.1 Solid Radioactive Waste

The extant authorisation allows for the disposal of solid radioactive waste to either the Shaft (for intermediate level waste) or the LLW disposal pits.

#### 11.1.1 The ILW Shaft

Disposals to the Shaft ceased in 1977 following an explosion at the facility. In 1998, the UK Government endorsed UKAEA's proposals for the removal of the radioactive waste in the Shaft. As part of the preparatory work, UKAEA have examined the disposal records for the facility and other information and have published (1998) an estimate of the quantity and activity of waste disposed to the Shaft.

#### 11.1.2 The LLW Pits

Historically low-level waste (LLW) has been disposed of by shallow land burial in six LLW pits located close to the shoreline at the northern end of the site. The pits contain waste in drums and bags. Pits 1-4 and pit 6 are full and are covered with one metre of clean soil, in accordance with the LLW authorisation. Subsequently some were grassed and others tarred over. Pit 5, which is still operational is covered with removable engineered steel covers but will be covered similarly with clean soil when closed. Any future low-level waste disposal facilities will have provisions for a more substantial, engineered capping to be fitted after filling is complete.

The LLW pits are virtually full and SEPA is monitoring closely and pressing UKAEA to finalise its strategy with regard to the future disposal of solid low-level waste. UKAEA is currently exploring options for the future management of LLW. This involves consideration of the option of constructing new facilities for the permanent disposal of LLW at the Dounreay site. The activity and radionuclide content of low-level waste is currently assessed by UKAEA at source, but further monitoring using the Waste Receipt Assay Characterisation and Supercompaction facility (WRACS) will be undertaken. SEPA intends to undertake an inspection to review UKAEA's methods and underlying basis for solid low-level radioactive waste characterisation. This will include a judgement on the robustness of the methods to meet the condition in SEPA's proposed authorisation that requires

[4] The data were forwarded to the verification team sometime after the visit.

UKAEA to "keep on the premises for inspection by SEPA a true and accurate record of all the waste deposited in the designated place". SEPA's proposed authorisation also requires UKAEA to notify SEPA of the total activity of waste deposited in the pits since disposals commenced and up and until the 31 December 1998.

11.1.3 The Waste Receipt Assay Characterisation and Supercompaction facility

The Waste Receipt Assay Characterisation and Supercompaction facility (WRACS), construction of which was recently completed, is now being commissioned. WRACS is designed to improve the characterisation of solid low-level waste by using modern methods to measure the radioactivity in the drums (alpha assay and beta/gamma assay). Improved characterisation is expected to enhance the efficiency of disposal by making possible the transfer to a disposal site: for every individual drum an electronic record is kept containing, between others, identification, origin and measurement results.

The plant receives 200 l drums containing non-combustible solid low-level waste originating from site operations. WRACS takes X-ray pictures of a random selection of drums in order to assess contents before further processing. Any drum containing 'illicit' items (i.e. liquids or shielded items) are rejected and returned to sender for repackaging according to specifications. Accepted drums are measured for radioactive contents, then compacted (typically fivefold). Finally, the compacted drums are stored in half-height ISO containers. ISO containers when full will be stored on site.

Drums may nonetheless contain moist absorbent materials such as tissues with decontamination reagents. Small quantities of such liquid may therefore be expelled during the compaction stage of the process. These liquids are collected on an absorbent granular material which, when the compactor module is cleaned out, is subsequently processed as solid low-level waste. Additionally, the compactor is fully contained and fitted with a sump.

## 11.2 Verification activities

The verification team was invited to visit the low-level solid waste Pits and the immediate surrounding of the Dounreay Shaft.

11.2.1 The ILW Shaft

The verification team visited the surface plant above the Shaft and observed the drainage system in place. The drainage system extracts ground water that accumulates in the Shaft thus keeping a constant water level as required by the regulator. The accumulated water originates from the surrounding water table. The extracted water (on average 16 $m^3$/day) is sent to the site's low active drain network and from there to the liquid effluent discharge tanks at the Low Active Effluent Collection and Disposal Plant (building D1211).

A seaward concrete containment wall is in place; designed in such a manner that rainwater run-off from around the top of the Shaft is collected and thus would prevent the migration of radioactivity washout towards the foreshore. The rainwater collected is checked for radioactivity prior to transfer into the site's low active drain network.

The verification team observed that a series of boreholes are present around the Shaft. These boreholes (up to 80 m deep) are part of the hydrogeological survey undertaken around the Shaft.

> *The verification team recommends that these boreholes be used for environmental monitoring purposes insofar that frequent analysis of water samples extracted from the said boreholes may monitor activity escaping from the Shaft to the environment.*

11.2.2 The LLW Pits

The verification team visited the LLW Pits and observed that drainage pumps are present for each individual pit. Water infiltrates from the water table and accumulates in the pits at an average rate of 100 $m^3$/month (rainwater only marginally contributes to the overall volume collected). Water needs to be extracted from the pits in order to avoid contamination of the surrounding bedrock. Extracted water is sent to the site's low active drain network and from there to the liquid effluent discharge tanks at the Low Active Effluent Collection and Disposal Plant (building D1211).

The verification team also noted that drycloth filters (tacky shades) are positioned around the area at strategic locations. The tacky shades are not required by the regulator but are part of UKAEA's complementary environmental monitoring programme.

*The observations made by the verification team do not give rise to a specific recommendation.*

11.2.3 WRACS

Please refer to section 8.3.4 above.

## 12. RADIOACTIVE PARTICLES IN THE MARINE ENVIRONMENT

This section of the report is a summary of information contained in references 1, 3, 10 to 14, 17 and 20.

### 12.1 Introduction

Sand-sized fragments of irradiated nuclear fuel probably originating from reprocessing operations at Dounreay in the 1960s have been discovered intermittently since 1983 on the Dounreay foreshore (around 12 per annum). Survey work by UKAEA (summer 1997) revealed that the contamination of the seabed near Dounreay by such particles is much more extensive than previously thought (see annex 9, figures 1 to 4). Subsequently the Scottish Office, on 29 October 1997, imposed a comprehensive fishing restriction under the 1985 Food and Environment Protection Act (FEPA) in an area of 2km radius around the end of the Dounreay site outfall pipe. The Scottish Office requested SEPA along with the NRPB to undertake a review to provide information for the reassessment of the necessity for fishing restrictions.

In June 1997, monitoring of sediments for fragments was undertaken by UKAEA in order to investigate the possibility of offshore contamination. By mid-September 1997, UKAEA reported that 35 fragments had been recovered from the seabed, 4 from DFR (fast reactor) origin and 31 from MTR (test reactor) origin. The range of Cs-137 activity in the fragments is between 4E+02 Bq and 2E+07 Bq with an average of 1E+06 Bq. From the 35 offshore fragments found 13 were sufficiently radioactive to cause deterministic effects (physical harm). However, it must be noted that a single fragment with levels around 1E08 Bq has been discovered on the Dounreay foreshore. The route by which these fragments entered the environment has still not been unequivocally defined.

### 12.2 Present situation

On behalf of SEPA the NRPB produced an independent report titled 'Radiological implications of the presence of fragments of irradiated fuel in the sub-tidal zone at Dounreay' (reference NRPB-M1005, approved 12 November 1998). This report states that the extent of the contaminated marine area is still to be determined and the extent of the contamination at present remains unknown, and that these

essential parameters need to be known before more certain risk estimates can be made. Based on the limited data on fragment density in the seabed, together with information on catches and consumption rates, the NRPB report cautiously estimates that the probability that a local consumer could ingest a fuel fragment is indeed very small.

In March 1999, UKAEA issued a summary report on its findings. The report summarises the programme of work carried out to investigate the cause and distribution of radioactive particles that have contaminated the seabed and have been found on the Dounreay foreshore since 1984. It is reported that a number of possible sources have been investigated since 1995 and eliminated from further enquiry. However, the same report states that two significant possibilities remain: historical releases via the liquid effluent pipeline and diffuser chamber, and continuing releases either from the old diffuser chamber or from the Shaft.

The MTR particles found are reported to be mainly fragments of aluminium the size of sand grains that contain small specks of irradiated uranium fuel. Searches of old records and techniques indicate that the MTR particles are likely to have originated in the process of separating the aluminium cladding from the uranium/aluminium fuel matrix by a milling machine located in one of the Dounreay fuel storage ponds prior to reprocessing. At the time and up to about 1973, the swarf so generated was discharged by the authorised route to the Shaft. Investigations have identified several incidents in the 1960s and 1970s, which potentially could have allowed swarf to enter the low active drain system and be discharged to sea via the (old) diffuser chamber. Although work to date has shown the likelihood to be very low, the possibility that these particles could leak out via groundwater has been considered. Since 1986, the water pumped from the Shaft has passed through a filter without particles having been collected. No particles have been found in springs on the beach or on the seabed where underwater springs have been identified. Test carried out in 1997 and earlier, indicated that the pipework in the old diffuser chamber is no longer sound. Leaks from this pipework could have built up a reservoir of particles in the chamber. Investigations as performed by UKAEA are beginning to indicate that the old diffuser chamber is the most likely source of particles (see annex 9, figures 5 to 7).

Recovery of 35 particles in 1997 and a further 89 particles in 1998 has demonstrated the presence of a significant population of particles in an area spreading to the north-east from the location of the original low-level liquid effluent outfall. The highest concentration of particles has been identified in a local area to the east of the point on the seabed where authorised discharge of low-level liquid waste is made, the 'Diffuser Signature'. Until 1992, when a new diffuser and pipework were installed, low-level liquid waste discharges were made via a chamber (the old diffuser chamber) which is located some 25 metres below the seabed and joined to the site by a 600 m long tunnel. It is UKAEA's opinion that the diffuser signature may be the remnant of an historical plume that came from the old outfall, which is connected to the old diffuser chamber by 16 vertical exit pipes referred to as risers. Seabed monitoring work will be completed during the summer of 1999. Before particles were recovered from the area around the diffuser, the expectation was that sediments would be very mobile. This may not be the case, and more work has to be done to demonstrate that these sediments could be sufficiently stable to hold a reservoir of particles for 20 years or more. Since the hydraulic properties of the fuel particles are very similar to those of sand, they are likely to move with the body of sand in which they are found. In the meantime, it is conjectured that mechanisms are operating which could maintain substantially the same body of sand in the offshore area near Dounreay for a period of several years. It is UKAEA's understanding that particles could be brought to the surface during the remixing that occurs during storms; thereby making previously buried particles available to be brought up on shore.

Sandside Bay is separated from Dounreay by an extensive rock platform. Investigation of this area has found no particles. However, to the north of this platform, six particles have been found. This could be the remnant of a western extension of the historical plume and may be responsible for the

three particles found on Sandside Bay during the last 16 years. UKAEA says that the mechanism carrying the particles to Sandside Bay is however difficult to envisage.

### 12.3 Future prospects

UKAEA has further studies planned or in progress to determine the explanation(s) and to understand the distribution and dynamics of the particles in the environment and to establish the need for appropriate remediation. A clear demonstration of the source(s) of particles and their likely future movement and eventual dispersion is needed to provide a more reliable estimate of the risk to the public at Dounreay and the surrounding areas. Investigations are planned to determine the presence of particles in the old diffuser chamber. In addition reassurance monitoring will continue and be expanded where there is a potential for members of the public to encounter particles.

The new authorisation that SEPA is minded to grant will include an expanded beach-monitoring programme (see annex 6A, section 3).

The two kilometres fishing restrictions will not be lifted by the Scottish Office until UKAEA find and quantify the extent of contamination in the local marine environment.

## 13. CONCLUSIONS

All verifications that had been planned by the verification team were completed successfully. In this regard, the information supplied in advance of the visit, as well as the additional documentation received before the start and during the verification, was useful. The information provided and the outcome of the verification activities led to the following observations:

1. The verification team notes that, since its 1993 Art.35 verification, the internal quality assurance and control at UKAEA's effluent and environmental laboratories have improved. Verification activities revealed no departure from standards with regard to sample management, analytical procedures and record keeping. Maintenance and calibration procedures with respect to analytical measurement devices and monitoring equipment are well organised. The shortcoming which, from 1996 to 1998, resulted in under-reported atmospheric discharge data for the Fuel Cycle Area main stack, and which points to unsatisfactory quality assurance at that time, has been appropriately remedied through implementation of SEPA's Enforcement Notice serial No RSA/EN/N/50002/98. The verification team audited the modified procedure and revised discharge data to satisfaction. The verification team recommends that SEPA endeavours to ensure that failures in quality assurance and control programmes are timely detected.

2. Data management is coherent and adequate archiving of results obtained is in place. With regard to the environmental monitoring reports prepared by AEA Technology (as contractor to UKAEA), the verification team could not be provided timely with underlying data for the 1997 report [5]. The verification team underlines UKAEA's ultimate responsibility for the reports submitted to SEPA.

3. During its visit at SEPA's headquarters, the verification team was informed that SEPA was internally discussing the transition of its electronic environmental data management system

[5] The underlying data were forwarded to the verification team after the visit.

from spreadsheet to database format. The verification team, while encouraging such a transition, recommends that historical data, prior to SEPA's establishment in 1996, are included in the data management system. During the same visit, the verification team noted that only one SEPA staff member had in-depth knowledge of the data management system. The verification team recommends SEPA to ensure permanent availability of competence in the handling of the data management system.

4. In general, the verification team had the impression that SEPA lacks thoroughness with respect to quality assurance and control on environmental data transmitted by NRPB and UKAEA. Environmental data received are apparently not subjected to in-depth verifications upon receipt or prior to publication. As SEPA is ultimately responsible for the data published in the RIFE reports, the verification team recommends SEPA to review its internal quality assurance and control on environmental data transmitted by its contractor or by nuclear operators.

5. The verification team noted that, for 1998, the quantity of marine samples collected had been small, in particular with respect to lobster, salmon and whelks, resulting in an insufficient availability of Sr-90 data. Consequently, UKAEA's statutory environmental monitoring programme could not fully comply with SEPA's regulatory requirements. The verification team therefore recommends that either sample collection would proceed until such quantities are gathered that allow for a full implementation of the environmental monitoring programme or, where a sample type is not available in sufficient quantity, that this be reported and documented.

6. The air sampler, part of the environmental monitoring station located at Shebster Water Treatment Works, when inspected, was out of order. Its power supply had been switched off (by people unknown) without the operator's knowledge. The verification team recommends that environmental monitoring stations be provided with guaranteed power supplies supported by early warning systems in case of failure. Furthermore, the verification team recommends that SEPA install independent air samplers as part of its check monitoring programme in Caithness.

7. Subsequent to the SEPA/NRPB report on radioactive particles in the Dounreay marine environment, and more in particular with respect to recommendations made therein for improved beach monitoring, AEA Technology developed a vehicle-mounted Groundhog monitoring system. The verification team recommends the use of the vehicle-mounted Groundhog which, in conjunction with the frequency and extent of beach monitoring SEPA is requesting in the new Authorisations, will ensure an appropriate monitoring programme of public beaches around Dounreay [6].

8. The verification team endorses the recommendations made in the SEPA/NRPB report on radioactive particles in the Dounreay marine environment as well as UKAEA's intended investigative programme to definitively establish the origin of the particles. Current indications tend to pinpoint the old seabed diffusion chamber as a possible reservoir from which the particles escape. The verification team would appreciate it to be kept informed about investigation results and remedial actions envisaged for the radioactive particles in the Dounreay marine environment.

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[6] At report date (15/09/1999) the verification team had been informed that the vehicle-mounted system had been deployed.

9. The verification team observed that a series of boreholes are present around the Shaft. These boreholes are part of the hydrogeological survey undertaken around the Shaft. The verification team recommends that these boreholes be used for environmental monitoring purposes insofar that frequent analysis of water samples extracted from the said boreholes may monitor activity escaping from the Shaft to the environment. The verification team would appreciate it to receive the final report on the hydrogeological investigations currently undertaken around the Shaft.

10. With respect to the Marshall Laboratory the verification team recommends that the laboratory's stack be provided with adequate facilities for continuous alpha monitoring of gaseous effluent. Efforts need to be made to overcome the technical problems resulting from a high background of radon progeny.

11. With respect to the Sodium Disposal Facility operated by AEA Technology, and after having witnessed the inadequacy of the current gaseous effluent monitoring provisions of the facility, the verification team endorses SEPA's Prohibition Notice serial No RSA/PR/N/50000/97 served in 1997. The verification team recommends that appropriate and prompt remedial action be undertaken before resuming operation.

12. With respect to the new Waste Receipt Assay Characterisation and Supercompaction facility (WRACS), the verification team noted that the facilities for gaseous effluent monitoring are in line with modern standards.

13. The verification team had been invited to visit the new Low Level Liquid Effluent Treatment Plant (LLLETP) currently under construction in order to observe the monitoring facilities already installed. It is the verification team's opinion that the LLLETP will improve UKAEA's future control over liquid effluent discharges.

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**ANNEX 1**

## HSE / SEPA DOUNREAY SAFETY AUDIT RECOMMENDATIONS

**1 With respect to the management of radiological protection:**

- R106 UKAEA should ensure that adequate radiological protection advice is available to meet the demands from site.
- R107 UKAEA should provide a health physics monitoring service for staff working in high-hazard radioactive contamination areas rather than relying on self-monitoring.
- R108 UKAEA should ensure that sufficient Health Physics Surveyors are available to meet all the demands on their specialist services.
- R109 UKAEA should issue practical guidance and instructions on control of contamination particularly for working with pressurised/air fed suits, the use of tents, glove boxes, and fume cupboards.
- R110 UKAEA should remove existing radioactive contamination hot-spots where reasonably practicable and ensure that new contamination is removed as soon as possible after it is detected.
- R111 UKAEA should review the equipment and arrangements for personnel monitoring at contamination zone boundaries and at the point of exit from individual plants on the site to bring them into line with modern practice and standards.
- R112 UKAEA should install modern walk-through monitors with turnstiles at the exits of the main controlled areas on the site.

**2 With respect to radioactive waste discharge monitoring facilities:**

- R121 UKAEA should review the facilities and arrangements for the monitoring and reporting of airborne discharges and implement reasonably practicable improvements.

**3 With respect to environmental monitoring systems:**

- R122 UKAEA should continue to develop and improve the monitoring strategy for fragments of irradiated fuel in intertidal areas near the site where there is public access.

**4 With respect to the various waste facilities:**

- R137 UKAEA, as a matter of urgency should take action to improve the deficiencies in the filter arrangements in D9867 ventilation system. This should be carried out independently of any wider review and improvements to ventilation systems.
- R138 UKAEA should seek to avoid the use of ISO containers as temporary waste stores but where such use is unavoidable there should be more effective control on their contents and better management of their use.
- R139 UKAEA should stop storing large contaminated items of radioactive waste in the open air.
- R140 UKAEA should review its policy on storage of non-UKAEA radioactive waste or material.
- R141 UKAEA, as a matter of urgency should review the adequacy of the current storage arrangements for contaminated sodium.
- R142 UKAEA should take action to segregate and store or dispose of the contaminated scrap metal at the east of the site.

**ANNEX 2**

## REFERENCES & DOCUMENTATION


1. HSE and SEPA, 1998. *Safety audit of Dounreay 1998.* HSE books.
2. UKAEA, 1998. *Dounreay – The Way Ahead.* UKAEA response to the 1998 HSE/SEPA safety audit of Dounreay. UKAEA Dounreay.
3. SEPA, 1998. *Fragments of irradiated nuclear fuel in the Dounreay local environment.* SEPA Stirling.
4. SEPA and MAFF, 1998. *Radioactivity in food and the environment, 1997.* RIFE-3, London.
5. AEAT, 1998. *Survey and analysis results for the Environmental Monitoring programmes undertaken at Dounreay – 1997.* AEA Technology.
6. UKAEA, 1997. *Radioactive waste discharges from UKAEA establishments during 1996 and associated monitoring results.* UKAEA/SD R015 ISBN: 07058-1751-2
7. UKAEA, 1996. *Radioactive waste discharges from UKAEA establishments during 1995 and associated monitoring results.* UKAEA/SD R014 ISBN: 07058-1720-2
8. UKAEA, 1995. *Radioactive waste discharges from UKAEA establishments during 1994 and associated monitoring results.* UKAEA/SD R013 ISBN: 08535-6426-4
9. UKAEA, 1994. *Radioactive waste discharges from UKAEA establishments during 1993 and associated monitoring results.* UKAEA/SD R012 ISBN: 08535-6414-0
10. SEPA, 1999. *Decision by SEPA on the Application from UKAEA to dispose of radioactive wastes from Dounreay, Caithness, Scotland.* SEPA Stirling
11. NRPB, 1999. Sixth COMARE report. *A reconsideration of the possible health implications of the radioactive particles found in the general environment around the Dounreay Nuclear Establishment in the light of the work undertaken since 1995 to locate their source.* ISBN: 085951-428-5
12. RWMAC, 1999. *The Radioactive Waste Management Advisory Committee's review of radioactive particles at UKAEA Dounreay.*
13. UKAEA, 1999. *Dounreay particles: a summary report.* UKAEA-FC028a.CDR(03/99)9
14. UKAEA, 1999. *Radioactivity levels outside the UKAEA Dounreay site: a summary report.* UKAEA-FC029a.CDR(03/99)
15. UKAEA, 1999. *Aerial radiological survey of are around Dounreay.* UKAEA-FC023a.CDR(03/99)

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16. Scottish Office presentation — *Overview of UK environmental monitoring.*
17. Scottish Office presentation — *The food and environment protection act 1985. Order prohibiting the harvesting of seafood within 2km of the outfall pipe of UKAEA Dounreay.*
18. SEPA presentation — *The regulation of radioactive discharges to the environment.*
19. SEPA presentation — *Environmental and compliance monitoring for radioactivity in the north of Scotland – the interface of SEPA's programme with the UKAEA programme and changes made since the 1993 EC Article 35 verification.*
20. UKAEA presentation — *Metallic particles on the Dounreay foreshore.*

| | | |
|---|---|---|
| 21. | UKAEA presentation | *The Dounreay Shaft.* |
| 22. | UKAEA presentation | *The Prototype Fast Reactor, history since 1993.* |
| 23. | UKAEA presentation | *Overview of the FCA loss of power incident of 07 May 1998.* |
| 24. | UKAEA presentation | *Effects of the 07 May 1998 power cut on continuous monitoring, remedial actions.* |
| 25. | UKAEA presentation | *Aerial survey to determine the distribution of natural and artificial radionuclides in the vicinity of Dounreay.* |

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26. Current UKAEA Dounreay site Authorisations (including AEA Technology authorisations) and Technical Implementation Documents.
27. SEPA Prohibition Notice (serial No RSA/PR/N/50000/97).
28. SEPA Enforcement Notice (serial No RSA/EN/N/50001/98).
29. SEPA Enforcement Notice (serial No RSA/EN/N/50002/98).

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30. Most recent environmental monitoring data (1998, 1999 – unpublished).
31. Flow diagrams for stack monitoring.
32. FCA main stack, corrected discharge data (1996 – 1998).

**ANNEX 3**

## THE VERIFICATION PROGRAMME

| | | |
|---|---|---|
| Mon 15 March | morning: | Welcome to the Scottish Office (Edinburgh).<br><br>Presentations and discussions on:<br>- Overview of UK environmental monitoring.<br>- Regulation of radioactive discharges to the environment.<br>- Environmental monitoring for radioactivity in the north of Scotland.<br>- The SEPA programme and its interface with the UKAEA programme.<br>- The Food and Environmental Protection Act 1985. |
| | afternoon: | Team-1: Visit of NRPB laboratories (Glasgow).<br>- Environmental monitoring techniques.<br>- Laboratory methods and results.<br>- National monitoring.<br>Team-2: Visit of SEPA Head Office (Stirling).<br>- RIFE report, Article 35 data transfer.<br>- Public register.<br>- RIMNET. |
| Tue 16 March | morning: | Travel from Edinburgh to Dounreay. |
| | afternoon: | General visit of the UKAEA Dounreay site.<br><br>Presentations and discussions on:<br>- Dounreay site history and operations.<br>- Radioactive particles in the marine environment.<br>- Installation D1225 (Dounreay ILW Shaft).<br>- Overview of the FCA loss of power incident.<br>- Effect of power cut on continuous monitoring, remedial actions.<br>- Dounreay PFR, situation report. |
| Wed 17 March | morning: | Team-1: Monitoring for final waste disposal facilities.<br>Monitoring of gaseous discharges (minor stack).<br>Team-2: Monitoring of gaseous discharges (main and minor stacks). |
| | afternoon: | Presentation and discussion on:<br>- Aerial survey.<br>- Equipment for offshore monitoring.<br><br>Team-1: Off-site environmental monitoring.<br>Monitoring for particles (Sandside Bay).<br>Team-2: Monitoring for particles (Dounreay foreshore).<br>Monitoring for particles (Sandside Bay).<br><br>Discussions. |
| Thu 18 March | morning: | Team-1: District laboratories.<br>Dosimetry laboratory.<br>Team-2: Effluent laboratories.<br><br>Debriefing with UKAEA. |
| | afternoon: | Travel from Dounreay to Edinburgh.<br><br>Round-up meeting at the Scottish Office. |

**ANNEX 4**

# CURRENT DISCHARGE LIMITS [7]

## 1. Gaseous discharges - Fuel Cycle Area.

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| α activity (ex. Cm-242 and Cm-244) | 1 |
| β activity (ex. H-3 and Kr-85) | 45 |
| tritium | 40000 |
| krypton-85 | 1000000 |
| strontium-90 | 5 |
| ruthenium-106 | 7 |
| iodine-129 | 4 |
| iodine-131 | 3 |
| caesium-134 | 1 |
| caesium-137 | 7 |
| cerium-144 | 7 |
| plutonium-241 | 5 |
| curium-242 | 1 |
| curium-244 | 0.1 |

## 2. Gaseous discharges –Prototype Fast Reactor.

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| tritium | 30000 |
| argon-41 | 1500 |
| krypton-85m | 10000 |
| krypton-87 | 20000 |
| krypton-88 | 20000 |
| xenon-133 | 3750000 |
| xenon-133m | 75000 |
| xenon135 | 350000 |

## 3. Gaseous discharges – Dounreay Fast Reactor.

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| β activity (ex. H-3 and Kr-85) | 1.5 |
| tritium | 130000 |
| krypton-85 | 0.4 |

[7] The discharge limits are applicable to any period of 12 consecutive calendar months.

## 4. Gaseous discharges – Sodium Disposal Facility. [8]

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| β activity (ex. H-3) | 0.08 |
| Tritium | 1200 |

## 5. Gaseous discharges – Low Specific Activity Descaling Facility. [9]

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| α activity | 0.001 |
| β activity | 0.0004 |

## 6. Liquid discharges.

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| α activity (ex. Cm-242) | 750 |
| β activity (ex. H-3) | 110000 |
| Tritium | 130000 |
| cobalt-60 | 1000 |
| strontium-90 | 12000 |
| zirconium-95 / niobium-95 | 6000 |
| ruthenium-106 | 12000 |
| silver-110m | 400 |
| caesium-137 | 50000 |
| cerium-144 | 12000 |
| plutonium-241 | 15000 |
| curium-242 | 1000 |

## 7. Liquid discharges – Sodium Disposal Facility.

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| β activity (ex. H-3) | 300 |
| Tritium | 1200 |

## 8. Liquid discharges – Low Specific Activity Descaling Facility.

| Radionuclide(s) | Activity (in GBq) |
|---|---|
| α activity | 0.0001 |
| β activity | 0.0016 |

[8] Facility operated by AEA Technology.
[9] Facility operated by AEA Technology.

**ANNEX 5**

# SEPA ENVIRONMENTAL MONITORING PROGRAMME AROUND DOUNREAY APRIL 1997 – MARCH 2000

## 1. Marine monitoring.

### 1.1 Programme

| Location | Sample | Analysis | Per year | Notes |
|---|---|---|---|---|
| Brims Ness | Seaweed | Gamma spec | 4 | |
| | Winkles | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of 2 of quarterly samples |
| Oigins Geo | Dose rate at 1m | Gamma dose rate | 4 | Over spume/sludge |
| | Sediment (sludge/spume) | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of quarterly samples |
| Sandside Bay | Dose rate at 1m | Gamma dose rate | 1 | Over gill nets |
| | | Gamma dose rate | 1 | Over sand |
| | Seaweed | Gamma spec | 4 | |
| | | Technetium radionuclides | 4 | |
| | Seawater | Caesium radionuclides | 4 | |
| | | Salinity | 4 | |
| | | Tritium | 4 | |
| | Sediment | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of 2 of quarterly samples |
| | Winkles | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of 2 of quarterly samples |
| | Dose rate at 1m | Gamma dose rate | 4 | Over winkle bed |
| PLZ | Crab | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of 2 of quarterly samples |
| | | Technetium radionuclides | 1 | |
| | Fish | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of 2 of quarterly samples |
| | | C-14 | 1 | Bulk of quarterly samples |
| | Lobster | Gamma spec | 4 | |
| | | Alpha spec | 1 | Bulk of 2 of quarterly samples |
| | | Technetium radionuclides | 1 | |
| | Dose rate over lobster pots | Contact beta dose rate | 1 | |
| Castletown Harbour | Dose rate at 1m | Gamma dose rate | 1 | Over mud |
| Brims Ness | Strandline dose rate | Gamma dose rate | 1 | |
| Oigins Geo | Strandline dose rate | Gamma dose rate | 1 | |
| Sandside Bay | Strandline dose rate | Gamma dose rate | 1 | |

## 1.2 Reporting requirements

| Analysis | Reporting period [10] |
|---|---|
| Alpha spectrometry | Within 3 months of end of sample period |
| Sr-90 | Within 3 months of end of sample period |
| Technetium radionuclides | Within 3 months of end of sample period |
| C-14 | Within 3 months of end of sample period |
| Pu-241 | Within 3 months of end of sample period |
| Gamma spec | Within 3 months of end of sample period |
| Caesium radionuclides | Within 3 months of end of sample period |
| Salinity | Within 3 months of end of sample period |
| Tritium | Within 3 months of end of sample period |
| Total Beta | Within 1 month of end of sample period |
| Total Alpha | Within 1 month of end of sample period |
| Total Gamma | Within 1 month of end of sample period |
| Gamma doserate | Within 1 month of end of measurement |
| Beta doserate | Within 1 month of end of measurement |

## 1.3 Limits of detection [11]

| Analysis | Limit of detection (in Bq/kg or Bq/l) |
|---|---|
| Gamma spectrometry | 0.1 (Co-60) |
| Caesium radionuclides | 0.05 |
| Tritium | 1.0 |
| Alpha spectrometry | 0.0001 |
| Sr-90 | 0.1 |
| C-14 | 15 |
| Technetium radionuclides | 0.05 |
| Pu-241 | 0.1 |
| Total Beta (as Cs-137) | 0.1 |
| Total Gamma | 0.05 |
| Total Alpha | 0.0001 |

## 1.4 Units of measurement

| | |
|---|---|
| Dose | µGy/h |
| Water | Bq/l |
| Sediment | Bq/kg (dry) |
| Seaweed | Bq/kg (wet) |
| Fish/shellfish | Bq/kg (wet) |

# 2. Terrestrial monitoring.

---

10 For a reporting period "within 3 months of end of sample period": all calendar year data (up and including December's environmental monitoring data) must be received by SEPA before the end of February of the following year to ensure adequate preparation time for publication (the reporting period of within 2 months applies to this data).

11 The detection limits are applicable to all samples taken in Scotland.

## 2.1 Programme

| Analysis | Sheep liver | Sheep thyroid | Grass | Soil |
|---|---|---|---|---|
| Tritium | | | x | x |
| C-14 | | | | |
| S-35 | | | | |
| Sr-90 | | | x | x |
| I-129 | | X | x | x |
| I-131 | | x | x | x |
| Cs-137 | | | x | x |
| Am-241 | x | | x | x |
| Plutonium radionuclides | x | | x | x |
| Total alpha | | | | |
| Gamma spec | x | | | |

## 2.2 Limits of detection in Bq/kg [12]

| Analysis | Grass | Soil | Sheep Liver | Sheep Thyroid | Milk [13] |
|---|---|---|---|---|---|
| Tritium | 25 | 25 | | | 25 |
| C-14 | 15 | | | | 15 |
| S-35 | 5 | | | | 5 |
| Sr-90 | 0.1 | 0.1 | | | 0.1 |
| I-129 | 0.05 | 0.05 | | 0.05 | |
| I-131 | 0.05 | 0.05 | | 0.05 | 0.05 |
| Cs-137 | 0.05 | 0.05 | | | 0.05 |
| Am-241 | 0.05 | 0.05 | 0.01 | | |
| Plutonium radionuclides | 0.05 | 0.05 | 0.01 | | |
| Total alpha | 0.01 | | | | |
| Gamma spec | 0.05 | | 0.05 | | |

## 2.3 Monitoring of freshwater and detection limits, programme in Caithness/Orkney Islands

| Sample type | Sample size | Reporting period | Number per annum | Date of despatch | Analysis required |
|---|---|---|---|---|---|
| Type 1 | 25 litres | Within 4 weeks of sample receipt | 27 | May<br>September<br>February<br>(in each FY) | Gamma spec<br>Total alpha<br>Total beta |
| Type 2 | 25 litres | Within 8 weeks of sample receipt | 16 | March<br>(at the end of each FY) | Total alpha<br>Total beta<br>Sr-90<br>Tritium |

[12] The detection limits are applicable to all samples taken in Scotland.
[13] Milk is not sampled in Caithness (absence of dairy cows).

| Analysis | Detection limit (Bq/l) |
|---|---|
| Total alpha | 0.01 |
| Total beta | 0.01 |
| Gamma spec (per individual radionuclide) | 0.01 |
| Sr-90 | 0.005 |
| Tritium | 1.0 |

| Sample name | Local authority | Sample type |
|---|---|---|
| Loch Calder | Highland | 1 |
| Loch Calder | Highland | 1 |
| Loch Calder | Highland | 1 |
| Loch Shurrerey | Highland | 2 |
| Loch Baligill | Highland | 2 |
| Heldale Water | Orkney Islands | 2 |

## 2.4 Liquid effluent monitoring programme and detection limits for Dounreay [14]

| Analysis | 14 per year [a] | 4 per year [d] | 8 per year [b] | 6 per year [c] | 4 per year [d] |
|---|---|---|---|---|---|
| Tritium | x | x | x | x | |
| S-35 | x | x | x | | |
| Sr-90 | x | | | x | |
| Am-241 | | | | x | |
| Plutonium radionuclides | | | | x | |
| Total beta | x | x | | x | x |
| Total alpha | x | x | | x | x |
| Gamma spec | x | x | | x | x |
| Alpha spec | | | | x | |

a. Comprises 3 samples at quarterly intervals plus 2 samples at 6 monthly intervals.
b. Comprises 2 samples at quarterly intervals.
c. Comprises 6 samples at 2 monthly intervals.
d. Quarterly samples.

| Analysis | Detection limit (Bq/l) |
|---|---|
| Tritium | 50 |
| S-35 | 10 |
| Sr-90 | 200 |
| Am-241 | 0.2 |
| Plutonium radionuclides | 0.2 |
| Total Beta | 100 |
| Total Alpha | 10 |
| Gamma spec (individual radionuclides) | 100 |

[14] Sampling activities are witnessed by NRPB and samples are sealed by NRPB, ready for dispatch.

2.5 Dounreay grab sample, 1 sample per year

| Analysis | | Detection limit (Bq/l) |
|---|---|---|
| Tritium | x | 50 |
| S-35 | | 10 |
| Sr-90 | x | 200 |
| Am-241 | | 0.2 |
| Plutonium radionuclides | x | 0.2 |
| Total beta | x | 100 |
| Total alpha | x | 10 |
| Gamma spec | x | 100 |
| Alpha spec | x | Not given [15] |

## 3. Drycloth monitoring.

This part of the programme has been halted in 1997.

[15] SEPA's contract specification gives no limit of detection. NRPB reports all results above the detection limit of their equipment and analytical techniques (0.1 Bq/l).

**ANNEX 6A**

# UKAEA – STATUTORY ENVIRONMENTAL MONITORING PROGRAMME

## 1. Environmental monitoring programme associated with gaseous effluent discharges.

Notes: 1) Inner ring <4 km from Dounreay, outer ring >4 km from Dounreay.
2) Gamma spec means high resolution gamma spectrometry;
the following radionuclides should be specifically reported:
Ru-106, I-131, Cs-134, Cs-137, Ce-144.

### 1.1 Internal

| Sample | Analysis | Sampling frequency | Analysis frequency | Sampling location |
|---|---|---|---|---|
| Grass | Gamma spec<br>Sr-90<br>Actinides | fortnightly (*)<br>fortnightly (*)<br>fortnightly (*) | weekly<br>3 monthly (**)<br>6 monthly (**) | In any week half of inner and outer ring locations with the remainder on the following week. |
| Root mat and soil core | Gamma spec<br>Sr-90<br>Actinides | 6 monthly (*)<br>6 monthly (*)<br>6 monthly (*) | 3 monthly<br>3 monthly<br>6 monthly (**) | In any quarter half of inner and outer ring locations with the remainder on the following quarter. |
| Air | Gamma spec<br>Sr-90<br>Actinides | continuous<br>continuous<br>continuous | monthly<br>monthly<br>monthly | All locations. |
| Rain water | Gamma spec<br>Sr-90<br>Actinides | continuous<br>continuous<br>continuous | monthly<br>monthly<br>monthly | All locations. |

(*) For any individual location.
(**) Bulk sample.

### 1.2 Indicators

| Sample | Analysis | Sampling frequency | Analysis frequency | Sampling location |
|---|---|---|---|---|
| Sheep faeces | Gamma spec<br>Actinides | monthly<br>monthly | monthly<br>monthly | 2 inner and 2 outer locations as for grass. |
| Goat milk | I-129<br>I-131<br>Cs-137<br>Sr-90 | quarterly<br>quarterly<br>quarterly<br>quarterly | quarterly<br>quarterly<br>quarterly<br>quarterly | From inner ring if available, otherwise from outer ring location. |

### 1.3 External

| Sample | Analysis | Sampling frequency | Analysis frequency | Sampling location |
|---|---|---|---|---|
| Gamma survey | Gamma | 12 weekly (*) | 6 weekly | In any 6 week period half of inner and outer ring locations with remainder on the following 6 week period. |

(*) For any individual location.

## 1.4 Grass sampling locations

| Sample reference | Ring | Location |
|---|---|---|
| Grass 01 | Inner | Nr Oigins Geo |
| Grass 02 | Inner | East airfield |
| Grass 03 | Inner | Main runway |
| Grass 04 | Inner | West runway |
| Grass 05 | Inner | Vulcan road |
| Grass 06 | Inner | Vulcan perimeter |
| Grass 07 | Outer | Borrowston turn off |
| Grass 08 | Outer | Balmore |
| Grass 09 | Outer | Upper Dounreay |
| Grass 10 | Outer | Nr Archvarasdale |

## 1.5 Air sampling and deposition monitoring points

| Location |
|---|
| Reay Golf Club |
| Shebster water treatment works |
| Forss (hill of Lybster) |
| Vulcan NRTE |
| Murkle |
| Wick airport |

## 1.6 Gamma survey locations

| Group | Ring | Location |
|---|---|---|
| 1 | Inner | Nr Oigins Geo |
| 1 | Inner | Achraemie |
| 1 | Inner | Upper Dounreay |
| 1 | Inner | Reay |
| 2 | Outer | Borrowston |
| 2 | Outer | Dounreay road (A882) |
| 2 | Outer | Achnabust |
| 2 | Outer | Gunns croft |

## 2. Environmental monitoring programme associated with liquid effluent discharges.

Note: Gamma spec means high resolution gamma spectrometry;
the following radionuclides should be specifically reported:
Mn-54, Co-60, Zr-95 Nb-95, Ru-106, Ag-110m, Cs-134, Cs-137, Ce-144.

### 2.1 Internal

| Sample | Analysis | Sampling frequency | Analysis frequency | Sampling location |
|---|---|---|---|---|
| Winkles | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | monthly<br>monthly<br>monthly<br>monthly | monthly<br>monthly<br>annual (*)<br>annual (*) | Sandside, Kirk Ebb and Crosskirk. |
| Soil core | Gamma spec<br>Actinides | end of salmon fishing season | once per year | From vicinity of salmon net cleaning area (Melvich or Sandside). |
| Salmon | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | twice per year<br>twice per year<br>twice per year<br>twice per year | twice per year<br>twice per year<br>annual (*)<br>annual (*) | Purchased from Sandside fishery. |
| Round fish | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | 6 weekly<br>6 weekly<br>6 weekly<br>6 weekly | 6 weekly<br>quarterly (*)<br>annual (*)<br>annual (*) | To be caught in the area from Holborn Head to Strathy Point. |
| Flat fish | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | 6 weekly<br>6 weekly<br>6 weekly<br>6 weekly | 6 weekly<br>quarterly (*)<br>annual (*)<br>annual (*) | To be caught in the area from Holborn Head to Strathy Point. |
| Crabs | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | 6 weekly<br>6 weekly<br>6 weekly<br>6 weekly | 6 weekly<br>quarterly (*)<br>annual (*)<br>annual (*) | To be caught in the area from Holborn Head to Strathy Point. |
| Lobster | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | 6 weekly<br>6 weekly<br>6 weekly<br>6 weekly | 6 weekly<br>quarterly (*)<br>annual (*)<br>annual (*) | To be caught in the area from Holborn Head to Strathy Point. |
| Whelks | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | 6 weekly<br>6 weekly<br>6 weekly<br>6 weekly | 6 weekly<br>quarterly (*)<br>annual (*)<br>annual (*) | To be caught in the area from Holborn Head to Strathy Point. |

(*) Bulk sample.

### 2.2 Indicator

| Sample | Analysis | Sampling frequency | Analysis frequency | Sampling location |
|---|---|---|---|---|
| Seaweed | Gamma spec | quarterly | quarterly | 13 locations in the area 23 km east to 16 km west of Dounreay. |

## 2.3 External

| Sample | Analysis | Monitoring frequency | Analysis frequency | Sampling location |
|---|---|---|---|---|
| | Beta/gamma surveys | weekly<br>monthly | | Locations 1 to 5 and 7 & 13.<br>All other locations. |
| Intertidal deposited material | Gamma spec<br>Actinides<br>Pu-241<br>Sr-90 | | For each sample obtained | At beta/gamma survey locations when dose rates measured at 1 metre exceed 0.25 μSv/h at locations 1 to 5 and 7 & 13, and 0.2 μSv/h at all other locations. |

| Survey | Survey type | Monitoring frequency | Sampling location |
|---|---|---|---|
| Strandline | Beta and/or gamma | Fortnightly | At Sandside Bay and Dounreay foreshore on alternate weeks. Monitoring concentration on tide lines. To be supplemented following severe storms. |
| Salmon nets | Beta/gamma dose rate | Weekly during salmon fishing season | Sandside fishery leader nets and bag nets. |
| Salmon net store | Beta/gamma survey | End of salmon fishing season | Salmon net store. |

## 2.4 Beta/gamma survey areas

| Location | Location |
|---|---|
| 1 - Edwards Geo | 10 - Brim's east |
| 2 - Sandside Bay (rocky area) | 11 - Clardon Haven |
| 3 - Vulcan NRTE foreshore | 12 - Portskerra |
| 4 - Oigins Geo (west) | 13 - Sandside Bay (sandy area) |
| 5 - Oigins Geo (east) | 14 - Thurso Bay |
| 6 - Thurso east (Pocket Geo) | 15 - Scrabster |
| 7 - Borrowston (Gie Usig Geo) | 16 - Castletown |
| 8 - St Mary's Chapel | 17 - Dunnet |
| 9 - Brims Ness (Sandy Geo) | |

## 2.5 Seaweed sampling areas

| Location | Location |
|---|---|
| 1 - Point of Ness (Nr Dunnet) | 8 - Vulcan NRTE foreshore |
| 2 - Holborn Head (by Stn) | 9 - Sandside Bay (rocky area) |
| 3 - Brims Ness (Sandy Geo) | 10 - Sandside Bay (sandy area) |
| 4 - Borrowston (Gie Usig Geo) | 11 - County boundary (Geodh Eisgiadh) |
| 5 - Oigins Geo | 12 - Portskerra |
| 6 - Boundary perimeter (east) | 13 - Strathy Point (jetty) |
| 7 - Pump house | |

## 3. Frequency and extent of beach monitoring for fragments of irradiated fuel

Note: Low water means as reasonable practicable to low water springs, but at least to neap low water.

| Beach | Extent of monitoring | Frequency | Detection criteria |
|---|---|---|---|
| Sandside Bay | All sandy areas that can be accessed by a vehicle from MHWS to low water. | Monthly | > 1.0E+07 Bq of Cs-137 at 10 cm depth |
| Sandside Bay | All sandy areas that can be accessed by a vehicle from MHWS to low water. | Twice per year | > 1.0E+05 Bq of Cs-137 at 10 cm depth |
| Thurso Bay | All sandy areas that can be accessed by a vehicle from MHWS to low water. | Twice per year | > 1.0E+07 Bq of Cs-137 at 10 cm depth |
| Thurso Bay | All sandy areas that can be accessed by a vehicle from MHWS to low water. | Once per year (*) | > 1.0E+05 Bq of Cs-137 at 10 cm depth |
| Scrabster Bay | All sandy areas that can be accessed by a vehicle from MHWS to low water. | Twice per year | > 1.0E+07 Bq of Cs-137 at 10 cm depth |
| Scrabster Bay | All sandy areas that can be accessed by a vehicle from MHWS to low water. | Once per year (*) | > 1.0E+05 Bq of Cs-137 at 10 cm depth |
| Crosskirk Bay | All sandy areas that can be accessed by a vehicle from MHWS to MLWS. | Twice per year | > 1.0E+05 Bq of Cs-137 at 10 cm depth |
| Brims Ness | All sandy areas that can be accessed by a vehicle from MHWS to MLWS. | Twice per year (*) | > 1.0E+05 Bq of Cs-137 at 10 cm depth |

(*) Or equivalent coverage by several visits.

**ANNEX 6B**

## UKAEA –ENVIRONMENTAL MONITORING SYSTEM

Note: the system detailed in this annex is part of UKAEA's site emergency response capacity.

There are two types of monitoring stations.

| Type | Details |
|---|---|
| 1 | Gamma only monitors |
| 2 | Alpha, beta gamma and iodine monitor |

The monitors are located both on-site and off-site to provide coverage for the whole of Dounreay and outlying areas. They are linked back t a hub station on site and this is achieved via a modem or radio link.

| Number | Location | Type | Number | Location | Type |
|---|---|---|---|---|---|
| 1 | PFR | 2 | 11 | D1200 | 2 |
| 2 | DN023 | 1 | 12 | D1226 | 2 |
| 3 | D1120 | 1 | 13 | D1249 | 2 |
| 4 | DN016 | 2 | 14 | DN088 | 2 |
| 5 | D9807 | 1 | 15 | Vulcan | 2 |
| 6 | D8525 | 1 | 16 | Reay (W) | 2 |
| 7 | D1310 | 2 | 17 | Upper Dounreay (S) | 2 |
| 8 | D1300 | 1 | 18 | Buldoo (E) | 2 |
| 9 | D8538 roof | 2 | 19 | Mobile unit | 2 |
| 10 | D8538 ground floor | 1 | | | |

They have the following alarm levels (for gamma this is averaged over a 10 minute period). Air activity is also averaged over 10 minute periods.

| Type | Alarm level indication | Yellow | Yellow and red | Red |
|---|---|---|---|---|
| 1 | Gamma monitor | 1 mSv/h | 2.5 mSv/h | 10 mSv/h |
| 2 | Alpha, beta gamma and iodine monitor | 40 DAChr | 100 DAChr | 400 DAChr |

**ANNEX 7**

# ENVIRONMENTAL MONITORING – MAPS

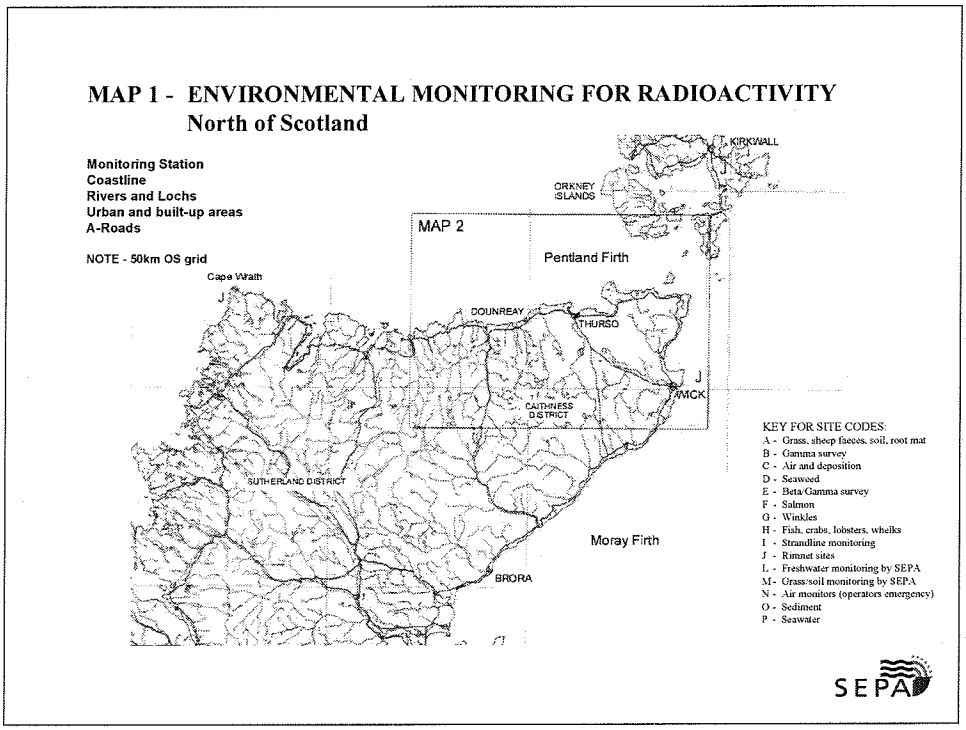



**Figure 1**

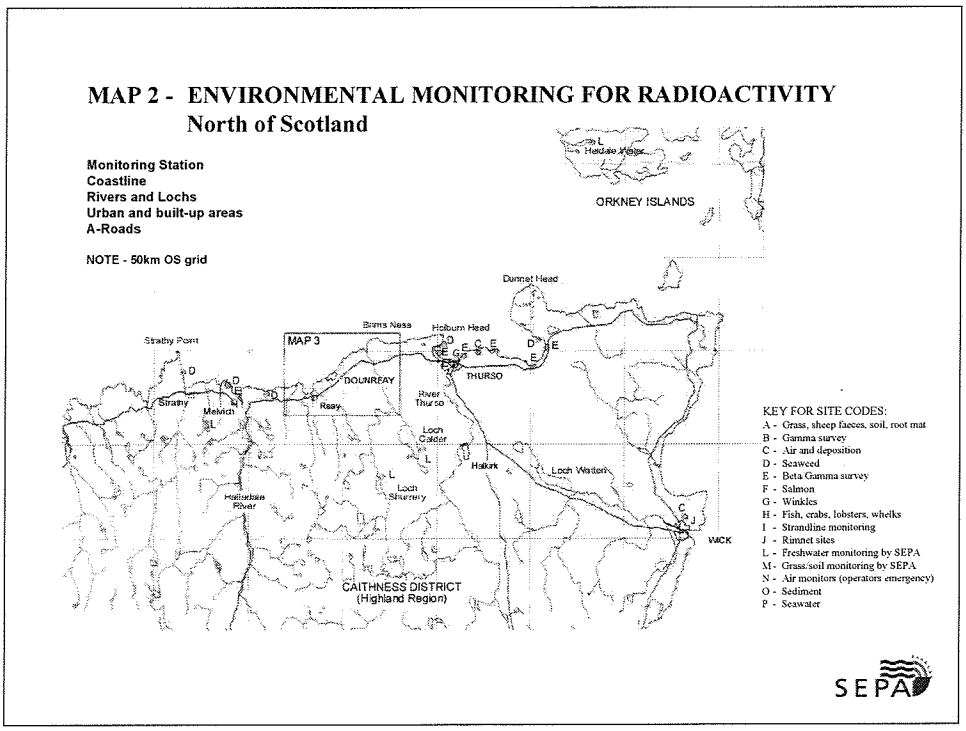



**Figure 2**

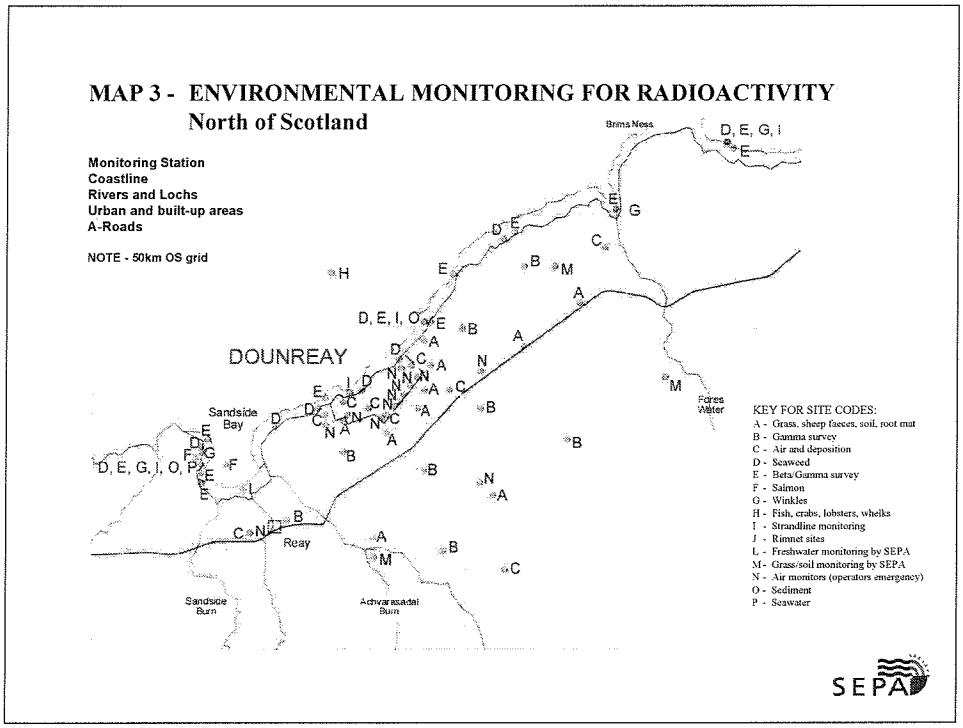

MAP 3 - ENVIRONMENTAL MONITORING FOR RADIOACTIVITY
North of Scotland
Monitoring Station
Coastline
Rivers and Lochs
Urban and built-up areas
A-Roads
NOTE - 50km OS grid
DOUNREAY
Brims Ness
Forss Water
Sandside Bay
Reay
Sandside Burn
Achvarasdal Burn
KEY FOR SITE CODES:
A - Grass, sheep faeces, soil, root mat
B - Gamma survey
C - Air and deposition
D - Seaweed
E - Beta/Gamma survey
F - Salmon
G - Winkles
H - Fish, crabs, lobsters, whelks
I - Strandline monitoring
J - Rimnet sites
L - Freshwater monitoring by SEPA
M - Grass/soil monitoring by SEPA
N - Air monitors (operators emergency)
O - Sediment
P - Seawater
SEPA

**Figure 3**

**Figure 4**

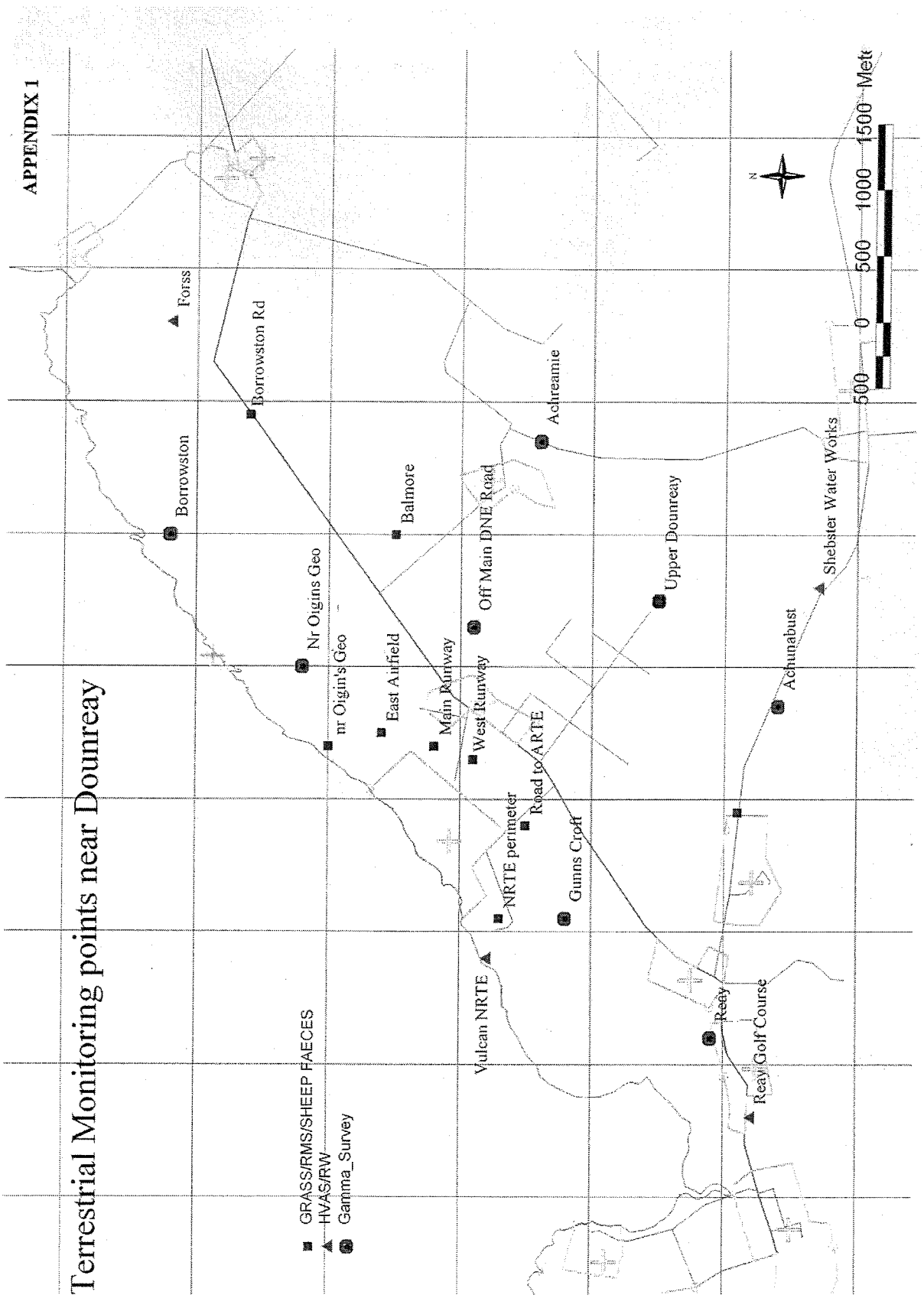

APPENDIX 1
Terrestrial Monitoring points near Dounreay
GRASS/RMS/SHEEP FAECES
HVAS/RW
Gamma_Survey
Forss
Borrowston Rd
Borrowston
Achreamie
Nr Oigins Geo
nr Oigin's Geo
Balmore
East Airfield
Main Runway
West Runway
Off Main DNE Road
Upper Dounreay
Shebster Water Works
Achunabust
Road to ARTE
NRTE perimeter
Gunns Croft
Vulcan NRTE
Reay
Reay Golf Course
N
500 0 500 1000 1500 Metr

**Figure 5**

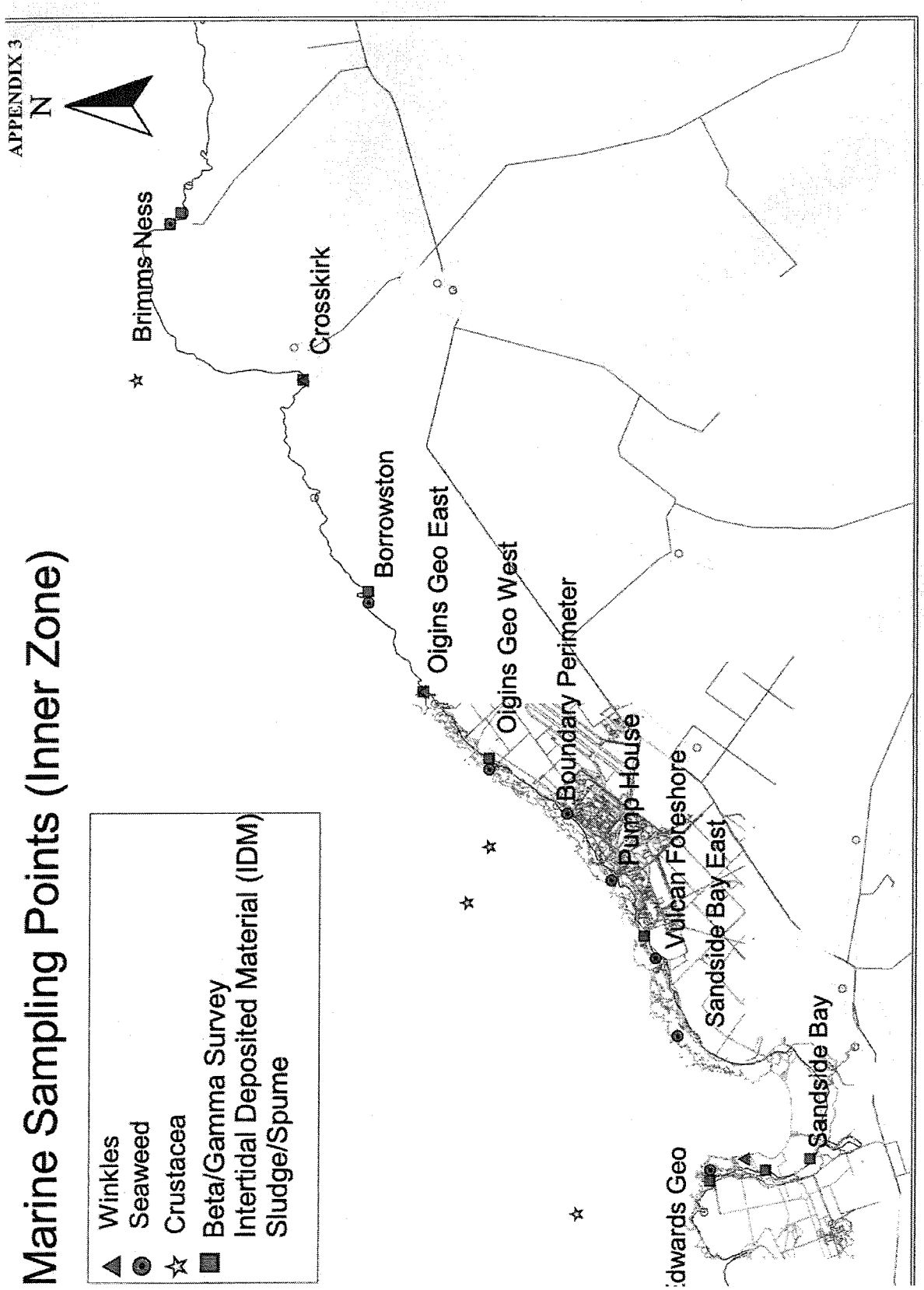
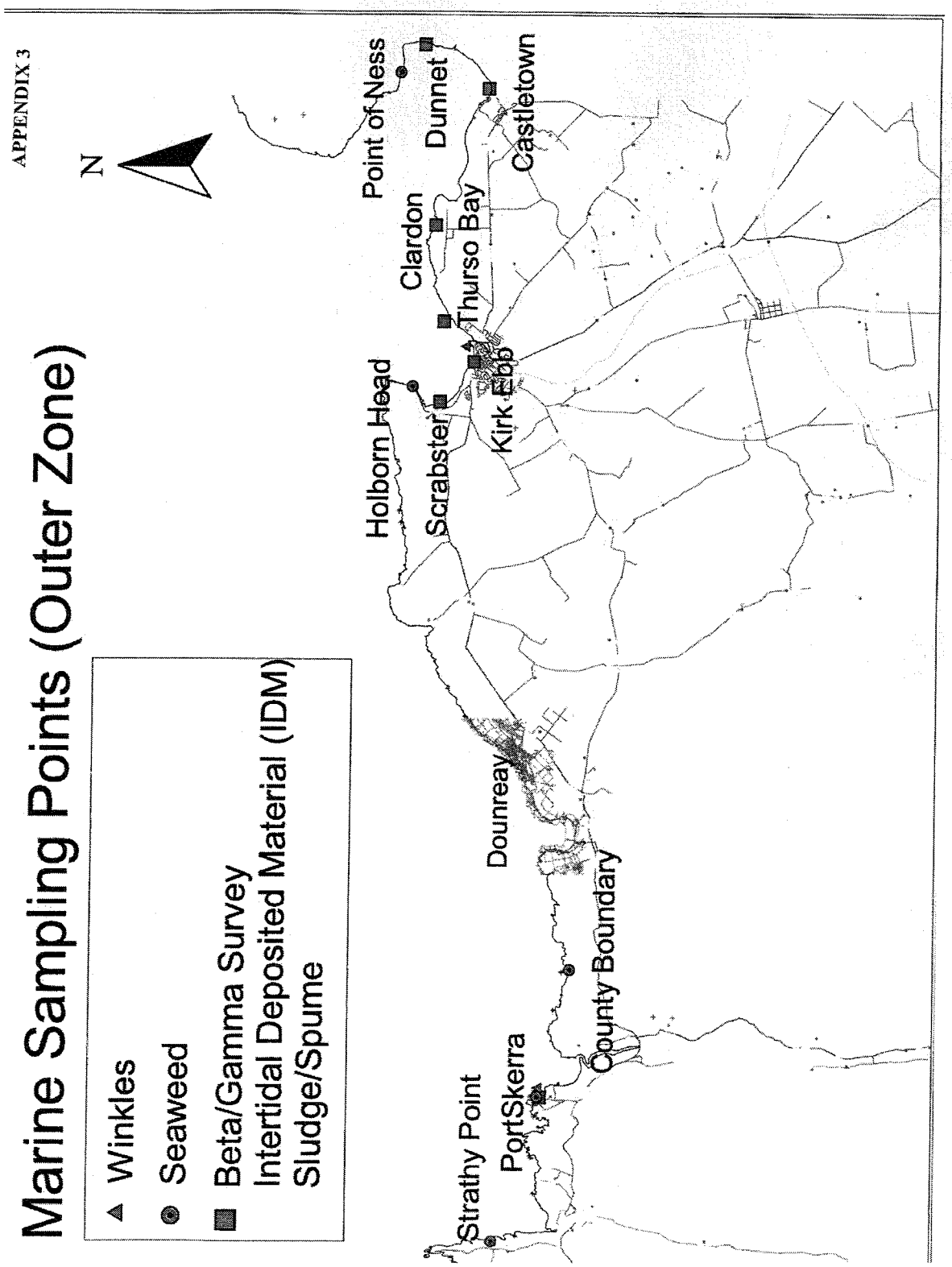

APPENDIX 3
N
Marine Sampling Points (Inner Zone)
Winkles
Seaweed
Crustacea
Beta/Gamma Survey
Intertidal Deposited Material (IDM)
Sludge/Spume
Brimms Ness
Crosskirk
Borrowston
Oigins Geo East
Oigins Geo West
Boundary Perimeter
Pump House
Vulcan Foreshore
Sandside Bay East
Sandside Bay
dwards Geo

**Figure 6**


APPENDIX 3
Marine Sampling Points (Outer Zone)
N
Winkles
Seaweed
Beta/Gamma Survey
Intertidal Deposited Material (IDM)
Sludge/Spume
Point of Ness
Dunnet
Castletown
Clardon
Thurso Bay
Holborn Head
Scrabster
Kirk Ebb
Dounreay
County Boundary
Strathy Point
PortSkerra

**Environmental monitoring after FCA power failure of 7 May 1998**

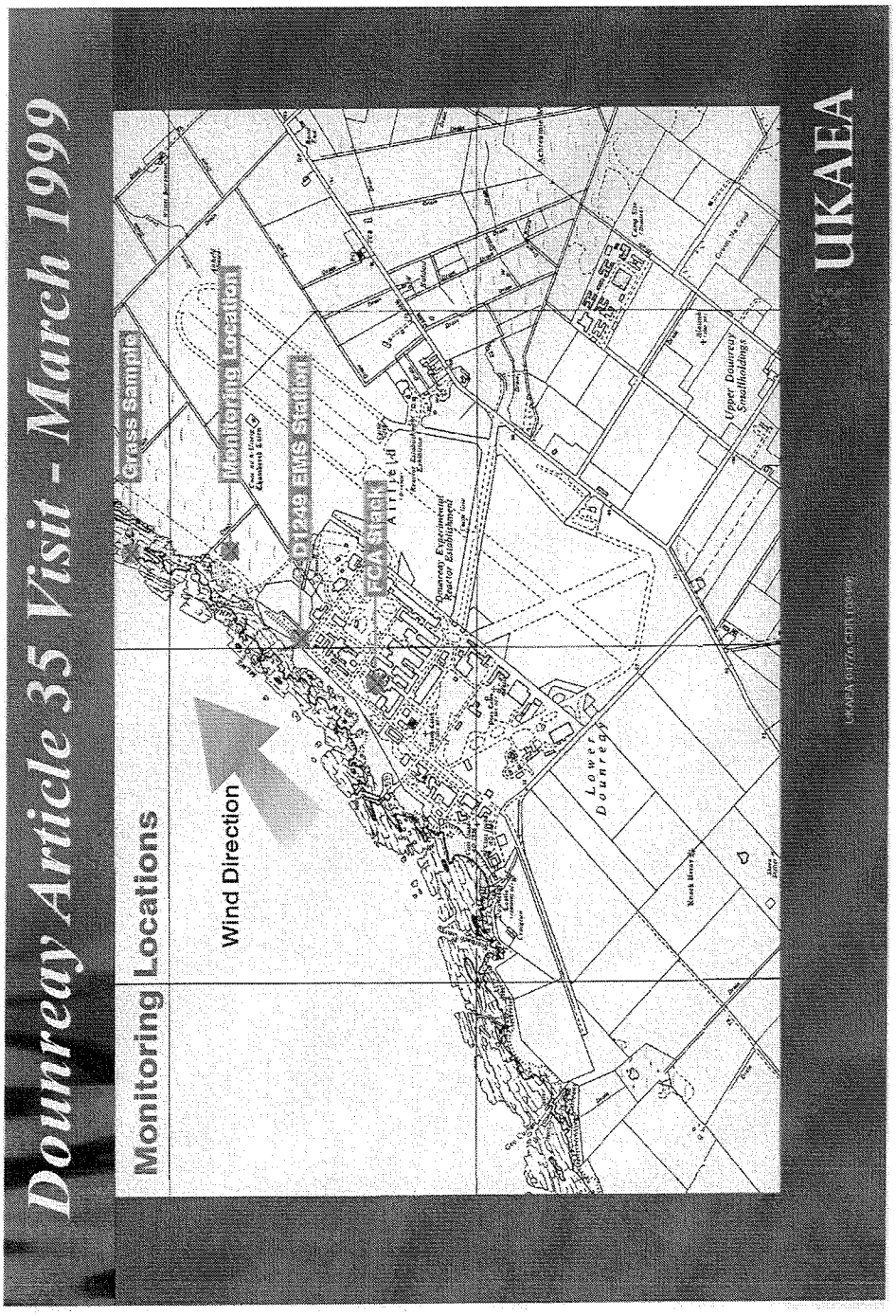



**Figure 7**

**Figure 8**

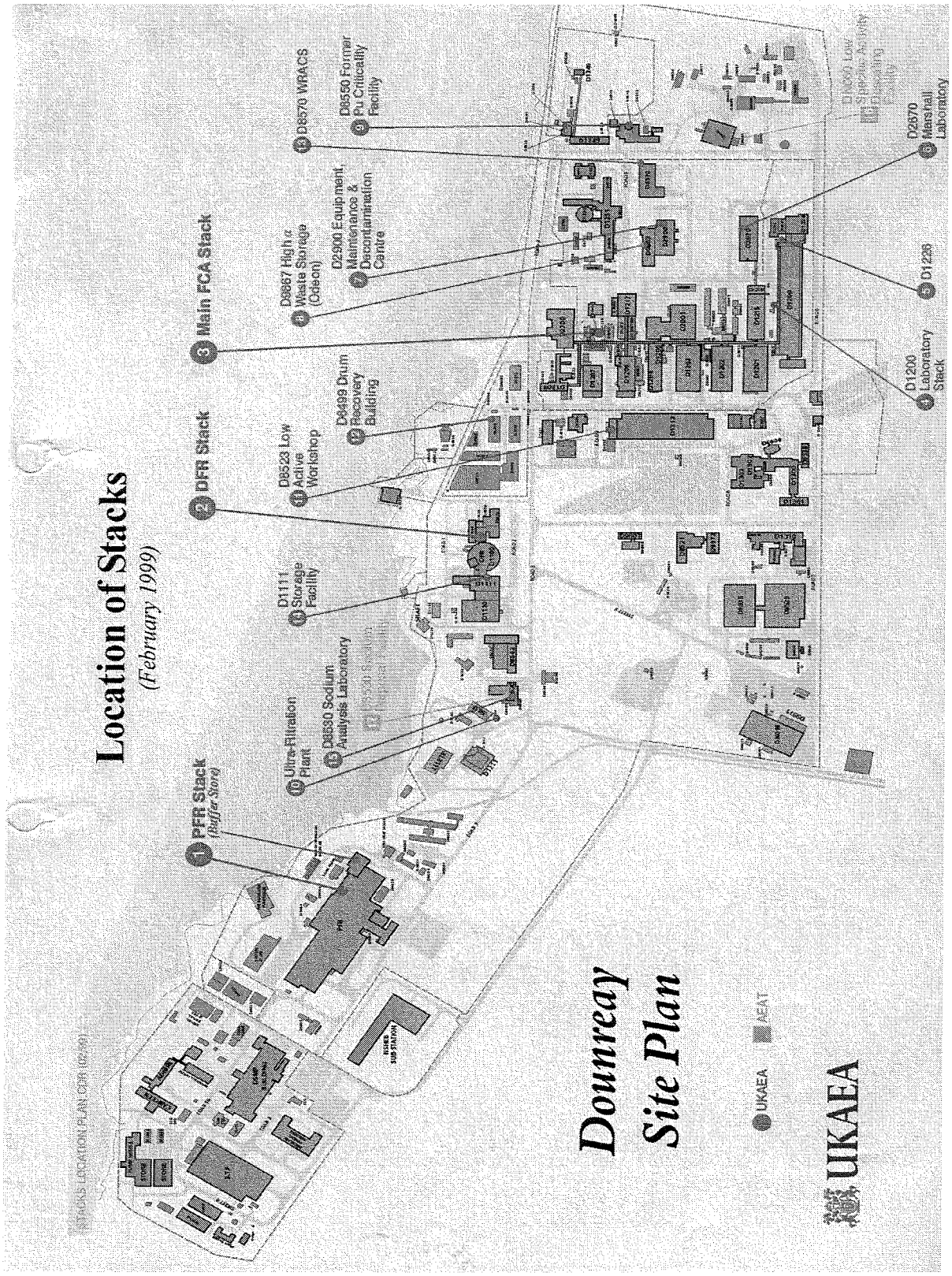

Location of Stacks
(February 1999)
1 PFR Stack (Buffer Store)
2 DFR Stack
3 Main FCA Stack
D1111 Storage Facility
D8523 Low Active Workshop
D4499 Drum Recovery Building
D8667 High α Waste Storage (Orion)
D2900 Equipment Maintenance & Decontamination Centre
D8570 WRACS
D8550 Former Pu Criticality Facility
D1200 Laboratory Stack
D1228
D2870 Marshall Laboratory
Ultra-Filtration Plant
D8530 Sodium Analysis Laboratory
Downreay Site Plan
UKAEA
AEAT
UKAEA

**Figure 9**

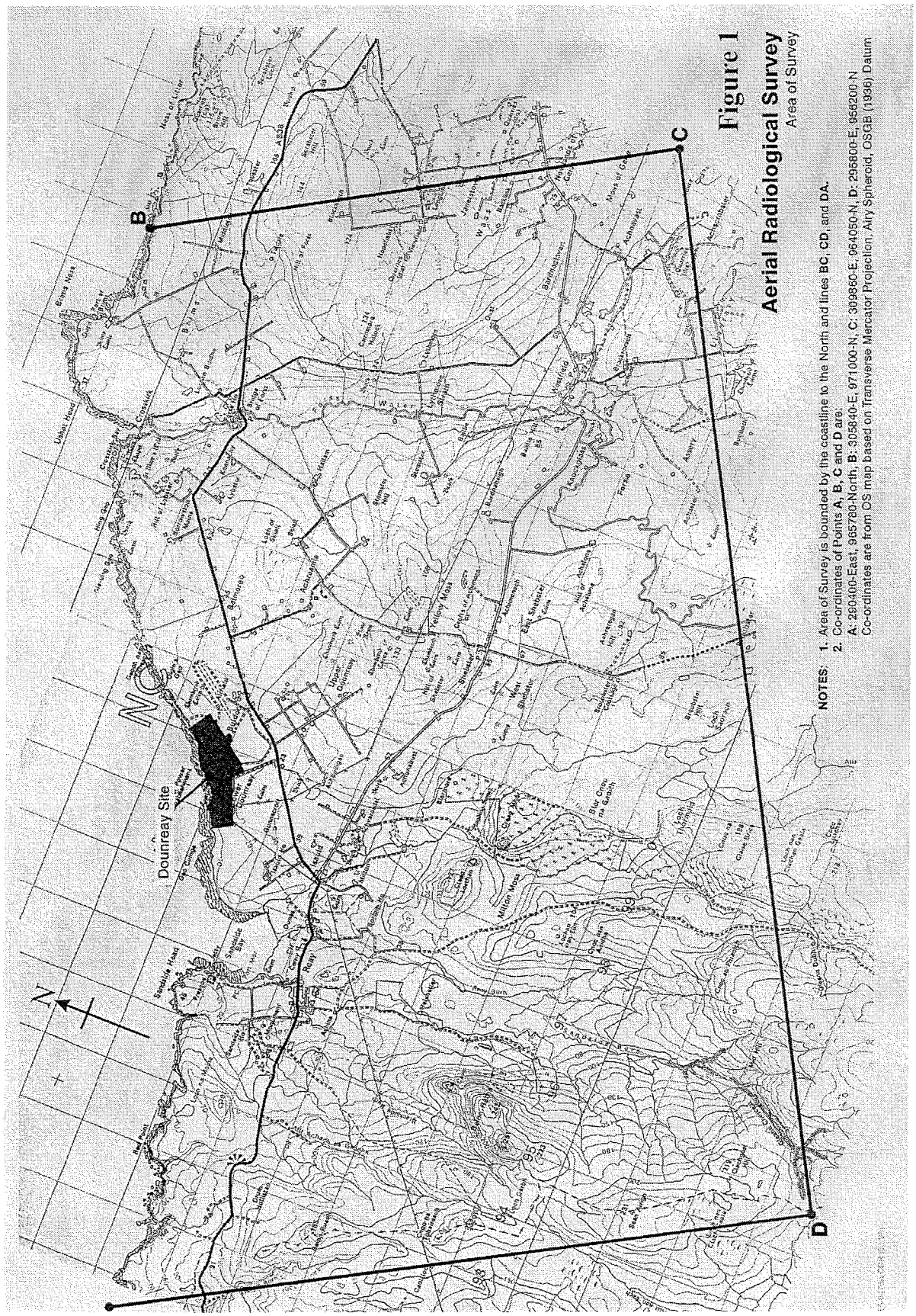


Figure 1
Aerial Radiological Survey
Area of Survey
NOTES: 1. Area of Survey is bounded by the coastline to the North and lines BC, CD, and DA.
2. Co-ordinates of Points A, B, C and D are:
A: 290400-East, 965780-North, B: 305840-E, 971000-N, C: 309850-E, 964050-N, D: 295800-E, 956200-N
Co-ordinates are from OS map based on Transverse Mercator Projection, Airy Spheroid, OSGB (1936) Datum
A
B
C
D
Dounreay Site
N

**ANNEX 8**

## THE DOUNREAY SHAFT

**Figure 1**

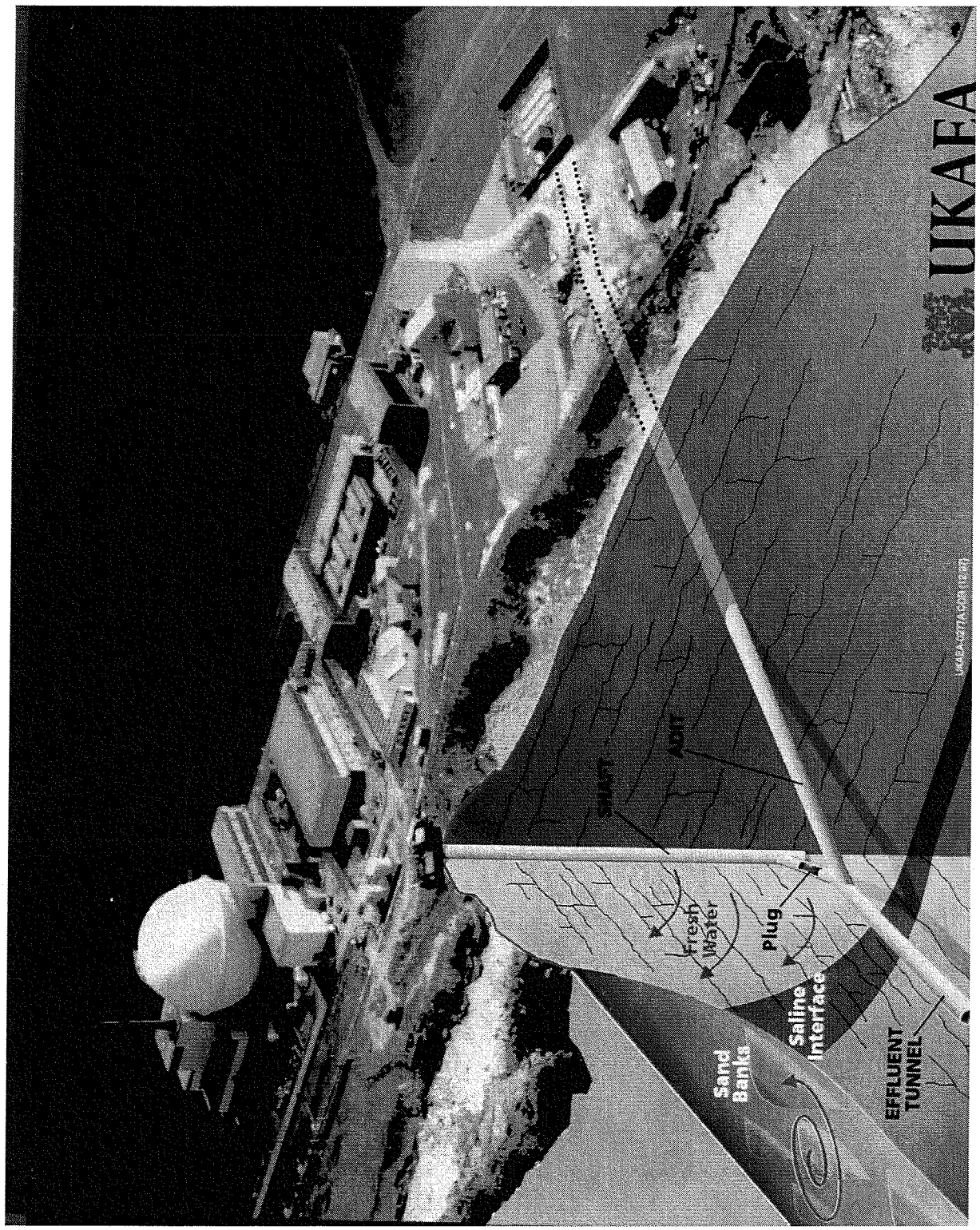


**Figure 2**

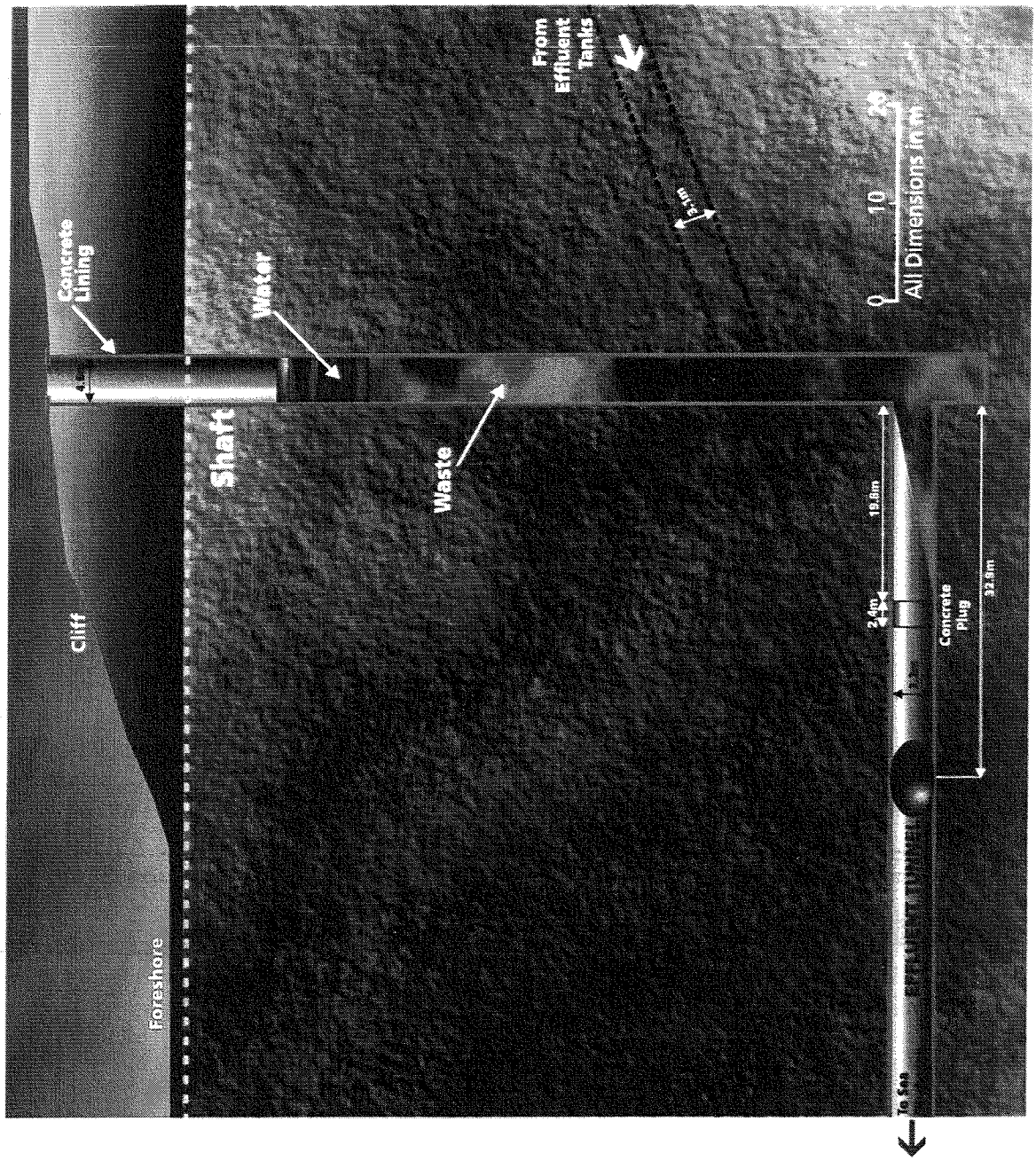
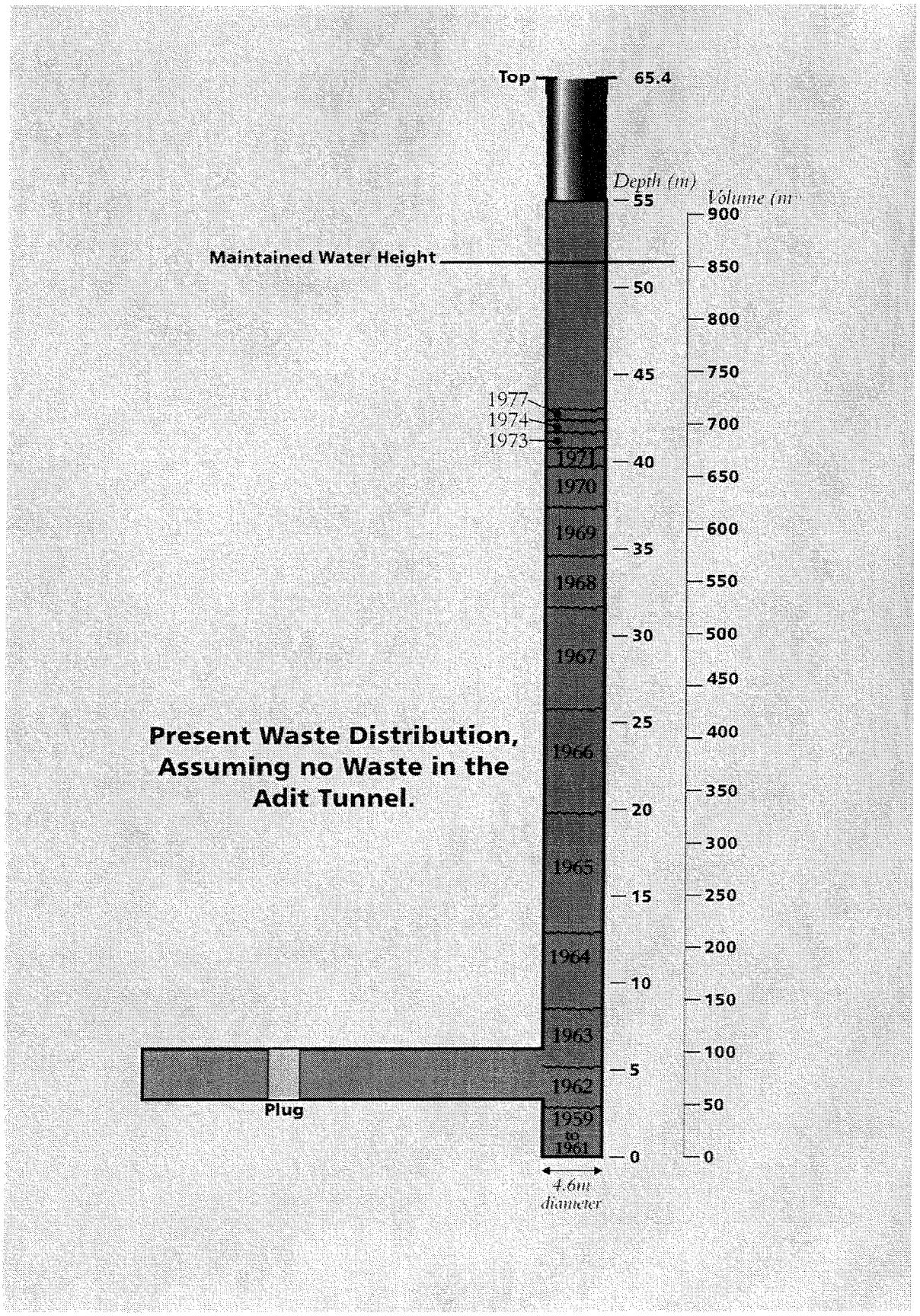

From Effluent Tanks
Concrete Lining
Water
Shaft
Waste
Cliff
Foreshore
19.8m
2.4m
Concrete Plug
32.5m
All Dimensions in m
0
10
20

**Figure 3**


Top
65.4
Depth (m)
Volume (m³)
55
900
Maintained Water Height
850
50
800
45
750
1977
1974
1973
700
1971
40
650
1970
1969
600
35
1968
550
30
500
1967
450
25
400
1966
Present Waste Distribution, Assuming no Waste in the Adit Tunnel.
350
20
300
1965
15
250
200
1964
10
150
1963
100
5
1962
50
Plug
1959 to 1961
0
0
4.6m diameter

**ANNEX 9**

## PARTICLES IN THE MARINE ENVIRONMENT

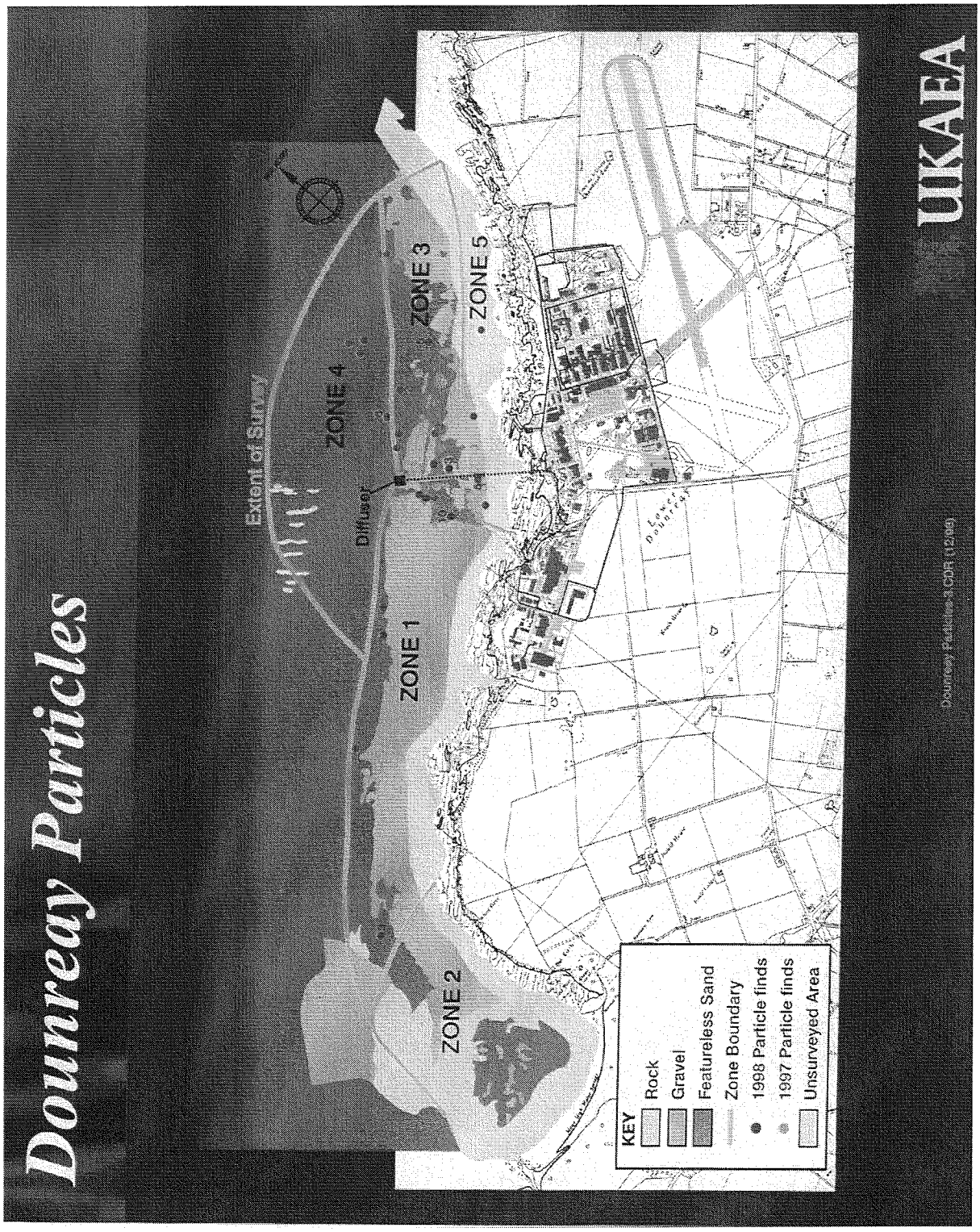



**Figure 1**

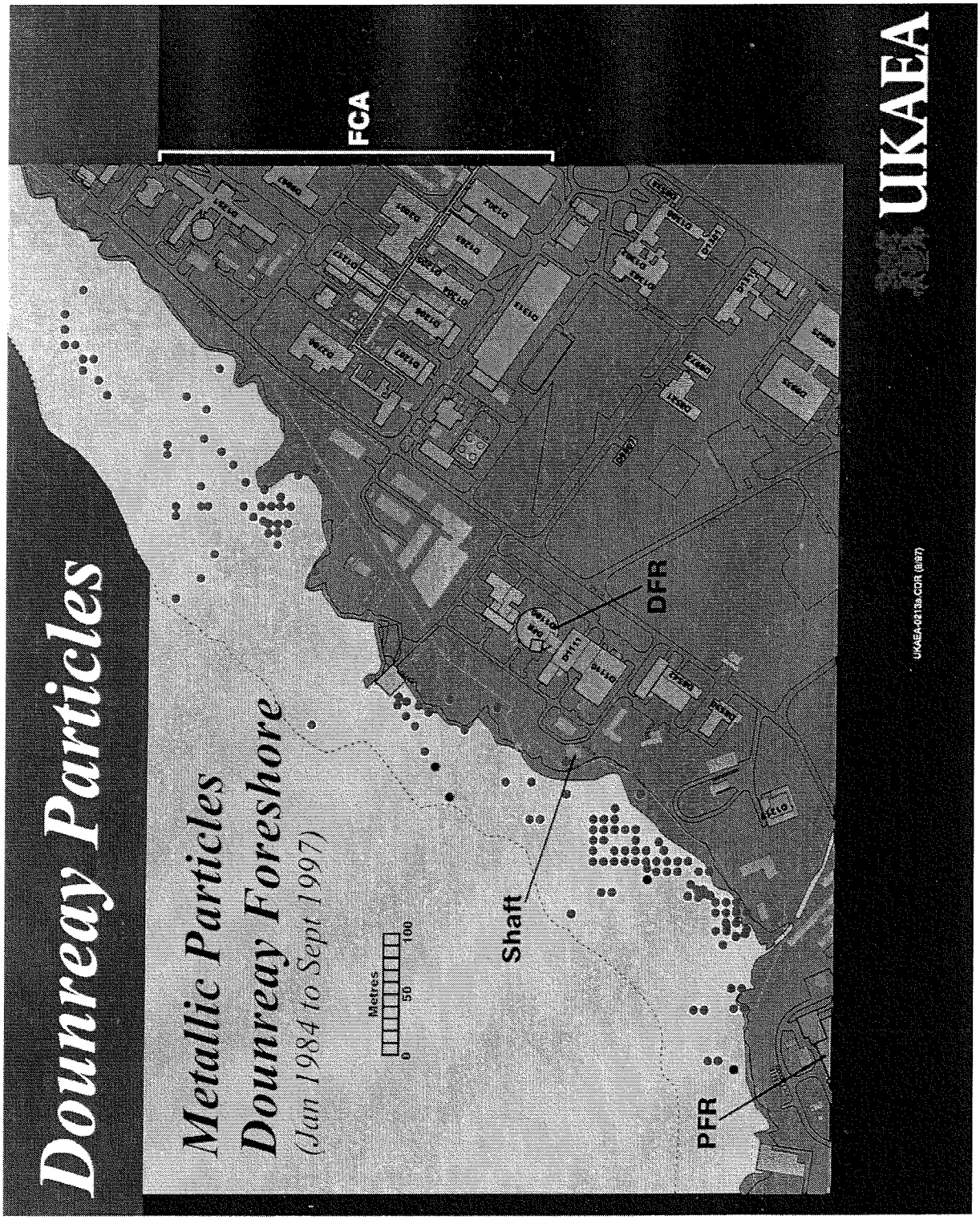

Dounreay Particles
Metallic Particles
Dounreay Foreshore
(Jan 1984 to Sept 1997)
Metres
0
50
100
FCA
DFR
Shaft
PFR
UKAEA
UKAEA-0213a.CDR (8/97)

**Figure 2**

**Figure 3**

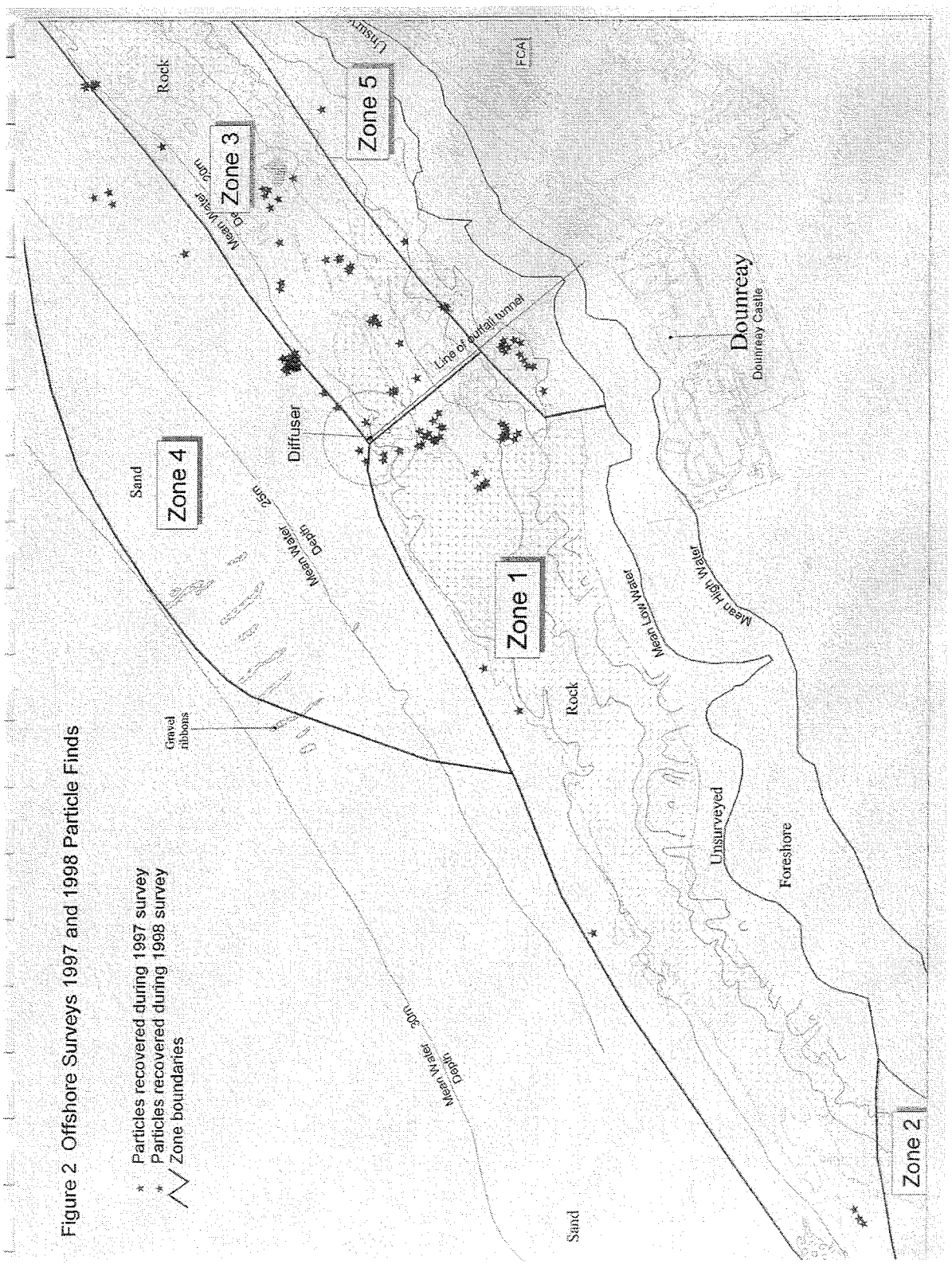


Figure 2 Offshore Surveys 1997 and 1998 Particle Finds
Particles recovered during 1997 survey
Particles recovered during 1998 survey
Zone boundaries
Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
Diffuser
Line of outfall tunnel
Mean Water Depth 25m
Mean Water Depth 30m
Mean Low Water
Mean High Water
Dounreay
Dounreay Castle
Foreshore
Unsurveyed
Rock
Sand
Gravel ribbons
FCA
Lossy

**Figure 4**

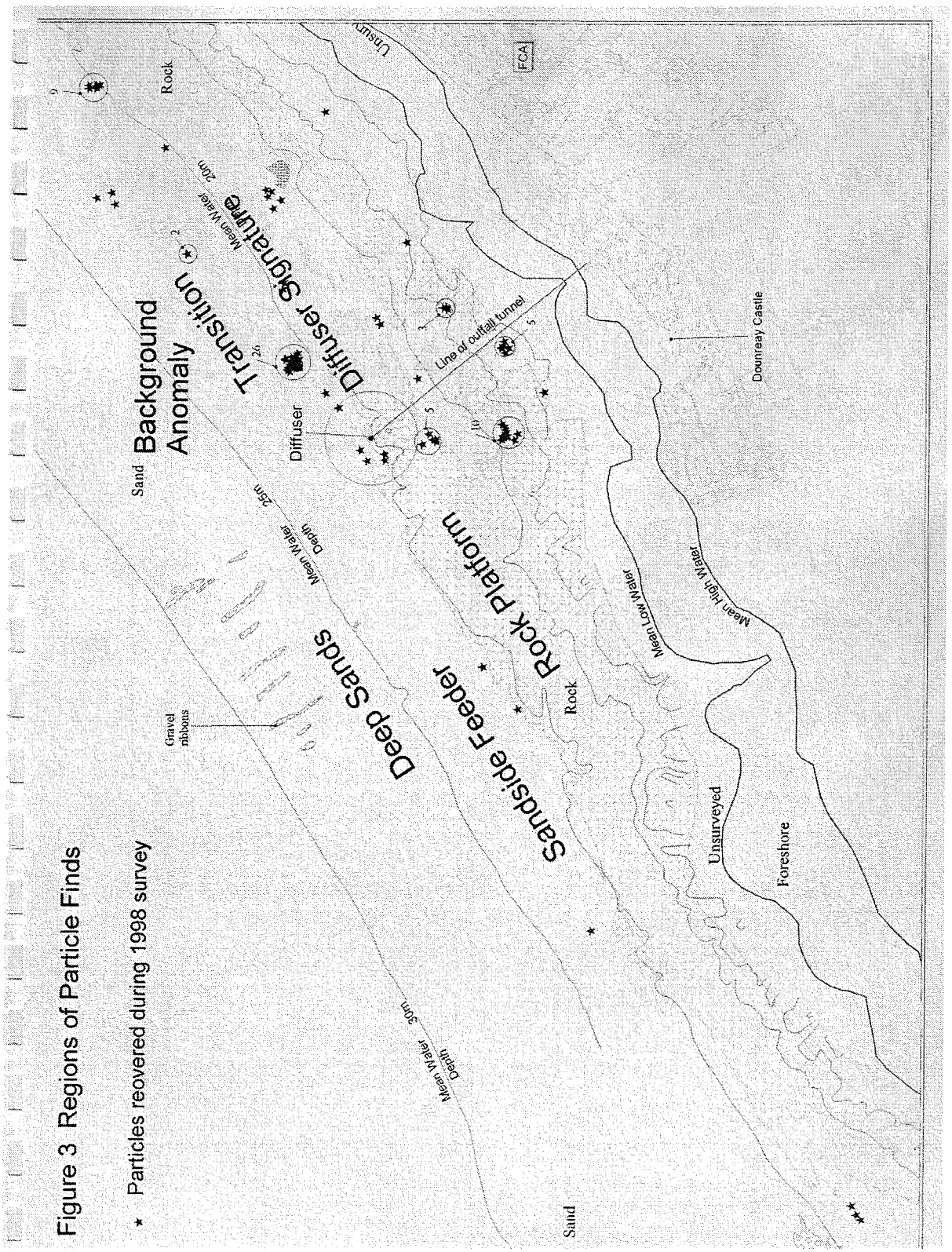


Figure 3 Regions of Particle Finds
Particles reovered during 1998 survey
Background
Anomaly
Transition
Diffuser Signature
Deep Sands
Sandside Feader
Rock Platform
Sand
Rock
Gravel ribbons
Diffuser
Line of outfall tunnel
Mean Water Depth 25m
Mean Water Depth 20m
Mean Water Depth 30m
Mean Low Water
Mean High Water
Unsurveyed
Foreshore
Dounreay Castle
FCA

**Figure 5**

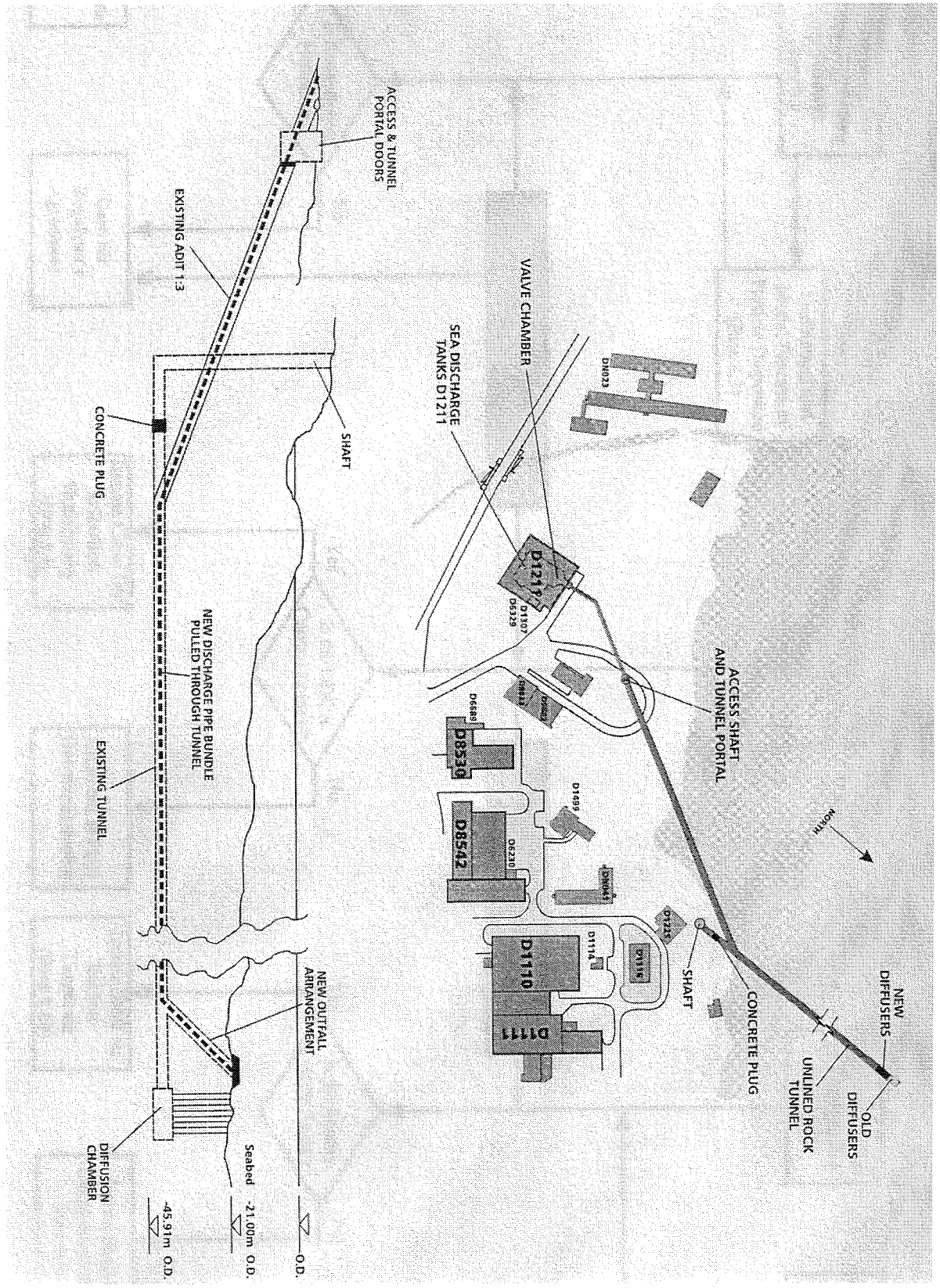

ACCESS & TUNNEL PORTAL DOORS
EXISTING ADIT 1:3
CONCRETE PLUG
SHAFT
NEW DISCHARGE PIPE BUNDLE PULLED THROUGH TUNNEL
EXISTING TUNNEL
NEW OUTFALL ARRANGEMENT
DIFFUSION CHAMBER
Seabed -21.00m O.D.
-45.91m O.D.
O.D.
VALVE CHAMBER
SEA DISCHARGE TANKS D1211
D1211
D1307
D6329
D1673
D6689
D8539
D8542
D6230
D1459
D1114
D1110
D1111
D1225
D1115
SHAFT
ACCESS SHAFT AND TUNNEL PORTAL
CONCRETE PLUG
NEW DIFFUSERS
OLD DIFFUSERS
UNLINED ROCK TUNNEL
NORTH

**Figure 6 – details of sea discharge pipe route and old diffusion chamber**

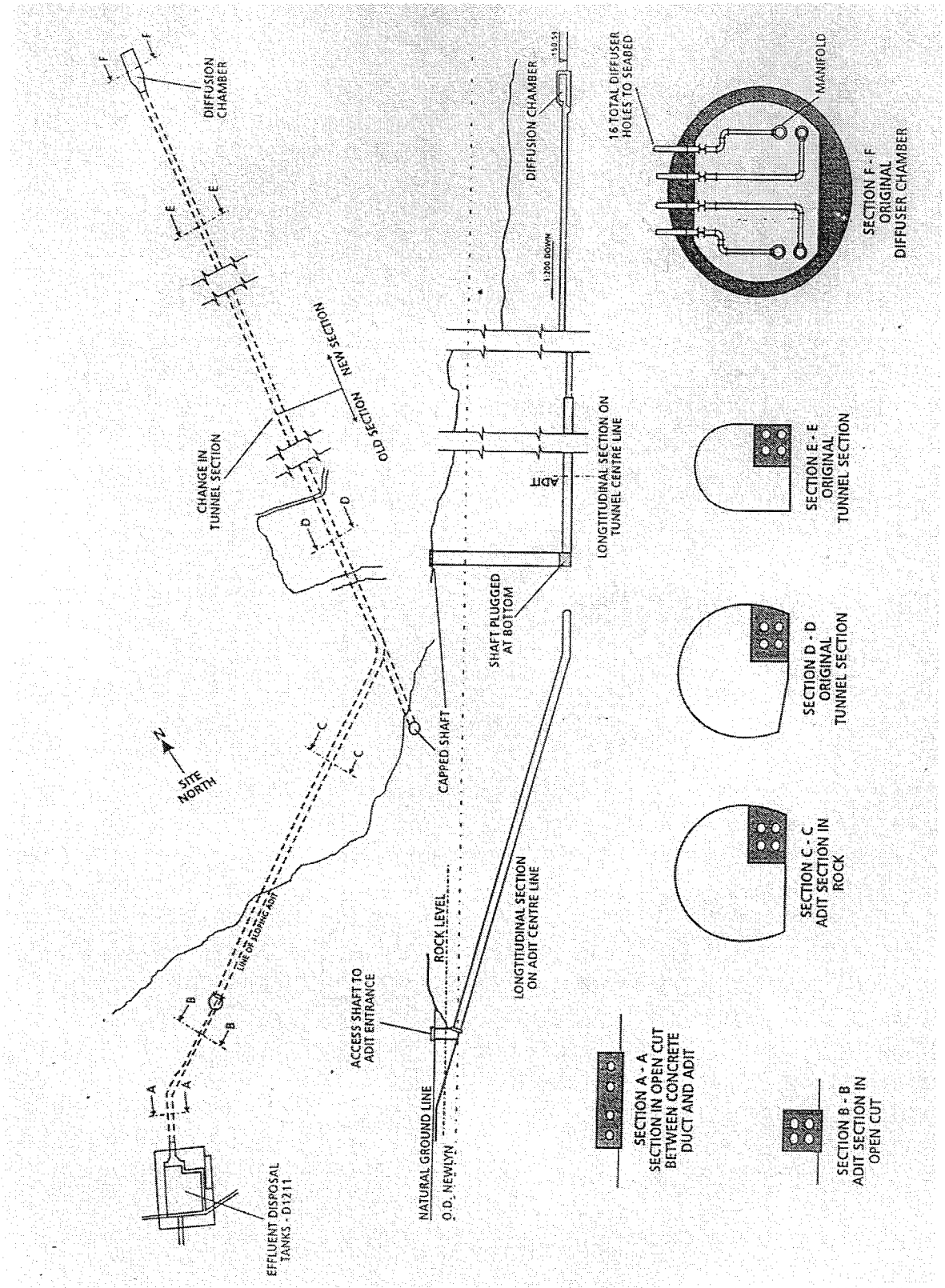


**Figure 7 – current seabed diffuser**