Defence Estates

Dalgety Bay Radiological Support

Completion Report
DE Project No.: 12920

19 October 2010

Entec UK Limited
Prepared by Entec UK Limited for the Ministry of Defence, under commission DE4/4513

DEFENCE ESTATES
Delivering Estate Solutions to Defence Needs

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Report for

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Executive Summary

Purpose of this Report

This Completion Report has been produced for Defence Estates with the purpose of collating the findings reported in four previous Entec reports (references S23218n057, issued 28/07/09, S23218n064, issued 17/09/09, S23218rr090i0, issued as draft on 30/10/09, and S23218rr099i1, issued 24 March 2010), together with findings of more recent characterisation and monitoring works. In addition, the findings of all Entec surveys and investigations are drawn together to provide a statement of hazard presence at the site.

Summary of Works Undertaken to Date

Survey and sampling works have been carried out at Dalgety Bay from June 1990. The works reported in this report are those which have been carried out by Entec, on behalf of Defence Estates (DE) during 2009 and 2010, which are based on defined tasks that DE undertook to carry out, in their letter to SEPA of March 2009 following a Dalgety Bay Forum meeting, as follows:

- Task 2: Slipway:
  - Intrusive investigations of the beach sediments between the Jetty and slipways (28 May-1 June);
  - Sampling and trial trenching intrusive investigations of the beach sediments to either side of the slipway/Jetty area (1 July and 2-6 November).
- Task 2B: Coastal Path:
  - Walkover survey of the coastal path, from the New Harbour to St Bride's Kirk (26 May).
- Task 3: Bay Area Surveys
  - 'Clearance' walkover surveys of the beach and slipway areas (26 May-2 June);
  - 'Baseline' walkover surveys of the beach and slipway areas (29 June-1 July).
- Both Tasks 2 and 3:
  - Monitoring Survey 1: 13 August 2009: first of a series of non-intrusive repopulation monitoring surveys of the general slipways area;
  - Monitoring Survey 2: 23 October 2009;
  - Monitoring Survey 3: 16-18 December 2009;
  - Monitoring Survey 4: 3-5 March 2010;
  - Monitoring Survey 5: 7-9 April 2010 ('Storm Event');
  - Monitoring Survey 6: 18-20 May 2010.

Each survey and investigation campaign recovered the detectable/locatable point sources from the beach which were present at the time, and transferred them to a temporary store on site. Sampled point sources were placed into separate laboratory sample pots, to await further analysis or storage pending disposal. A very small number of sources were detected but not recovered, due to tidal movement.

Principal Conclusions

Six monitoring surveys, and three intrusive investigations, carried out by Entec over the course of twelve months have found that radioactive point sources have been present at the Site, potentially partially derived from a bed of ashy material on the site. Following the thorough investigation of this ash horizon, and the removal of the detectable point sources encountered, recontamination of the beach continued, indicating that either the ash horizon was not the only potential host material, or that point sources continued to be present in the local environment and continued to re-contaminate the beach. Of the 128 point sources, 48 were recovered from intrusive investigations of the ash bed, 28 from clearance surveys of the beach and coastal path, and 51 from subsequent baseline and regular monitoring visits.

The recovered point sources have been generally similar in physical form, size and activity as those recovered in previous surveys and investigations (SEPA, 2008).

The process of survey and investigation has resulted in the recovery of 128 radioactive point sources, and thus a net benefit, in terms of hazard term reduction, to the Site. However, the data do not indicate a reducing rate of hazard recurrence (or repopulation) at the site. Consequently, it could be argued that there will be a progressive increase in the number of point sources present on the beach over time, depending on the nature of specific depositional and erosional phases.

Contents

1. Introduction

1.1 Terms of Reference

The Ministry of Defence (MOD) was undertaking specific management actions agreed between Defence Estates (DE) and the Dalgety Bay Forum in relation to the radium containing material on the beach at the Site (defined as the area between the high water and low water marks) at Dalgety Bay, Fife.

Entec UK Ltd (Entec) has been commissioned by DE to provide radiological survey, investigation and interpretative support to DE for the site, under various commissions under the Environmental Consultancy Support Contract DE4/4513 between Entec and Defence Estates.

1.1.1 Project Aim and Objectives

The project aim is generally to provide support to DE in meeting their objectives for the specific management actions agreed between DE and the Dalgety Bay Forum in relation to the radium containing material on the beach at Dalgety Bay. Specific project objectives are to:

- Undertake surface walkover surveys of the site, as defined by DE, to evaluate if repopulation of the beach is occurring through re-deposition of radioactively contaminated materials;
- Undertake appropriate intrusive characterisation works to investigate the radioactive anomaly at the site;
- Ensure that any radioactively contaminated materials encountered are removed from the beach, thus providing 'clearance' of detected radioactive contamination from the surveyed areas;
- Provide an independent report on findings and progress at the site.

1.2 Site Location

The site consists of the intertidal region of Dalgety Bay, generally between the Old Harbour to the west and the sewer outfall pipe to the north of Dalgety Bay Sailing Club, as defined on DE's Public Notice drawing, (DE, 2009b). The site is centred at approximate National Grid Reference (NGR) 316500 683200 (NT 165 832), as shown on Figure 1.

1.3 Background and Brief Site History

SEPA (2008) and Enviros (2007) contain extensive details of the background to the management of radium contamination at the site; the key points are summarised in the table below:

Table 1.1 Site History and Previous Surveys

Year	Note
1917-1959	Military use of the site commenced in approximately 1917, with the development of the RNAS Donibristle Airfield, which saw extensive development to include aircraft maintenance operations, salvage and other associated supporting facilities - re-opened as RNAS Merlin in 1939, with a 'Salvage Section' in the south east of the site (between the current location of the Sailing Club and The Spinneys) (Enviros, 2007). The Donibristle site closed in 1959.
1960-1970	Following the disposal of the Donibristle site from the MOD estate during the early 1960s, residential development of the Dalgety Bay settlement commenced, and was progressively added to up to the present day.
1971-1972	The Sailing Club was built in 1971, and opened in 1972. (Enviros, 2007)
1990	Radioactive items were first found at Dalgety Bay in June 1990.
1991-1994	A series of surveys were undertaken by the NRPB between 1991 and1994. (Enviros, 2007)
1996	A further survey and interpretative reporting were carried out by the University of Aberdeen and Auris Environmental, reported in June 1996.
1997-2006	Table 1 of SEPA, 2008, summarises six surveys, carried out by Babcock Rosyth and RWE Nukem Ltd., in 1997, 1998, 2000, 2002, 2005 and 2006. The 2006 monitoring and removal survey was followed by a probabilistic and hazard screening assessment carried out by SEPA.
2008	The SEPA report itself reports a further survey and sampling exercise, carried out on their behalf by Nuvia Ltd., during 2008.
2007/08	MoD carried out surveys, sampling and removal exercises on the landward portion of the site in 2007/08.
2008	Entec were first commissioned by DE in August 2008 to provide radiological support to DE's management of the issues at the site.
2009	Continuing Entec surveys.

1.4 Project Evolution and Overall Works Programme

This section describes the development of the project following Entec's involvement, and the current plan for survey, investigation and reporting.

Following a meeting of the Dalgety Bay Forum, DE presented a plan and programme of works to SEPA in their letter of 2 March 2009 (DE reference ROS/FFE/ESM/005). This plan defined the following key tasks:

- Task 1: erection of warning signage at the site;
- Task 2: investigation of slipway area;
- Task 2B: investigation of coastal path;
- Task 3: investigation of beach and foreshore area.

The execution of these tasks is discussed in more detail in the sections below:

1.4.1 Task 1: Warning Signage

The Task 1 scope was agreed by all Forum parties, and was completed by DE during Spring 2009.

1.4.2 Task 2: Slipway

In brief, the work outline for this task involved the design, specification, tendering and procurement of a geotextile to be placed between the Jetty and slipway by a specialist subcontractor, followed by its periodic monitoring, after which the geotextile would be removed.

At the time that DE wrote the letter referenced above, it was not clear whether new sources of contamination found on the beach originated from the land, the foreshore itself (through sediment disturbance) or as a result of repopulation from an offshore source. A strategy was evolved by DE, which featured the design and placement of a geotextile between the eastern slipway and western Jetty at the Dalgety Bay Sailing Club, owing to this area exhibiting the greatest concentration of contamination found during SEPA's most recent surveys of the Bay, to segregate deposited contamination from contamination within sediments.

1.4.3 Task 2B: Coastal Path

A radiometric survey of the coastal path was to be undertaken and, if practicable, any point sources removed.

1.4.4 Task 3: Investigation of Beach and Foreshore

Investigation of the slipways area as Task 2 above would not provide any information on the potential for repopulation over the remainder of the Bay suspected to have been affected. Consequently, wider area surveys, based around the beach area agreed within the Dalgety Bay Forum and defined on the warning signage, were to be undertaken to provide an evaluation of the potential for progressive repopulation of the Bay as a whole.

1.4.5 Works Commissioned from Entec

Entec was commissioned by DE to undertake a range of survey and sampling works in connection with the above defined Tasks. As a result, investigation of the Dalgety Bay site was targeted on several particular areas, with specific objectives:

1. Slipway Area investigations - Initial non-intrusive surface surveying of the area, followed by an intrusive trial pitting exercise to establish the three-dimensional characterisation of the beach sediment, as a precursor to geotextile placement;

2. Coastal Path Survey - The coastal path, with several branches, runs north east from the Dalgety Bay Sailing Club for approximately 1.2 km. A surface survey was required to record the radioactivity present;

3. Bay Area Surveys - A non-intrusive surface survey undertaken across the wider bay area, extending to the west and north east of the Sailing Club, to record the radioactivity present across the bay, and to remove any sources detected, followed by intrusive investigations of selected areas; and

4. Slipways Monitoring - Regular monitoring of an area around the slipway and Jetty area on an approximate monthly/bi-monthly basis, depending on tidal cycles and by general agreement with the Dalgety Bay Forum.

1.5 Summary of Entec Investigations

1.5.1 Site Zoning/ Area Referencing

This report presents detail of the work activities undertaken by Entec and, following a description of the methodology and quality control procedures adopted for the works, is divided into discussion of the following site 'Zones' for clarity:

Zone A. The area around the slipway /Jetty, which has been found to be underlain by a horizon of ashy material: the 'Ash Bed';

Zone B. The remainder of the beach, from the New Harbour in the west of the Sailing Club, to the outfall pipe to the north; and

Zone C. The coastal path.

Figure 2 shows the extent of each defined Zone. This and subsequent figures are based on Ordnance Survey base data, which does not show the third slipway at the site. The third slipway runs from the head of the western Jetty to the seaward end of the eastern Slipway.

1.5.2 Work Activities

The following distinct investigation works, both intrusive and non-intrusive, have been carried out by Entec at the site during 2009; these are associated with the Tasks established in DE's March 2009, letter:

Table 1.2 Summary of Entec Investigations

Task/Zone*	Description of Works
Task 2/Zone A	Intrusive investigations of the beach sediments between the Jetty and slipways (28 May-1 June: trial trenching).
	Intrusive investigations of the beach sediments to either side of the slipway/Jetty area (1 July: sampling investigation, and 2-6 November: trenching investigation.
Task 3/Zone B	'Clearance' walkover surveys of the beach and slipway areas (26 May-2 June).
	'Baseline' walkover surveys of the beach and slipway areas (29 June-1 July).
Tasks 2 & 3/Zones A & B	Monitoring Survey 1: 13 August 2009: first of a series of non-intrusive repopulation monitoring surveys of the general slipways area.
	Monitoring Survey 2: 23 October 2009.
	Monitoring Survey 3: 16-18 December 2009.
Task 2B/Zone C	Walkover survey of the coastal path, from the New Harbour to St Bride's Kirk (26 May).

* See Section 1.5.3 below.

1.5.3 Summary Findings

In summary, the findings of these works are:

- A total of 128 radioactive point sources have been found and recovered from the beach; due to the nature of the beach sediments it was only possible to collect 5 of these as undisturbed samples;
- 51 of these radioactive point sources were found and recovered in surface monitoring surveys following an initial clearance survey, and so are potentially the result of re-deposition of material onto the beach;
- A distinct horizon of ashy material, containing some discrete radioactive sources, was found beneath the beach sediments and overlying the bedrock to either side of the jetty and slipway.

A number of figures are appended to this report for further information. Figures 3 and 4 present the coverage and findings of the Clearance and Baseline surveys of Zones A, B and C, and Zones A & B respectively. Figures 5 to 9 present the results of intrusive works to either side and between the jetty and slipway at the Sailing Club, whilst Figures 10 to 12 present the findings of regular monitoring surveys over various areas of the site. A sample log is presented in Annex A, which records relevant details of all samples recovered from the site.

2. Investigation Method

2.1 Instrumentation

The instruments used for surface gamma monitoring were Southern Scientifics Radsurvey probes containing 76 mm x 76 mm sodium iodide crystal detectors with Global Positioning System (GPS) spatial data logging. The instruments are calibrated such that a reading of 1000 counts per second (cps) above background is equivalent to an activity concentration of 1 becquerel per gramme (Bq/g) Ra-226 in a nominally homogeneous source at ground level. As expected, probe readings due to the presence of naturally occurring background radiation at the site varied depending on surface composition (mud, rock or gravel), but were typically around 220 cps.

During a surface survey, the equipment is configured such that a continuous and audible signal reflecting the measured count rates is emitted, and that an audible alarm will sound in the following cases:

- Where the measured count rate is in excess of 1000 cps; and/or
- Where the measured count rate at a data point differs by more than 100 cps from the previous data point.

This ensures that the equipment operator is informed of a radioactive measurement anomaly as soon as one is measured, so that they may cease walkover and carry out more detailed evaluation of the radioactive anomaly. The Radsurvey equipment also has the capacity to rapidly record radiation spectra.

2.1.1 Calibration and Instrument Performance

Equipment was maintained in calibration for all surveys.

Equipment Calibration for Homogeneous Sources

Each instrument is calibrated to respond to radium-226 (the suspected contaminant) as shown in Table 2.1 below. The radiological monitoring instruments used hold valid Health Protection Agency calibration certificates.

Natural background radioactivity is ubiquitous, and for this purpose needs to be considered separately from ‘contaminating’ radioactivity arising from human actions. At the site, the typical background measurement was 220 cps using the RadSurvey probe.

For *context*, the following table provides the equipment calibration against current statutory thresholds for radioactive waste management registration and, by extension, disposal, which are independent of dose and risk measurements:

Table 2.1 Summary of Radiological Survey Equipment Calibration Factors and Indicative Count Rates (Homogeneous Contamination)

Instrument	Calibration Factor (cps/Bqg-1)	Uncontaminated Background Count Rates (cps)	Indicative Probe Measurements for Exempt Waste Threshold - 0.37 Bg/g (cps)	Indicative Probe Measurements for Low Level Waste Threshold - 4.9 Bq/g (cps)
RadSurvey Probe	1000	220	590	5120

Note: Calibration factor and count rates are for radium-226.

This calibration process was used to calculate the radioactive inventory stored on site awaiting disposal, as it represents a relatively conservative approach.

Instrument Calibration for Point Sources

The following calibration factors have been calculated using the instrument calibration certificates issued by HPA, and standard radiological protection data extracted from The Handbook of Radiological Protection. The calibration, presented in Table 2.2 below, assumes that the measuring probe is located 0.1 m above the ground surface.

Table 2.2 Calibration Factors for Point Source Contamination

Source	Calibration Factor (cps/KBq)
Ra-226 source at the ground surface	69.6
Ra-226 source buried at 0.1m below the surface	32

The lower limits of detection of the survey methodology can be estimated as the square-root of detected background, as follows:

- Measured Background – 220 cps
- Square-root of background – 14.83 cps
- Equivalent point source activity at surface – 0.213 KBq
- Equivalent point source activity at 0.1m – 0.463 KBq.

Cross Calibration from Gamma Spectroscopy

Selected recovered samples underwent gamma spectroscopy at DSTL's laboratory in Alverstoke. Source activities, estimated from direct probe measurement in the manner described above, were then compared against gamma spectroscopy results; the results of this comparison are presented in Table 2.3 below:

Table 2.3 Comparison of Probe Measurements and Laboratory Spectroscopy for Selected Samples

Dstl Laboratory Sample Reference	Sample Log Reference	Weight (g)	Activity from Laboratory Gamma Spectroscopy (KBq)	Estimated Activity from Probe Measurement (KBq)
1	S007	8.62	25	79
2	S022	9.79	12	32
3	S026	17.83 & 5.35	17	27
4	S034	0.41	10	20
5	S042	0.11	6.4	86
6	S048	7.25 & 3.46	89	19
7	S067	<0.01	20	172
8	S083	10.20	85	85

These data indicate that source activities estimated by probe measurement are within an order of magnitude of the source activity as recorded within a laboratory environment. On average, it would appear that source activities estimated by direct probe measurement may over-state the magnitude of the source by a factor of 2.

Caution should be exercised when comparing field probe measurements with laboratory measurements. The detection of radioactivity can be impacted by a wide range of variables including geometry, distance (between source and detector) and attenuation.

2.2 Survey Methodology

The survey methodology was fully defined in internal Entec radiological survey protocols. In summary, the equipment operator carried the equipment in a bespoke backpack, and walked across the area to be surveyed in lines which were as straight as reasonably practicable. The surveyor was guided in this using road cones or similar, to ensure an even coverage of the site. Line spacing was maintained as close to 1 metre (m) horizontally as far as possible, and the operator walked at approximately 1 metre per second (ms^{-1}), leading to an approximate data point representation of each square metre of the site.

2.2.1 Actual Survey Coverage

In order that the assumed resolution of the survey methodology could be verified, a comparison between the target resolution and actual achieved resolution was carried out.

A total of 32166 data points were taken during the recent 'Storm Event' survey (7-9 April 2010), which covered a gross area of 23 356 m^2. On a coarse level, therefore, each data point could be argued to represent 0.73 m^2, with a coarse average separation (i.e. all data points - irrespective of continuity) between eastings and northings data points of 0.45 m and 0.51 m respectively. As this includes the more major effect of moving between survey areas, this represents an effective maximum average separation.

Consequently, it can be concluded that the actual achieved data point representation of the site is greater than one data point per square metre.

2.2.2 Sample Recovery

The initial aim of all intrusive investigation work at the site was that, if practicable, a proportion (approximately 10%) of the finds was to be recovered as undisturbed samples. However, due to the nature of the beach sediments this sampling method was found to only be practical in the north eastern area of the bay where the beach is predominantly made up of mud and sandy patches.

Undisturbed sampling was carried out broadly in accordance with BS5930:1999, which industry recognise as the best available current standard. Although it does not explicitly define the collection conditions for a sample to be considered to be undisturbed, it presents the industry-standard methodology of collecting undisturbed samples from boreholes using a piston sampler.

The possibility of using a driven-box sampling method was considered but rejected due to the nature of the beach sediments.

Undisturbed samples were collected using a piston sampling principle, in the following manner:

- The general location of the find was established with the RadSurvey tool, following which its precise location was established using a hand-held instrument;
- A 450 millimetre (mm) length of 110 mm nominal diameter plastic sampling tube was driven into the beach sediment around the find using a block and rubber faced mallet;
- Once the tube was driven into the beach as far as possible, bearing in mind that this process may be limited by the presence of gravel or cobbles at depth, the upper end was capped using an appropriate plastic end cap, which was marked 'TOP' with indelible marker and sealed with tape;
- The lower end of the sampling tube was exposed using hand digging tools, and the tube lifted and cleaned, with a spade being used to prevent core loss from the open bottom end;
- The bottom end of the tube was capped using an appropriate plastic end cap, which was sealed with adhesive tape;
- The body of the sampling tube was identified with the sample number and other details, in indelible marker;
- The sampling tube was transported and stored in an upright condition, with the top end kept at the top.

Circumstances which wholly precluded the collection of an undisturbed sample were:

- Where the find was located in cracks or on the surface of bedrock;
- Where the find was located in beach sediment which is predominantly gravel sized or greater;

- Where the find was located at depth in excess of 0.3 metres below the surface.

In all such cases, a disturbed sample was collected using a trowel.

Disturbed samples were collected by hand trowel and placed into sample pots. Following identification of an increased count rate, the beach materials were removed sequentially until the precise location of any contamination or the presence of enhanced levels of naturally occurring radioactive material in construction materials such as bricks, concrete or tarmac was identified. Where contamination was detected, an estimate of the activity was made from the measured count rate and a gamma spectrum obtained. The material was then removed into a sample container and placed in secure storage.

2.2.3 QA/QC Checks

Throughout the project, the following checks and controls were made to ensure and maintain sample quality:

Sampling Process

- The location of samples were marked using flags, and recorded on the radiological survey data card, to assist re-location;
- Samples taken as undisturbed were taken in the manner described above;
- Any disturbance of the sample during sampling, for example, by slippage and partial loss through the base of the tube, resulted in the sample being re-graded as a disturbed sample.

Sample Containers and Identification

- Undisturbed sample containers were as described above, and disturbed sample containers were new snap-seal plastic pots of 500 ml nominal volume;
- Samples were recorded on the sample log, and uniquely identified using a number from the log. Sample containers were marked with the sample details using an indelible marker. Details included sample log number, date collected and probe activity reading.

2.2.4 Sample Logging and Management

All samples which were taken were logged on a continuation sample log, as described above. The current sample log is presented as Annex A to this report.

Samples were stored in a locked steel temporary storage facility located at the Sailing Club, sorted by their condition (i.e. disturbed or undisturbed) and by their log number. Samples with the highest contact dose rates were segregated and stored in a separate enclosure within the facility. The configuration of stored samples was adjusted as necessary to control dose rates at the outside of the storage facility.

Previous surveys (as reported in SEPA, 2008) had recorded the physical dimensions, weight and volume of recovered samples. However, in order to maintain field operator doses As Low As Reasonably Practicable, this survey did not replicate these actions whilst on site. Eight samples

submitted to DSTL for analysis were size and weight characterised whilst in the laboratory, resulting in the following data:

Table 2.4 Physical Characteristics of Selected Point Sources

Dstl Laboratory Sample Reference	Sample Log Reference	Weight (g)	Approximate Dimension- x	Approximate Dimension- y
1	S007	8.62	2.6 cm	1.9 cm
2	S022	9.79	2.3 cm	2.7 cm
3	S026	17.83 &	2.3 cm	3.4 cm
		5.35	2.2 cm	1.6 cm
4	S034	0.41	0.9 cm	0.9 cm
5	S042	0.11	0.6 cm	0.3 cm
6	S048	7.25	2.1 cm	2.7 cm
		3.46	1.6 cm	1.7 cm
7	S067	<0.01	0.1 cm	0.05 cm
8	S083	10.20	3.0 cm	3.1 cm

2.2.5 Radioactive Substances Regulation

A Radioactive Substances Act (1993) (RSA) authorisation was gained for DE's previous campaign of investigations at the site in March 2007, reference RSA/B/70115. This was subsequently varied in September 2007, April 2008, September 2008 and April 2009 (latter applicant reference RSA/E/20088), to amend and remove required disposal dates for the accumulated wastes.

The current Authorisation was audited by SEPA on 16th December 2009, and the arrangements in force were considered satisfactory.

2.3 Design of Investigation Sequencing

As part of the design process for the survey and investigation works, it was considered that a form of preliminary survey was required to provide a 'Clearance' of the entire site area, so that future surveys could be considered to be a relatively true indication of the change in site condition with time, as opposed to a combination of historic and contemporary 'contamination'.

2.4 Zone A: Area Underlain by Ash Bed

2.4.1 Initial 'Clearance' Survey of Zone A

The scope of works comprised the positionally referenced radiometric walkover survey of the area between the eastern slipway and western Jetty at the Dalgety Bay Sailing Club, together with the intrusive trial trenching of the beach (discussed below). All radioactive sources found during this work were recovered as samples.

The initial non-intrusive survey of the slipway area was undertaken on 27 May 2009, in conjunction with the non-intrusive Clearance survey of Zone B.

2.4.2 Baseline Survey of Zone A

A non-intrusive surface survey of Zone A was undertaken as part of the wider Zone B Baseline survey, between 29 June and 2 July 2009. This survey is more fully described in Section 2.5.2 below.

2.4.3 Intrusive Investigations

Investigation between Slipway and Jetty

Following the positionally referenced radiometric walkover survey of the area between the eastern slipway and western Jetty at the Dalgety Bay Sailing Club, described above, intrusive trial trenching of the beach was carried out, with the intention to sample as much of the beach material between the Jetty and slipway as possible (i.e. not a statistically-based sampling point exercise).

This approach was designed to minimise the potential for cumulative uncertainties, with the only uncertainties imposed by the physical conditions on the beach (i.e. bedrock depth/occurrence, structures and other obstructions). Data collection included the recording of the location, depth and count rate of the point sources found, to result in a three-dimensional record of the slipways area, and recovery and collection of all radioactive sources found during this work as samples (with an attempt to recover 10% in an undisturbed condition).

A total of 64 trial pits were excavated in the area between 28 May and 2 June 2009. The work involved the excavation of adjacent trial pits in a series of approximately 0.1 m layers to survey and characterise the three-dimensional composition of the beach sediments, which were separated by no more than 0.25 m horizontal distance, so as to maximise source detectability in remaining undisturbed sediments.

Investigation Outwith Slipway and Jetty

Sampling Exercise

Following on from the identification of the ash bed layer between the slipways during the previous 'Clearance' survey and investigation campaign in May/June 2009, DE requested that further intrusive works be undertaken outwith the area between the slipway and Jetty to establish the potential extent of deposition of the ash and clinker material. The intrusive investigation works were undertaken on 1 July 2009, and comprised the excavation of 24 trial pits, finding 3 point sources. The intrusive works were undertaken in three discreet areas across the site:

1. The area to the west of the slipways;

2. The area to the east of the slipways;

3. The area to the north east of the Sailing Club.

The investigation was planned as a sampling exercise, with the objective of establishing the presence or absence of the ash horizon previously found between the Jetty and eastern slipway, together with the approximate physical extent of the ash bed, and the presence of radioactive material.

Trenching Exercise

The sampling exercise reported above found the ash bed in all three areas investigated, and found point sources of elevated radioactivity in two of the three areas - to either side of the slipway and Jetty. Consequently, it was decided that a trial trenching exercise, to the same specification as that carried out between the slipway and Jetty, should be carried out to evaluate the three-dimensional contamination distribution within the beach sediments and ash bed.

The trial trenching exercise was carried out between 2-6 November 2009.

2.5 Zone B: Remaining Bay Area

The scope of works comprised the positionally referenced radiometric walkover survey of the Bay area between the eastern edge of New Harbour, to the south west of the Sailing Club, and the Ross Plantation outfall pipeline, to the north of the Sailing Club. Data collection included the recording of the location, depth and count rate of any point sources found, and all radioactive sources found during this work were to be collected as samples. As discussed in Section 2.3 above, it was considered that two stages of survey were required: a 'clearance' survey to remove as many detectable point sources of contamination practicable, and a 'baseline' survey, to provide the basis for evaluation of future surveys.

2.5.1 Initial 'Clearance' Survey of Zone B

The non-intrusive surface survey of the wider bay area was undertaken between 26 May and 3 June 2009. A total of 28 point sources were detected and removed from Zone B.

2.5.2 'Baseline' Survey of Zone B

A non-intrusive surface survey of Zone B was undertaken between 29 June and 2 July 2009. This survey aimed to replicate the 'Clearance' survey, and was carried out over a similar area. The maximum area agreed for survey was the area denoted as the potential hazard area on the Dalgety Bay Forum's public signs in place at the site, and was amended in the field due to incident tidal conditions.

However, the Baseline re-survey area did not extend quite as far out into the Bay as the Clearance survey, as the Clearance survey was carried some distance beyond the boundary of the agreed survey area as a result of tidal opportunity. No point sources of contamination were found in this extension area during the Clearance survey. Consequently, owing to this and the physical hazard of attempting survey over this area of mudflats, survey of this area was not replicated in future surveys.

Due to the extant tidal range during the Baseline re-survey, it was not possible to re-survey the full extent of the beach to the west of the slipways. A strip of the beach amounting to around 10 metres' width could not be surveyed as the tide did not expose this area. However, during the previous Clearance survey of the beach to the west of the Jetty, no radioactive point sources were encountered in the lower portion of the beach.

2.6 Zone C: Coastal Path

2.6.1 Task 2B: Coastal Path Investigation

The scope of works comprised the positionally referenced radiometric walkover survey of the coastal path between the point at which the path leaves The Wynd residential road, to the eastern end of the Sealstrand residential road. All radioactive sources found during this work were to be collected as samples. The coastal path survey was undertaken on 26 May 2009.

2.7 Monitoring Surveys

It was concluded that regular monitoring of both Zone A and Zone B would provide a useful data set against which the initial surveys could be measured to evaluate potential repopulation and contamination occurrence. The area to be surveyed was nominally the immediate area of the slipways (i.e. Zone A), as this is the area with the most point source finds noted during SEPA's previous surveys. However, this was viewed as a 'core' survey area, and the actual surveyed area was increased on occasion to examine neighbouring areas of the beach, prompted by the result of the findings of other investigations.

Table 2.5 below presents the dates and extents of each monitoring survey:

Table 2.5 Area Coverage of Surface Surveys

Survey and Date	Zones Covered	Total Area Surveyed - m^2
Clearance: 26 May-3 June 2009	Zones A & B	51568
Baseline: 29 June-2 July 2009	Zones A & B	37136
Monitoring Survey 1: 13 August 2009	Zone A (part)	3392
Monitoring Survey 2: 23 October 2009	Zone A	3625
Monitoring Survey 3: 16-18 December 2009	Zone A and Zone B (part)	19968
Monitoring Survey 4: 3-5 March 2010	Zones A & B	24607
Monitoring Survey 5: 7-9 April 2010	Zones A & B	20673
Monitoring Survey 6: 18-20 May 2010	Zones A & B	27747

3. Results of all Surveys and Investigations

3.1 Overview

The survey and investigation work included substantial intrusive investigations of the beach, and resulted in the discovery of what appeared to be a deposit of host material in the area between and around the slipways. The deposit appeared to have been in place for some time and consisted of a sub-surface layer of ash which was clearly distinguishable from the surrounding sand, and contained dispersed and discernable point sources of contamination.

As a result of this, the project strategy was amended to include the removal of the identified areas of primary contamination host material. Having carried out this work, it was considered prudent to review the usefulness of installing the membrane mentioned previously, and the results of this review are described below.

3.1.1 Presentation of Data

For ease of reference, the survey results are grouped according to the findings of the intrusive investigations and by the survey frequency, which was greatest in the areas where most contamination had been found in recent surveys.

The count rate data presented on figures in this report has been collated using a geographic information system (GIS), to permit the presentation of spatial radiometric data against a scaleable map background. Measured radioactivity levels in counts per second are displayed using a colour shading legend, from green (lower count rates) through yellow/ orange to red (higher count rates). This applied colour shading is for the purposes of displaying indicated count rate at levels close to or just above natural background levels, to ensure a thorough visual screen of *all* data, and so the presence of a yellow, orange or red coloured data point does not necessarily indicate the presence of point source or other contamination. The presence or absence of contamination in any area of increased activity has been determined by the subsequent intrusive investigations.

3.2 Zone A

3.2.1 Walkover Survey

The initial non-intrusive survey of the slipway area was undertaken on 27 May 2009. A total of six radioactive sources were identified during the survey, extending from the high water mark to approximately 35 m down the beach. Probe readings on identified sources of radioactive contamination ranged from 2200 cps to 22 000 cps. Following the completion of the non-intrusive survey, the identified sources of contamination were recovered from the beach. The contaminated materials contained sand, gravel and pieces of clinker and were taken from the surface of the beach or shallow depths of 0.05 m bgl. The recovered material was logged and placed in a secure store established on site for that purpose. Following sampling, in all

locations levels of radioactivity were recorded at typical background levels, indicating that all surface-detectable radioactive contamination had been removed by the sampling exercise. Figure 3 presents the results of this survey, and that of Zone B.

3.2.2 Intrusive Investigations

Investigations between Slipway and Jetty

The intrusive works identified a layer of ashy sand and clinker present underlying the upper part of the beach. The ash layer was encountered at depths ranging from 0.1 m to 0.7 m bgl. It was present at greatest thickness close to the high tide mark and reduced down the beach to approximately 0.1 m at 40 m from the shore. The ash and clinker layer was typically present overlying shallow bedrock or sandstone outcrops and typically recorded probe measurements between 300-700 cps.

As a result of this planned work, 33 detectable point sources were removed from the area between the Jetty and slipways. It may be stated with a reasonable degree of confidence that the vast majority of radioactive sources were recovered during this operation; therefore, it was judged that the installation of a membrane, whose original purpose was to prevent 'churn' of in-situ sources, was no longer required. The repopulation survey therefore proceeded without the need for a membrane. All of the identified sources were found within the ashy clinker layer or from the material overlying this layer. The sources were encountered in 20 of the trial pits excavated, with a further 3 sources identified in areas adjacent to the excavated trial pits.

Sources of radioactive contamination were identified by probe readings ranging from 916 cps to 103 000 cps, with the majority between 2000-7000 cps. The contaminated materials typically comprised pieces of clinker, ashy sand and gravel and were located at depths ranging from the beach surface to 0.6 m bgl.

Figure 5 shows the location of the trial pits and the probe readings recorded at various depths. Following source recovery in each location, normal background levels of radioactivity were measured, indicating that the recovery exercise had removed the radioactive contamination. All recovered sources were placed in the secure store on site.

Owing to structural constraints (e.g. the Jetty, slipways and bedrock presence), the intrusive investigation works between the slipways did not turn over all of the materials underlying the surface of the beach. Therefore, whilst a thorough practical clearance of the area has been carried out, there remains a potential for residual contamination.

Investigation Outwith the Slipway and Jetty: Findings of Sampling Exercise

The measured activity levels taken during the sampling works, expressed as colour bands, are shown on Figure 6. All probe readings presented on this Figure are inclusive of background radioactivity. Trial pit locations are also shown on this Figure. All sources detected during this work were removed.

Western Area

A total of seven trial pits were excavated in the area to the west of the Jetty and slipways. The ground level of the beach in this area is approximately 1 m higher than to the east of the western Jetty. The ash bed was encountered in all of the seven trial pits at depths ranging from 0.4-0.5 m bgl (TP18a), at the lower level of the beach, to 0.6-1.1 m bgl (TP24a) at the top of the beach. One point source of contamination was identified and sampled from trial pit TP18a. The

point source was encountered within the ash layer at ~0.45 m bgl and a probe reading of 39 000 cps was recorded.

Eastern Area

A total of eight trial pits were excavated in the area to the east of the slipways. The ash bed was encountered in all of the trial pits excavated in this area at depths ranging from 0.2-0.7 m bgl (TP10a), immediately to the east of the slipways adjacent to the shore, to 0.1-0.2 m bgl (TP17a), approximately 25 m to the east of the slipways. One point source of radioactive contamination was identified during the intrusive works in this area of the Bay. The point source was identified and sampled from TP10a at a depth of ~0.40 m bgl and a probe reading of 2200 cps was recorded.

North Eastern Area

A total of nine trial pits were excavated close to the shore in the bay area to the north east of the slipways investigation area. A thin layer of Made Ground was encountered in a number of the trial pits in this area, but this material was not consistent with the ash layer encountered elsewhere. Made Ground was typically encountered between 0.15-0.35 m bgl and contained pieces of clinker, but the Made Ground did not exhibit the elevated readings typical of the ash layer. No point sources of radioactive contamination were encountered during the intrusive works in this area of the bay.

Investigation Outwith the Slipway and Jetty: Findings of Trenching Exercise

The measured activity levels taken during the trial trenching works, expressed as colour bands, are shown on Figures 7 to 9. All probe readings presented on these Figures are inclusive of background radioactivity. All sources detected during this work were removed.

Western Area

The results of the trial trenching investigation in the area to the west of the Jetty and slipways are shown on Figure 7. The investigation, which was limited in extent by the rock armour, the slipway and the state of the tide, found 4 point sources in the western area.

Eastern Area

The results of the trial trenching investigation in the area to the east of the slipways are shown on Figure 8. The investigation found 8 point sources in the eastern area.

North Eastern Area

The results of the trial trenching investigation in the bay area to the north east of the Sailing Club are shown on Figure 9. The investigation found ashy materials of a similar nature to those elsewhere in Zone B, but did not find any significantly elevated point sources of radioactivity within these materials. Investigations were terminated at relatively shallow depth owing to the presence of bedrock at relatively shallow depth across much of this area.

3.2.3 Interpretation of Intrusive Survey Results

Western Area
The findings indicate a similar pattern of ash deposition as encountered in the area between the Jetty and slipways, with a wedge shaped layer present within the beach, becoming thinner further down the beach from the high water mark, and containing radioactive sources.

Due to the tidal range during the time of the investigation it was not possible to extend the survey to the west of the headland at the sailing club. However, due to the position of the ash layer and the thicknesses it has been encountered at the same relative distance from the shore, it is considered unlikely that this material is present at any significant depth in this area of the Bay. A hand dug trial pit was attempted in this area of the bay but was abandoned at a depth of 0.2 m bgl due to the nature of the beach materials, and water ingress into the pit. No ash layer was encountered at this depth.

Eastern Area
The findings indicate that the ash layer is present and extends to the east of the slipways, but thins with distance to the east and from the shore, and that it contained radioactive point sources.

North Eastern Area
The findings indicate that Made Ground derived from combustion wastes is present in the Bay area to the north east of the Sailing Club, but that this material may not necessarily contain residues from the burning of radioactive materials.

3.3 Zone B

3.3.1 Clearance Survey

The survey extended across the bay to west and north east of the slipway area, as well as including Zone A. The survey coverage and the measured activity levels expressed as colour level bands are shown on Figure 3. All probe readings on Figure 3 are inclusive of background.

Detailed Discussion: Western Area
Seven radioactive sources were identified in the area to the west of the slipways. Probe measurements of radioactivity ranged from 1200 cps to 7800 cps. Sampling was undertaken in six of the source areas with samples typically comprising gravel and clinker, at various depths between the surface of the beach and up to 0.05 m. During the recovery operation, one source (recorded at 7800 cps) was unable to be recovered due to the advancing tide. Later resurvey of this area did not locate the source; therefore, it was not possible for it to be recovered; a situation which supports the consideration of the beach as a dynamic and mobile environment. In all other cases where recovery was undertaken, the removal of the sources resulted in a reduction in probe readings to typical background levels.

Detailed Discussion: North Eastern Area
A total of sixteen radioactive sources were identified during the non-intrusive survey of the north eastern bay area. The radioactive sources included a plastic artefact to sand and pieces of clinker. The north eastern bay area comprises large open areas of sand and mud. Where

sources were identified in these areas it was possible to try and collect undisturbed samples of the contamination. This exercise was attempted at five locations and was successful in three cases. Recovery of the remaining sources of radioactive contamination was undertaken through the collection of disturbed samples. Source areas were recorded with readings ranging from 720 to 22 000 cps and were collected from depths ranging from the surface of the beach to 0.2 m bgl. During the recovery operation, one source (recorded at 22 000 cps) was unable to be recovered due to the advancing tide. Later resurvey of this area failed to locate the source; therefore, it was not possible for it to be recovered. In all other cases where recovery was undertaken, the removal of the sources resulted in a reduction in probe readings to typical background levels.

3.3.2 Baseline Survey

The survey coverage and the measured activity levels expressed as colour level bands are shown on Figure 4. All probe readings presented on Figure 4 are inclusive of background radioactivity, and so may vary according to variations in both natural and man-made components of the overall radioactivity present within the measured area.

Western Area

No radioactive sources were identified in the surveyable area to the west of the slipways during the non-intrusive re-survey, indicating that no repopulation of radioactive contamination has occurred in this area over the monitoring interval.

Eastern and North Eastern Areas

A total of ten radioactive point sources were identified during the non-intrusive survey of the eastern and north eastern Bay areas. The radioactive sources included sand-sized particles to gravel and pieces of clinker. The north eastern Bay area comprises large open areas of sand and mud. Two radioactive point sources were identified in the northern extreme of the bay and were collected as undisturbed samples. Surface probe readings were recorded at 1200 cps and 2000 cps respectively. Due to the samples being collected as ‘undisturbed’ it was not possible to determine the precise original burial depth of the point sources within the beach material. A further seven point sources were identified and sampled from the north eastern area of the bay. These point sources were all collected as disturbed samples and were removed from the beach. Sample burial depths ranged 0.05 m below ground level (bgl) to 0.20 m bgl, with probe readings ranging from 1700 cps to 65 000 cps.

One point source of contamination was identified in the area to the east of the slipways. The point source was sampled from a depth of 0.10 m bgl and a probe reading of 35 000 cps was recorded.

As with the initial survey works, the recovered materials were logged and placed in the secure store established on site for that purpose. Following sampling in all locations levels of radioactivity were recorded at typical background levels, indicating that all surface-detectable radioactive contamination had been removed by the sampling exercise.

3.4 Monitoring Surveys

Monitoring Survey 1 (13 August 2009)
No further radioactive point sources were found during this survey. The survey data are presented on Figure 10.

Monitoring Survey 2 (23 October 2009)
One radioactive point source was found and recovered during this survey, from 0.2 m bgl. The probe measurement at 0.1 m of this source was 5000 cps, and it was recovered as a disturbed sample. The survey data are presented on Figure 11.

Monitoring Survey 3 (16-18 December 2009)
As a result of the December 2009 project team meeting, it was decided to extend the third monitoring survey beyond the immediate Zone A area into as much of Zone B as was surveyable in the time available. This activity was carried out over three days, from 16 to 18 December 2009, as a result of daylight and tide availability.

Seventeen point sources were found across the area surveyed, from a range of depths between the beach surface and 0.2 metres below the surface, although biased towards the upper 0.1 m of beach sediments. Probe measurements ranged from 800 to 12 400 cps. The survey data are presented on Figure 12.

Monitoring Survey 4 (3-5 March 2010)
A similar area of beach to that surveyed in December 2009 was surveyed. One point source was recovered, from the central north eastern area of the beach, which consisted of a point source within a sand and gravel matrix. The survey data are presented on Figure 13.

Monitoring Survey 5 (7-9 April 2010: 'Storm Event')
A period of deteriorating weather in late March 2010 culminated in two days of heavy storms during 1/2 April 2010, which resulted in substantial erosion and damage to the beach. Selected photos of the area are presented in Annex B.

As a result of the substantial material movement which took place during this storm, it was considered prudent that a follow-up survey was carried out. Consequently, Entec mobilised to site and carried out a survey of Zones A and B, together with the areas of material cast up onto the headland areas by the storm. These survey data are presented on Figure 14.

21 point sources were detected and removed from the beach during this survey, from the beach surface and at depths ranging to a maximum of 0.2 m bgl.

Monitoring Survey 6 (18 - 20 May 2010)
To provide a twelve-month dataset of surveys at the site, the final, sixth, monitoring survey was carried out in late May 2010, over the maximum available area of the beach. These survey data are presented on Figure 15.

3.5 Zone C

One area of radioactive contamination was identified during the surface survey of the coastal path, as shown on Figure 2. The area was identified on one of the minor side paths that link the two main paths in the southern area, to the north of the Sailing Club. The contaminated material was recorded with a reading of 1120 cps, against a typical background reading for the site of 180 cps, and was present at 0.05 m below ground level (bgl), within soil material. The recovery of the source resulted in the removal of the radioactive contamination, and follow-up monitoring of the area showed readings typical of background levels.

The north eastern area of the coastal path was observed to be made up of aggregate materials that typically contain naturally occurring radioactivity. Some slightly elevated measurements, ranging from 300-500 cps, were recorded in this area, but these were not deemed to be the result of the presence of radioactively contaminated materials.

Further walkover survey and monitoring of Zone C was not carried out, as all detectable radioactivity had been removed, and Zone C is beyond the areas considered to potentially be subject to repopulation.

3.6 Confirmatory Laboratory Analysis

Three batches of samples were forwarded to DSTL's Radiochemistry Lab for gamma spectrometry:

- December 2009: nine samples (S007, S022, S026, S034, S042, S048, S067, S083, S085 - not analysed);
- December 2009: two samples of bedrock from the site;
- May 2010: eighteen samples (S088 - S0105 inclusive).

The analysis data from this exercise has previously been compared with probe measurements made at the time of detection of these point sources, and discussed in Section 2.1.1 above.

Certificates of analysis of these samples are presented in Annex C.

4. Hazard Reduction Assessment

The purpose of this section is to draw together the information, both previously known and arising from the Entec survey works, regarding the Dalgety Bay Site, in order that a statement of the level of hazard reduction achieved by the Entec survey works may be made. This assessment is not a quantitative assessment of risk, but does, however, consider the components and factors that may contribute to a quantitative assessment of risk at the site insofar as these may effect or be informed by work at the site.

4.1 Regulatory Regime

The regulatory regime for defining, identifying and remediating contaminated land is Part IIA of the Environmental Protection Act (EPA) 1990. Within Scotland, this is implemented by the Contaminated Land (Scotland) Regulations 2000 & 2005, and provides the regime for the identification and remediation of contaminated land. Under the regime, contaminated land is defined as:

> *"any land which appears to the local authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land that*
>
> - *Significant harm is being caused or there is significant possibility of such harm being caused; or*
> - *Significant pollution of the water environment is being caused, or there is significant possibility of such pollution being caused."*

Table A (of Annex 3, Part 3, Chapter A) and Part 4 of the Statutory Guidance (Scottish Executive, 2006) defines the following situations where harm is to be regarded as 'significant':

i) Death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions of humans;

ii) Irreversible or other substantial adverse change to an ecological system, or harm which affects any special interest and which endangers the long term maintenance of the population of that species;

iii) Structural failure, substantial damage, or interference with the right to occupation of buildings;

iv) Death, serious disease, diminution or other physical damage to property including livestock, produce, crops or wild animals which are the subject of fishing or shooting rights;

v) Significant pollution of the water environment, where the substance is continuing to enter, or is likely to enter, the water environment.

Central to the Part IIA regulatory approach is a rigorous procedure of risk assessment which is used to determine whether land meets the definition of 'contaminated land' in accordance with the Statutory Guidance (Scottish Executive, 2000a and 2000b, the latter as amended for

radioactivity by Scottish Executive, 2006). Under the risk assessment procedure, for such harm to humans, the environment or significant pollution of the water environment to be possible, there must be a 'pollutant linkage', as follows:

- A Source of pollution (**contaminant**);
- A **Pathway** for the pollutant to move from source to receptor;
- A **Receptor** (Target) which is affected by the pollutant. This includes human beings, other living organisms, the water environment, physical systems and built structures which could be affected by the hazard.

For a potential risk to exist at a site all three of the above elements must be present, and linked together so that a contaminant has been identified, a receptor is located on the site and there is an exposure pathway that links the contaminant to the receptor. The term **pollutant linkage** is used to describe a particular combination of contaminant-pathway-receptor relationship. The following sections summarise the relevant contaminants, receptors and pathways which collectively constitute the relevant pollutant linkages for the Site.

In addition, in order for 'contaminated land' to exist, significant harm, or the significant possibility of significant harm arising must apply to the pollutant linkages. Table B (Annex 3, Part 3, Chapter A) of the augmented Statutory Guidance (SEPA,2006) also provides guidance on whether there is significant possibility of significant harm relating to each receptor group. The consideration takes into account 'relevant information' for the type of pollutant linkage under scrutiny. Relevant information is information which is:

a) scientifically-based;

b) authoritative;

c) relevant to the assessment of risks arising from the presence of contaminants in soil; and

d) appropriate to the determination of whether any land is contaminated land for the purposes of Part IIA, in that the use of the information is consistent with providing a level of protection in line with the qualitative criteria set out in Tables A and B.

Typically, 'relevant information' includes comparison of observed concentrations of pollutants in environmental media with accepted guideline values for acceptable and unacceptable concentrations, which themselves are based on a series of risk assessment criteria and designed to meet the four requirements for relevant information defined above.

A qualitative assessment of hazard and risk at the site was prepared and included in earlier drafts of this report, but has been removed from this issue at the request of SEPA.

4.1.1 Radioactive Contamination

Since 2006, Part IIA of the Environmental Protection Act 1990 has been extended to include radioactive contamination (Scottish Executive Circular SE/2006/44, which superseded 01/2000). Local Authorities had a new duty to identify sites that are potentially contaminated with radioactive material by virtue of past operational activities. This was subsequently superseded in 2007 with updated regulations which, although the definition of contaminated land has not been modified, the effect of the modifications made by the Radioactive

Contaminated Land (Scotland) Regulations 2007 has been to create a different definition of contaminated land which applies specifically to radioactive contaminated land:

> "any land which appears to SEPA to be in such a condition, by reason of substances in, on or under the land, that -
>
> "(a) significant harm is being caused or there is a significant possibility of such harm being caused; or
>
> "(b) significant pollution of the water environment is being caused or there is a significant possibility of such pollution being caused".

Where substance is defined in S78A(9) as:

"substance" means, whether in solid or liquid form or in the form of a gas or vapour, any substance which contains radionuclides that are or have been processed as part of a work activity or past practice, but shall not include radon gas and any radionuclide present as a result of the radioactive decay of radon.

The criteria for harm are based on 'intervention' scenarios; i.e. situations in which site users are currently being exposed, and the decision must be made whether an 'intervention' (i.e. remedial action) is necessary to reduce exposure levels. Lower dose thresholds apply for 'practices', which generally refer to consented radioactive discharges but also include redevelopment projects that result in a different exposure scenario, i.e. a change of land use. The general principles of radiation protection, as established by the ICRP, require that an intervention should be optimised and justified on the basis of doing more good than harm, including socio-economic factors.

The modified Part IIA requires that Radioactive Contaminated Land is designated as a Special Site. Unlike other types of contamination there is no requirement that land must be identified as contaminated land before designation as a Special Site takes place. For Radioactive Contaminated Land identification and designation will occur simultaneously. Radioactive Contaminated Land is always designated as a Special Site; therefore SEPA is the Enforcing Authority for the purposes of the Part IIA regime.

4.1.2 Note on Receptors

The augmented Statutory Guidance (Scottish Executive, 2006) also defines the types of flora/ fauna or ecological systems receptors which may be considered. It states that an ecological system is defined as 'any ecological system, or living organism forming part of such a system, within a location which is:

- an area notified as an area of special scientific interest (commonly called a Site of Special Scientific Interest - SSSI) under section 28 of the Wildlife and Countryside Act 1981;
- any land declared a national nature reserve under section 35 of that Act;
- any area designated as a marine nature reserve under section 36 of that Act;
- an Area of Special Protection for Birds, established under section 3 of that Act; - any European Site within the meaning of regulation 10 of the Conservation

(Natural Habitats etc) Regulations 1994 (i.e. Special Areas of Conservation and Special Protection Areas);

- any candidate Special Areas of Conservation (see Scottish Office Circular 6/1995) or potential Special Protection Areas given equivalent protection;
- any habitat or site afforded policy protection (i.e. candidate Special Areas of Conservation, potential Special Protection Areas and listed Ramsar sites);
- any nature reserve established under section 21 of the National Parks and Access to the Countryside Act 1949; or
- any National Park designated under the National Parks (Scotland) Act 2000. Consequently, owing to the lack of appropriate designations in the vicinity of the site, it is concluded that there are no 'ecological systems' receptors associated with the site.

4.1.3 Status of Determination as Radioactive Contaminated Land

SEPA, 2008, provides a similar assessment of the regulatory position to the foregoing. This former report summarised the position of the work at that point as providing further information to allow SEPA to reach an informed decision on whether any land at Dalgety Bay should be classed as Radioactive Contaminated Land (RCL). The SEPA report does not provide firm conclusions on whether the site should, or should not, be determined as RCL, but recommends further risk assessment work to refine the uncertainties within the risk assessment at that point in time.

Consequently, at the current time, it would appear uncertain as to whether the site is capable of determination as RCL. However, SEPA has indicated (SEPA, 2010) that it considers that the intervention measures undertaken during 2009/10 (namely, the erection of warning signage and carrying out of a regular surveying and source removal programme) to be essential components of an interim intervention, thus negating the need to further consider the potential for determination.

4.2 Factors for Consideration: Source

4.2.1 Spatial Distribution

Figures 16 and 16a present the spatial distribution of source finds for the recovered and found sources, and for those recovered and found during baseline and successive surveys only. These figures show that the point sources are distributed across the site; although biased towards the region of Zone A, they are by no means confined to this area. Such bias is no doubt due to the combination of surface survey and intrusive investigation in the data set, and is at least partially due to the concentration of intrusive investigation of the ashy bed within the Zone A area. When the spatial distribution is examined in terms of which point sources were recovered during surveying works, and which were recovered during intrusive works, it is apparent that the point sources which were not found within the ash bed (i.e. all those found during the survey), are distributed across the entire area surveyed, with a general increase in the density of finds along the Sailing Club frontage.

Similarly, the recovery of samples from depth (i.e. not from the beach surface) is also biased towards the area of the Sailing Club frontage, but this is influenced by the presence of the ash bed, and the investigation of this feature, in this area.

Figure 16a, showing only those samples found and recovered during surface surveys following the clearance survey, presents a broadly similar picture, with relatively evenly distributed incidences of repopulation across the beach, and an enhanced density in the slipways / Jetty area. The finds from the survey carried out immediately following the storm event, which resulted in substantial relocation of the beach sediments, and was thus a point in time at which a 'worst-case' repopulation could be said to have occurred, are shown in red, and are relatively evenly distributed along the beach.

4.2.2 Occurrence of Point Source Recontamination with Time

The discussion is principally focussed on recontamination in Zones A and B. The main issue in attempting to draw a conclusion on whether Zones A and B are subject to repopulation is the establishment of a known baseline over a known area. This has substantially been done, through a combination of the Zone A/B 'Clearance' and 'Baseline' investigations, although is complicated by the following factors:

- It is possible that inaccessible, or shielded, sources may have been detected in later surveys and therefore may account for a small proportion of what would otherwise be regarded as new finds;
- The dynamic nature of the foreshore environment, resulting in sediment and point source movement and variation with time.

These processes mean that the data are considered on the basis of 'monitoring period' as opposed to absolute, which permits some time-series evaluation and comparison, to present a baseline within the constraints outlined above. Figures 16 and 16a provide summaries of all recovered point sources at the site, and Table 4.1 below summarises the finds by survey campaign, and a nominal recontamination rate in finds / ha / day.

Table 4.1 Point Source Recoveries and Nominal Recontamination Rate

Survey/ Investigation Task	Elapsed Time (days)*	Area Surveyed (m2)	Number of Point Sources Recovered (Intrusive Works)	Number of Point Sources Recovered (Non-Intrusive Works)	Recontamination Rate (finds/ha/day)
Zone A: Ash Bed Investigations Between Slipways - 100% Characterisation			33		
Zone A: Ash Bed Investigations, Outside Slipways (2 exercises in July and November)			2 & 13		
Zone B: Bay Area (Clearance: 26/05/09 – 03/06/09)				27	
Zone C: Coastal Path (26/05/09)	N/A			1	N/A
Zone B: Bay Area (Baseline: 29/06/09 – 02/07/09)	29	37136		9	0.0836
Zone A (part): Monitoring Survey 1 (13/08/09)	42	3392		Nil	0.0000
Zone A (full): Monitoring Survey 2 (23/10/09)	71	3625		1	0.0389
Zones A & B (part): Monitoring Survey 3 (16-18/12/09)	56	19968		17	0.1520
Zones A & B (part): Monitoring Survey 4 (3-5/03/10)	77	24607		1	0.0053
Zones A & B: Monitoring Survey 5 (7-9/04/10)	35	20673		20	0.2764
Zones A & B: Monitoring Survey 6 (18-20/05/10)	41	27747		3	0.0264
Total / Average (Monitoring Only)	351	19593	N/A	51	0.0742

* Elapsed time since last relevant survey or initial clearance

Zone A (Slipways Area)

The slipways area was cleared and baseline surveyed as part of the overall works within Zone B, and was also investigated using trial pits (outwith the slipways) and trenches (within the slipways; the latter two exercises finding and removing 35 point sources. This initial work scope was followed by a monitoring survey in August 2009 (which found no point sources), and a second in October 2009 (which found one point source, to the east of the slipway). Following this work, the area outwith the slipways was investigated using trial trenches in November 2009, which found a further 13 point sources of activity, and was further investigated as part of the December 2009, Monitoring Survey, which found 12 point sources. Given the presence and number of point sources noted in the uppermost 0.1 metres of sediment, it is considered that the majority of finds are associated with new sources as opposed to previously unidentified deeper contamination.

A further 3 point sources, from surface or near-surface horizons, were found in the monitoring round following the storm, in early April 2010, whilst 1 further point source was found on the surface of the beach in Zone A in the following month.

Zone B (Bay Area)

Zone B was cleared, during which 27 point sources were recovered. The 'baseline' survey was undertaken a month after this clearance, and found 10 point sources.

A further 5 radioactive point sources, in locations which suggest that they were 'new' contamination, were noted in Zone B in the next Monitoring Survey which extended into this Zone; undertaken in December 2009.

A further 20 point sources were found across the next three monitoring surveys (March, April and May 2010), the bulk of which (17 No.) were found in the monitoring survey immediately after the storm event.

Zone C (Coastal Path)

Zone was investigated on a single occasion, and one point source was found. Recontamination is not considered to be of concern for Zone C as it lies beyond the area of tidal influence, and so this is not discussed.

Overall Recontamination Rate

A nominal recontamination rate, of finds per hectare per day, has been calculated for unbiased comparison between monitoring surveys (albeit some overall bias remains as a result of variation of areas surveyed between monitoring rounds). The preliminary 'clearance' survey and intrusive works are excluded from this evaluation to limit it to probable surface recontamination.

In both Zones A and B, the data indicate that recontamination is occurring with time at the site. The nominal recontamination rate averages at 0.0742 finds/ hectare/day, but ranges from 0 to 0.276 finds/ hectare /day, the latter arising from the post-storm event survey in April 2010. Extrapolating the measured average recontamination rate to future years results in an overall quota of 100 new sources being deposited on the site each year (based on 3.7ha site area, 365 days and 0.0742 finds/ha/day).

4.2.3 Potential Host Material - Ash Bed

Findings from the intrusive works indicate that the ash layer is restricted to the southern area of the bay, comprising an area approximately 100 m wide and extending out from the shore for approximately 40 m. The ash layer is of greatest vertical thickness close to the shore, and becomes thinner as it extends from the high water line towards the low water line. The ash layer has typically recorded probe readings of 400-700 cps, compared to background readings of 150-250 cps. A total of 35 point sources of contamination were identified and removed as samples from the ash and clinker material, of which 33 were sampled during the initial intrusive investigation between the slipways, and the remaining 2 were sampled during the further intrusive works.

The work between the slipways established that the ash bed ranged in thickness from 0.1 to 0.7 m, across an area approximately 40 m x 30 m. If an average thickness of 0.5 m is assumed for the ash bed, then this equates to a point source frequency of one point source per 18 m^3 of ash material.

Whilst the ash horizon is present beneath some depth of beach sediments, it is possible that movement of material containing radioactive point sources from this horizon may have occurred as a result of the following events:

- Progressive erosion of a suspected exposed 'toe' of the wedge through tidal and marine action;
- Erosion of the beach overburden and liberation of ashy material as a result of single events, such as storms or localised tidal scour.

As noted above, it is concluded that, given that repopulation of the beach has been observed since the ash bed was excavated, sampled and point sources therein recovered, it is possible that the ash bed is not the only host material for radioactive point sources in the area.

4.2.4 Potential of Point Source to cause 'Harm'

Paragraphs A28, A33, A34 and A35 of the Statutory Guidance (Scottish Government, 2007), provide guidance on what dose criteria should be used by SEPA to evaluate whether significant harm, or significant possibility of significant harm, is being caused. The table below summarises these criteria:

Table 4.2 Significance and Harm

Dose Criterion	Condition 1 (A28)	Condition 2 (A33)	Condition 3 (A34)
Effective Dose	>3 mSv/annum	>100 mSv	<3 mSv/annum
Equivalent dose to the lens of the eye	>15 mSv/annum		<15 mSv/annum
Equivalent dose to the skin	>50 mSv/annum		<50 mSv/annum
Contact skin dose		>10Gy in 1 hour	
Where:			
Condition 1 is true: "SEPA should regard significant harm as being caused to human beings when lasting exposure gives rise to an individual dose exceeding one or more of the following:"			
Condition 2 is true: "SEPA shall regard the possibility of significant harm as significant, irrespective of the probability of radiation dose being received."			
Condition 3 is true: "SEPA should **not** regard the possibility of significant harm as significant, irrespective of the probability of radiation dose being received."			

Furthermore, paragraph A. 35 states that "If the conditions in A.33 and A.34 are not met, the probability of radiation dose being received needs to be taken into account. SEPA shall regard the possibility of significant harm as significant where:

(a) the potential total effective dose multiplied by the probability of exposure is greater than 3 mSv; or

(b) the potential equivalent dose to the lens of the eye multiplied by the probability of exposure is greater than 15 mSv; or

(c) the potential equivalent dose to the skin multiplied by the probability of exposure is greater than 50 mSv.

The likelihood of sources on the beach resulting in a dose in excess of 100mSv (i.e. the potential for Condition 2 to exist) is currently under investigation by SEPA, and so further comment is not provided here.

4.2.5 Point Source Homogeneity, Friability, Particle Size and Physical Characteristics

The physical form of the contaminated material was quite varied in the point sources recovered, but was generally associated with an obvious combustion residue (i.e. clinker particle). On occasion, the point source was associated with a recognisable artefact, and conversely there were several samples where no discernibly different particle or artefact was noted.

As discussed in Section 2.1 above, DSTL performed laboratory testing of a selection of recovered samples, and undertook some basic dissociation experiments with selected recovered point sources. When agitated, the samples under test did shed small particulates, but on subsequent analysis, these particulates were not found to contain radioactive materials. Consequently, it is concluded that recovered point sources are not necessarily homogeneous in

nature, which indicates that a partial/ relatively uncontrolled combustion environment, as opposed to a controlled systematic incineration, resulted in the production of the ashy materials on the beach.

This is generally in agreement with the findings/conclusions of the SEPA, 2008, study, which noted that sources were fragile, and that several point sources were found at some of the single detection 'hotspots' inferring that in-situ breakdown was occurring. Whilst the current study is not conclusive on this latter point, laboratory experimentation by DSTL has established that the combustion residue will dissociate under physical force.

4.3 Factors for Consideration: Pathway

4.3.1 Environment: Beach and Tidal Characteristics

Out of a total of 131 point sources found, 3 point sources were not re-located for subsequent recovery, indicating that point sources remain mobile within and in/out of the site, primarily due to the action of wave and tide.

An elevation profile of the beach is not available. An approximate profile, from field observations and photographs, is a relatively evenly slope from the high tide mark down to just above the low tide point, from where the gradient reduces and results in a much more level beach. The tidal range at this approximate point in the Forth Estuary approaches 6 metres at Spring tides (UKHO, 2009-10). The entire potentially affected area of beach is thus only exposed approximately an hour either side of low tide. Furthermore, with two tides per 24 hour period, the beach is typically thus *fully* accessible during daytime on only one of these low tides. Further discussion on this point, in relation to the potential use of the beach, is presented in Section 4.4.1 below.

Figure 17 provides an illustration of the combinations of wind and tide which could provide the optimum conditions for beach erosion/ redeposition, and the relation of these times over the monitoring period with the monitoring exercises themselves. Figure 18 provides an annual summary of tidal ranges at the nearest approximately similar gauging point (i.e. Port of Leith), illustrating the tidal range at this point in the Firth of Forth.

4.3.2 Current Institutional Control

The beach is currently subject to a level of institutional control; namely, the erection of warning signage and briefing/ education of Sailing Club members which provides advice aimed at limiting the potential for exposure to or spread of contamination. It is considered that, over the past year, this passive institutional control has been effective in controlling and reducing potential exposure arising from the point sources.

4.4 Factors for Consideration: Receptor

4.4.1 Use and Population of Area

The site area is predominantly poor quality beach, which provides amenity to the local community as follows:

- Zone A: an ostensibly relatively intense use of the beach area, slipway and Jetty adjacent to the Sailing Club for operations in connection with tuition and other activities of the Club, and the possibility of bait diggers over much of the beach;
- Zones A and B: the markedly less intensive use of the beach for 'traditional' beach activities; and
- Zone C: use of the coastal path for walkers and dog exercisers.

The beach itself is composed mainly of shingle, exposed bedrock and, in the northern portion, extensive mudflats below the strand line. Very few sandy areas are evident, and the widespread presence of anthropogenic material on the beach is noted, including brick, glass, plastic, clinker, ash, pottery and miscellaneous waste items.

Past monitoring surveys report on the habits observed during their respective sampling periods. The early NRPB surveys report a lack of bait diggers and suggest that there is little recreational activity in the Bay. However, later reports suggest that there are numerous groups using the Bay for a variety of different reasons. The key parameter influencing ultimate dose is the level of occupancy of the different groups. Based on a review of the previous reports and information presented by Defence Estates, the following groups have been identified:

- High occupancy group - there is some observational evidence presented in previous reports that bait digging actually occurs at an *occupational* level in Dalgety Bay. This group is considered as indicative of a high occupancy adult group. The level of occupancy has been amended to take account of a more realistic occupancy pattern. The standard 2000 hours a year data is based on 40 hours a week, 50 weeks per year, and assume an eight-hour working day. However, this does not take account of the tidal and daylight limitations likely to affect such an occupation at the site:
  - Dalgety Bay is fully inundated twice a day. It is assumed that the inundation is an average of 6 hours per day for 5 days a week;
  - It is assumed that the average amount of daylight over a year is just over 12 hours per day;
  - An occupational operation would involve employees working approximately 47.2 weeks of the year (i.e. exclusive of the current statutory leave levels); therefore;
  - over 47.2 weeks this yields a total of 1132 hours, based on 6 access hours per working day. This is an arbitrary assessment, but is considered to be a more realistic work pattern.
- Low occupancy group (e.g. dog walker) - assuming 1 hour per day 365 days per year; other groups such as walkers, bird watchers are assumed to spend less time than the dog walkers over the course of a year.

The high occupancy leisure user, e.g. member of the sailing club, has not been separately identified as it is considered unlikely that they would have a higher occupancy that the bait digger. Given that the use of the beach in connection with the sailing club is often transitory in nature, associated with boat launching and recovery, it is considered that the activities of the sailing participants are such that exposure to particles is lower than their occupancy would

otherwise suggest. Additionally, observation suggests that the use of slipways allows participants to launch their boats without accessing the inter-tidal area. Exposure pathways are still likely to be associated with direct contact with, or inadvertent ingestion of, particles.

4.4.2 Routes of Human Exposure

The theoretical potential exists for human exposure to arise through inhalation, ingestion or direct irradiation of radioactive contamination at the site.

The potential likelihood of exposure through these routes may vary slightly, given that an inhalation exposure is only likely to occur as a result of an airborne particle, whilst an ingestion exposure would be reliant on both the adherence of a particle and its subsequent transferral to the mouth. Of the three potential pathways, direct irradiation is the most likely to occur, given that this would only require that a receptor is positioned close to a point source for a period of time.

5. References

Table 6.1 Reference List

Reference	Document
CIRIA, 2001	'Contaminated land risk assessment: A Guide to Good Practice', Construction Industry Research & Information Association Publication C552, Rudland D J, Lancefield R M, Mayell P N. ISBN 0 86017 552 9, 2001.
DE, 2009a	Letter, Defence Estates to SEPA, 2 March 2009 (DE reference ROS/FFE/ESM/005).
DE, 2009b	Public Notice: Dalgety Beach Radioactive Contamination Area, saved as Entec document reference S23218C045, originated by DE, May 2009.
Enviros, 2007	Dalgety Bay, Information Review - Final, report for Defence Estates under contract DE11/4416, dated February 2007.
SEPA, 2008	'Dalgety Bay Radium Contamination: Preliminary Assessment (Draft)', Scottish Environment Protection Agency RS Policy Unit, 15 December 2008.
SEPA, 2010	Letter, SEPA to Entec, no SEPA reference, issued 11 June 2010, 'Dalgety Bay: Interim Report Comments'.
Scottish Executive, 2000b	Scottish Executive Circular 1/2000, 'Environment Protection Act 1990: Part IIA Contaminated Land', 12 July 2000.
Scottish Executive, 2006	'Environmental Protection Act 1990: Part IIA Contaminated Land Statutory Guidance: Edition 2', Scottish Executive Paper SE/2006/44, May 2006.
Scottish Government, 2008	Scottish Government Circular SE/2007/168, 'The Radioactively Contaminated Land (Scotland) Regulations, 2007, Statutory Guidance', 31 March 2008.
SEPA, 2008	Approved Draft Report, 'Dalgety Bay Radium Contamination', Dale P and Hunter G. SEPA RS Policy Unit, 15 December 2008.
UKHO, 2009-10	UK Hydrographic Office, 'EasyTide' tide times/range predictor for points during 2009 and 2010, location: Burnt Island, Fife.

Figures

Annex A
Sample Log

4 Pages

Annex A

23218 - Dalgety Bay Sampling Log

Notes:
* Samples with a stated depth of 0.0 m bgl indicate samples which were present at the surface, and are highlighted with coloured shading
** Nominal source activity is based on the equipment calibration factor of 1000 cps/Bqg-1. This approach assumes that the total radiation field is due to Ra-226 and daughter products in total equilibrium, and that the source is a homogeneous source.
*** Total nominal activity is based on the nominal source activity and an assumed average weigth of 250g per sample

Entry No.	Sample Reference	Sample Location (Eastings)	Sample Location (Northings)	Depth (m bgl)*	Date & Time Taken	Material Description / Main Constituents	Disturbed / Undisturbed	Wet / Dry	Field Probe Reading (cps)	Probe Used	Nominal Source Activity** (Bq/g)	Total Nominal Activity*** in Sample (Bq)	Sampler	Sample Storage Location	Comments	Campaign	Zone	Intrusive / Surface Survey	Sent for gamma-spec?
1	23218-S001	316479	683191	0	26/05/09 - 14:45	Maroon plastic artefact	Disturbed	Wet	2250	White	2.250	562.5	JSR	Container Store	Artefact on surface of beach, likely to have been laid down by tide.	Bay Area (Clearance)	B	Survey	
2	23218-S002	316275	683311	0.05	26/05/09 - 16:20	Soil	Disturbed	Dry	1120	Silver	1.120	280.0	JSR	Container Store	Contaminated soil from minor coastal path	Coastal Path	C	Survey	
3	23218-S003	316258	683341	0	27/05/2009	Large clinker / metal artefact	Disturbed	Wet	2000	Silver	2.000	500.0	LM	Container Store	Large object on surface of beach	Bay Area (Clearance)	B	Survey	
4	23218-S004	316199.63	683384.5	0.05	27/05/2009	Small clinker object and sand	Disturbed	Wet	4300	Silver	4.300	1075.0	LM	Container Store	Attempted undisturbed sample but missed source	Bay Area (Clearance)	B	Survey	
5	23218-S005	316493	683085	0	27/05/2009	Sand, gravel and clinker	Disturbed	wet	2200	White	2.200	550.0	JSR	Container Store		Bay Area (Clearance)	A	Survey	
6	23218-S006	316497	683096	0	27/05/2009	Sand, gravel and clinker	Disturbed	Dry	5500	White	5.500	1375.0	JSR	Container Store		Bay Area (Clearance)	A	Survey	
7	23218-S007	316451.27	683024.02	0.1	27/05/2009	Sand, gravel and clinker	Disturbed	Dry	22000	White	22.000	5500.0	JSR	Container Store	Sample sent to dstl for gamma-spec and analysis	Bay Area (Clearance)	B	Survey	Dec-09
8	23218-S008	316447	683018	0	27/05/2009	Sand, gravel and clinker	Disturbed	Wet	7500	White	7.500	1875.0	JSR	Container Store		Bay Area (Clearance)	B	Survey	
9	23218-S009	316443	683014	0.05	27/05/2009	Sand, gravel and clinker	Disturbed	Dry	7300	White	7.300	1825.0	JSR	Container Store		Bay Area (Clearance)	B	Survey	
10	23218-S010	316483	683082	0	27/05/2009	Sand, gravel and clinker	Disturbed	Dry	1800	White	1.800	450.0	JSR	Container Store		Bay Area (Clearance)	B	Survey	
11	23218-S011	316489	683102	0	27/05/2009	Piece of brick with clinker attached	Disturbed	Dry	7300	White	7.300	1825.0	JSR	Container Store		Bay Area (Clearance)	A	Survey	
12	23218-S012	316482	683113	0	27/05/2009	5mm piece of clinker	Disturbed	Dry	1400	White	1.400	350.0	JSR	Container Store	Adjacent to sample S013	Bay Area (Clearance)	A	Survey	
13	23218-S013	316483	683112	0.05	27/05/2009	Sand and gravel	Disturbed	Dry	1200	White	1.200	300.0	JSR	Container Store	Adjacent to sample S012	Bay Area (Clearance)	A	Survey	
14	23218-S014	316494.23	683125.17	0.05	27/05/2009	Sand and gravel	Disturbed	Dry	5100	White	5.100	1275.0	JSR	Container Store		Slipways 100%	A	Intrusive	
15	23218-S015	316401	683000	0.05	27/05/2009	Sand and gravel	Disturbed	Dry	2200	White	2.200	550.0	JSR	Container Store		Bay Area (Clearance)	B	Survey	
16	23218-S016	316399	683000	0.05	27/05/2009	Gravel and clinker	Disturbed	Dry	2000	White	2.000	500.0	JSR	Container Store		Bay Area (Clearance)	B	Survey	
17	23218-S017	316484.08	683108.56	0.15	28/05/09 - pm	Ashy clinker	Disturbed	Dry	21700	White	21.700	5425.0	JSR	Container Store	TP01 0.15m bgl	Slipways 100%	A	Intrusive	
18	23218-S018	316485.3	683110.2	0	28/05/09 - pm	Sand and gravel	Disturbed	Dry	2300	White	2.300	575.0	JSR	Container Store	TP04 Surface	Slipways 100%	A	Intrusive	
19	23218-S019	316494	683125	0.5	28/05/09 - pm	Ashy clinker	Disturbed	Dry	2300	White	2.300	575.0	JSR	Container Store	TP07 0.5m bgl	Slipways 100%	A	Intrusive	
20	23218-S020	316495	683122	0.5	28/05/09 - pm	Ashy clinker	Disturbed	Dry	3300	White	3.300	825.0	JSR	Container Store	TP07 0.5m bgl	Bay Area (Clearance)	B	Survey	
21	23218-S021	316488	683094	0	28/05/09 - pm	Large lump clinker	Disturbed	Dry	2250	White	2.250	562.5	JSR	Container Store	TP20 Surface	Bay Area (Clearance)	A	Survey	
22	23218-S022	316491	683092	0.3	28/05/09 - pm	Sand, gravel and clinker	Disturbed	Dry	4600	White	4.600	1150.0	JSR	Container Store	TP22 0.3m bgl. Sample sent to dstl for gamma-spec and analysis	Bay Area (Clearance)	A	Survey	Dec-09
23	23218-S023	316456	683284	0.05	28/05/09 - pm	Wet clinker object in gravel	Disturbed	Wet	2600	Silver	2.600	650.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
24	23218-S024	316426	683295	0	28/05/09 - pm	Sand and gravel, nothing obvious	Disturbed	Dry	720	Silver	0.720	180.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
25	23218-S025	316424	683292	0	28/05/09 - pm	Sand and gravel	Disturbed	Dry	1900	Silver	1.900	475.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
26	23218-S026	316409	683295	0.05	28/05/09 - pm	Two objedts 15cm apart (clinker) in sand and gravel	Disturbed	Wet	4900	Silver	4.900	1225.0	LM	Container Store	Sample sent to dstl for gamma-spec and analysis	Bay Area (Clearance)	B	Survey	Dec-09
27	23218-S027	316336	683308	Unknown	28/05/09 - pm	Sand (undisturbed sample)	Undisturbed	Dry	6300	Silver	6.300	1575.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
28	23218-S028	316443.4	683263.73	0	28/05/09 - pm	Sand and clinker	Disturbed	Dry	2900	Silver	2.900	725.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
29	23218-S029	316479	683202	Unknown	29/05/09 - pm	Wet sand	Undisturbed	Wet	4300	Silver	4.300	1075.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
30	23218-S030	316501	683212	Unknown	29/05/09 - pm	Wet sand	Undisturbed	Wet	3200	Silver	3.200	800.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
31	23218-S031	316500.99	683199.2	0.2	29/05/09 - pm	Wet sand and shells	Disturbed	Dry	2200	Silver	2.200	550.0	LM	Container Store		Bay Area (Clearance)	B	Survey	
32	23218-S032	316496.67	683121.01	0.3	29/05/2009	Clinker lump	Disturbed	Dry	916	White	0.916	229.0	JSR	Container Store	TP28	Slipways 100%	A	Intrusive	
33	23218-S033	316492.45	683123.69	0.4	29/05/2009	Sand an ash	Disturbed	Dry	1360	White	1.360	340.0	JSR	Container Store	TP28	Slipways 100%	A	Intrusive	
34	23218-S034	316501.23	683107.76	0.5	29/05/2009	Sand, ash and clinker	Disturbed	Dry	6300	White	6.300	1575.0	JSR	Container Store	TP31. Sample sent to dstl for gamma-spec and analysis	Slipways 100%	A	Intrusive	Dec-09
35	23218-S035	316491.49	683108.86	0.1	29/05/2009	Sand and ash	Disturbed	Dry	3600	White	3.600	900.0	JSR	Container Store	TP32	Slipways 100%	A	Intrusive	
36	23218-S036	316503	683080	0.2	29/05/2009	Sand, ash and clinker	Disturbed	Dry	3300	White	3.300	825.0	JSR	Container Store	TP39	Slipways 100%	A	Intrusive	
37	23218-S037	316500.29	683080.08	0.1	29/05/2009	Ashy sand	Disturbed	Dry	3600	White	3.600	900.0	JSR	Container Store	TP40	Slipways 100%	A	Intrusive	

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Notes:
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*** Total nominal activity is based on the nominal source activity and an assumed average weigth of 250g per sample

Entry No.	Sample Reference	Sample Location (Eastings)	Sample Location (Northings)	Depth (m bgl)*	Date & Time Taken	Material Description / Main Constituents	Disturbed / Undisturbed	Wet / Dry	Field Probe Reading (cps)	Probe Used	Nominal Source Activity** (Bq/g)	Total Nominal Activity*** in Sample (Bq)	Sampler	Sample Storage Location	Comments	Campaign	Zone	Intrusive / Surface Survey	Sent for gamma-spec?
38	23218-S038	316494.32	683089.42	0.1	29/05/2009	Ashy sand and clinker	Disturbed	Dry	1100	White	1.100	275.0	JSR	Container Store	TP45	Slipways 100%	A	Intrusive	
39	23218-S039	316494.32	683089.42	0.2	29/05/2009	Ashy sand and clinker	Disturbed	Dry	2200	White	2.200	550.0	JSR	Container Store	TP45	Slipways 100%	A	Intrusive	
40	23218-S040	316490	683087	0.3	29/05/2009	Ashy sand and clinker	Disturbed	Dry	2050	White	2.050	512.5	JSR	Container Store	TP45	Slipways 100%	A	Intrusive	
41	23218-S041	316488.54	683089.69	0.3	29/05/2009	Ashy sand and clinker	Disturbed	Dry	6000	White	6.000	1500.0	JSR	Container Store	TP45	Slipways 100%	A	Intrusive	
42	23218-S042	316491.78	683091.43	0.1	29/05/2009	Ash and clinker	Disturbed	Dry	3800	White	3.800	950.0	JSR	Container Store	TP46. Sample sent to dstl for gamma-spec and analysis	Slipways 100%	A	Intrusive	Dec-09
43	23218-S043	316494.01	683102.23	0.2	01/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	998	White	0.998	249.5	JSR	Container Store	TP47	Slipways 100%	A	Intrusive	
44	23218-S044	316502	683106	0.6	01/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	4300	White	4.300	1075.0	JSR	Container Store	TP50	Slipways 100%	A	Intrusive	
45	23218-S045	316497.27	683109.66	0.15	01/06/09 - pm	Ash and clinker	Disturbed	Wet	103000	White	103.000	25750.0	JSR	Container Store	TP51	Slipways 100%	A	Intrusive	
46	23218-S046	316504.72	683105.41	0.4	01/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	13600	White	13.600	3400.0	JSR	Container Store	TP51	Slipways 100%	A	Intrusive	
47	23218-S047	316503	683105	0.6	01/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	1300	White	1.300	325.0	JSR	Container Store	TP51	Slipways 100%	A	Intrusive	
48	23218-S048	316505.99	683089.42	0.1	01/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	21000	White	21.000	5250.0	JSR	Container Store	Adjacent to TP52 slightly NW. Sample sent to dstl for gamma-spec and analysis	Slipways 100%	A	Intrusive	Dec-09
49	23218-S049	316505	683093	0.1	01/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	1500	White	1.500	375.0	JSR	Container Store	TP53	Slipways 100%	A	Intrusive	
50	23218-S050	316505.3	683092.63	0.3	02/06/09 - pm	Ash , sand and clinker	Disturbed	Wet	4050	White	4.050	1012.5	JSR	Container Store	South of TP54 ~0.5m	Slipways 100%	A	Intrusive	
51	23218-S051	316493.21	683096.6	0.1	02/06/09 - pm	Ashy gravel	Disturbed	Wet	4900	White	4.900	1225.0	JSR	Container Store	TP55	Slipways 100%	A	Intrusive	
52	23218-S052	316498	683096	0.3	02/06/09 - pm	Ashy gravel	Disturbed	Wet	1700	White	1.700	425.0	JSR	Container Store	TP55	Slipways 100%	A	Intrusive	
53	23218-S053	316498	683096	0.3	02/06/09 - pm	Clinker lump	Disturbed	Wet	4400	White	4.400	1100.0	JSR	Container Store	TP55	Slipways 100%	A	Intrusive	
54	23218-S054	316493.21	683096.6	0.4	02/06/09 - pm	Ashy gravel	Disturbed	Dry	1000	White	1.000	250.0	JSR	Container Store	TP56	Slipways 100%	A	Intrusive	
55	23218-S055	316490	683092	0.2	02/06/09 - pm	Clinker piece	Disturbed	Dry	4700	White	4.700	1175.0	JSR	Container Store	TP58	Slipways 100%	A	Intrusive	
56	23218-S056	316490	683092	0.2	02/06/09 - pm	Ashy sand and gravel	Disturbed	Dry	4300	White	4.300	1075.0	JSR	Container Store	TP58	Bay Area (Clearance)	A	Survey	
57	23218-S057	316499	683094	0.3	02/06/09 - pm	Ashy clinker and gravel	Disturbed	Dry	4000	White	4.000	1000.0	JSR	Container Store	TP63	Bay Area (Clearance)	A	Survey	
58	23218-S058	316499	683094	0.4	02/06/09 - pm	Ashy clinker and gravel	Disturbed	Dry	1400	White	1.400	350.0	JSR	Container Store	TP63	Bay Area (Clearance)	A	Survey	
59	23218-S059	316554	683166	0	03/06/09 - am	Clinker lump	Disturbed	Dry	5950	White	5.950	1487.5	JSR	Container Store	Clearance Survey	Bay Area (Clearance)	B	Survey	
60	23218-S060	316554	683162	0	03/06/09 - am	Sandy rock	Disturbed	Dry	3500	White	3.500	875.0	JSR	Container Store	Clearance Survey	Bay Area (Clearance)	B	Survey	
61	23218-S061	316519	683159	0.2	03/06/09 - am	Gravel	Disturbed	Dry	5500	White	5.500	1375.0	JSR	Container Store	Clearance Survey	Bay Area (Clearance)	B	Survey	
62	23218-S062	316171.8	683431.17	unknown	29/06/09 - pm	sand and mud	Undisturbed	Wet	1200	White	1.200	300.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
63	23218-S063	316158	683424	unknown	29/06/09 - pm	sand and mud	Undisturbed	wet	2000	White	2.000	500.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
64	23218-S064	316197	683380	0.05	29/06/09 - pm	sand and gravel	Disturbed	Dry	2000	White	2.000	500.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
65	23218-S065	316355	683315	0.2	29/06/09 - pm	sand and gravel	Disturbed	Dry	1700	White	1.700	425.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
66	23218-S066	316441	683263	0.1	29/06/09 - pm	clinker piece	Disturbed	Dry	12000	White	12.000	3000.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
67	23218-S067	316515.29	683183.17	0.2	30/06/2009	sand and gravel	Disturbed	Dry	4800	White	4.800	1200.0	JSR	Container Store	Baseline Survey. Sample sent to dstl for gamma-spec and analysis	Bay Area (Baseline)	B	Survey	Dec-09
68	23218-S068	316524.87	683183.34	0.1	30/06/2009	gravel and clinker	Disturbed	Dry	6500	White	6.500	1625.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
69	23218-S069	316531.71	683199.24	0.15	30/06/2009	clinker piece	Disturbed	Wet	65000	White	65.000	16250.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
70	23218-S070	316497.85	683191.37	0.1	30/06/2009	sand, clinker and gravel	Disturbed	Wet	6600	White	6.600	1650.0	JSR	Container Store	Baseline Survey	Bay Area (Baseline)	B	Survey	
71	23218-S071	316509	683127	0.4	01/07/2009	clinker	Disturbed	Dry	2200	White	2.200	550.0	JSR	Container Store	intrusive works TP/10a (eastern area)	Ash Bed Investigations, Outside Slipways	B	Intrusive	
72	23218-S072	316497.51	683062.58	0.45	01/07/2009	clinker	Disturbed	Dry	39000	White	39.000	9750.0	JSR	Container Store	Intrusive works TP/18a (western area)	Ash Bed Investigations, Outside Slipways	B	Intrusive	
73	23218-S073	316523.02	683123.66	0.1	01/07/2009	clinker and gravel	Disturbed	Dry	35000	White	35.000	8750.0	JSR	Container Store	Ash bed, eastern area	Ash Bed Investigations, Outside Slipways	B	Intrusive	

Annex A

23218 - Dalgety Bay Sampling Log

Notes:
* Samples with a stated depth of 0.0 m bgl indicate samples which were present at the surface, and are highlighted with coloured shading
** Nominal source activity is based on the equipment calibration factor of 1000 cps/Bqg-1. This approach assumes that the total radiation field is due to Ra-226 and daughter products in total equilibrium, and that the source is a homogeneous source.
*** Total nominal activity is based on the nominal source activity and an assumed average weigth of 250g per sample

Entry No.	Sample Reference	Sample Location (Eastings)	Sample Location (Northings)	Depth (m bgl)*	Date & Time Taken	Material Description / Main Constituents	Disturbed / Undisturbed	Wet / Dry	Field Probe Reading (cps)	Probe Used	Nominal Source Activity** (Bq/g)	Total Nominal Activity*** in Sample (Bq)	Sampler	Sample Storage Location	Comments	Campaign	Zone	Intrusive / Surface Survey	Sent for gamma-spec?
74	23218-S074	316519	683132	0.15	23/10/2009	Sand and gravel	Disturbed	Dry	5000	White	5.000	1250.0	CN	Container Store	Monitoring Survey 2	Monitoring Survey 2	B	Survey	
75	23218-S075	316488	683074	0.3	02/11/2009	Ash and Gravel	Disturbed	Wet	1500	White	1.500	375.0	JSR	Container Store	TP04 November Intrusive works (western area)	Outwith Slipways 100%	B	Intrusive	
76	23218-S076	316484	683076	0.7	02/11/2009	Clinker piece	Disturbed	Dry	8200	White	8.200	2050.0	JSR	Container Store	TP07 November Intrusive works (western area)	Outwith Slipways 100%	B	Intrusive	
77	23218-S077	316479	683087	0.7	02/11/2009	Clinker lump	Disturbed	Dry	5150	White	5.150	1287.5	JSR	Container Store	TP10 November Intrusive works (western area)	Outwith Slipways 100%	B	Intrusive	
78	23218-S078	316488	683075	0.3	03/11/2009	Clinker piece	Disturbed	Dry	11000	White	11.000	2750.0	JSR	Container Store	TP14 November Intrusive works (western area)	Outwith Slipways 100%	B	Intrusive	
79	23218-S079	316487	683074	0.2	03/11/2009	3 inch thin Metal disc	Disturbed	Dry	56000	White	56.000	14000.0	JSR	Container Store	TP15 November Intrusive works (western area)	Outwith Slipways 100%	B	Intrusive	
80	23218-S080	316516	683111	0	04/11/2009	Ash and Gravel	Disturbed	Dry	1900	White	1.900	475.0	JSR	Container Store	TP18 November Intrusive works. *Hotspot found on surface following backfilling of pit (eastern area)	Outwith Slipways 100%	B	Intrusive	
81	23218-S081	316519	683114	0.2	04/11/2009	Ash and Gravel	Disturbed	Dry	8000	White	8.000	2000.0	JSR	Container Store	TP19 November Intrusive works (eastern area)	Outwith Slipways 100%	B	Intrusive	
82	23218-S082	316532.7	683130.48	0.2	04/11/2009	Clinker piece	Disturbed	Dry	5900	White	5.900	1475.0	JSR	Container Store	TP22 November Intrusive works (eastern area)	Outwith Slipways 100%	B	Intrusive	
83	23218-S083	316516	683120	0.3	05/11/2009	Ash	Disturbed	Wet	72000	White	72.000	18000.0	CN	Container Store	TP26 November Intrusive works (eastern area). Sample sent to dstl for gamma-spec and analysis	Outwith Slipways 100%	B	Intrusive	Dec-09
84	23218-S084	316524	683117	0.1	06/11/2009	Ash	Disturbed	Wet	10000	White	10.000	2500.0	CN	Container Store	TP36 November Intrusive works (eastern area)	Outwith Slipways 100%	B	Intrusive	
85	23218-S085	316519	683125	0.2	06/11/2009	Clinker	Disturbed	Wet	10000	White	10.000	2500.0	CN	Container Store	TP36 November Intrusive works (eastern area). Sample sent to dstl for gamma-spec and analysis	Outwith Slipways 100%	B	Intrusive	Dec-09
86	23218-S086	316527	683125	0.2	06/11/2009	Ash	Disturbed	Wet	12000	White	12.000	3000.0	CN	Container Store	TP37 November Intrusive works (eastern area)	Outwith Slipways 100%	B	Intrusive	
87	23218-S087	316529	683120	0.2	06/11/2009	Ash	Disturbed	Wet	10000	White	10.000	2500.0	CN	Container Store	TP38 November Intrusive works (eastern area)	Outwith Slipways 100%	B	Intrusive	
88	23218-S088	316445	683215	0.1	16/12/2009	PIECE OF BURNT METAL	Disturbed	DRY	2005	White	2.005	501.3	CM	Container Store	Found during beach Survey (north eastern area)	Monitoring Survey 3	B	Survey	May-10
89	23218-S089	316414	683292	0	16/12/2009	PIECES OF CLINKER	Disturbed	DRY	1600	White	1.600	400.0	CM	Container Store	Found during beach Survey (north eastern area)	Monitoring Survey 3	B	Survey	May-10
90	23218-S090	316464	683025	0.05	17/12/2009	GRAVEL AND SAND	Disturbed	DRY	5000	White	5.000	1250.0	CM	Container Store	Found during beach Survey (western area)	Monitoring Survey 3	B	Survey	May-10
91	23218-S091	316517	683146	0.05	17/12/2009	CLINKER LUMP	Disturbed	DRY	1100	White	1.100	275.0	CM	Container Store	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
92	23218-S092	316534	683139	0.05	17/12/2009	CLINKER PIECES	Disturbed	DRY	5500	White	5.500	1375.0	CM	DSTL Alverstoke	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
93	23218-S093	316532	683142	0.1	17/12/2009	GRAVEL AND SAND	Disturbed	WET	10000	White	10.000	2500.0	CM	Container Store	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
94	23218-S094	316555	683154	0	17/12/2009	CLINKER LUMP	Disturbed	DRY	5000	White	5.000	1250.0	CM	Container Store	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
95	23218-S095	316554	683157	0	17/12/2009	CLINKER PIECE	Disturbed	DRY	2500	White	2.500	625.0	CM	DSTL Alverstoke	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
96	23218-S096	316534	683134	0	17/12/2009	CLINKER LUMP	Disturbed	DRY	3700	White	3.700	925.0	CM	DSTL Alverstoke	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
97	23218-S097	316529	683135	0.1	17/12/2009	GRAVEL	Disturbed	DRY	2800	White	2.800	700.0	CM	Container Store	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
98	23218-S098	316499	683092	0.2	17/12/2009	GRAVEL AND SAND	Disturbed	DRY	12400	White	12.400	3100.0	CM	Container Store	Found during beach Survey (western area)	Monitoring Survey 3	A	Survey	May-10
99	23218-S099	316527	683127	0.1	17/12/2009	CLINKER LUMP	Disturbed	DRY	8300	White	8.300	2075.0	CM	Container Store	Found during beach Survey (eastern area)	Monitoring Survey 3	B	Survey	May-10
100	23218-S100	316499	683095	0.1	17/12/2009	GRAVEL AND SAND	Disturbed	DRY	11000	White	11.000	2750.0	CM	Container Store	Found during beach Survey (western area)	Monitoring Survey 3	A	Survey	May-10
101	23218-S101	316517	683126	0.1	17/12/2009	GRAVEL	Disturbed	DRY	800	White	0.800	200.0	CM	Container Store	Found during beach Survey	Monitoring Survey 3	B	Survey	May-10
102	23218-S102	316489	683200	0.05	18/12/2009	GRAVEL AND SAND	Disturbed	DRY	1700	White	1.700	425.0	JSR	Container Store	Found during beach Survey (north eastern area)	Monitoring Survey 3	B	Survey	May-10
103	23218-S103	316460	683207	0	18/12/2009	CLINKER PIECE	Disturbed	DRY	1200	White	1.200	300.0	JSR	Container Store	Found during beach Survey (north eastern area)	Monitoring Survey 3	B	Survey	May-10
104	23218-S104	316463	683236	0.05	18/12/2009	GRAVEL AND SAND	Disturbed	DRY	3600	White	3.600	900.0	JSR	Container Store	Found during beach Survey (north eastern area)	Monitoring Survey 3	B	Survey	May-10
105	23218-S105	316454	683251	0.1	04/03/2010	GRAVEL AND SAND	Disturbed	DRY	10000	White	10.000	2500.0	CN	Container Store	Found during beach Survey (north eastern area)	Monitoring Survey 4	B	Survey	May-10
106	23218-S106	316445.94	683253.51	0.1	07/04/2010	SAND AND GRAVEL	Disturbed	DRY	6060	White	6.060	1515.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
107	23218-S107	316411	683288	0.1	07/04/2010	SAND AND GRAVEL	Disturbed	DRY	2000	White	2.000	500.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
108	23218-S108	316410	683289	0.1	07/04/2010	SAND AND GRAVEL	Disturbed	DRY	1081	White	1.081	270.3	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	

Annex A

23218 - Dalgety Bay Sampling Log

Notes:
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*** Total nominal activity is based on the nominal source activity and an assumed average weigth of 250g per sample

Entry No.	Sample Reference	Sample Location (Eastings)	Sample Location (Northings)	Depth (m bgl)*	Date & Time Taken	Material Description / Main Constituents	Disturbed / Undisturbed	Wet / Dry	Field Probe Reading (cps)	Probe Used	Nominal Source Activity** (Bq/g)	Total Nominal Activity*** in Sample (Bq)	Sampler	Sample Storage Location	Comments	Campaign	Zone	Intrusive / Surface Survey	Sent for gamma-spec?
109	23218-S109	316380	683297	0	07/04/2010	CLINKER PIECE	Disturbed	DRY	16300	White	16.300	4075.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
110	23218-S110	316193.15	683403.53	0.2	07/04/2010	SAND AND GRAVEL	Disturbed	DRY	4260	White	4.260	1065.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
111	23218-S111	316412.98	683292.9	0.2	07/04/2010	CLINKER AND SOIL	Disturbed	DRY	4500	White	4.500	1125.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
112	23218-S112	316408	683290	0.2	08/04/2010	CLINKER PIECE	Disturbed	DRY	1600	White	1.600	400.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
113	23218-S113	316326.01	683318.05	0.1	08/04/2010	MUD AND GRAVEL	Disturbed	WET	2030	White	2.030	507.5	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
114	23218-S114	316446	683228	0	08/04/2010	SAND AND FINE GRAVEL	Disturbed	DRY	8400	White	8.400	2100.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
115	23218-S115	316522.06	683196.8	0	08/04/2010	CLINKER LUMP	Disturbed	DRY	2000	White	2.000	500.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
116	23218-S116	316453.98	683277.35	0.1	08/04/2010	SAND AND GRAVEL	Disturbed	DRY	2900	White	2.900	725.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
117	23218-S117	316465.72	683046.41	0.05	09/04/2010	CLINKER LUMP	Disturbed	DRY	8900	White	8.900	2225.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
118	23218-S118	316150.41	683427.22	0.1	09/04/2010	MUD AND SAND	Disturbed	DRY	2600	White	2.600	650.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
119	23218-S119	316423	683042.2	0.2	09/04/2010	SAND	Disturbed	DRY	3900	White	3.900	975.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
120	23218-S120	316490	683098	0.1	09/04/2010	GRAVEL AND SAND	Disturbed	DRY	7600	White	7.600	1900.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	A	Survey	
121	23218-S121	316480	683084	0	09/04/2010	GRAVEL AND SAND	Disturbed	DRY	2750	White	2.750	687.5	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
122	23218-S122	316497	683102	0.15	09/04/2010	SAND AND GRAVEL	Disturbed	WET	1200	White	1.200	300.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	A	Survey	
123	23218-S123	316489	683129	0	09/04/2010	CLINKER PIECE	Disturbed	DRY	2900	White	2.900	725.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	A	Survey	
124	23218-S124	316536	683131	0.05	09/04/2010	SAND AND GRAVEL	Disturbed	WET	2800	White	2.800	700.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
125	23218-S125	316521	683159	0	09/04/2010	SAND AND GRAVEL	Disturbed	DRY	2200	White	2.200	550.0	JSR	Container Store	Found during beach survey following storm event	Monitoring Survey 5	B	Survey	
126	23218-S126	316492.77	683115	0	18/05/2010	CLINKER PIECE	Disturbed	DRY	6000	White	6.000	1500.0	SP	Container Store	Beach survey: between slips	Monitoring Survey 6	A	Survey	
127	23218-S127	316350.29	683313.71	0.1	19/05/2010	SAND AND GRAVEL	Disturbed	DRY	7000	White	7.000	1750.0	CN	Container Store	Beach survey: N area	Monitoring Survey 6	B	Survey	
128	23218-S128	316283.83	683316.89	0.1	19/05/2010	SAND AND GRAVEL	Disturbed	DRY	2000	White	2.000	500.0	CN	Container Store	Beach survey: N area	Monitoring Survey 6	B	Survey	
129	Missed Sample 1	316466	683023						7785						Area near to New Harbour		B	Survey	
130	Missed Sample 2	316531	683096						2705						Area near end of Jetty		A	Survey	
131	Missed Sample 3								2200							TP 17 November intrusive works 09	A	Survey	

Annex B
Photographs

1 Page

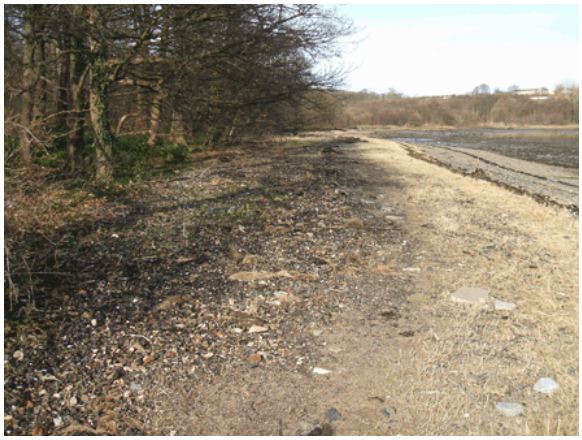

Plate 1: General View of Beach Material Cast onto Land Areas

Plate 2: Erosion Adjacent to Dingy Park

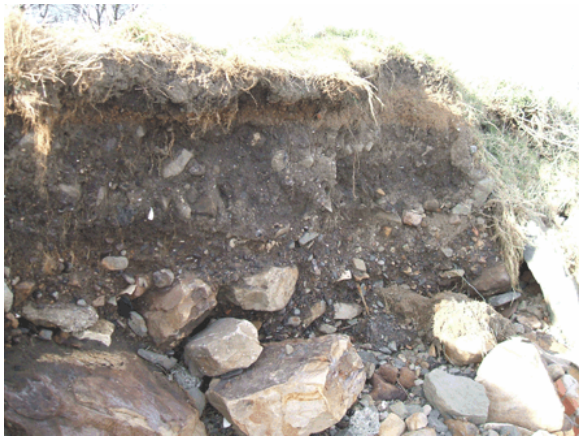

Plate 3: Damage and Erosion to Area Formerly Protected by Rock Armour

Plate 4: General Damage in Northern Portion of Bay Area

Annex C
Laboratory Analysis Certificates

6 Pages

Certificate of Testing

of radiological samples issued by
Dstl Environmental Sciences Department
for Job Number : 006/10

[dstl]

Administration

Laboratory Address	**Dstl Environmental Sciences Department** **Radiochemistry Laboratory** Institute of Naval Medicine Crescent Road, Alverstoke Gosport, Hants, PO12 2DL Tel 023 92768164 Fax 023 92768150	Customer Name:	R Brown
		Customer Address:	Bld34, Alverstoke
Date of Receipt:		Date of Testing:	

Analysis and Reporting

Analysis Type and Technical Comments:	These soil samples have been analysed by Gamma Spectrometry. The reporting units are Bq/kg for the samples marked with * and Bq for all other samples.

Reporter: Matthew Simpson cn=Matthew Simpson, c=GB, o=DSTL, ou=ESD, email=msimpson1@dstl.gov.uk 2010.02.01 11:25:43 Z

Countersigner: Digitally signed by Terry Gingell DN: cn=Terry Gingell, o=Dstl, ou=ESD, email=tgingell@dstl.gov.uk, c=GB Date: 2010.01.26 19:29:12 Z

Information

The reported uncertainty is calculated from both the counting and preparation. The confidence level is 95% (k factor = 1.96). It provides traceability of measurement to recognised national standards and to the units realised by the National Physical Laboratory or other recognised National Standards Laboratory. This certificate may not be reproduced other than in full, except with the prior approval of the issuing laboratory.

Certificate of Testing

of radiological samples issued by
Dstl Environmental Sciences Department
for Job Number : 006/10

[dstl]

Sample Analysis Reference No.	Customer's Reference	^{40}K	^{60}Co	^{137}Cs	^{208}T	^{212}Pb	^{214}Pb	^{214}Bi	^{226}Ra	^{228}Ac	^{234}Th	^{235}U	Sample mass (g)
0b006001	S007	<392	<40	<35	<32	<66	47217±2937	38899±2424	25154±1730	<128	<1039	<251	8.62
0b006002	S022	<207	<22	<20	<21	<33	13239±828	13102±821	12380±854	<76	<684	<140	9.79
0b006003	S026	<264	<30	<22	<24	<38	18343±1145	17442±1090	17254±1723	<72	<668	<272	17.83+5.35
0b006004	S034	<177	<19	<18	<19	<33	11221±703	11264±707	10455±859	<6	<608	<124	0.41
0b006005	S042	<157	<16	<14	<14	<20	7228±455	7189±454	6418±478	<48	<425	<95	0.11
0b006006	S048	<465	<62	<55	<56	<97	89160±5542	87224±5423	89321±6058	<135	<1565	<365	7.25+3.46
0b006007	S067	<265	<25	<21	<22	<37	19054±1189	18584±1161	20305±1583	<67	<627	<154	<0.01
0b006008	S083	<997	<97	<90	<87	<458	140711±8744	147398±9161	84584±5471	<294	<3207	<544	10.20
0b006009	S085	Not analysed											
0b006010	S007 *	600±98	<2	<4	13±6	33±7	73±14	84±12	125±68	35±11	<138	<8	-
0b006011	S022 *	293±56	<2	<3	6±3	18±4	673±44	572±43	816±80	21±6	<156	<7	-
0b006012	S026 *	196±24	<1	<2	5±2	11±2	45±6	4±5	60±20	15±3	<54	<2	-
0b006013	S034 *	310±34	<1	<2	7±2	20±3	58±6	57±7	74±26	25±6	<70	<3	-
0b006014	S042 *	309±37	<1	<2	7±2	16±3	121±10	119±12	181±95	25±9	<96	<4	-
0b006015	S048 *	307±50	<3	3±2	5±3	19±4	611±40	576±38	668±134	17±7	<162	<7	-
0b006016	S067 *	323±37	<1	<2	9±2	21±3	75±8	70±7	111±32	22±5	<84	<4	-
0b006017	S083 *	319±34	<1	3±1	5±3	12±2	101±8	93±8	232±40	16±4	<67	<3	-
0c006rad	S007 unopened	<556	<51	<51	<49	<114	63148±3836	53536±3258	64308±4360	<198	<1929	<439	-
0C006grt	Dirt from handling*	<221	<4	<8	<13	<22	6091±437	5771±436	8095±1399	<512	<831	<28	-

[ ] Certificate of Testing

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Dstl Environmental Sciences Department
for Job Number : 016/10

[dstl]

Administration

Laboratory Address	**Dstl Environmental Sciences Department** **Radiochemistry Laboratory** Institute of Naval Medicine Crescent Road, Alverstoke Gosport, Hants, PO12 2DL Tel 023 92768164 Fax 023 92768150	Customer Name:	R Brown
		Customer Address:	Bld34, Alverstoke
Date of Receipt:		Date of Testing:	

Analysis and Reporting

Analysis Type and Technical Comments: These soil samples have been analysed by Gamma Spectrometry. The reporting units are Bq/kg.

Reporter: JGO. Digitally signed by Terry Gingell DN: cn=Terry Gingell, o=Dstl, ou=ESD, email=tgingell@dstl.gov.uk, c=GB Date: 2010.02.24 11:53:20 Z

Countersigner: JGO. Digitally signed by Terry Gingell DN: cn=Terry Gingell, o=Dstl, ou=ESD, email=tgingell@dstl.gov.uk, c=GB Date: 2010.02.24 11:51:43 Z

Information

The reported uncertainty is calculated from both the counting and preparation. The confidence level is 95% (k factor = 1.96). It provides traceability of measurement to recognised national standards and to the units realised by the National Physical Laboratory or other recognised National Standards Laboratory. This certificate may not be reproduced other than in full, except with the prior approval of the issuing laboratory.

Certificate of Testing

of radiological samples issued by
Dstl Environmental Sciences Department
for Job Number : 016/10

Sample Analysis Reference No.	Customer's Reference	^{40}K	^{60}Co	^{137}Cs	^{208}TL	^{212}Pb	^{214}Pb	^{214}Bi	^{226}Ra	^{228}Ac	^{234}Th	^{235}U	^{241}Am
0b016001	Rock 1	199.7±31.3	<0.8	<1.2	2.7±1.3	<3.5	8.4±3.9	5.8±2.5	<33.5	<5.2	<66.3	<2.2	<6.1
0b016002	Rock 2	192.8±28.6	<0.8	<0.9	<2.0	4.9±2.3	11.0±3.7	10.7±3.0	<28.9	8.8±4.0	<63.8	<2.2	<4.9

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Certificate of Testing

of radiological samples issued by
Dstl Environmental Sciences Department
for Job Number : 148/10

Administration

Laboratory Address	**Dstl Environmental Sciences Department** **Radiochemistry Laboratory** Institute of Naval Medicine Crescent Road, Alverstoke Gosport, Hants, PO12 2DL Tel 023 92768164 Fax 023 92768150	Customer Name: Customer Address:	Guy Hitchins Entec UK Ltd (Gosforth)
Date of Receipt:	27/04/10	Date of Testing:	05/05/10

Analysis and Reporting

Analysis Type and Technical Comments:	These soil samples have been analysed by Gamma Spectrometry. The result quoted for ^{226}Ra is only an estimate and not covered by the UKAS accreditation. The reporting units are Bq/kg. * These results (5, 8, 9) are estimates as they were too large to re-pot (and weigh) and 9 was not counted on the normal geometry for samples of this type.

Reporter: Digitally signed by Alison Boler
DN: cn=Alison Boler, o=DSTL, ou=ESD, email=acboler@dstl.gov.uk, c=GB
Date: 2010.05.20 11:56:34 +01'00'

Countersigner: Matthew Simpson
cn=Matthew Simpson, c=GB, o=DSTL, ou=ESD, email=msimpson1@dstl.gov.uk
2010.05.20 11:48:54 +01'00'

Information

The reported uncertainty is calculated from both the counting and preparation. The confidence level is 95% (k factor = 1.96). The certificate is issued in accordance with the requirements of the United Kingdom Accreditation Service as specified in the UKAS Accredited Standard and UKAS regulations. It provides traceability of measurement to recognised national standards and to the units realised by the National Physical Laboratory or other recognised National Standards Laboratory. This certificate may not be reproduced other than in full, except with the prior approval of the issuing laboratory. The * denotes the ^{226}Ra result is only an estimate based on the activity of the daughter products and the deconvolution of the spectral peaks and therefore not covered by the UKAS accreditation.

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Certificate of Testing

of radiological samples issued by
Dstl Environmental Sciences Department
for Job Number : 148/10

Sample Analysis Reference No.	Customer's Reference	^{40}K	^{60}Co	^{137}Cs	^{208}TL	^{212}Pb	^{214}Pb	^{214}Bi	^{226}Ra*	^{228}Ac	^{234}Th	^{235}U	^{241}Am
10c148001	Sand/ Gravel SO88	<1359	<332	<139	<147	<303	460730±27913	397789±24107	559548±34705	<498	<12340	<429	<1591
10c148002	Sand/ Gravel SO89	<5650	<1428	<471	<500	<991	2288229±138607	2009921±121757	2668240±165185	<1710	<63002	<1342	<5018
10c148003	Sand/ Gravel SO90	<756	<236	<81	<85	197±114	391651±24328	352057±21869	449664±28222	<242	<6938	<230	<908
10c148004	Sand/ Gravel SO91	<1259	<163	<63	<90	215±114	171997±10426	151529±9192	194528±13021	<304	<5907	<247	<899
10c148005*	Clinker SO92	<211	<18	<18	<21	<43	37728±2343	39316±2441	396677±2582	<589	<1417	<53	<183
10c148006	Sand/ Gravel SO93	<404	<115	<59	<34	<81	125836±7809	115491±7167	146731±9309	<102	<10524	<98	<1071
10c148007	Sand/ Gravel SO94	613±267	<233	<39	<42	<91	155492±9660	148038±9197	153807±9611	<142	<3458	<115	<451
10c148008*	Clinker SO95	<147	28±15	<13	<15	<29	25719±1598	24047±1495	29073±1919	<48	<1193	<42	<140
10b148009*	Clinker SO96	<121	<15	<13	<15	<31	17904±1099	18929±1162	17940±1242	<50	<537	<33	<56
10c148010	Sand/ Gravel SO97	<3994	<382	<327	<343	<647	1517861±91940	1208317±73207	1646278±100084	<1225	<23152	<995	<3556
10c148011	Sand/ Gravel SO98	<2239	<1319	<424	<209	1465±266	1949357±118065	1650286±99955	2220948±135056	<597	<15248	<534	<2086
10c148012	Sand/ Gravel SO99	<869	<317	<89	<96	204±120	476924±28888	425660±25784	544536±33378	506±207	<5943	<249	<2015
10c148013	Sand/ Gravel SO100	777±455	<167	<51	<56	145±75	151665±9423	156838±9744	142972±9182	<112	<3951	<130	<516
10c148014	Sand/ Gravel SO101	411±138	<4	<7	<15	44±18	617±56	572±65	<404	<45	<800	<26	<92
10c148015	Sand/ Gravel SO102	<346	<38	<34	<37	<79	59790±3626	57031±3459	64066±4198	<107	<4498	<93	<340
10b148016	Sand/ Gravel SO103	<1412	<206	<112	<107	<190	188076±11675	175195±10879	212023±13977	<319	<4247	<280	<551
10b148017	Sand/ Gravel SO104	<627	<212	<54	<5	<106	105401±6540	103080±6398	115913±7684	<204	<2043	<136	<553
10b148018	Sand/ Gravel SO105	323±176	<50	<26	<30	<53	66837±4097	63780±3910	71138±4515	<92	<1260	<70	<326