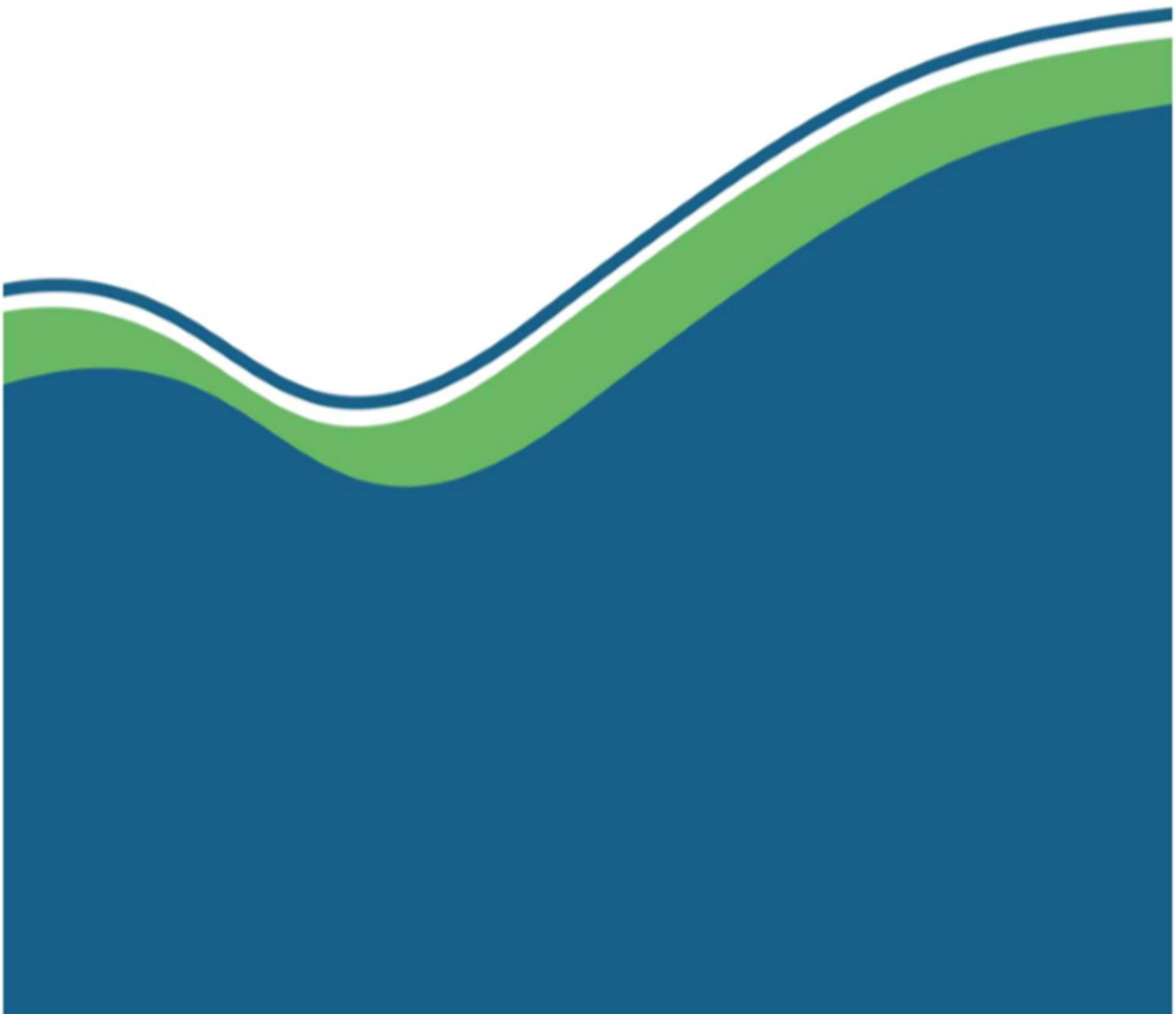
SEPA
Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

Radiological Habits Survey: Dounreay 2018



Radiological Habits Survey: Dounreay 2018

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List of Abbreviations and Definitions

ALB	All Weather Lifeboat
BSS	Basic Safety Standards
CEFAS	Centre for Environment, Fisheries and Aquaculture
DCC	Dose Conversion Coefficient
DORIS	Dispersion of Radionuclides into the Sea
DSRL	Dounreay Site Restoration Limited
ERL	Environmental Radioactivity Laboratory, University of Stirling
FEPA	Food and Environment Protection Act
GPS	Global Positioning System
GRANIS	Gamma Radiation above Nuclides in Soil
HSE	Health and Safety Executive
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
LLW	Low Level Waste
MET	Meteorological
MoGSS	Mobile Gamma Spectrometry System
MoD	Ministry of Defence
NDA	Nuclear Decommissioning Authority
NDAWG	National Dose Assessment Working Group
ONR	Office of Nuclear Regulation
PC-CREAM	Consequences of Releases to the Environment: Assessment Methodology
RESUS	The Re-Suspension Model
RIFE	Radioactivity in Food and the Environment
RNLI	Royal National Lifeboat Institute
RSA	Radioactive Substances Act 1993
SEPA	Scottish Environment Protection Agency
UKAS	United Kingdom Accreditation Service

Units

Bq	Becquerel	M	milli (one thousandth, E^{3})
TBq	TeraBecquerel	µ	micro (one millionth, E^{-6})
Gy	gray	%	percentage
[H*(0.07)]	Directional dose equivalent at 0.07 mm skin depth	Ha	hectare
Sv	Sievert	Km	kilometre
mSv	milliSieverts	M	metres
µSv	microSieverts	cm	centimetre
nGy	nano Gray	y^{-1}	per year
eV	electron-volt	w^{-1}	per week
keV	kiloelectron volt	d^{-1}	per day
L	litres	h^{-1}	Per hour
M	Mega (one million, E^{6})	Hz	Hertz

Summary

This report presents the results of the 2018 habits survey to determine the habits and consumption patterns of people living and undertaking recreational activities in the vicinity of the Dounreay nuclear licensed site. The Dounreay Site Restoration Limited (DSRL) operation at Dounreay is authorised by SEPA to discharge low level effluent into the Pentland Firth via a pipeline outfall 600 m offshore and gaseous discharges via several stacks. The Vulcan facility also discharges gaseous waste to the atmosphere and liquid waste to the sea via the DSRL outfall, which discharges into the Pentland Firth.

The survey targeted three areas that were likely to be affected by discharges from the site, defined as:

- An aquatic survey area; this included the intertidal areas and waters of the Pentland Firth extending from Armadale Bay in the west to Dunnet Head in the east;
- A terrestrial survey area; this included a 5 km radial zone from the Dounreay nuclear licensed site boundary extending to Crosskirk in the east and Red Point in the west; and,
- The direct radiation survey area; extending from the boundary of the nuclear licensed site (covering housing and land use close to the site) which relates to ionising radiation emanating directly from the site.

Interviews with members of the public were carried out over a period of 14 days split into two periods, the first conducted between 24th – 30th May and the second repeated between 5th – 11th July at both terrestrial and coastal sites to assess the seasonal difference between the pre-school holiday period and the local school holiday period. A total of 398 individual surveys are presented and discussed. Those high-rate individuals are identified using established methods comprising a ‘cut-off’ to define the high-rate group and 97.5th percentiles for dose assessment analysis. The face-to-face surveys were followed up in late August and early September of 2018 as a means of validation and are discussed within the report. The two survey periods are referred to

as Phase 1 (one week in each of May and July 2018) and Phase 2 (validating surveys undertaken in late August/September 2018).

The aquatic survey area

Fish, crustaceans and molluscs are consumed by adults within the survey area. The mean consumption rates for adult high-rate groups for each of these food groups were:

- 66.3 kg y^{-1} for fish (comprising bass, cod, mackerel, pollock, haddock, salmon, sea trout, plaice, flounder, monk fish, lemon sole, halibut, whiting, hake and ling);
- 26.2 kg y^{-1} for crustaceans (comprising brown crab, common lobster and prawn); and,
- 21.3 kg y^{-1} for molluscs (comprising mussels, scallops and whelks).

Seaweed was found to be used by five individuals collected from the shores at Sandside Bay, Sandside Harbour and Crosskirk Bay for use as a fertiliser on their gardens (for vegetables). One individual reported to collect a small quantity of seaweed from Scrabster beach for their own consumption.

The mean occupancy rates for the adult high-rate group within the aquatic survey area were:

- 1 103 h y^{-1} for intertidal activities;
- 679 h y^{-1} for activities in the water;
- 2 008 h y^{-1} for activities on the water;
- 1 945 h y^{-1} for handling of equipment; and,
- 730 h y^{-1} for handling of sediment.

The terrestrial survey area

The mean consumption rates for the adult high-rate groups for terrestrial foods were:

- 39.9 kg y^{-1} for green vegetables;
- 25.7 kg y^{-1} for other vegetables;
- 33.6 kg y^{-1} for root vegetables;
- 77.0 kg y^{-1} for potatoes;
- 166 kg y^{-1} for domestic fruit;

- 1.00 kg y^{-1} for wild fruit;
- 5.00 kg y^{-1} for wild fungi;
- 52.0 kg y^{-1} for beef;
- 6.75 kg y^{-1} for game birds;
- 43.3 kg y^{-1} for game (venison);
- 26.0 kg y^{-1} for sheep meat;
- 40.0 kg y^{-1} for pork;
- 42.4 kg y^{-1} for eggs; and,
- 0.20 kg y^{-1} for honey.

The direct radiation survey area

The highest occupancy rates in the direct radiation area were as follows (holidays taken into account):

- 8 760 h y^{-1} for the total occupancy rate (for a resident);
- 8 395 h y^{-1} for the indoor occupancy rate (for a resident); and,
- 1 225 h y^{-1} for the outdoor occupancy rate (for a resident).

A significant portion of the direct radiation survey area was surveyed by car-borne and back-pack gamma spectrometry.

Suggestions for changes to the monitoring programme

The following suggestions for changes to the current environmental monitoring programme are provided for consideration.

(i) It is recommended that apples within the domestic fruit food group be sampled as part of the monitoring programme. Consumption of apples was identified as being the highest contribution within the domestic fruit food group, as was also determined within the 2013 survey.

(ii) Despite no winkle pickers being identified in the 2018 survey, it is recommended that winkles remain to be part of the monitoring programme as winkle pickers were reported to be operating in the survey area.

(iii) It is recommended that pig meat be sampled and incorporated into SEPA's routine monitoring programme annually due to consumption of local pig meat being identified within the survey area.

(iv) It is recommended that venison be added to the routine monitoring programme. Wild venison was the highest consumption of meat identified within the survey area sourced from around Shebster and Sandside.

(v) Within the wild/free food groups, it was noted that the following are the most consumed: (a) blackberries were consumed around Borlum walk within the survey area; (b) nettles and meadow sweet were consumed within the Achvarasdal area. Consideration should be given to the inclusion of these additional food items within the routine sampling campaigns.

1 Introduction

1.1 Regulatory Context

Dounreay is a nuclear licensed site located on the coastline of Caithness, close to Thurso that covers an area of 54 hectares (Nuclear Decommissioning Authority (NDA), 2014) and operated three reactors. The site is currently undertaking decommissioning. The site previously held an Authorisation under the Radioactive Substances Act 1993 (as amended) (RSA93), which allows the disposal of solid, liquid and gaseous radioactive wastes. On 1st September 2018, the Environmental Authorisations (Scotland) Regulations 2018 (EASR18) came into effect replacing RSA93.

The impact of the disposal of the wastes is monitored in accordance with the requirements of Article 35 of the Basic Safety Standards (BSS) 96/29 Euratom Treaty to ensure that the total dose to the representative person is below both 1 mSv committed effective dose and the 50 mSv skin annual dose limit.

The site discharges radioactive effluent and gases into the environment that may result in the exposure of the public by three primary pathways of exposure to the public:

(i) discharges to the aquatic environment;
(ii) discharges to the atmosphere; and
(iii) direct exposure from the site.

From these pathways, members of the public may be exposed to radiation shine from the licensed site or through inhalation and/or indirectly due to exposure to contaminated materials and primarily foodstuffs (Smith and Jones, 2003). It is also recognised that enhanced doses from external exposure due to authorised discharges and the consumption of locally sourced foods may occur as a result of contemporary and historical discharges accumulating in the environment (Dale *et al.,* 2008; Tyler *et al*., 2013). It is the responsibility of the Scottish Environment Protection Agency (SEPA) to regulate the discharges from site to ensure that the public are not exposed to doses in excess of the legal limits. Exposure to direct shine from nuclear, radiation or waste facilities is the responsibility for the Office of Nuclear Regulation (ONR), (within a nuclear licensed site), and the Health and Safety Executive (HSE), (outside a nuclear licensed site) where any direct exposure impacts on facility workers.

1.2 Definition of the Representative Person

The optimal approach for assessing doses to the public is through a combination of site-specific habit data and an environmental monitoring programme to determine ambient dose rates and concentrations in foodstuffs. In addition to the various interactions an individual may have with exposure routes, the actual doses received are also dependent upon age, size and metabolism. Thus, the standard approach is to identify and consider these sources of variability in appropriate groups. The concept of the *representative person* was introduced by the International Commission on Radiological Protection, (ICRP), (2006) and recommended to replace the previously used concept of the *critical group* in 2007 (ICRP, 2007). The *representative person* is the individual that represents the more highly exposed members of the public and is typically defined by a cut-off, for example the top 97.5 % of the dose distribution within one or more routes of exposure. Within this concept, if the dose received by the *representative person(s)* can be demonstrated to be within the accepted dose limits and constraints, then the public are considered to be protected.

1.3 Dose Limits and Constraints

The system of dose limitation recommended by ICRP (2007), and subsequently by the Radioactive Substances BSS, requires that dose equivalents received by individuals shall not exceed the limits set out in Article 13 of Council Directive 96/29/Euratom (CEC, 1996).

The *retrospective* maximum permissible dose limits are set out as 1 mSv yr^{-1}. For *prospective* assessments, the maximum permissible doses or constraints used by SEPA are:

(i) 0.3 mSv yr^{-1} for any single source of radioactivity; and

(ii) 0.5 mSv yr^{1} for a single site from which radioactive discharges are made.

It is also accepted by the UK Government that it should be possible to operate existing nuclear facilities without exceeding the 0.3 mSv yr^{-1} constraint (Hunt *et al.,* 1982; Leonard *et al.,* 1982). It is therefore incumbent upon SEPA to ensure that these dose limits/constraints are not exceeded for all authorised discharges of ionising radiation to the environment.

1.4 Habits Survey Aim

The aim of the habits survey is to collect site-specific data to allow a bespoke assessment to be made that identifies the representative individual(s). The identification of the representative person is a result of combining known information on the consumption of local foods and occupancy times with data from SEPA's routine environmental monitoring programme. The survey aims to collect data on the consumption rates of locally grown foods and occupancy times to identify the doses to the most representative person(s). The survey also aims to identify any habits which the routine programme does not currently adequately cover and may recommend the adoption of new monitoring due to new or changing habits or the removal of monitoring that is no longer required. The survey does this by:

(i) Collecting data on a range of habits/activities by the general public in the environment immediately surrounding the nuclear site and surrounding areas that might lead to exposure to radioactivity or radiation from any combination of licensed liquid or gaseous discharges, or direct radiation from on-site activities at Dounreay;

(ii) Collecting information on consumption of food grown or produced (including wild & free foods) in the survey area and determining an annual rate of consumption for each individual surveyed and household members of all ages; and,

(iii) Quantifying the amounts of radioactivity, radiation and subsequent doses to individual members of the general public as a result of the discharges or operations of the nuclear site.

This report presents the findings for the 2018 habits survey of the Dounreay nuclear licensed site. All raw data can be found in Appendix A1. The previous survey was undertaken (fieldwork components) during the period July 16th to 30th, 2013 (Papworth *et al*., 2014).

2 The Survey

2.1 Introduction

This chapter describes the site characteristics including recent and prospective site activities, a dose assessment from licensed discharges to air and sea and the surrounding land cover characteristics. In preparation for the survey, a meeting was held with DSRL, the site operators in February 2018 and with the Ministry of Defence (MoD) in April 2018. To raise the profile of the survey, SEPA brought the Dounreay Habits Survey to the attention of the local stakeholders during the March 2018 stakeholder group meeting. In addition, an advertisement was placed in two local newspapers inviting local individuals for interviews, bringing the survey to the attention of the public.

2.2 Dounreay Site Activity

2.2.1 Current on-site activity

The Dounreay nuclear licensed site occupies 54 hectares (NDA, 2014) on the Caithness coastline close to the town of Thurso. The site consists of the reactor development site, which is operated by DSRL, a subsidiary of the Cavendish Dounreay Partnership Ltd, and the adjoining Vulcan Naval Reactor Test Establishment operated by the MoD. The site was first developed in 1955 with the primary aim to develop research reactors.

Three reactors were built and commissioned on the Dounreay site: Dounreay Materials Test Reactor was the first to begin operation in 1958; the Dounreay Fast Reactor was the second to start operation in 1959; and Prototype Fast Reactor was the third reactor to start in 1974. All three reactors and associated fuel processing activities ceased operation by 2006 (NDA, 2014) and are now currently the focus for the decommissioning activities by DSRL. The site is currently undergoing decommissioning with an interim end state in the early to mid 2020's (NDA, 2014). Fuel reprocessing operations previously undertaken on the Dounreay site have resulted in the inadvertent release of fragments of fuel, known as particles, into the marine environment. Following the discovery of the first particles in the offshore environment (Tyler *et al*., 2010), the site operators were required to introduce rapid and extensive beach monitoring, which has been in place for around twenty years and

the subject of a number of reports by the Dounreay Particles Advisory Group and the Particles Retrieval Advisory Group (Dounreay).

Particles are recovered routinely from the Dounreay foreshore which is largely inaccessible to the public) and Sandside Beach (Dounreay: https://dounreay.com/about/decommissioning-projects/particles/; SEPA: https://www.sepa.org.uk/regulations/radioactive-substances/nuclear-industry/).

The DSRL operation at Dounreay is authorised by SEPA to discharge low level effluent into the Pentland Firth via a pipeline outfall 600 m offshore and gaseous discharges via several stacks.

The Vulcan Naval Reactor Test Establishment was built around the same time as the Dounreay site and operated two reactors, one of which has been defuelled. The current reactor has yet to be defuelled. During this phase the Vulcan facility continues to discharge gaseous waste to the atmosphere and liquid waste to the sea via the DSRL outfall, which discharges into the Pentland Firth. Vulcan hold a Letter of Approval for the disposal of radioactive waste.

For the purposes of this report, both the DSRL and Vulcan sites shall be considered together as one site.

2.2.2 Off-Site Activity

DSRL operates an environmental monitoring programme around the site and across the local district. This monitoring programme considers the effects of liquid and aerial discharges from the site on land, water courses and the sea. The programme is periodically reviewed to reflect any changes identified for on/off-site activity in the local area.

2.2.3 Change Since 2013

In 2014 Dounreay published *A Guide to Closure* facilitated by the *Environmental Restoration Program Plan* providing an overview of the decommissioning project to reach an interim end state assumed to be in the 2030's. Site closure will be attained on a zone by zone basis, based on the restoration of 11 zones. The closure process

is based upon four distinct stages, decommissioning, demolition, remediation and restoration.

A new low-level waste (LLW) disposal site adjoins the licensed site. Planning permission was granted in 2009 with construction in three phases to construct six disposal vaults. Phase 1 was completed in 2014 and LLW waste being accepted from late April 2015.

2.3 Estimated Activity Concentrations from Licensed Discharges from Dounreay

Permitted liquid discharges from the site are: ^{3}H (6.90E+12 Bq y^{-1}); ^{90}Sr (1.77E+11 Bq y^{-1}); ^{137}Cs (6.29E+11 Bq y^{-1}); other alpha (modelled as ^{239}Pu (3.40E+09 Bq y^{-1})). Other non-alpha discharges (4.80E+10 Bq y^{-1}) were included in the ^{137}Cs calculations. These were used to calculate aquatic activity concentrations in water using the DORIS model within PC-CREAM (Public Health England, 2008). Assuming an effectively continuous release, activity concentrations were modelled in unfiltered seawater, fish, seaweed, crustaceans and molluscs, with outputs at 1, 5, 50, 500, 10 000 and 100 000 000 years. For all element dependent parameters (sediment distribution coefficients, K_d and deep water), local compartment details (depth, coastline length, volumetric exchange rate, suspended sediment load, sedimentation rate, sediment density and diffusion rate) and regional model information (volume, depth, suspended sediment load, sedimentation rate, sediment density, diffusion rate) the default values of the Dounreay area on PC-CREAM were used.

Activity concentration values reported at 50 years for unfiltered seawater in the survey area of Dounreay were estimated to be:

^{3}H, 4.37E-02 Bq l^{-1}

^{90}Sr, 1.12E-03 Bq l^{-1}

^{137}Cs, 4.29E-03 Bq l^{-1}

^{239}Pu, 2.11E-05

Activity concentrations in different foodstuffs (Table 2.1) were estimated as:

Table 2.1 Estimated activity concentrations in foodstuffs.

	^{3}H Bq kg^{-1}	**^{90}Sr Bq kg^{-1}**	**^{137}Cs Bq kg^{-1}**
Fish	4.37E-02	2.25E-03	3.97E-01
Crustaceans	4.37E-02	2.25E-03	1.19E-01
Molluscs	4.37E-02	1.12E-03	1.19E-01

Atmospheric activity concentrations were also modelled using the PLUME model in PC-CREAM. The permitted discharges from Dounreay of ^{3}H (1.72E+13 Bq y^{-1}), ^{85}Kr (5.69E+14 Bq y^{-1}), ^{129}I (1.08E+08 Bq y^{-1}), ^{137}Cs (as an analogue for other non-alpha) (1.70E+09 Bq y^{-1}) and ^{239}Pu (as an analogue for other alpha) (3.10E+07 Bq y^{-1}) were used as input. PLUME was set to calculate activity concentrations released. The activity concentrations in air for discharges from five stacks of 0 to 30 m height are reported here over a range of distances from 500 m to 25 km. The meteorological (MET) sampling scheme was applied using the default settings. However, the data extracted for the dose rates were based on the MET Pasquill D with rain category as being most typical of the UK weather (see Chapter 7). The calculated activity concentrations in air are presented in Table 2.2.

The GRANIS (external exposure model) and RESUS (resuspension model) modules in PC-CREAM were to estimate the external dose rates at the same specified distances from the Dounreay site, using the data presented in Table 2.2.

Table 2.2 Calculated activity concentrations in air (Bq m^{-3}) for permitted discharges from Dounreay discharged from five stacks at 0 to 30 m height.

Distance (m)	^{3}H	^{85}Kr	^{129}I	^{137}Cs	^{239}Pu
500	4.18E-01	1.38E+01	2.58E-06	4.12E-05	7.54E-07
1 000	1.85E-01	6.09E+00	1.12E-06	1.80E-05	3.25E-07
5 000	1.43E-02	4.73E-01	7.80E-08	1.31E-06	2.35E-08
10 000	4.78E-03	1.58E-01	2.32E-08	4.03E-07	7.24E-09
15 000	2.57E-03	8.45E-02	1.13E-08	1.99E-07	3.60E-09
20 000	1.67E-03	5.49E-02	6.66E-09	1.20E-07	2.15E-09
25 000	1.19E-03	3.95E-02	4.36E-09	7.98E-08	1.44E-09

Assessed as: ^{3}H (1.72E+13 Bq y^{-1}); ^{85}Kr (5.69E+14 Bq y^{-1}); ^{129}I (1.08E+08 Bq y^{-1}); ^{137}Cs (as analogue for other non-alpha) (1.70E+09 Bq y^{-1}); and, ^{239}Pu (as analogue for other alpha) (3.10E+07 Bq y^{-1}).

Table 2.3 reports the estimated external doses modelled from PC-CREAM for adults, children and infants.

Table 2.3 Modelled Total External Doses (µSv y^{-1}) to adults, children or infants at the specified distances from Dounreay's five stacks after 50 years of release.

Distance (m)	Adult	Child	Infant
500	4.20E-01	3.41E-01	2.56E-01
1 000	2.37E-01	1.90E-01	1.40E-01
5 000	2.95E-02	2.33E-02	1.70E-02
10 000	1.07E-02	8.48E-03	6.18E-03
15 000	6.06E-03	4.81E-03	3.51E-03
20 000	4.09E-03	3.25E-03	2.38E-03
25 000	3.05E-03	2.42E-03	1.77E-03

2.4 Survey Areas

The modelling of PC-CREAM (Section 2.3) demonstrates very low activity concentrations within the Pentland Firth as a result of liquid discharges and in the surrounding environment from gaseous discharges from the Dounreay site. The survey area for the 2018 Habits Survey is designed to encompass the marine and terrestrial environments likely to be affected by discharges, including the area of

potential direct radiation *shine* from ionising radiation emanating directly from the Dounreay nuclear licensed site.

These areas are consistent with the previous habits survey and are shown in Figure 2.1 and Figure 2.2. However, the terrestrial survey area extends from the site boundary compared to the site centre in the 2013 survey.

The 2018 survey areas focus on:

(i) The 1 km zone from the boundary of the nuclear licensed site (covering housing and land-use close to the site) which relates to the ionising radiation directly from the site;
(ii) The terrestrial survey areas included the 5 km radial zone from the Dounreay nuclear licensed site boundary; and,
(iii) The aquatic survey areas include the intertidal areas and waters of the Pentland Firth extending from Armadale Bay in the west to Dunnet Head in the east. Particular attention will be paid to fishing activities near the 2 km marine exclusion zone around the site and intertidal activities on Sandside Bay.

2.5 Land Cover Data

The land cover is presented in Figure 2.3. The Dounreay site is immediately surrounded by an area of improved grassland on all sides with the exception of a small coastal strip to the north east of the site boundary which is unimproved grassland. It is in this latter area that the new LLW facility has been constructed.

Within 5 km of the site, the main land use is agricultural with improved grassland for animal grazing. Isolated houses and farmsteads are scattered throughout the zone.

Beyond the 5 km zone, to the west of the site, the coastal fringe is predominantly unimproved heather grassland with improved grassland along river valleys and estuaries. To the east, as far as Castletown, the land is predominantly improved grassland with extensive agricultural activity. Thurso is the largest urban area within 20 km with a population of 7 933 followed by Castletown with a population of 798 (2011 census). Beyond Castletown, land use is unimproved grassland behind Dunnet Beach

with a small area of plantation. Around Dunnet village the land use is improved grassland whilst Dunnet Head is acid grassland.

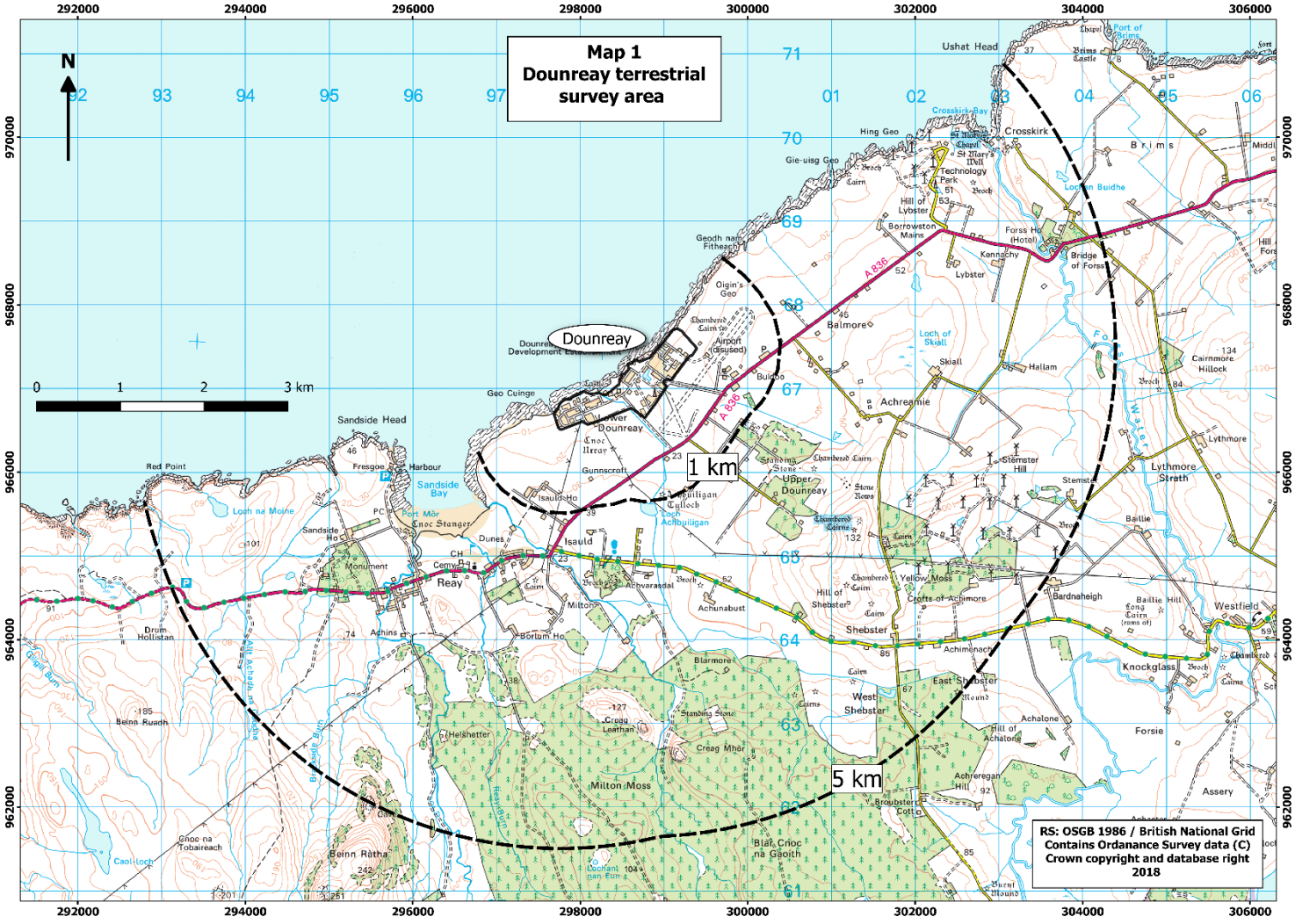

Figure 2.1 The terrestrial survey area for the 2018 Dounreay Habits Survey.

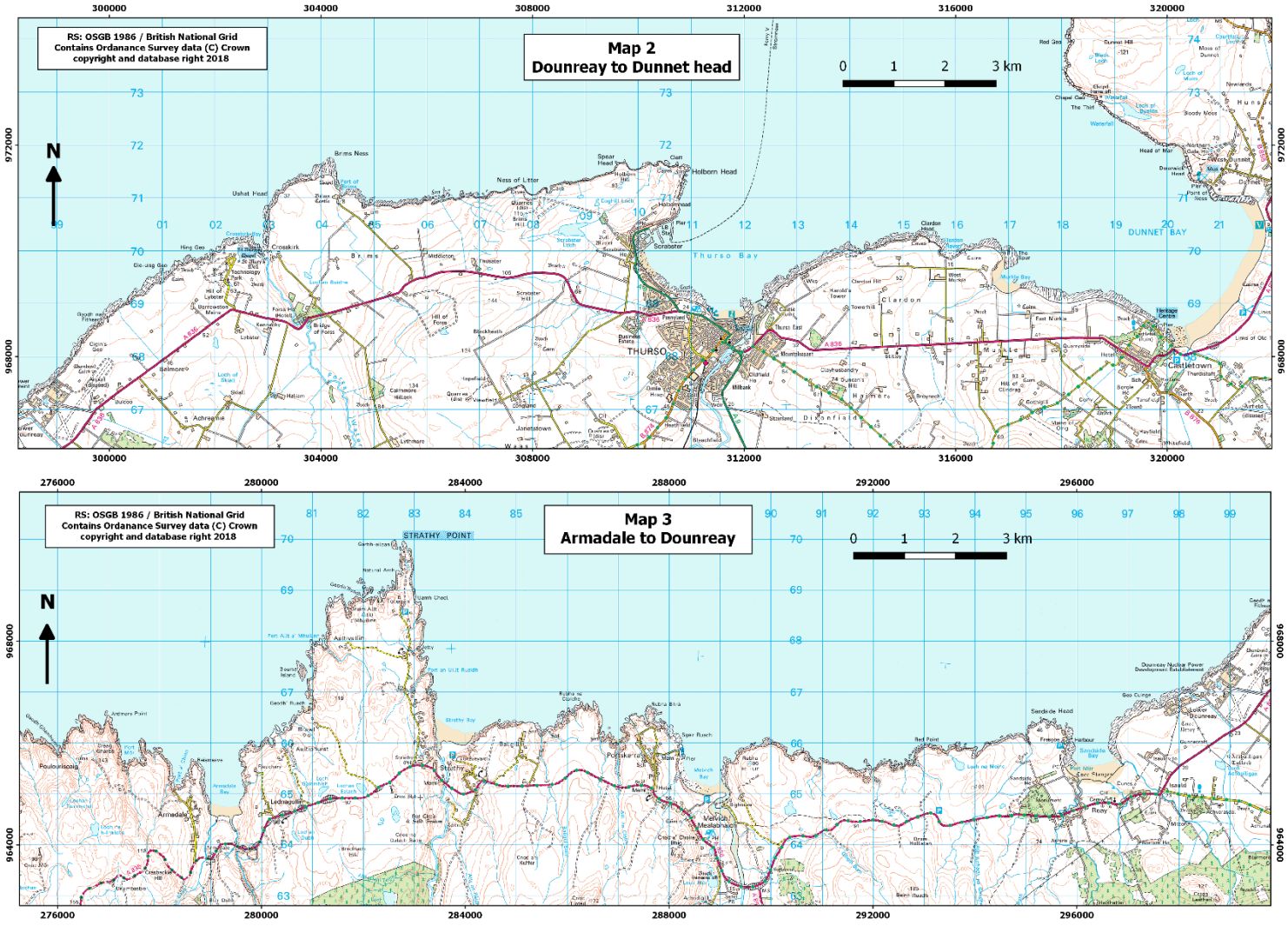

Figure 2.2 The aquatic and intertidal survey area for the 2018 Dounreay Habits Survey.

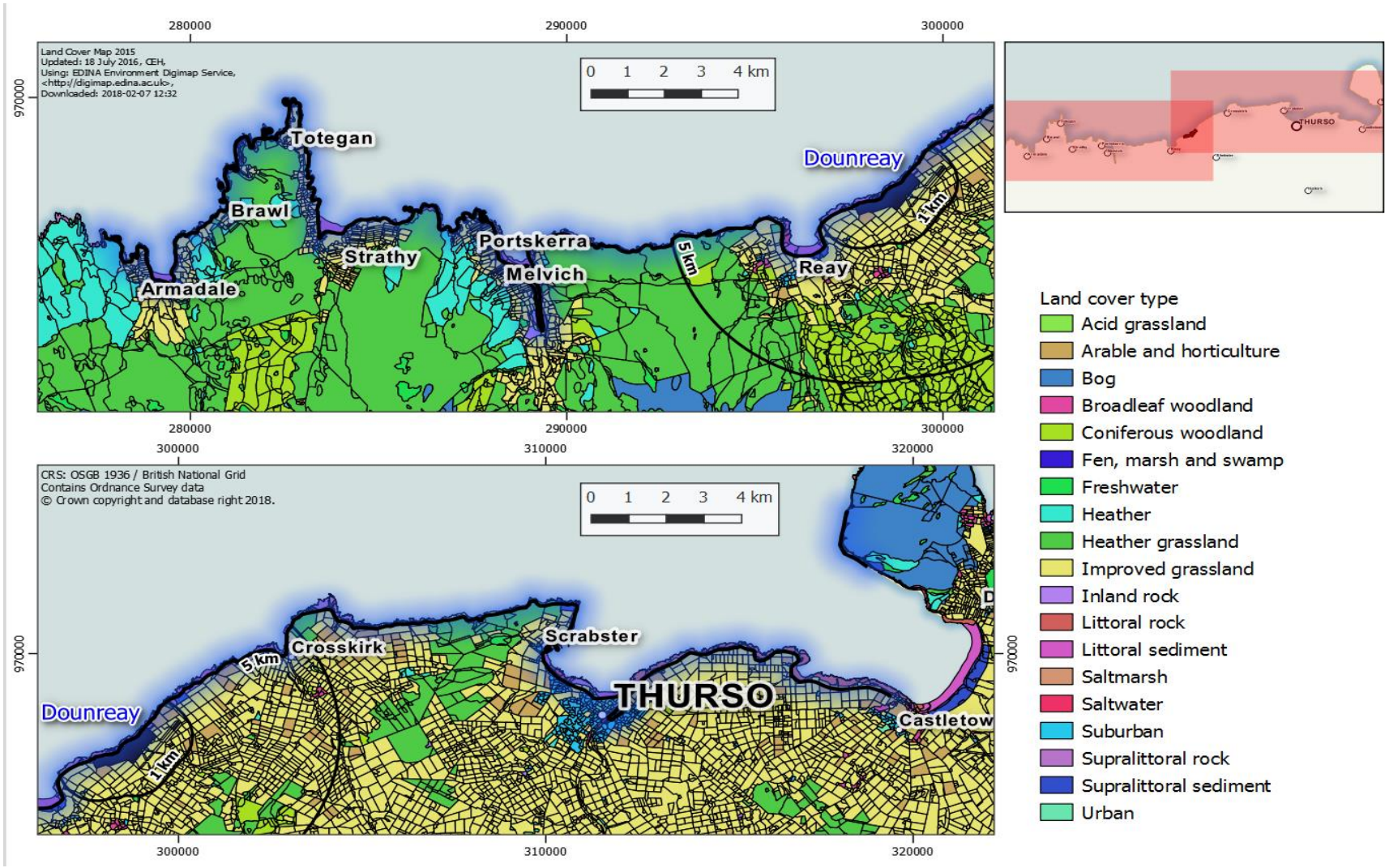

Figure 2.3 The land cover characterising the Dounreay survey area and surrounds (Land Cover Map, 2015; Ordnance Survey Great Britain, 2018).

2.6 Soil Data

The soil data are presented in Figure 2.4. The Dounreay site sits on an area of non-calcareous gley soils which is the most common soil type to the east of the site around the coastal fringe as far as Castletown. Brown calcareous soils surround Dunnet Bay with a small area of brown earths around Dunnet village. Dunnet Head is covered by peaty gley podzols. Westwards, along the coast to Armadale Bay, the soils are more varied with differing peaty soil types including peaty podzols, peat and peaty gleys.

2.7 Topographic Wetness Index

Catchment hydrology can be important in the redistribution of radionuclides. For example, organic soils can allow radionuclides (e.g. ^{137}Cs from fallout) to be transported in solution as well as in particulate form. When these hydrological flow paths cross from organic to mineral rich soils, the radionuclides can become bound to clays and oxides within the soil matrices. In extreme conditions, these areas have been shown to result in elevated concentrations of radioactivity (Tyler and Heal, 2000). Building on the soil and 50 m resolution digital elevation model for Scotland using the OS Terrain 50 product (https://www.ordnancesurvey.co.uk/business-and-government/products/terrain-50.html). Figure 2.5 shows details of the hydrological flow paths within the survey area. The lighter area indicates low flow, water flowing away, whilst areas of increasing blueness represent wetter areas. This provides more detail of hydrological flow paths than would otherwise be possible from standard maps and highlights areas where radionuclides from atmospheric fallout might accumulate.

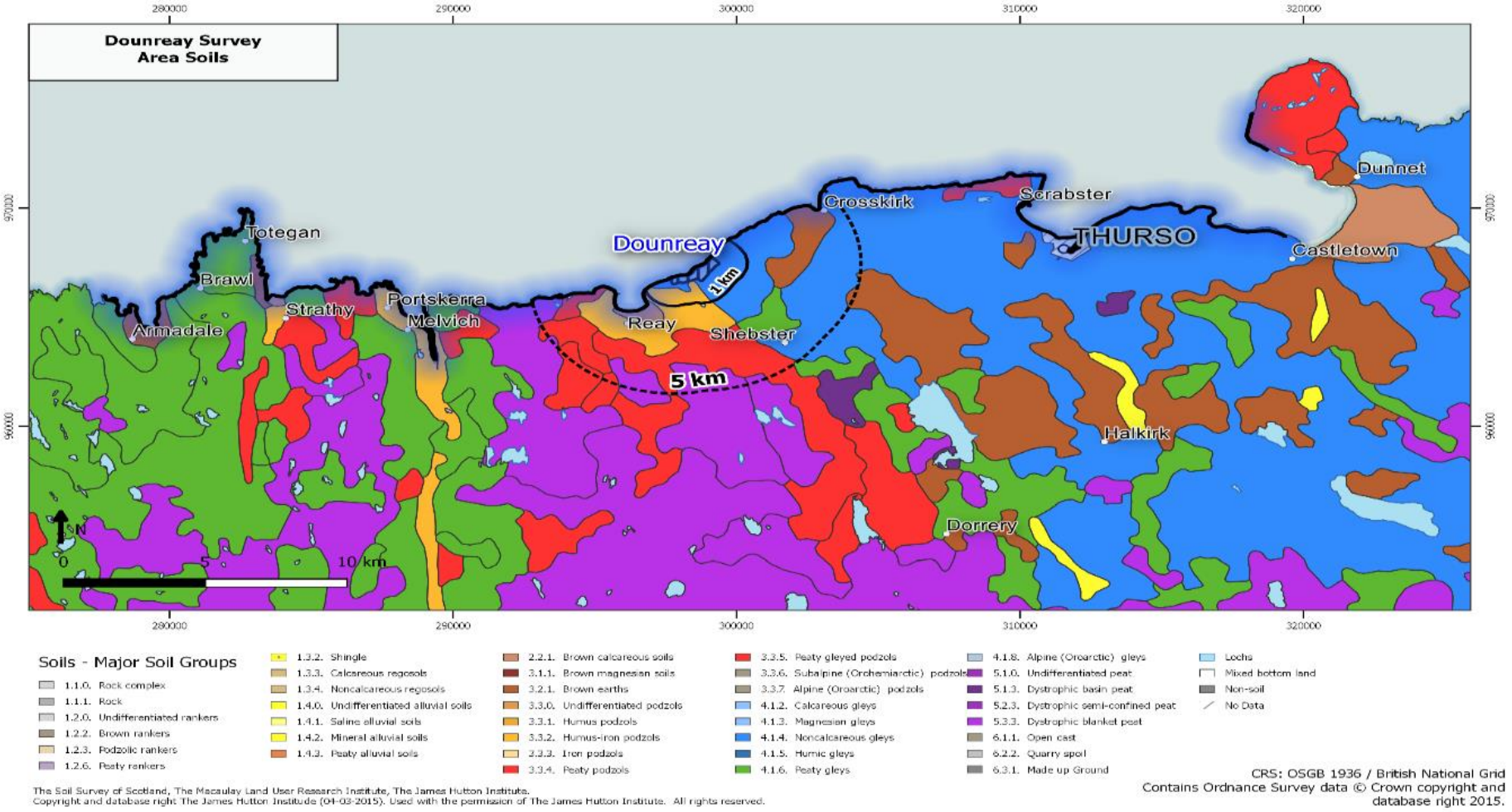

Figure 2.4 Soil types dominating the Dounreay survey area (The James Hutton Institute, 2015).

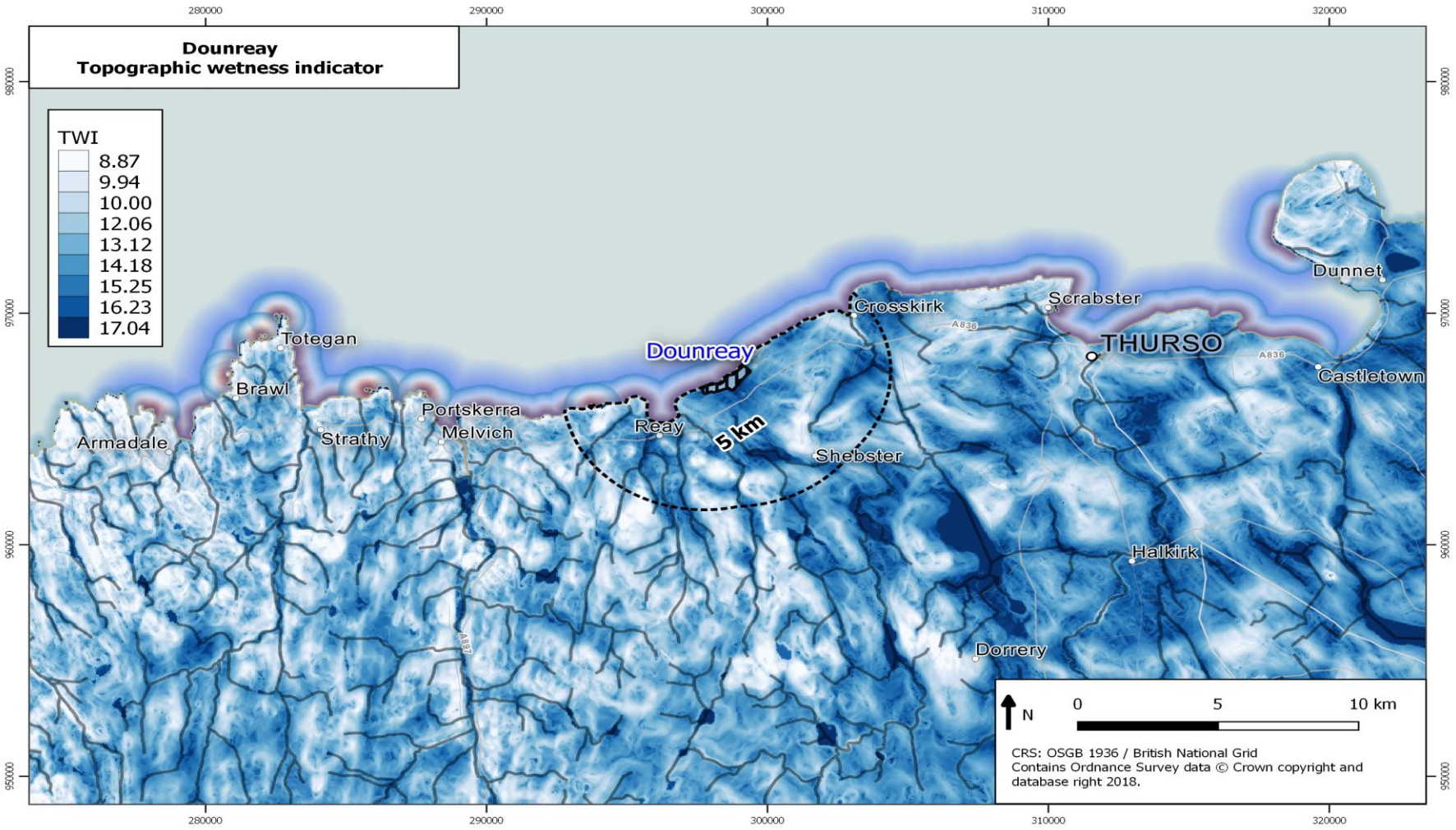

Figure 2.5 The Topographic Wetness Index in the Dounreay survey area (Ordnance Survey Great Britain, 2018).

2.8 Agricultural Production

The Scottish Agricultural Census 2017 data for parishes (defined by postcodes as used by the Scottish Government – Olrig, Dunnet, Reay, Thurso and Farr) surrounding the Dounreay site have been assessed and are summarised in Table 2.4 for grass and crop production and Table 2.5 for livestock production. Please note that this area is significantly greater than the Dounreay terrestrial survey area of 5 km.

Table 2.4 Summarises the crop and grass production and land-use figures from census data, June 2017. Statistics prepared by Scottish Government RESAS Statistics (Agriculture).

Crops and fallow land	Number of holdings	Area (ha)
Spring barley	45	1 214
Spring oats	43	669
Ware potatoes	18	2.00
Turnips & fodder beet for stock feeding	19	38.0
Rape for stock feeding	7	55.0
Other fodder crops	10	23.0
Vegetables for human consumption	9	3.00
Soft and orchard fruit	6	1.00
All other crops	10	12.0
Total crops, fallow and set-aside	123	2 283
Grass under five years old	145	2 239
Grass five years and older	515	15 726
Rough grazing	329	66 996
Common grazing land	28	29 173
Fallow	42	205
Woodland	97	5 113
Other land	314	1 869
Total agricultural area	**673**	**94 225**

Table 2.5 Summary of the livestock production in the Dounreay area, June 2017. Statistics prepared by Scottish Government RESAS Statistics (Agriculture).

Animal groups	**Number of holdings**	**Number of head (ha^{-1})**
Total female dairy cattle	10	12
Total female beef cattle	141	9 579
Total male cattle	117	2 232
Total calves	124	5 988
Total cattle	150	17 811
Lamb	211	48 313
Total sheep	251	100 728
Total pigs	13	120
Fowls for producing eggs	75	9 435
Fowls for breeding	37	109
Total poultry	77	9 802
Goats and kids	5	79

3 Methods

3.1 Introduction

To provide consistency and traceability to previous habit surveys, the methods employed and described in this chapter are largely based on the approach outlined in Leonard *et al.,* (1982), Green *et al.,* (2001) and National Dose Assessment Working Group (NDAWG) (2013). The previous habit surveys of the Dounreay nuclear licensed site provided a useful frame of reference for undertaking this survey. Chapter 2 described the desktop study undertaken to characterise and define the Habits Survey, including:

(i) A review of site activities;
(ii) The modelling of the atmospheric and marine discharges from the site to define the survey area boundary; and
(iii) An assessment of the land cover and agricultural activity.

The 2018 Habits Survey of Dounreay covers activities and food consumption. The survey introduced the following methods:

(i) A mobile radiometric survey to characterise the heterogeneity of radiation in the environment surrounding the Dounreay nuclear licensed site;
(ii) Global Positioning System (GPS) tracking on a limited number of volunteers to better understand the time spent by individuals as they interact with the environment; and
(iii) Information meetings during and after the face-to-face surveys to validate the data and findings.

3.2 Postal Survey

To obtain a provisional independent assessment of the activity and food consumption habits of the local community living within the study area through the survey, a postal questionnaire for households was designed, piloted and distributed to 2 000 households. The postal survey was undertaken using a random selection of 2 000 households, although this was moderated to result in only one postal survey being sent to one household where more than one individual was selected.

The survey included questions on food consumption, activities and a map for identifying the range of activities undertaken by household members. The sample included populations living within 20 km of the site. Further information can be found in Appendix A2.

3.3 Radiometric Surveys

The radiometric surveys comprised a car-borne gamma spectrometry survey, *in-situ* gamma dosimetry and beta skin dosimetry. The car-borne survey work is described in Appendix A3.

3.3.1 *In-Situ* Dosimetry

The Environmental Radioactivity Laboratory (ERL) has ISO 17025:2005 accredited procedures for the deployment and recording of gamma dose rate in air, using ISO 17025:2005 accredited (UKAS) calibrations for two Thermo Radeye instruments. Measurements were undertaken at all locations where occupancy or location may lead to higher exposure to radioactivity or radiations as a result of site activities. These included areas that may have elevated radionuclide concentrations, where fine sediment is known to accumulate (e.g. salt marshes and mudflats). The effective dose from terrestrial gamma radiation was calculated and reported in μSv h^{-1}. Further details of the *in-situ* methodology can be found in Appendix A4.

3.3.2 Beta Dosimetry

A ruggedized Thermo BP19RD /Electra instrument was deployed to assess the Beta dosimetry of skin dose [H*(0.07)]. The BP19RD provided a wide area monitor instrument (100 cm^2) and was used to monitor items that were potentially exposed to the higher radioactivity concentrations, i.e. close to licensed discharge points. Items monitored included boats and fishing equipment. Further details of the beta skin dosimetry can be found in Appendix A5.

3.4 GPS Tracking

Over a period of up to five days GPS tracking units were provided to a number of individuals to provide empirical data on areas visited and duration. To ensure consistency in data a wearable GPS tracking device was considered the most suitable

device for the Dounreay Habits Survey. Further details of the system deployed are described in Appendix A6.

3.5 Conduct of the Survey

The pre-survey preparations involved a range of investigations with SEPA being contacted to discuss the requirements for the Dounreay survey. Past survey reports and maps for this site were investigated giving substantial and vital information. A directory of key groups involved in activities in the area was compiled from web searches and from contacting people within the local area with relevant knowledge pertaining to the survey. A proposed programme for the fieldwork being undertaken was then established and passed to SEPA for their view.

3.6 Meetings and Informal Contacts

In the 2018 survey, habits data and information were collected through a variety of approaches. This included contacting relevant parties and individuals for potential focus groups as well as a 'standard' face-to-face interview schedule. The multi-methods approach provided a means to 'triangulate' (verify) the data gathered through the different approaches: for example to check occupancy and activity data against the 'snapshot' observations recorded over a limited number of days in one season acquired from the individual face-to-face interviews. It also provided some additional information about local produce grown and consumed by householders, garden clubs, horticulturalists and farmers and consumption of particular types of local food such as honey and game. Such information also facilitated some snowballing of the survey because the individual contact with relevant parties provided additional contacts to follow-up. These groups were approached prior to, during and after the face-to-face interviews by telephone and email.

Prior to the survey a directory of local groups, bodies and organisations, that potentially undertake activities, within the survey area relevant to the survey was compiled. The directory proved an invaluable resource through the survey period both for contacting groups and for use as a checklist against which responses and non-responses from potentially important groups with regard to activity, occupancy, exposure and local food consumption could be recorded. For future surveys, the directory will provide a useful starting point and a means of monitoring any changes in group/business or other activity in the area. The directory development required

extensive web searches, follow-up telephone calls and use of earlier contacts across organisations and businesses.

3.7 Data Conversion & Analyses

During the face-to-face interviews, data on food consumption were recorded in units provided by respondents (e.g. pounds, grams, and ounces) and later converted into kilograms per year. The weights provided are for the fresh weight prepared and consumed. In some cases, respondents were unable to estimate food consumption in kilograms per year and instead gave the number of plants grown or the length and number of rows. These data were converted into consumption rates using conversion weights where possible e.g. one broccoli plant yields 700g (Garden Forum Horticulture, 2009; Hessayon, 2014) so that all consumption figures were reported in kilograms per year. Some individuals however were precise with the weight of some foods consumed with these figures mainly given as an annual consumption. Data from the paper copies of each survey were transferred to a bespoke database for analyses. The figures reported from individuals were utilised within the report with the percentage of any gifting or waste deducted from the final figure.

3.8 Data Rounding and Grouping

All data collected from the face-to-face and postal surveys were reported to two significant figures. For the food consumption data, the total annual consumption (kg) of different food types were calculated by multiplying the quantity (kg) and frequency (times per year). The food items were placed into groups with similar attributes (Table 3.1). These groups are similar to those used in previous survey reports but focussed on the most common food items. Individuals were given the option to add any additional food items in the ‘Other’ food category.

The time individuals spent carrying out activities was calculated by multiplying frequency (occasions per year) and duration (hours), whilst taking into account seasonality where appropriate. Individuals accounted for any holidays and working hours within their survey replies. In addition to food consumption a ‘liquid’ category was also added and individuals who carried out aquatic activities that could result in the inadvertent ingestion of water, e.g. outdoor swimming/sailing, were identified to account for this pathway.

Table 3.1 Food groups used in the Dounreay Habits Survey.

Food group	Example of foods within this group
Green leafy vegetables	Asparagus, broccoli, brussel sprouts, cabbage, calabrese, cauliflower, celery, chard, herbs, kale, kohl rabi, lettuce, pak choi, rhubarb, marrow, spinach
Other domestic vegetables (legumes)	Broad bean, French bean, pea, runner bean
Root vegetables	Beetroot, carrot, celeriac, fennel, garlic, Jerusalem artichoke, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip
Potato	Potato
Domestic fruit	Apple, blackberry, blackcurrant, blueberries, corn, courgette, cucumber, gooseberry, grape, pear, pepper, plum, raspberry, redcurrant, strawberry, tayberry, tomato
Milk	Milk, yoghurt, cheese
Cattle meat	Beef, buffalo
Pig meat	Pork
Sheep meat	Lamb, mutton
Poultry	Chicken, duck, goose, turkey
Eggs	Eggs
Wild/free foods	Blackberry, chestnuts, crab apples, damson, dandelion root, garlic, elderberry, elderflower, nettle, raspberry, rowanberry, sloe, strawberry
Honey	Honey
Venison	Venison
Fish	Bass, cod, dover sole, kipper (herring), mackerel, pollock, salmon, sea trout, trout (freshwater)
Crustaceans	Brown crab, common lobster, shrimps
Molluscs	Mussels, razor clams, scallops, winkles
Wildfowl	Mallard, pink-footed goose, teal, widgeon
Game - bird	Partridge, pheasant, quail

The age groupings used in this report are based on ICRP recommendations and are listed below in Table 3.2.

Table 3.2 ICRP age groups used in the dose assessment.

Name of age group	Age range
Group 1 - Infant	0-5 year old
Group 2 - Child	6-15 year old
Group 3 - Adult	16 year old and over

3.9 Qualitative and Quantitative Observations

Whilst undertaking the face-to-face surveys, observational data were acquired on obvious changes to each location such as new build housing, along with information on site usage and numbers of individuals undertaking specific habits. Observations were acquired over a specified time period, e.g. 20 minutes, and onshore and offshore (including intertidal) activities were noted. The number of individuals, their gender and their approximate age group undertaking each activity were also noted or estimated where large numbers were observed, e.g. beach activities. Some individuals were approached where possible and subsequent face-to-face surveys were conducted. Contact with individuals during face-to-face interviews frequently allowed the accuracy of observations to be checked and sometimes to be expanded, e.g. dog walkers might also engage in beachcombing and sailing at other times. Along with noting the weather conditions at the time of survey, this approach provided a basis for making a comparison with habits at different times and within and outwith the period of the local school holidays.

3.10 Dose Assessment Tool

The Habits Dose Assessment Spreadsheet Tool collated the data from the face-to-face survey for Dounreay and then used the consumption rates and habits data to calculate the retrospective dose to each interviewed member of the public, covering the total exposure from all pathways. It should be noted that only the consumption of locally produced food has been included in the retrospective dose assessment (i.e. food from outwith the survey area is not included within the assessment). Dose assessment was carried out following the guidance in NDAWG and ICRP for the *Representative Person*.

Activity concentration values came from modelling Dounreay discharges for 2016 using the default settings in PC-CREAM 08 (Public Health England, 2008). Dose coefficients for different age groups are described by ICRP (2012). As described in Section 3.8, data for the 2018 Dounreay Habits Survey were collected in three age groups. The dose conversion coefficients (DCCs) for each age group were taken from ICRP: Group 1 for infants; Group 2 for children; and Group 3 for adults.

The tool analyses four general exposure pathways:

(i) *Internal terrestrial*, which includes the consumption of locally produced meat, fruit and vegetables;
(ii) *External terrestrial,* which determines the external doses from exposure to radiation present in the terrestrial environment as a result of deposition from atmospheric discharges and direct exposure through shine from on-site activities with radioactive materials;
(iii) *Internal aquatic*, which includes consumption of fish, crustaceans, molluscs and inadvertent ingestion of seawater. A proxy for inadvertent drinking of water was calculated by multiplying the time spent on aquatic activities by the known average of water ingested in such activities as described in Leonard *et al.,* (2015) and Stone *et al.,* (2008); and
(iv) *External aquatic,* which estimates the dose from external exposure through aquatic activities e.g. from radionuclides present in the aquatic environment (in water and sediments in saltmarshes or intertidal areas).

The direct exposure to shine from on-site activities was included in the analysis using *in-situ* measurements. These data were used to calculate direct exposure to members of the public that regularly travelled through the site.

The representative person was calculated independently for the total consumption and habits first and then by each exposure pathway. To identify the representative person, the 97.5th percentile rate cut off method was applied (see Chapter 1). The representative person was calculated separately for external terrestrial and external marine exposure, internal terrestrial and internal marine consumption related exposure. The combined calculated total integrated all routes of exposure.

4 POSTAL SURVEY

4.1 Introduction

The results from the postal survey provide an overview of the habits within the area centred on the Dounreay nuclear licensed site extending approximately 20 km from west to east for the aquatic and intertidal areas and 5 km around the site for the terrestrial area.

Of the 2 000 postal surveys that were sent out to households in the survey area, 208 households returned their surveys within the deadline of which four were returned unopened and four were blank (Figure 4.1). There were 23 returns either incomplete or illegible of which 16 yielded some useful information. A total of 193 postal returns were used in the analyses which was comparable with previous habit surveys.

The postal survey proved useful for identifying where households undertook popular activities and the proximity of these activities to the Dounreay site. The survey was not designed to capture the length of time individuals spent doing these activities. The postal survey results are presented in Appendix A7.

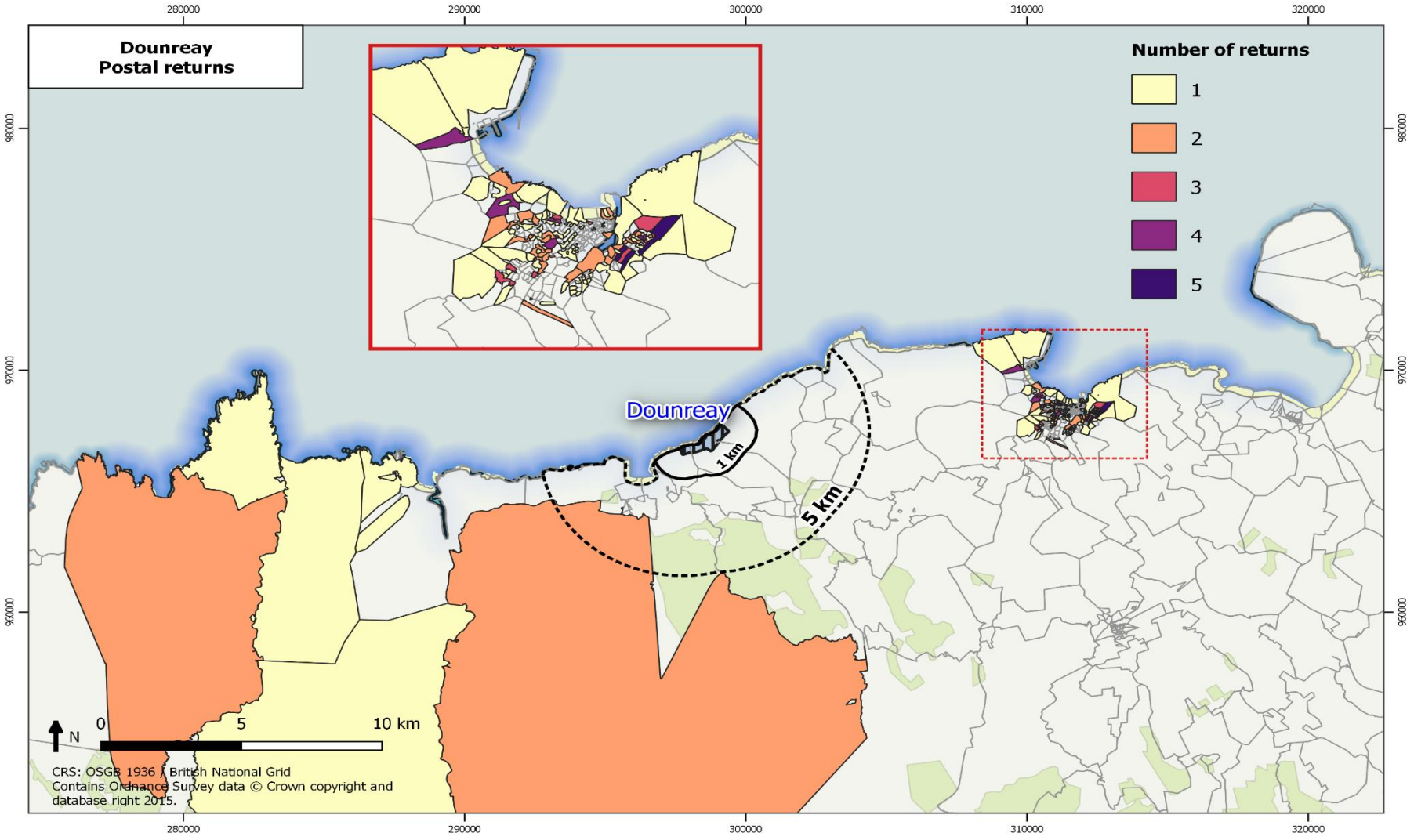

Figure 4.1. Postal survey return density map.

5 Aquatic Radiation Pathways

5.1 Introduction

The survey locations were established following the desktop review of the site characteristics presented in Chapter 2 and to allow effective comparison with the previous Dounreay Habits Survey undertaken in 2013 (Papworth *et al*., 2014). The sites were visited throughout the survey period and observations of offshore and onshore activities were undertaken at each site. The survey schedule was designed to ensure that each site was visited at different times of the day, which reflected the activities occurring at each site and proximity to the Dounreay site.

5.1.1 Aquatic survey area descriptions

The survey locations were visited throughout two survey periods, the first outwith the school holiday period (24th May to 30th May) and the second within the school holiday period (5th July to 11th July) of 2018. Offshore and onshore observations were undertaken at each site.

The survey area included the intertidal areas and waters of the Pentland Firth extending from Armadale Bay (including Port a' Chinn) in the west to Dunnet Head in the east, see Figure 2.2. A 2 km fishing exclusion zone is in effect around the offshore diffuser at Dounreay (Food and Environment Protection Act (FEPA), FEPA Order – http://www.legislation.gov.uk/uksi/1997/2622/contents/made The Food Protection (Emergency Prohibitions) (Dounreay Nuclear Establishment) Order 1997). Part of the survey area forms a Site of Special Scientific Interest, which attract bird watchers and wildlife enthusiasts to the area to observe the intertidal birdlife. The North Coast 500 route is reported to be very popular with tourists, particularly in the summer months, with many individuals visiting intertidal areas within the aquatic survey area.

The survey sites are reported from Armadale Bay in the west to Dunnet Head in the east. Site descriptions and observations can be seen in Appendix A8.

5.2 Commercial seafood operations

Commercial seafood operations within the survey area are mainly fishing by creeling. During 2017 approximately 1 100 fishing vessels (with the majority from outwith the survey area and outwith the United Kingdom) landed their catch into Scrabster harbour

catching a mixture of shellfish (brown crab, lobster, velvet crab), and white fish (cod, haddock, monkfish, megrim, plaice, whiting, saithe). Of these fishing vessels, the survey team determined there are three full-time inshore creel boats that catch mainly brown crab in the winter months and brown crab and lobster in the summer months. A further six or seven part-time inshore creel boats work out of Scrabster mainly fishing for lobster and velvet crab. In addition, there are four large offshore crabbers that land once weekly into Scrabster harbour.

There is one full-time creel fishing boat operating from Sandside Harbour with one part-time boat with a commercial license to commence work in 2018/2019. Two commercial creel fishing boats operate from Port Skerra with both boats creeling for crab and lobster. One commercial creel fishing boat operates from Castletown but the survey team were unable to secure an interview. It is also reported that a creel fishing boat operates from Melvich Bay but the survey team were unable to make contact. This was followed up by the survey team but the team were unsuccessful in achieving any further information.

There are several shellfish and whitefish buyers in Scrabster with the shellfish market being France, Spain, Portugal, China and a small amount staying within Britain. The whitefish market reaches France, Spain and Britain. Two shellfish/fish wholesalers and one local fish merchant operate from Scrabster harbour.

It is determined that a small percentage of the shellfish is sold locally with approximately 30 % of the whitefish sold through Scrabster market.

It was reported to the survey team that the slipway at Port Ghrantaich was sold and is now privately owned but is currently inaccessible due to its state of disrepair. The commercial fishing undertaken at Port Ghrantaich ceased since 2017.

The bag-net fishing operations (including all coastal letting) within the aquatic survey area has currently ceased. There is a Scottish Government moratorium in place for three years which enforces all coastal letting and catching of fish to cease, which came into force in 2016. This practice will be reviewed in 2019.

It was reported to the survey team that commercial winkle and whelk pickers operated at Sandside beach, who then sell their produce at Scrabster. The survey team were unable to contact them.

Within the aquatic survey area local fishmongers and fish bars were contacted. Two local fishmongers reported that all their fish were sourced from Scrabster market. The fish sourced included: haddock; monk fish; plaice; lemon sole; cod; hake; halibut; and skate, which was generally sourced seasonally. A fish van sourcing their fish from Scrabster harbour sells the fish within the aquatic survey area. Some proprietors reported their fish was sourced outwith the survey area.

5.3 Non-commercial Fishing and Angling

Angling was a popular activity and Table 5.1 shows areas where non-commercial fishing, bait digging, mollusc and crustacean collections took place within the aquatic survey area.

Table 5.1 Locations associated with hobby fishing activities

Bait Digging	Fishing from shore/rocks/pier/boat	Mollusc/crustaceans picking (non-commercial)
Sandside beach	Dwarwick (pier and boat)	Brown crab (Sandside Bay and Sandside harbour)
Strathy beach	Thurso Bay (boat)	Lobster (Sandside Bay)
Thurso beach	Thurso harbour	Mussels (Scrabster beach – rocks, Sandside beach and Melvich beach)
Dunnet beach	Scrabster beach (shore)	Whelks (Scrabster slipway, Melvich beach and Sandside beach)
Port Skerra harbour	Port Skerra (rocks and boat)	
	Dunnet Bay (shore and boat)	
	Melvich Bay (shore and boat)	
	St Ola's Pier	
	Holborn Head (rocks and boat)	
	Crosskirk (rocks and boat)	
	Strathy beach (shore)	
	Sandside Bay (boat)	
	Port of Brimms (boat)	

The River Forss (known as the Forss Water), the most easterly river within the terrestrial survey area near Crosskirk, is privately fished with rods (permits) issued for one week on a time share basis. It is estimated that approximately 60 % of the salmon caught is 'catch and release' with 40 % of the salmon caught being kept.

Chartered wildlife and fishing tours operate from Port Skerra harbour generally in the summer months from July to September. At Port Skerra, the Port Skerra Harbour Association was set up in 2017 with currently 27 members. It was set up to increase use of, and to develop the harbour and pier. It holds their first fishing competition this summer in 2018 with 33 entrants to date.

5.4 Wildfowling

Wildfowling was not identified in the 2018 habits survey.

5.5 Royal National Lifeboat Institute

Her Majesty's Coastguard and the Royal National Lifeboat Institute (RNLI) are located at Scrabster Harbour. The lifeboat at Scrabster is an all-weather lifeboat (ALB) and from a crew of 21 individuals, between five minimum and seven maximum individuals go out on the ALB when there is a call out. The lifeboat crews have weekly training exercises both on and offshore for two hours with occasional training in the water. Over the course of one month each crew member will attend at least one training session. Up to the end of April 2018, at time of contact, the lifeboat had been called out on four occasions. There are approximately between 15 – 20 callouts annually with some of these callouts requiring the crew to enter the water.

5.6 Sailing and Rowing

The Pentland Canoe Club is based in Thurso and has approximately 40 members. Much of the canoeing undertaken is weather dependent and during the summer months mainly sea canoeing/kayaking is carried out. The club have weekly evening meetings, depending on weather conditions, and canoe predominantly in Thurso Bay. In addition, the club meet at weekends for a sea trip that is generally between the hours of 0900 – 1600 hours, which is weather dependent. Day trips generally take place between Sandside Bay and Melvich Bay, Melvich Bay and Strathy beach, Strathy Point and Armadale Bay and between Dunnet Bay and Brough in the East side of Dunnet Head. In the winter months the club generally undertake canoeing/kayaking in River Thurso, Loch Calden, Loch Watton and Loch Main. Activities undertaken in the River Thurso however is subject to the water level. The club aim to meet weekly for three hours. The canoes/kayaks are washed down annually with any clothing belonging to the club dipped in fresh water after each use. All other members clothing

is taken home for cleaning. In addition to club meetings some members partake in canoe/kayak meetings outwith the club and also undertake other aquatic activities. It is reported by a club member that an increase of individuals canoeing/kayaking around Great Britain has shown a small increase in paddlers in the north coast taking approximately two days to paddle from Armadale Bay in the west to Dunnet Head in the east.

The Pentland Firth Yacht Club is a small club consisting of eight members and is based at Scrabster port. The club meets weekly from early April through to mid-October at the weekends for one afternoon with sailing restricted to Thurso Bay. When the boats are launched the members usually race for approximately two hours and then return to shore. All boats and boating equipment are washed at the Scrabster clubhouse, where there is access to fresh water. All members clothing is taken home and washed.

Thurso Sea Cadets launch from Thurso into the River Thurso beside their unit. They have 16 children (ages 10 – 18 years old) and 11 adults who go onto the water from the end of April to the end of October. They meet twice weekly on an evening during the week and generally fortnightly at a weekend for on water activities. During the week they spend approximately two to two and a half hours on the water and between three to seven hours at the weekend. The boating area is on the River Thurso and during the summer months in Thurso Bay. Boating activities include rowing, power boating and sailing. All boats are cleaned with freshwater on site at the end of season. Wetsuits and buoyancy aids are cleaned with freshwater if children have been in the water with lifejackets sent away from the site to be cleaned. All boating uniforms (shirt and trousers) are taken home with the children to be washed. In addition to boating there are three arranged beach clean-ups undertaken on the shoreline around Thurso with ad-hoc beach cleans undertaken on occasions when required. The survey team made enquiries to Highland Council who in turn advised contacting Environmental Health. Environmental Health, Highland Council Harbours and Highland Council Roads department were subsequently contacted and reported that there has been no collection of seaweed deposition within the survey area since at least early 2000.

5.7 Diving and Surfing

A diving club meet and undertake sub-aqua diving within the aquatic survey area. There are approximately 26 members all over 18 years of age. The club meet once weekly with approximately 50 % of their dives being within the aquatic survey area where they access the water via a small RIB, diving from Port Skerra, Dwarwick Pier and around Holburn Head to Brims Ness. Each dive in the water is approximately 45 minutes with two hours spent on the dive boat.

The Scottish Surf Federation is based in Thurso and host event several events throughout the year at Thurso East beach. The Scottish Nationals and the UK pro surf tour are held annually and are four-day events attracting approximately 80 surfers with a junior division (18 years old and under). The Celtic Cup and the British Champs are both weekend events attracting approximately 80 and 60 individuals respectively, which includes a junior division. All events comprise approximately 70 % adults and 30 % children. It is estimated from the Scottish Surf Federation that the average surfer would surf approximately three times weekly throughout the year.

A surf club is situated in Thurso and has approximately 25 child members. They meet once weekly surfing at Thurso Bay for approximately two hours.

5.8 Professional Dog Walkers

Professional dog walkers operate within the survey area. These groups will be active along the coastal strip for much longer periods. As dogs can enter the sea and the route of walks often encompasses muddy and sandy areas, the group may potentially have greater exposure to intertidal substrates. One professional dog walker was identified and interviewed. They reported to walk regularly all year within the intertidal area (70 % of walks) at Scrabster beach and Dunnet Bay and within the terrestrial survey area (30 % of walks) around Bailey's windfarm and Reay.

5.9 Animals Grazing

Cows and sheep were observed grazing in several fields within and around the survey area. No cattle or sheep were observed grazing on seaweed or within intertidal areas anywhere within the survey area.

5.10 Seaweed Foraging

Individuals interviewed reported collecting seaweed for use to grow vegetables and fruit. The amounts of seaweed collected by all individuals varied and all was used as a fertiliser for vegetable and fruit gardens for consumption. Seaweed was collected from Sandside Bay, Sandside Harbour and Crosskirk and were either bladder wrack, kelp or unknown variety. One individual added the seaweed to their general compost to be used the following year. Two individuals applied the seaweed to their vegetable patch and left it to be turned into the soil the following year. A fourth individual applied the seaweed fresh. All vegetables and fruit grown were for human consumption.

One company undertaking commercial harvesting of seaweed from within the survey area was contacted. It was determined that there was only one site within the survey where seaweed (Dulse – *Palmaria palmata*) was harvested in 2017 with a total wet weight of 100 kg. A further one site has just been licensed for the harvesting of seaweed within the survey area with a further one site being looked at to purchase the license within the survey area.

One individual reported to consume a small quantity of sea lettuce sourced from Scrabster beach.

5.11 Walking and Other Pathways

The Dunnet Head Visitor Centre situated at the most eastern survey point organises intertidal sea watching events from the shore at Holburn Head, Dunnet Head and Sandside Head. Each sea watching trip is approximately for two hours and the number of events arranged throughout the year depends on demand. School activities are also arranged approximately twice a year at Dunnet Beach which usually involves beach combing for one to two hours. A mixed group (adults and children) walk is also arranged for a four hour walk along the coast from Thurso East beach to Castlehill annually.

It was observed on Sandside beach that the use of sun cream on an infant had resulted in significant sediment adhering to their skin.

5.12 Internal Exposure – Phase 1

5.12.1 Adults consumption rates

Table 5.2 presents a summary of the consumption rates for aquatic food types including; fish, crustaceans, molluscs and wildfowl. Mean adult consumption rates for the high-rate groups and the observed 97.5th percentile rates are included in Table 5.2. The high-rate group was determined using a 'cut-off' method described by Hunt *et al*., (1982). This 'cut-off' method calculates the high-rate value by taking the mean of the values between the maximum observed rate and one third of the maximum observed rate. Therefore, the 'cut-off' method within this report is represented as the individuals derived to obtain the 'high-rate group'. The table also includes mean consumption rates and 97.5th percentile rates based on the full dataset.

Table 5.2 Summary of adults' consumption rates of foods from the aquatic survey area.

Food Group	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1})	Observed minimum for the high-rate group (kg y^{-1})	Observed mean for the high-rate group (kg y^{-1})	Observed 97.5th percentile (kg y^{-1})	Full dataset – Observed mean (kg y^{-1})	Full dataset – 97.5th percentile (kg y^{-1})	National Data mean (kg y^{-1})	National data 97.5th percentile (kg y^{-1})
Fish	110	4	93.6	46.8	66.3	91.3	15.8	51.1	15.0	40.0
Crustaceans	45	6	35.0	23.0	26.2	33.7	7.08	24.8	4.00	10.0
Molluscs	21	2	21.3	21.3	21.3	21.3	2.83	21.3	4.00	10.0

The generic mean and generic 97.5th percentile rates based on National Habit Data is also included (Smith and Jones, 2003). The national data is used to compare the high-rate mean and high-rate maximum consumers within the habits survey. During the course of the Dounreay habits survey it became apparent that the national data does not consider any extreme habits of consumption. For example, there may be regional or local differences in habits which may result in very different rates of consumption, for fish, crustaceans and molluscs (Table 5.2), which is vastly greater than the national mean and may represent an important local pathway. It may be necessary to consider that the national data cannot capture local or regional variations in habits, which may have local significance within habits based assessments.

Adults consumed Bass (14 individuals), cod (46 individuals), mackerel (42 individuals), pollock (19 individuals), haddock (81 individuals), salmon (five individuals), sea trout (six individuals), plaice (two individuals), flounder (two individuals), monkfish (two individuals), lemon sole (four individuals), halibut (one individual), whiting (one individual), hake (three individuals) and ling (one individual), all sourced from within the aquatic survey area. It should be noted that some adults consumed more than one fish type (flat and/or round). The observed maximum consumption (quantity times frequency) of fish was 93.6 kg y^{-1} and this individual consumed haddock (31.2 kg^{-1}), plaice (31.2 kg y^{-1}) and lemon Sole (31.2 kg y^{-1}), purchased from a local fishmonger within the survey area who source all their fish from Scrabster. The mean fish consumption for the adult high-rate group was 66.3 kg y^{-1}.

Crustacean consumption consisted of brown crab (43 individuals) and common lobster (14 individuals), and prawns (three individuals). The highest consumption was by an individual consuming 35 kg y^{-1}, the individual consumed brown crab (15 kg y^{-1}) and common lobster (20 kg y^{-1}) which were locally sourced and self-caught by one individual fishing in Sandside Bay. The mean crustacean consumption for the adult high-rate group was 26.2 kg y^{-1}. It should be noted that some adults consumed more than one crustacean type.

Mollusc consumption consisted of mussels (four individuals), scallops (19 individuals) and whelks (four individuals). The observed maximum consumption was by two individuals each consuming 21.34 kg y^{-1}, the two individuals consumed mussels (20 kg y^{-1}), scallops (1 kg y^{-1}) and whelks (0.34 kg y^{-1}) sourced from Sandside harbour

and a local fish van (sourcing their produce from Scrabster). The mean mollusc consumption for the adult high-rate group was 21.3 kg y^{-1}. It should be noted that some adults consumed more than one mollusc type. No wildfowl consumption was identified within the survey area.

5.12.2 Children and infant consumption rates

Table 5.3 presents a summary of children's consumption rates of fish and molluscs from the aquatic survey area. Mean consumption rates for the high-rate groups and the observed 97.5th percentile rates are included in Table 5.3.

Table 5.3 Summary of children's consumption rates of foods from the aquatic survey area.

Food Group	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1})	Observed minimum for the high-rate group (kg y^{-1})	Observed mean for the high-rate group (kg y^{-1})	Observed 97.5th percentile (kg y^{-1})	Full dataset – Observed mean (kg y^{-1})	Full dataset – 97.5th percentile (kg y^{-1})
Child age group (6 - 15 years old)								
Fish	7	2	42.1	42.1	42.1	42.1	18.0	42.1
Molluscs	4	2	0.50	0.50	0.50	0.50	0.44	0.50

The table also includes mean consumption rates and 97.5th percentile rates based on the full dataset. There was no consumption of fish, crustaceans, molluscs or wildfowl found for the infant age group.

For the child age group, bass (one individual), cod (three individuals), haddock (one individual), mackerel (six individuals), pollock (two individuals) and sea trout (one individual) were consumed by children. The observed maximum consumption was by two individuals each consuming 42.1 kg y^{-1} and these individuals consumed cod (18.8 kg y^{-1}) mackerel (4.5 kg y^{-1}) and pollock (18.8 kg y^{-1}) which was sourced from Dwarick Pier. Mollusc consumption consisted of mussels (two individuals), scallops (one individual) and whelks (two individuals). The observed maximum consumption was by two individuals each consuming 0.5 kg y^{-1} and these individuals consumed mussels (0.33 kg y^{-1}) and whelks (0.17 kg y^{-1}) which was sourced from Scrabster beach. No consumption of crustacean or wildfowl was found for the child age group. It should be noted that some children consumed more than one fish and mollusc type.

5.13 External Exposure – Phase 1

Occupancy rates for adults in intertidal, aquatic (in water), aquatic (on water), handling rates of equipment and handling rates of sediment can be found in Table 5.4.

Intertidal activities for adults included bait digging, barbeque/picnicking/sitting beach clean, beachcombing, bird/nature watching, boat maintenance, coastguard rope-works, collecting mussels, collecting whelks, dog walking, fishing, Groundhog operator, Guides & Brownies activities, horse-riding, jogging, metal detecting, paddling, painting, photography, playing, research/education, rock pooling and walking. The highest intertidal occupancy rate was 1 460 h y^{-1} for an individual who spent time bbq/picnicking/sitting (365 h y^{-1}), beachcombing (365 h y^{-1}) and walking (730 h y^{-1}) on Sandside beach.

Table 5.4 Summary of adults' external exposure for intertidal, aquatic, handling of equipment and handling of sediment.

Activity	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (h y^{-1})	Observed minimum for the high-rate group (h y^{-1})	Observed mean for the high-rate group (h y^{-1})	Observed 97.5th percentile (h y^{-1})
Intertidal	199	6	1 460	834	1 103	1 439
Aquatic (in water)	35	3	754	541	679	753
Aquatic (on water)	55	2	2 051	1 965	2 008	2 048
Handling equipment	60	2	1 965	1 924	1 945	1 964
Handling sediment	59	1	730	730	730	730

Activities in the water included body-boarding, cliff/rock jumping, coasteering, diving, outdoor swimming, snorkelling, surfing, RNLI duties, coastguard training and horse swimming. The highest occupancy rate for adults in the water was 754 h y^{-1} for an individual who spends time surfing at Thurso Bay, Melvich Bay, Sandside Bay, Strathy Bay and Dunnet Bay. Activities on the water included being on a dive boat, boat maintenance, canoeing, commercial creeling/fishing, commute via boat, creel fishing/handling, jet skiing, kayaking, kite surfing, power boating, rowing, safety boat duties, sailing, sea angling, stand-up paddle boarding, sea wildlife tours, working on a boat, RNLI duties, RNLI rescue and training. The highest occupancy rate for adults on water was 2 051 h y^{-1}, this individual undertakes boat maintenance (1 924 h y^{-1}), RNLI duties (120 h y^{-1}) and RNLI rescues (7 h y^{-1}). Adults were also found to handle equipment within the survey area, the activities for adults involved handling boats and boating equipment, handling clothes and overalls and fishing gear. The highest level of handling equipment was 1 965 h y^{-1}, this individual spent time undertaking boat maintenance (365 h y^{-1}) and commercial fishing/creeling (1 600 h y^{-1}). The highest level of handling sediment was 730 h y^{-1} and this is for an individual who spends time beachcombing (365 h y^{-1}) and bbq/picnicking/sitting (365 h y^{-1}). The occupancy data

for intertidal activities were used for estimating the external gamma dose rate. Selected relevant intertidal activity occupancy data were also used to derive the handling sediment category which was then used for estimating the beta skin dose rate.

Table 5.5 presents a summary of the children and infants' intertidal, aquatic (in water), aquatic (on water) occupancy rates, handling rates of equipment and handling rates of sediment. Intertidal activities for children included dog walking, paddling, playing, rock pooling, walking, bbq/picnicking/sitting and fishing.

Table 5.5 Summary of children's and infants' external exposure for intertidal, aquatic and handling of equipment.

Activity	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (h y^{-1})	Observed minimum for the high-rate group (h y^{-1})	Observed mean for the high-rate group (h y^{-1})	Observed 97.5th percentile (h y^{-1})
Child age group (6 - 15 years old)						
Intertidal	21	3	156	117	143	156
Aquatic (in water)	10	1	507	507	507	507
Aquatic (on water)	6	2	60.0	60.0	60.0	60.0
Handling equipment	6	3	78.0	65.0	69.3	77.4
Handling sediment	12	1	90.0	90.0	90.0	90.0
Infant age group (0 – 5 years old)						
Intertidal	11	3	107	104	106	107
Handling sediment	8	2	107	106	106	107

The highest intertidal occupancy rate for children was 156 h y^{-1} for two individuals who spent time dog walking at Dunnet Bay (south end). Intertidal activities for infants included bbq/picnicking/sitting, dog walking, paddling, playing and walking. The highest intertidal occupancy was 107 h y^{-1} for an infant who spent time playing (104 h y^{-1}) and paddling (3 h y^{-1}) at Melvich beach, Strathy beach and Sandside beach. Children's activities in the water included body boarding, outdoor swimming and surfing. The highest in water occupancy was 507 h y^{-1} for one individual who spent time body boarding (39 h y^{-1}) and surfing (468 h y^{-1}) at Sandside Bay, Thurso Bay, Strathy Bay, Dwarwick Pier, Dunnet Bay, Brims Ness and Melvich Bay. Children's activities on the water included canoeing, kayaking and sea angling. The highest occupancy rate was 60 h y^{-1} for two children, each spending time canoeing on Thurso Bay. There were no in or on water activities undertaken by infants found during the survey period.

The highest level of handling of equipment for children was 78 h y^{-1} for one individual who spent time fishing at Sandside harbour. No infants were found to handle equipment during the survey period.

The highest level of handling sediment for children was 90 h y^{-1} for one individual who spent time bbq/picnicking/sitting. The highest level of handling sediment for an infant was 107 h y^{-1} who spent time playing (104 h y^{-1}) and paddling (3 h y^{-1}) on Melvich beach, Strathy beach and Sandside beach. The occupancy data for intertidal activities were used for estimating the external gamma dose rate. Selected relevant intertidal activity occupancy data were also used to derive the handling sediment category which was then used for estimating the beta skin dose rate.

Gamma dose rate measurements over different substrates within the survey area can be found in Chapter 7.

6 Terrestrial Radiation Pathways

6.1 Introduction

Chapter 6 reports on inland routes of exposure immediately adjacent to the Dounreay site, coastal and intertidal areas (Figure 2.1). This chapter reports private food production details and the results from the face-to-face consumption levels for privately produced food stuffs.

6.1.1 Terrestrial survey area

The terrestrial survey area extends 5 km radial from the site boundary to the Crosskirk in the east and to west of Sandside House at Red Point in the west, extending inland to the Shebster area. Much of the land within the survey area is agricultural, predominantly livestock (mostly cattle and sheep). The terrestrial survey area comprises of several small villages (Lybster, Shebster, Buldoo, Upper Dounreay and Achvarasdal) and the town of Reay. Within the 1 km direct radiation survey Buldoo was included within this survey area due to the extensive land occupied by Dounreay resulting in limited house occupation within 1 km of the site centre.

6.2 Private Food Production

No allotments were found within the survey area but a local gardening group, Reay Garden Club, was identified. The Reay Garden Club have approximately nine members living within the 5 km terrestrial survey area who grow and consume fruit and vegetables in private gardens.

During both surveys many individuals were found to produce a wide variety of fruit and vegetables. Of those individuals interviewed, some were specific with the yield of their products, many of whom maintained detailed records of the crop grown and the respective yield. Face-to-face interviews indicated that much of the produce on the survey list was produced by one or more individual and the food grown was consumed by their families and friends. Over the survey period, 51 individuals grew their own fruit and vegetables within their own home gardens and land. These individuals yielded data of sufficient quality for quantitative estimates of food quantities grown and consumed. A total of 18 individuals surveyed reported keeping chickens and consuming their eggs and two individual's surveyed reported keeping ducks and consuming their eggs.

Game was shot on Shebster farming land and natural habitat land within the terrestrial survey area at Upper Dounreay and Achreamie. The game (Red deer, partridge and pheasant) was consumed by the individuals and their families. One individual who shot deer sold a proportion of the shoot to a game dealer outwith the survey area.

6.3 Commercial Food Production

Local butchers within the survey area were contacted. It was determined that all meat products were sourced from outwith the survey area.

6.4 Wild Foods

Within the terrestrial survey area wild food consumption was reported by 19 individuals. A breakdown of the foods, number of individuals, consumption and locations are detailed in Table 6.1.

6.5 Production of Honey

Beekeepers are not required to be a member of a bee keeping association or to be registered therefore the precise numbers in the survey area are unknown, however, if honey is to be sold commercially then a licence is required. The Olrig and District Beekeepers Association were contacted and reported that there are approximately 20 members with only one member that keep bees within the 5 km terrestrial survey area though no honey was produced in 2017. The Olrig and District Beekeepers Association are the only association and cover the whole of the Caithness County with some members from north Sutherland coast. During the survey period one beekeeper interviewed kept bees around the Dounreay site (though some hives did not survive the winter). Two beekeepers within the terrestrial survey area reported to the survey team they ceased beekeeping over the last couple of years. One individual however within the terrestrial survey area is to commence beekeeping (starting with one hive) this year (2018) with the view of honey consumption in 2019.

Table 6.1. Wild food summary of total number of individuals, highest annual consumption and locations

Food type	Total number of individuals	Maximum individual consumption (kg y^{-1})	Location of maximum consumption foraged	Other locations of foraging
Blackberry	7	0.50	Borlum walk	Achvarasdal and Reay
Elderflower	2	0.21	Reay	-
Mushroom	12	5.00	Achvarasdal	Skaill, Buldoo, Reay and Achreamie
Meadow Sweet	2	0.43	Reay	-
Nettle	2	0.50	Achvarasdal	-
Raspberry	4	0.50	Skaill and Achvarasdal	-

6.6 Farms

Within the Dounreay terrestrial survey area 16 working farms were identified. Farming included sheep/lamb, cattle and crops grown for cattle and sheep feed. Five farms keep cattle, all of which produce some of their own cattle feed consisting of oats, barley, silage and hay. Six farms keep both cattle and sheep with three of the farms producing some of their own cattle and sheep feed. One farm keeps only sheep. No farms reported that beef or lamb was consumed by the farmer and/or family members. One farm reported the shooting of deer on their land and this was consumed. One farm identified kept chickens for egg consumption for family only. All farm water supply for human consumption was provided by mains water supply. In addition to the mains water supply, animals on some farms had access to ditch, stream or river water whilst grazing. It should be noted that all farmhouses are situated within the 5 km terrestrial zone, though for a few farms, some of their land lies outwith the 5 km terrestrial zone. One organic farm was identified within the terrestrial survey area keeping cattle and

sheep. Silage and oats were produced for animal feed and animal water is provided by the mains water supply with access to stream water. Within the terrestrial survey area one small-holding was identified keeping pigs, sheep, chickens, geese and ducks. Consumption of pig meat and consumption of chicken and duck eggs was reported by the small holding owners. Within the terrestrial survey area five crofts were identified, two of which keep sheep, one keeps both sheep and cattle. Two keep both sheep and cattle and also produce some of their own animal feed, consisting of silage, hay, oats and turnip. One crofter consumes their own lamb and beef and shoots deer on the croft land. One crofter kept their own chickens and consumed the eggs.

6.7 Internal Exposure – Phase 1

6.7.1 Internal exposure adult consumption rate

Consumption data for locally produced foodstuffs potentially affected by atmospheric releases from Dounreay are presented in Table 6.2 for adults.

The table presents the adult consumption rates summarising the number of observations made, the number of people in the high-rate consumer group, the minimum and maximum observed consumption rates for the high-rate consumer group and the observed 97.5th consumption rate. The table contains the mean consumption rate for both the high-rate consumer group and the whole dataset collected from around Dounreay. The table also provides the mean and 97.5th consumption rates from national data (Smith and Jones, 2003) for comparison. The national data is used to compare the high-rate mean and high-rate maximum consumers within the habits survey. During the course of the Dounreay habits survey it became apparent that the national consumption data does not consider any extreme habits and this may be an area for further research. For example, there may be regional or local differences in habits which may result in different rates of consumption, (Table 6.2), with many of the food groups showing greater consumption than the national mean and may represent an important local pathway. It may be necessary to consider that the national data (which is aggregated and is useful as a broad comparison) cannot capture local or regional variations in habits, which may have significance.

Consumption of locally produced foods was identified for all food groups with the exception of poultry, milk and water.

Table 6.2 Summary of adult consumption rate of foods from the terrestrial survey area.

Food type	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1} or l y^{-1})	Observed minimum for the high-rate group (kg y^{-1} or l y^{-1})	Observed mean for the high-rate group (kg y^{-1} or l y^{-1})	Observed 97.5th percentile for high rate group (kg y^{-1} or l y^{-1})	Full dataset – Observed mean (kg y^{-1} or l y^{-1})	Full dataset – 97.5th percentile (kg y^{-1} or l y^{-1})	National mean (kg y^{-1} or l y^{-1})	National 97.5th percentile (kg y^{-1} or l y^{-1})
Vegetables- Green	26	4	44.0	33.9	39.9	44.0	13.9	44.0	15.0	45.0
Vegetables- Other	19	5	26.8	24	25.7	26.8	12.6	26.8	20.0	50.0
Vegetables- Root	30	6	35.0	31.3	33.6	35.0	11.5	35.0	10.0	40.0
Vegetables- Potatoes	34	2	77.0	77.0	77.0	77.0	20.0	77.0	50.0	120
Fruit- Domestic	39	2	171	161	166	171	28.3	161	20.0	75.0
Fruit- Wild	13	2	1.00	1.00	1.00	1.00	0.51	1.00	7.00	25.0
Wild Fungi	12	2	5.00	5.00	5.00	5.00	1.24	5.00	3.00	10.0
Meat- Beef	3	1	52.0	52.0	52.0	52.0	18.0	49.5	15.0	45.0
Meat– Game birds	10	2	6.75	6.75	6.75	6.75	2.36	6.75	ND	ND
Meat – Game (venison)	17	2	43.3	43.3	43.3	43.3	12.1	43.3	ND	ND
Meat – Poultry	0	0	0.00	0.00	0.00	0.00	0.00	0.00	10.0	30.0
Meat – Sheep	5	1	26.0	26.0	26.0	26.0	7.60	23.9	8.00	25.0
Meat – Pork	3	3	40.0	40.0	40.0	40.0	40.0	40.0	15.0	40.0
Eggs	24	1	42.4	42.4	42.4	42.4	11.7	29.5	8.50	25.0
Honey	3	3	0.20	0.20	0.20	0.20	0.20	0.20	2.50	9.50

ND – not determined

Four observed mean consumption rates for the high-rate consumer group were found to be greater than the national 97.5th value. This was for domestic fruit, beef, sheep meat and eggs. The high domestic fruit consumption is attributed to a large amount of apples that were consumed and also used to make cider for the individuals'

consumption. All high figures were checked with individuals for verification. Ten of the observed mean consumption rates for the high-rate consumer group were found to exceed the national mean consumption rates. These were for green vegetables, other vegetables, root vegetables, potatoes, domestic fruit, wild fungi, beef, sheep meat, pork and eggs. Four observed 97.5th percentile consumption rates exceeded the national 97.5th percentile consumption rates. These were domestic fruit, beef, sheep meat and eggs.

6.7.2 Children and infant consumption rates

Table 6.3 presents a summary of the children and infant's consumption rates. The table summarises the number of observations made, the number of people in the high-rate consumer group, the minimum and maximum observed consumption rates for the high-rate consumer group and the observed 97.5th consumption rate. The table also contains the mean consumption rate for both the high-rate consumer group and the whole dataset collected from around Dounreay.

Child consumption of locally produced foods was identified for green vegetables, root vegetables, potatoes, domestic fruit and eggs. One observed mean consumption rate for the high-rate consumer group was found to be greater than the 97.5th value for the full 2018 dataset, this was for root vegetables. Infant consumption of locally produced foods was identified for root vegetables, potatoes and game birds.

Table 6.3 Summary of children and infant consumption rates.

Food type	Number of observations	Number of people in the high-rate group	Observed maximum for the high-rate group (kg y^{-1} or l y^{-1})	Observed minimum for the high-rate group (kg y^{-1} or l y^{-1})	Observed mean for the high-rate group (kg y^{-1} or l y^{-1})	Observed 97.5th percentile for high rate group (kg y^{-1} or l y^{-1})	Full dataset – Observed mean (kg y^{-1} or l y^{-1})	Full dataset – 97.5th percentile (kg y^{-1} or l y^{-1})
Child age group (6 – 15 years old)								
Vegetables- Green	2	2	4.20	4.20	4.20	4.20	4.20	4.20
Vegetables - Root	3	1	1.00	1.00	1.00	1.00	0.44	0.96
Vegetables – Potatoes	3	2	13.9	13.9	13.9	13.9	11.2	13.9
Fruit – Domestic	2	2	23.9	23.9	23.9	23.9	23.9	23.9
Eggs	3	3	5.57	5.57	5.57	5.57	5.57	5.57
Infant age group (0 – 5 years old)								
Vegetables – Root	1	1	1.00	1.00	1.00	1.00	1.00	1.00
Vegetables – Potatoes	1	1	6.00	6.00	6.00	6.00	6.00	6.00
Meat – Game birds	1	1	0.50	0.50	0.50	0.50	0.50	0.50

6.8 GPS survey results

To provide more details on the use of the environment around the Dounreay survey area, three individuals were selected to wear trackers based from the knowledge gained of their habits from the face-to-face interviews. Trackers were deployed for a period of five days and results showed that in general, an over estimation of time and frequency spent undertaking activities appeared to be given.

7 Direct Radiation Exposure

7.1 Introduction

In order to measure wide-scale dose rate across the survey area a gamma-ray spectrometry survey was undertaken around the Dounreay site between Armadale beach and Dunnet Beach. Areas of particular focus were within 5 km radius of the facility and intertidal areas that could be accessed by the general public. All major roads were also surveyed covering more than 50 km across the survey area.

To measure such an extensive area, a Mobile Gamma-ray Spectrometry System (MoGSS) was utilised to measure the differential dose estimations for the natural radioelements (^{40}K and the ^{238}U and ^{232}Th series) alongside estimates for anthropogenic ^{137}Cs. The ability to separate dose contributors is especially important given that any potential contributions from ^{137}Cs could be singled out from the spatially variable background element concentrations, particularly on beaches close to the site. Dounreay, as a condition of its permit, is required to survey beaches for the presence of fragments of irradiated fuel (hot particles), described in Section 2.2.1. The detection of discrete radioactive items was not the focus of this survey.

MoGSS data were used to help target follow-up *in-situ* terrestrial gamma dose rate measurements, which were undertaken at all face-to-face survey locations, access point to intertidal area or at any location where an apparent anomaly was observed. Beta dosimetry was undertaken over intertidal environments to estimate the skin dose associated with the anthropogenic radioactivity in the environment. Measurements were conducted in intertidal areas spanning from between Armadale beach and Dunnet Beach. Measurements in these areas were made on fishing equipment and boats that were frequently immersed in the waters surrounding the Dounreay facility.

7.2 Mobile Gamma Spectrometry Survey

In total, over nine hours of data were captured encompassing 45 969 spectral measurements. (22 156 – road survey; 23 813 – backpack).

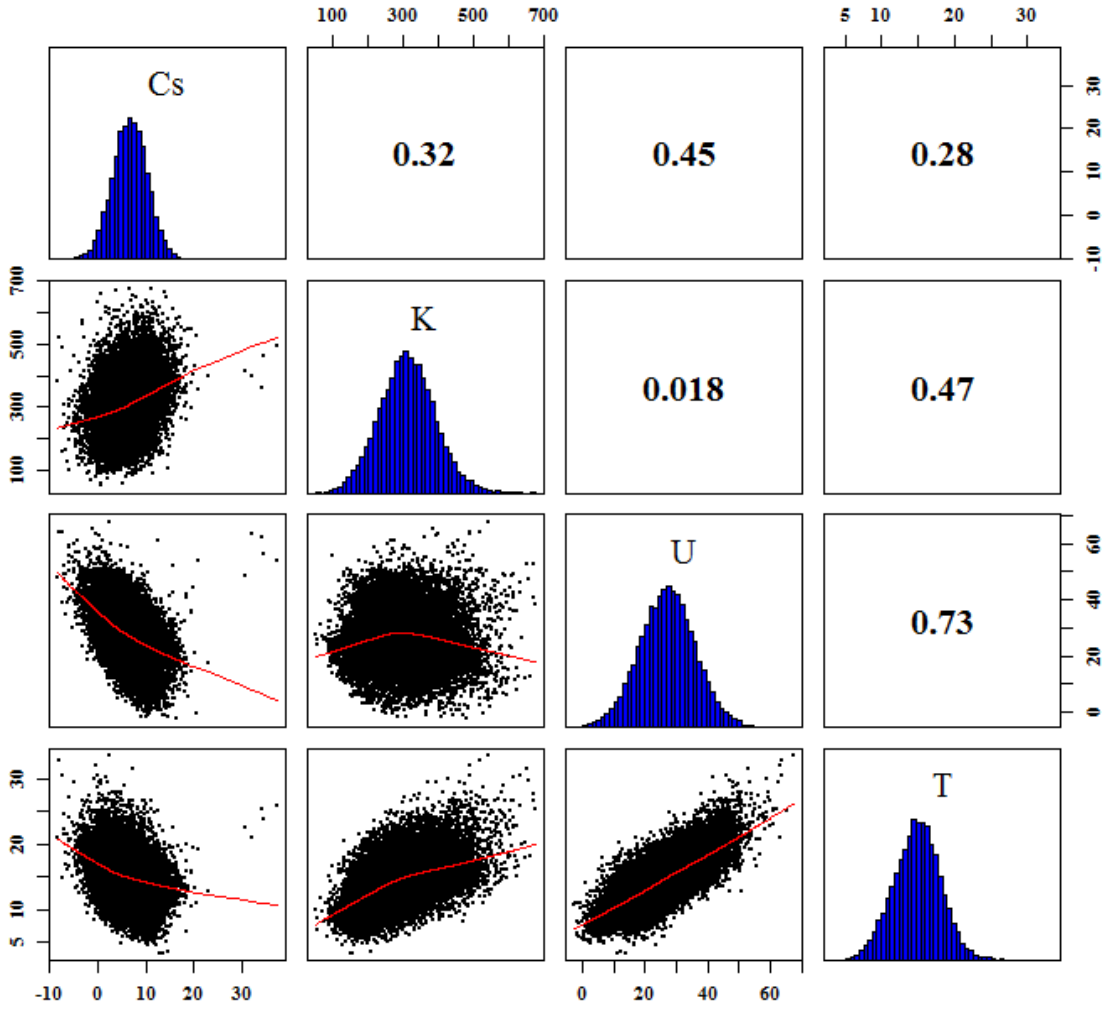

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Figure 7.1 Estimated soil activity values (Bq kg^{-1}) derived from car-borne data. Shows spectral correlations between windows.

Estimated concentrations for ^{40}K, ^{137}Cs and the ^{238}U and ^{232}Th series are plotted in Figure 7.1 for car-borne data. Concentrations exhibit a relatively low level of correlation between the natural radioelements, the highest being between ^{238}U and ^{232}Th (0.73). ^{40}K demonstrates the lowest correlation (0.018 and 0.47) with the other natural radioelements, probably as a result of varying amount of the radioelement being found in road surfaces and building materials. There is low correlation between ^{137}Cs and the natural radioelements, indicative of its spatial distribution not being connected to the underlying geology, but with atmospheric deposition from global weapons testing and Chernobyl. Notice there is a small amount of over-stripping within some of the ^{137}Cs window. In final dose calculations these values are omitted.

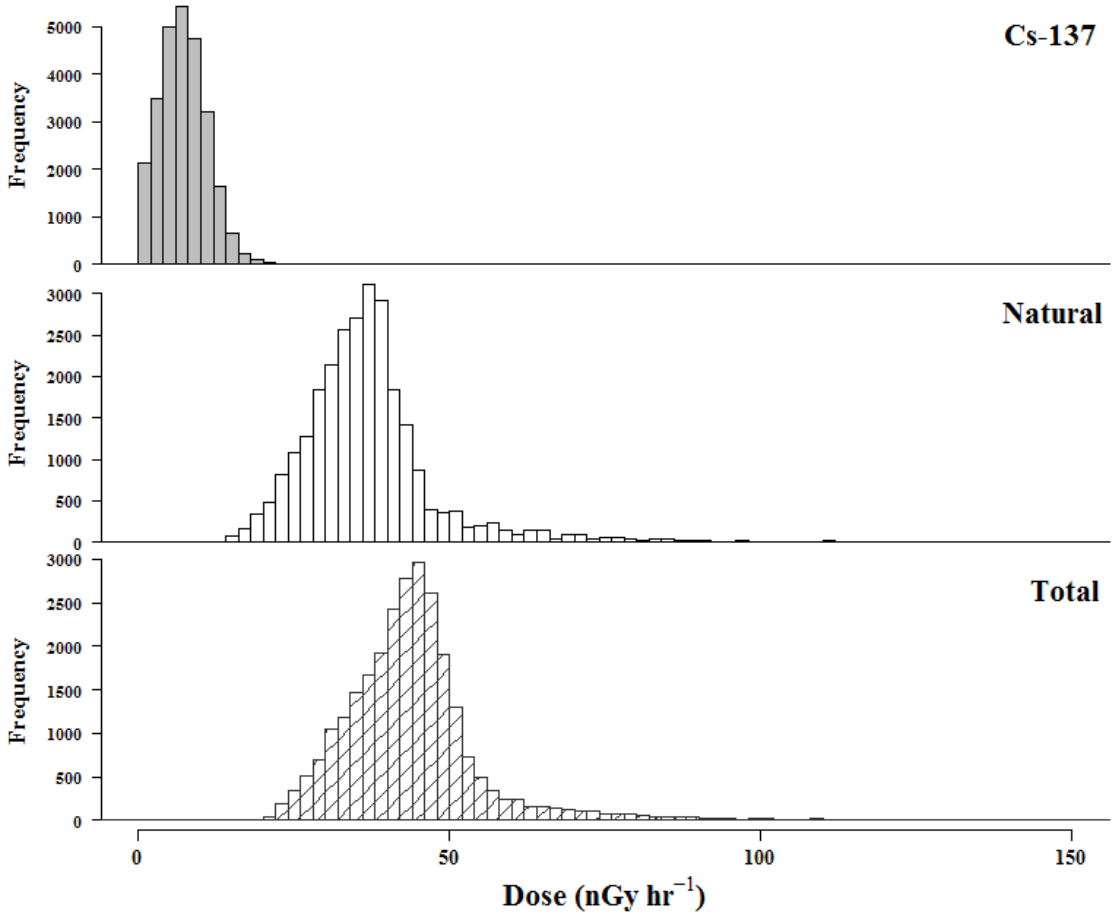

Figure 7.2 Estimated dose rates (nGy hr^{-1}) for the entire survey area. Doses are separated into ^{137}Cs, natural and the combined total.

The estimated dose distribution for both systems is presented in Figure 7.2. Dose contribution is dominated by natural contributions with small contributions from ^{137}Cs being observed. Typical dose rates across the survey area are around 50 nSv hr^{-1}

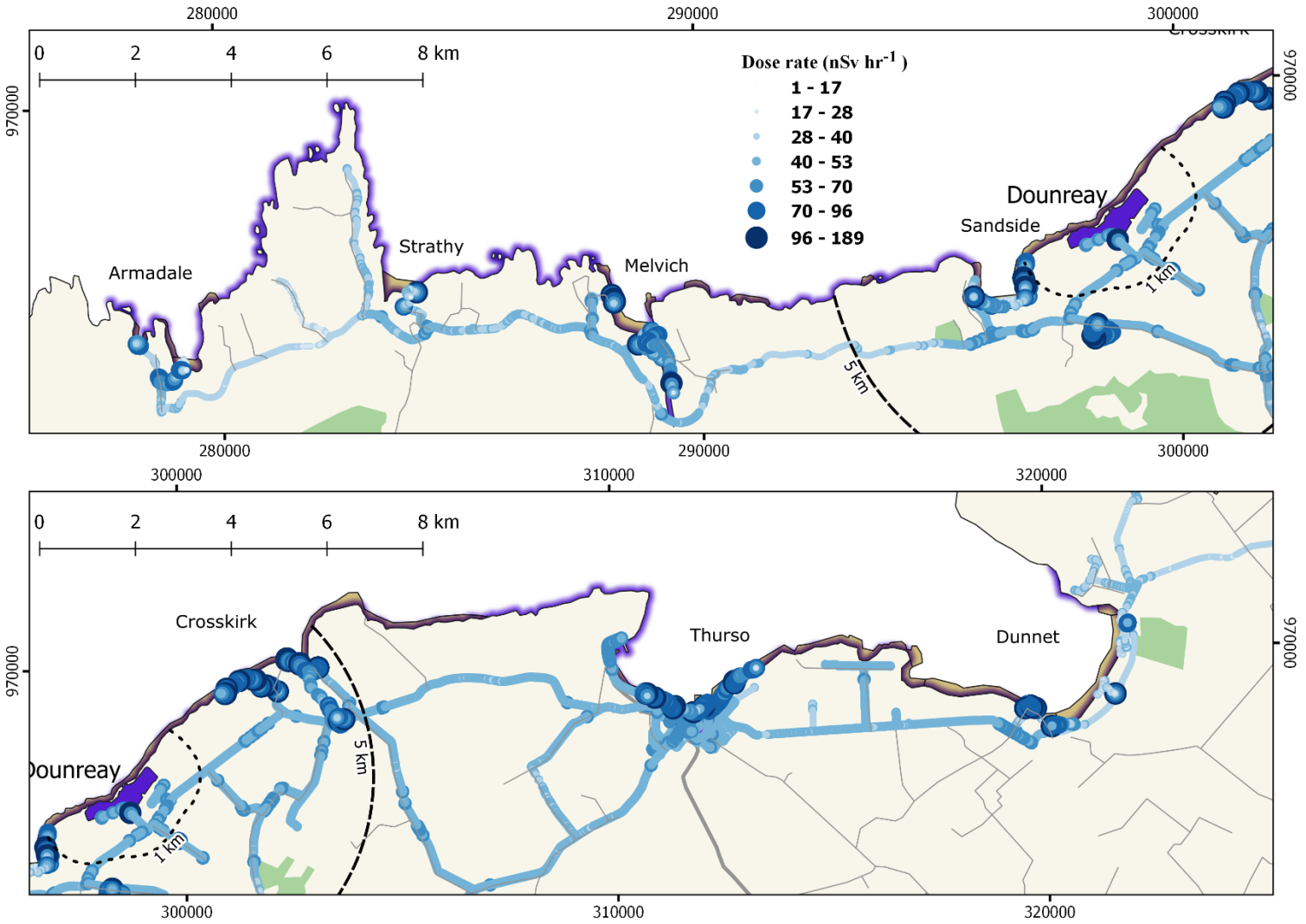

Figure 7.3 Map of total dose rate across the Dounreay survey area.

In terms of general spatial patterns in dose rate, much of the dose rate can be attributed to ^{40}K contributions and further contributions from the ^{238}U and ^{232}Th series (Figure 7.3). Elevated areas of dose tend to be found on rocky outcrops found in intertidal areas and in certain sections of the town, such as the seafront in Thurso, made up of concrete and surrounding buildings containing large proportions of the natural radioelements (Figure 7.4). Notice that on the beach dose rates immediately decease as the overall density of material is reduced and there is an increasing shielding effect from wet sand. This is commonly observation in field gamma-ray spectrometry.

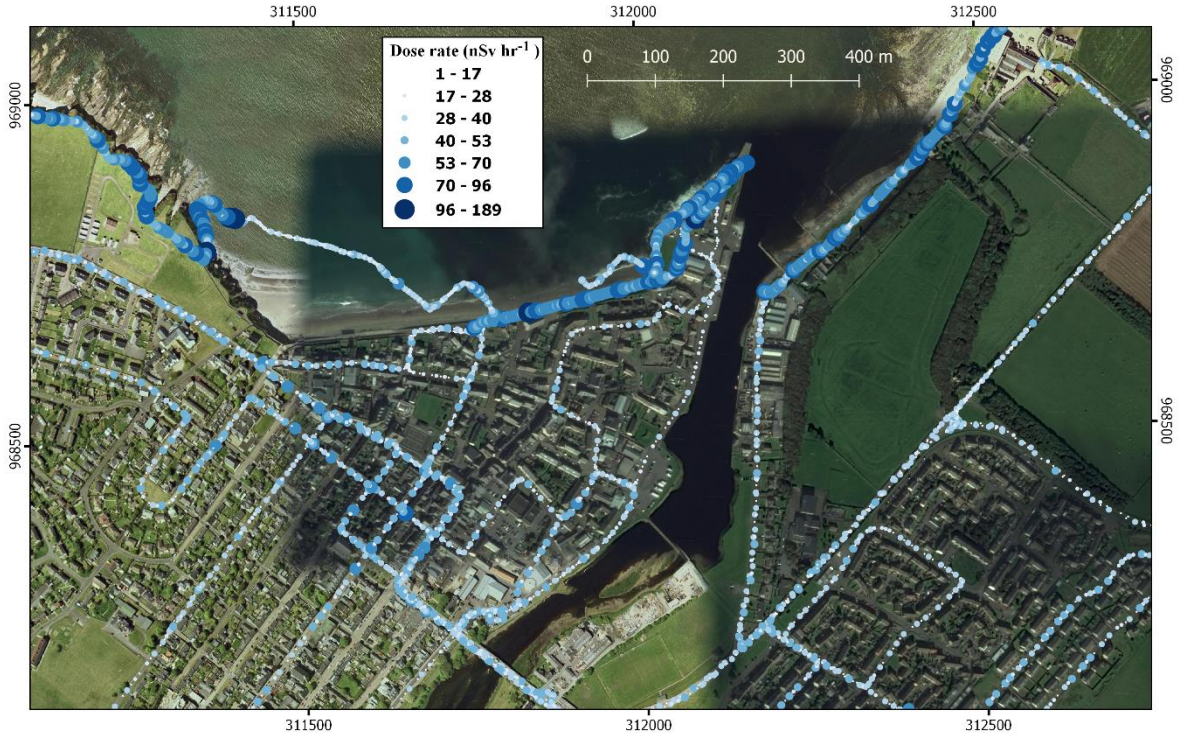

Figure 7.4 Total dose rates in and around Thurso.

In close proximity to the Dounreay site, there is no significant increase in dose rate, with the highest dose rates observed on the rocky outcrops to the east side of Sandside bay and within a wooded area to the south of the image (Figure 7.5).

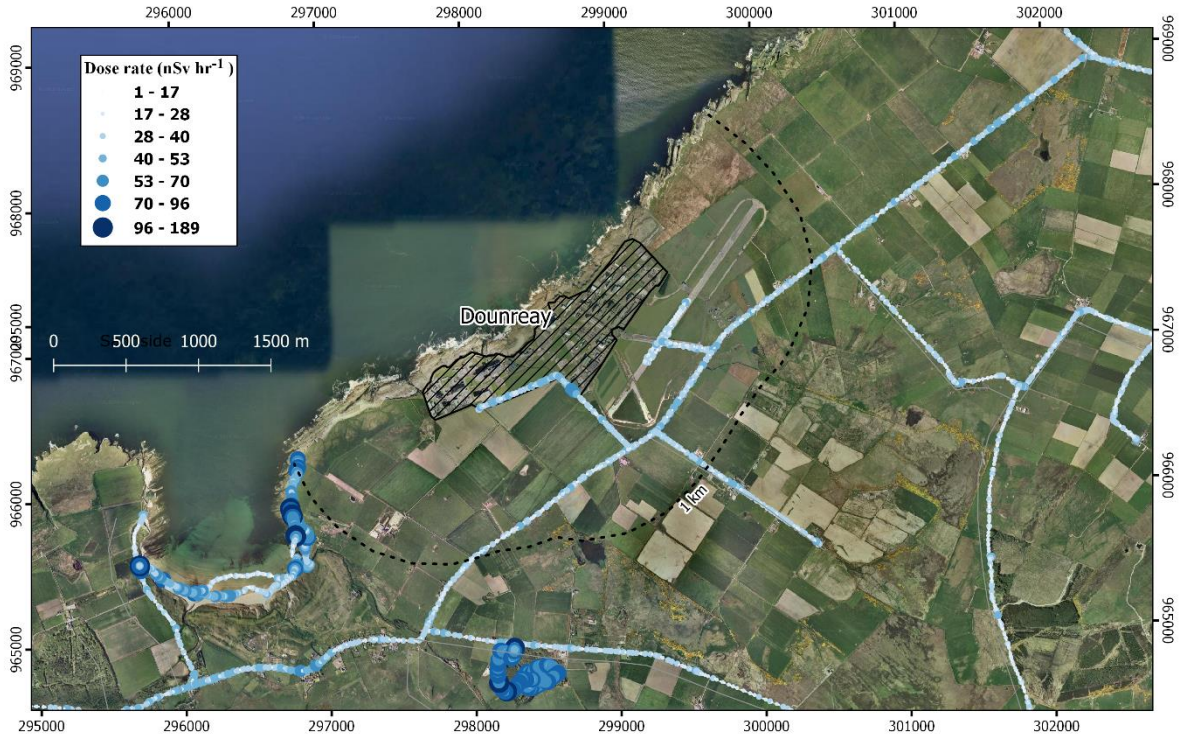

Figure 7.5 Total dose rate around the Dounreay site.

Although more comprehensive validations have been demonstrated in previous reports, notably in the Solway habits survey, it can be confirmed that dose rates generally corroborate between gamma dose rates and dose rates established from MoGSS taken in similar areas (Figure 7.6). Deviations are brought about by geometric changes to the source term as the mobile MoGSS detector is moved around particularly in rocky outcrops (observation in red). Only slight elevations in dose rate were found around the site, although contributions were deemed to be negligible in terms of total dose contribution.

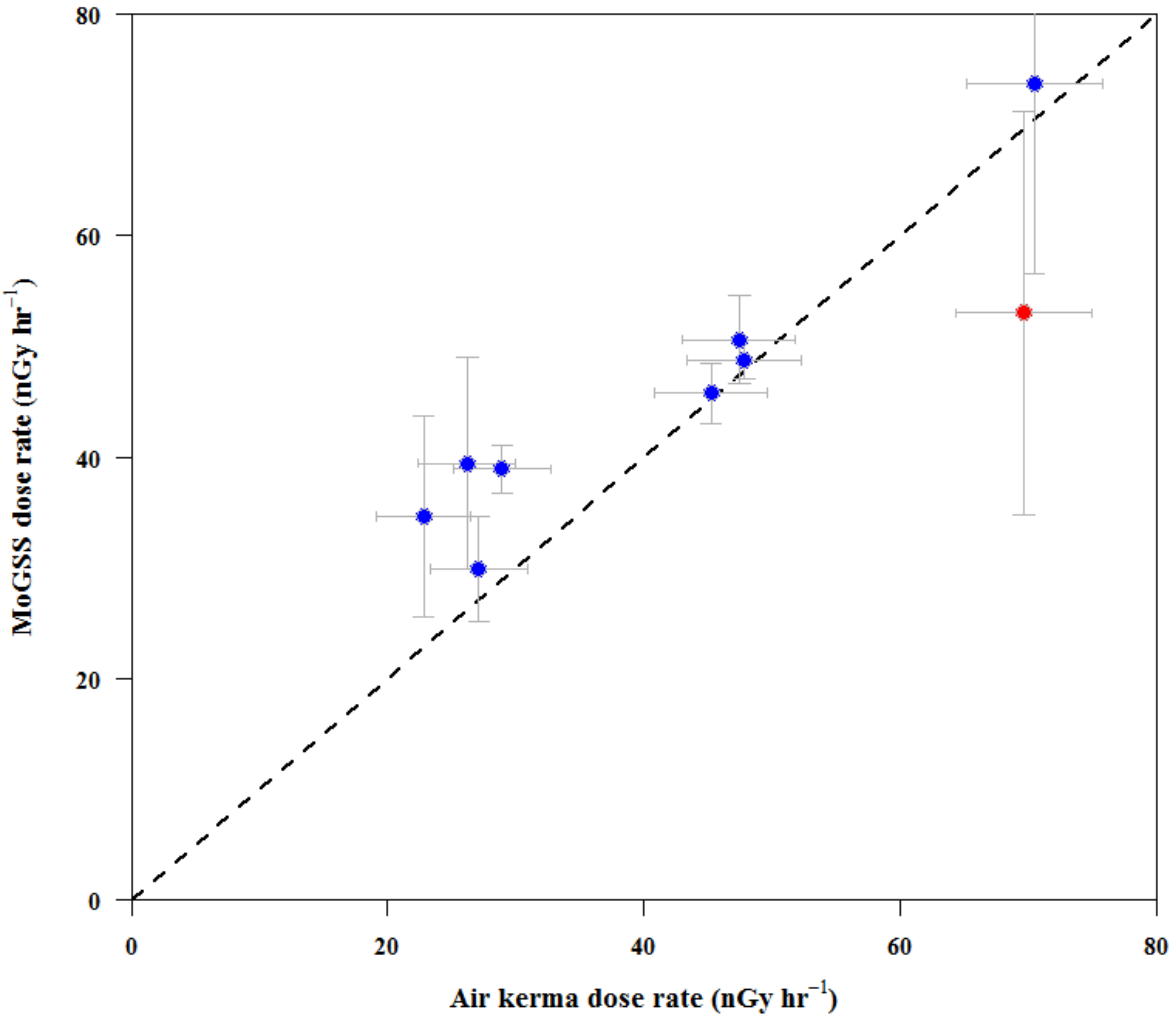

Figure 7.6 Gamma dose rate compared to MoGSS dose rate. The red point was performed at a location where there were significant geometry changes at a rocky outcrop.

7.3 *In-Situ* Gamma Dosimetry

Thirty-seven *in-situ* gamma dose rate measurements were collected at both terrestrial and intertidal sites during the survey (Figure 7.7). A UKAS accredited procedure was followed to estimate the terrestrial gamma dose rate. Since the vast majority of dose contribution was thought to be from the natural radionuclides a ^{226}Ra calibration was used to estimate dose rate for all gamma dose rate measurements given that ^{226}Ra occurs naturally in the environment and emits a number of gamma-rays spanning the entire environmentally relevant spectrum (0-2204 keV).

Table 7.1 Summary of gamma dose rate measurements collected across the Dounreay survey area.

Site	Surface	Eastings	Northings	Dose ($\mu Gy\ hr^{-1}$)	2σ Uncertainty ($\mu Gy\ hr^{-1}$)
Port a Chinn	Rock	278238	965094	0.0311	0.0044
Armadale Bay	Sand	279088	964574	0.0117	0.004
Strathy Bay	Sand	283964	966034	0.0125	0.004
Port Skerra Bay	Rock	287349	966303	0.0816	0.0062
Port Skerra Pier	Rock	288220	965647	0.0833	0.0063
Port Skerra Pier	Concrete	288243	965732	0.027	0.0043
Melvich Bay	Sand	288856	965035	0.015	0.004
Sandside Harbour	Sand	295788	965998	0.0306	0.0044
Sandside Harbour	Sand	295765	965545	0.027	0.0043
Crosskirk Bay	Rock	302902	969938	0.079	0.0061
Brims Ness	Rock	304305	971222	0.0991	0.007
Holburn Head	Rock	310857	971560	0.0894	0.0066
Scrabster Beach	Sand	309955	969928	0.0243	0.0043
Thurso Beach	Sand	311652	968700	0.032	0.0045
East Thurso	Rock	312483	969022	0.0824	0.0063
Murkle Bay	Sand	316787	969583	0.0147	0.004
Castletown Harbour	Sand	319798	968536	0.0342	0.0045
Dunnet Beach	Sand	321796	970433	0.0111	0.004
Burn of Midsand	Sand	321325	969132	0.0139	0.004
Dwarwick Pier	Rock	320728	971277	0.0239	0.0043
Lybster	Grass	302392	968555	0.0679	0.0057
Shebster	Grass	301804	963936	0.0536	0.0052
Achvarasdal Woods	Grass	298224	964941	0.0562	0.0053
Achvarasdal	Grass	298612	964907	0.0566	0.0053
Upper Dounreay	Grass	299788	965996	0.0842	0.0064
Strathy Point	Rock	282865	969685	0.031548	0.0045
Port Skerra Harbour	Rock	287881	966326	0.064286	0.0056

A summary of the dose rate measurements made across the survey area for terrestrial and intertidal areas can be found in Table 7.1. Notice that most of the higher readings are made over rock and next to roads on grassy verges. Lower readings tended to be recorded on sand. Spatially, there is little evidence to link patterns in dose rates to the Dounreay site.

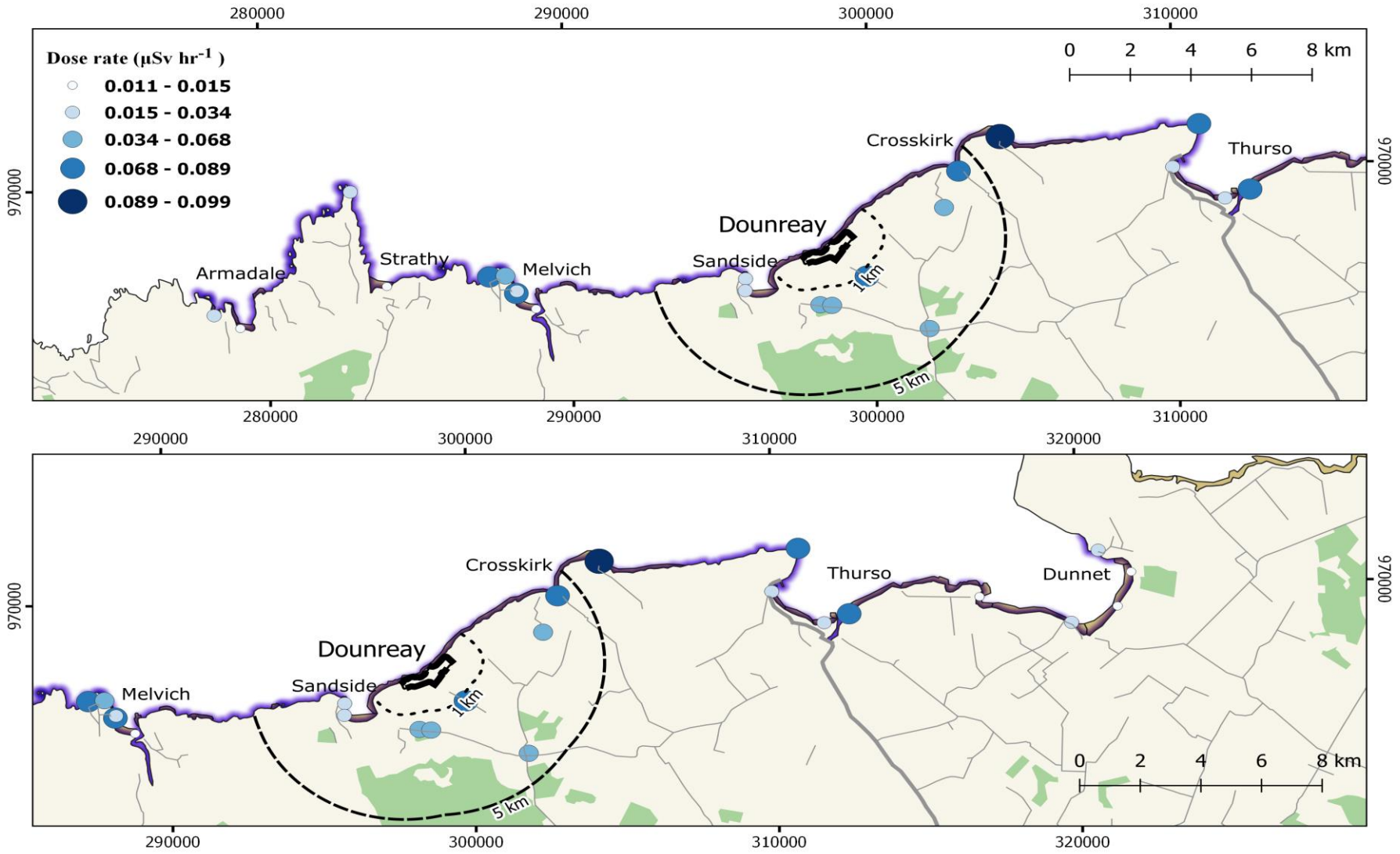

Figure 7.7 Summary of the gamma dose rate measurements across the Dounreay survey area.

7.4 In-Situ Beta Dosimetry

Beta dosimetry of skin dose [H*(0.07)] was measured over intertidal areas (stone, mud, sand and seaweed) and fishing equipment such as lobster pots and boat keels that were situated on or close to the coast.

A total of 28 *in-situ* beta dose measurements were collected at intertidal sites during the survey (Figure 7.8), the majority of which were below the 0.2 µSv h^{-1} per cm^{-2} detection limit with a total of seven readings found to be above this detection limit: beta doses and locations of these measurements are summarised in Table 7.2. The highest dose rate registered by the beta probe occurred in Sandside harbour over sediment substrate (sand). The remaining higher measurements were made predominantly over rock and seaweed. There is no observable spatial pattern in results indicating little influence from discharges.

Table 7.2 Estimated beta dose rates for Dounreay survey area.

Site	Surface	Eastings	Northings	Dose (µSv hr^{-1})	2σ Uncertainty (µSv hr^{-1})
Thurso Beach	Sand	311652	968700	0.23	0.07
Port Skerra Harbour	Rock	287881	966326	0.24	0.08
Crosskirk Bay	Seaweed	302898	969934	0.31	0.08
Port Skerra Bay	Rock	287338	966325	0.47	0.08
Brims Ness	Rock	304305	971222	0.51	0.09
Port Skerra Pier	Rock	288243	965732	0.54	0.09
Holburn Head	Rock	310857	971560	0.56	0.09
Sandside Bay	Sand	295765	965545	0.95	0.09

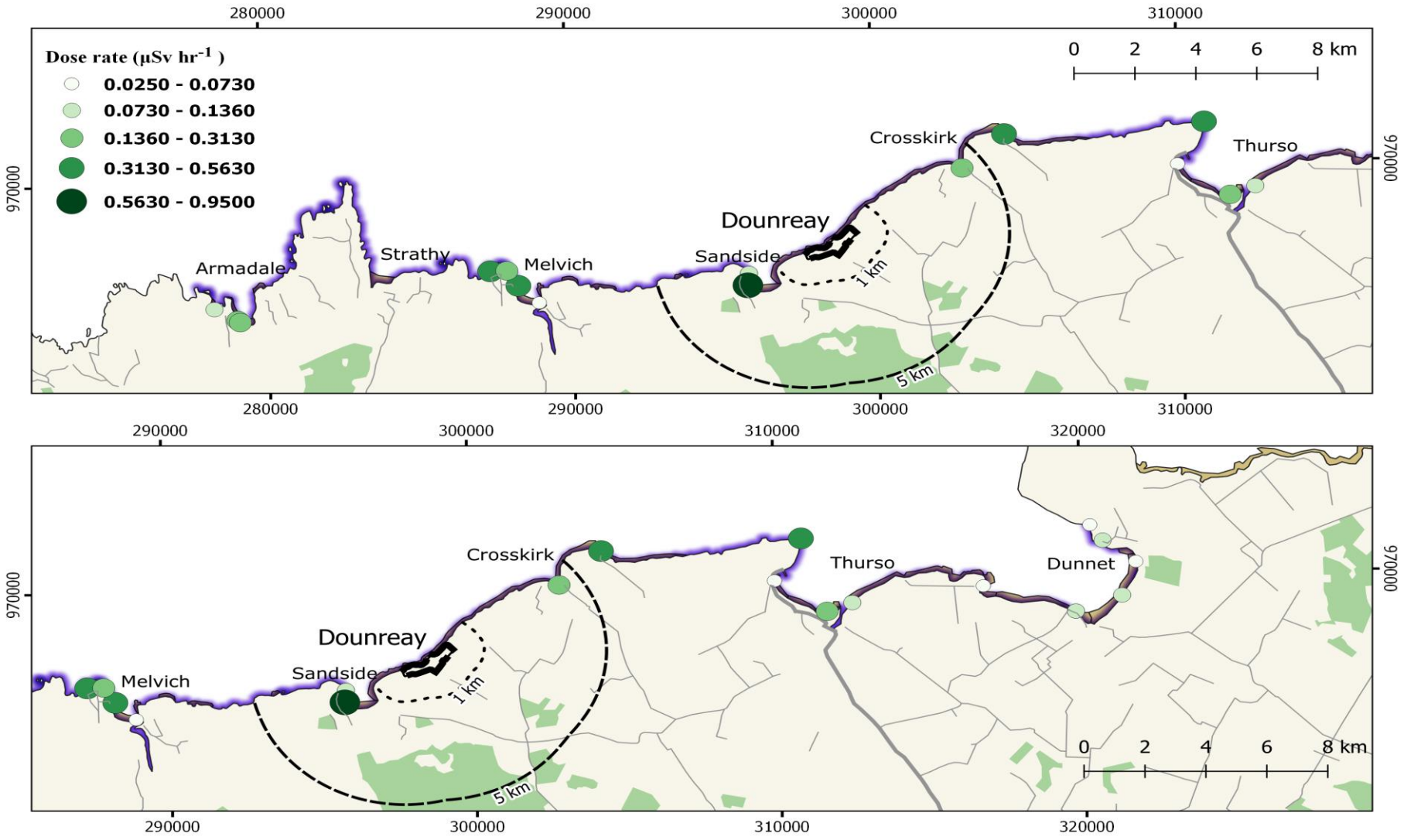

Figure 7.8 Summary of the beta dose rate measurements across the Dounreay survey area.

7.5 Occupancy Rates

7.5.1 Occupancy data for the survey area

The Phase 1 interviews revealed that individuals take part in a range of terrestrial, aquatic and intertidal activities within the survey area (Table 7.3). For terrestrial activities, the most popular activity was dog walking (34 individuals) with the highest occupancy spending 1 511 h y^{-1} at Balmore and Sandside. The activity with the overall maximum occupancy was farming spending 4 745 h y^{-1} at Skaill. For the aquatic activities, sea angling was the most popular (32 individuals) and the individual with the highest occupancy spent 312 h y^{-1} at Port Skerra. The aquatic activity with the overall maximum occupancy was for boat maintenance spending 1 924 h y^{-1} at Scrabster Harbour. For the intertidal activities, walking was the most popular (99 individuals) with the highest individual occupancy being 730 h y^{-1} at Sandside Beach. The intertidal acitivity with the overall maximum occupancy was for a Groundhog Operator spending 1 168 h y^{-1} at Murkle Beach, Sandside Beach and Strathy Beach.

Table 7.3. Summary of the activities and total number of individuals that take part in the activities. The location of the maximum occupancy is also given.

Activity type	Activity	Number of individuals	Maximum occupancy (h y^{-1})	Location of Maximum Occupancy (if provided)
Terrestrial	At work	1	658	Balmore
Terrestrial	Beekeeping	1	52.0	Upper Dounreay
Terrestrial	Bird/nature watching	4	365	Shebster
Terrestrial	Collecting wild produce	2	0.40	Achreamie
Terrestrial	Crofting	11	2 400	Achreamie
Terrestrial	Cycling	8	195	Buldoo
Terrestrial	Dog walking	34	1 511	Balmore and Sandside
Terrestrial	Education/research	1	6.00	Reay
Terrestrial	Farming	23	4 745	Skaill
Terrestrial	Fishing	1	6.00	Forss
Terrestrial	Gardening	31	1 095	Sandside
Terrestrial	Geocaching	2	182	Reay
Terrestrial	Golfing	8	780	Reay
Terrestrial	Grass strimming	1	6.00	Reay
Terrestrial	Green keeping	1	1 976	Reay
Terrestrial	Groundworks	1	120	Reay
Terrestrial	Horse riding	6	365	Achreamie and Reay
Terrestrial	Looking after horses	1	364	Achreamie
Terrestrial	Mucking out donkeys	2	104	Upper Dounreay

Activity type	Activity	Number of Individuals	Maximum Occupancy ($h\ y^{-1}$)	Location of Maximum Occupancy (if provided)
Terrestrial	Photography	2	24.0	Achreamie
Terrestrial	Playing	6	473	Upper Dounreay
Terrestrial	Rambling/walking	28	1 095	Sandside
Terrestrial	Running	5	26.0	Buldoo
Aquatic	Being on a dive boat	3	60.0	Port Skerra
Aquatic	Boat maintenance	7	1 924	Scrabster Harbour
Aquatic	Body boarding	6	42.0	Dunnet Bay
Aquatic	Canoeing	3	60.0	Thurso Bay
Aquatic	Cliff/rock jumping	2	4.00	Holburn Head
Aquatic	Coastguard training	1	15.0	Melvich Bay
Aquatic	Coasteering	1	1.00	Thurso Bay
Aquatic	Commercial fishing/creeling	6	1 64	Port Skerra
Aquatic	Commute via boat	4	6.00	Scrabster
Aquatic	Creel fishing/handling	2	24.0	Melvich Bay
Aquatic	Diving	2	38.0	Port Skerra, Scrabster and Dwarwick Pier
Aquatic	Horse swimming	1	0.80	Dunnet Bay and Murkle Bay
Aquatic	Jet Skiing	1	50.0	Scrabster
Aquatic	Kayaking	12	216	Holburn Head, Dunnet Head, Sandside Bay and Port Skerra
Aquatic	Kite surfing	1	6.00	Strathy Bay, Melvich Bay and Dunnet Bay
Aquatic	Outdoor swimming	20	39.0	Thurso Bay
Aquatic	Power boating	2	26.0	Thurso Bay
Aquatic	RNLI duties	5	120	Thurso Bay
Aquatic	RNLI rescue	4	30.0	Thurso Bay
Aquatic	Rowing	2	26.0	Thurso Bay
Aquatic	Safety boat duties	1	26.0	Thurso Bay
Aquatic	Sailing	4	104	Thurso Bay
Aquatic	Sea angling	32	312	Port Skerra
Aquatic	Snorkelling	1	20.0	Peedie Bay and Dwarwick Pier
Aquatic	Stand-up paddle board	1	6.00	Dunnet Bay, Armadale Bay and Strathy Bay
Aquatic	Surfing	21	754	Thurso Bay, Dunnet Bay, Strathy Bay, Melvich Bay and Sandside Bay

Activity type	Activity	Number of Individuals	Maximum Occupancy ($h\ y^{-1}$)	Location of Maximum Occupancy (if provided)
Aquatic	Training (RNLI)	3	156	Thurso Bay
Aquatic	Sea wildlife tours	1	24.0	Off Rubha an Tuir
Aquatic	Working on a boat	1	1 600	Sandside Harbour
Intertidal	Bait digging	4	20.0	Strathy Beach
Intertidal	Bbq/picnicking/sitting	27	365	Sandside Beach
Intertidal	Beach clean	1	4.00	Dunnet Beach
Intertidal	Beachcombing	6	365	Thurso East Mains and Sandside Beach
Intertidal	Bird/nature watching	2	20.0	Melvich Bay and Sandside Bay
Intertidal	Boat maintenance	1	50.0	Sandside Harbour
Intertidal	Coastguard ropeworks	1	15.0	Port Skerra
Intertidal	Collecting mussels	2	6.00	Sandside Bay
Intertidal	Collecting seaweed	2	4.00	Sandside Harbour
Intertidal	Collecting whelks	1	1.00	Melvich Beach
Intertidal	Dog walking	81	1 095	Dunnet Beach and Scrabster Beach
Intertidal	Fishing	18	610	Scrabster Bay, Port Skerra, Dwarwick Pier
Intertidal	Groundhog operator	1	1 168	Murkle Beach, Strathy Beach and Sandside Beach
Intertidal	Guides and Brownies	1	2.00	Dunnet Beach
Intertidal	Horse riding	3	520	Murkle Beach and Dunnet Beach
Intertidal	Jogging	4	183	Dunnet Beach
Intertidal	Metal detecting	1	2.00	Dunnet Beach
Intertidal	Paddling	28	26.0	Sandside Bay
Intertidal	Painting	1	6.00	Thurso Beach
Intertidal	Photography	1	12.0	Thurso East Mains
Intertidal	Playing	26	104	Melvich Beach
Intertidal	Praying	1	12.0	Crosskirk Bay
Intertidal	Research/education	3	208	Dunnet Beach
Intertidal	Rock pooling	6	8.0	Sandside Harbour
Intertidal	Walking	99	730	Sandside Beach

7.5.2 Occupancy rates within one kilometer of Dounreay (inside/outside work or home)

Individuals living or working within the immediate area of Dounreay were asked to estimate how much time they spend inside and outside their home or workplace. The results presented in Table 7.4 show the time spent indoors and outdoors on an annual basis. A total of four individuals interviewed worked within 1 km of the Dounreay nuclear licensed site. The highest amount of time spent indoors at work for two individuals each was 730 h y^{-1} and the highest amount of time spent outdoors at work for the same two individuals and one other was 3 650 h y^{-1}. A total of 15 individuals were interviewed who lived within 1 km of the Dounreay nuclear licensed site. The highest amount of time spent indoors for two individuals, each spending 8 395 h y^{-1} indoors, and the highest amount of time spent in the immediate area outside their house was 1 225 h y^{-1} for one individual. All figures take into account any holiday period away from home with all figures checked and confirmed by the individuals. The highest total occupancy living within 1 km of the Dounreay nuclear licensed site was 8 760 h y^{-1} for two individuals.

Table 7.4 Occupancy rates of those individuals working or living within 1 km of Dounreay.

Unique ID	Indoors at home ($h\ y^{-1}$)	Outdoors at home ($h\ y^{-1}$)	Indoors at work ($h\ y^{-1}$)	Outdoors at work ($h\ y^{-1}$)
366	4 380	730	0	3 650
15	8 395	365	-	-
25	8 030	730	-	-
41	8 030	78	-	-
42	8 395	0	-	-
31	3 650	365	730	3 650
83	3 650	365	730	3 650
84	3 580	358	-	-
85	3 580	358	-	-
99	4 044	1 011	101	2 022
216	4 044	337	-	-
394	4 200	1 225	-	-
321	4 200	104	-	-
18	3 640	728	-	-
396	4 550	208	-	-

8 Phase 2 Survey Results

8.1 Introduction

The aim of the Phase 2 surveys was to validate the Phase 1 face-to-face surveys, identify any major changes to internal/external exposure paths and to identify any new pathways within a select group of participants. These groups were determined according to the total dose received as calculated from the dose assessment tool (Table 8.1). The data achieved from the Phase 2 surveys were calculated to determine the total dose received. A comparison of the Phase 1 and Phase 2 total dose is presented in Section 9.5.4.

Through discussion with SEPA it was determined that Phase 2 surveys for nine individuals (three from the high exposure group, three from the medium exposure group and three from the low exposure group) should be established.

Table 8.1 Phase 2 survey groups based upon dose assessment

Dose Rate Group	Survey ID
High	G
High	H
High	I
Total in high group:	**7**
Medium	D
Medium	F
Medium	E
Total in medium group:	**11**
Low	C
Low	A
Low	B
Total in low group*:	**276***

*Number of surveys with dose value above zero

Sampling in the Phase 2 surveys was influenced by some individuals not wishing to be contacted again (when asked during Phase 1), incorrect contact details, or individuals not responding to approaches made by the survey team. Contact was made with individuals in each group in late August/early September, with seven individuals identified in the high-rate group.

8.2 Phase 2 Internal Exposure

8.2.1 Internal Terrestrial

Terrestrial food group consumption (all locally sourced within 5 km) reported by each individual is detailed in Table 8.2. Of those re-surveyed, no individual from the low dose group reported any terrestrial food consumption in Phase 1 or Phase 2 surveys. For those from the medium and high dose rate groups, differences were reported. Individuals F and H reported the most differences, particularly for domestic fruit. These differences may be due inconsistences in their assumed consumption when surveyed each time.

Table 8.2 Survey comparison of terrestrial consumption (kg y^{-1})

Food type	Phase	D MED	E MED	F MED	G HIGH	H HIGH	I HIGH
Vegetables - green	1	1.30		44.4		44.4	
	2	3.00		18.2		7.10	
Vegetables - other	1			24.0		24.0	
	2			1.16		-	
Vegetables - root	1			33.8		33.8	
	2			3.66		16.7	
Vegetables - potatoes	1			25.0		25.00	
	2			15.4		-	
Fruit - domestic	1		13.9	49.5	-	49.5	
	2		9.25	130	7.00	85.0	
Food - wild	1			0.50		0.50	
	2			3.00		0.50	
Wild fungi	1		0.05	5.00		5.00	
	2		0.10	1.00		1.00	
Meat - gamebirds	1				2.00		6.75
	2				2.00		6.75
Meat - poultry	1				-		
	2				4 .00		
Meat - venison	1			5.00	22.0	5.00	43.3
	2			-	15.0	1.50	67.2

Individual G reported consuming some domestic fruit and poultry in the Phase 2 survey that were not identified in Phase 1. Individual I reported a larger consumption of venison in the Phase 2 survey. The figures obtained within Phase 1 and Phase 2 for

game consumption were specific and consistent, with the exception of the exclusion of one type of venison consumed in Phase 1. This was captured in Phase 2 which is conveyed in the higher venison consumption.

8.2.2 Aquatic – Internal

Table 8.3 summarised reported changes in aquatic food consumption. No individual from the low assessment group and individual G from the high rate group reported any aquatic consumption in the Phase 1 survey and this did not change in Phase 2.

Table 8.3 Survey comparison of aquatic consumption (kg y^{-1})

Food type	Phase	D MED	E MED	F MED	H HIGH	I HIGH
Fish	1	93.6	18.2	1.50	1.50	12.6
	2	93.6	18.2	44.4	44.4	-
Crustaceans	1		0.90			
	2		0.90			
Molluscs	1			-		
	2			2.80		
Wildfowl	1					
	2					

Individuals F & H reported a significant increase in fish consumption in Phase 2 compared to that in Phase 1. Individual F reported consumption of squid (molluscs), obtained from a local fishmonger, not previously recorded in Phase 1. It is unclear if the squid is sourced from the local aquatic area. Individual I initially reported consuming 12.6 kg of fish in Phase 1 but none in Phase 2.

8.3 Phase 2 External Exposure

8.3.1 Terrestrial activities

Most individuals completing Phase 2 surveys reported some changes regarding terrestrial activities (Table 8.4) with some individuals reporting significant differences in activity time. For example, individual A reported dog walking for 417 h y^{-1} in Phase 1 but only 104 h y^{-1} in Phase 2, whilst individual H reported a change in gardening time from 780 h y^{-1} in Phase 1 to 117 h y^{-1} in Phase 2. Some individuals reported new activities in Phase 2 (D, F, G & H) such as walking and gardening, whilst individual B

reported walking activities in Phase 1 but none in Phase 2. Individual C reported no changes in the type of activities undertaken or the length of time doing so.

Table 8.4 Survey comparison of terrestrial activity times

			OCCUPANCY CHANGES:	
Survey ID	**Category**	**Activity**	**Phase 1**	**Phase 2**
LOW GROUP			**(h y^{-1})**	**(h y^{-1})**
A	Terrestrial	Dog walking	417	104
A	Terrestrial	Geocaching	182	117
A	Terrestrial	Cycling	156	104
B	Terrestrial	Dog walking	130	183
B	Terrestrial	Gardening	130	195
B	Terrestrial	Walking	78	-
MEDIUM GROUP				
D	Terrestrial	Walking	-	183
D	Terrestrial	Gardening	-	117
E	Terrestrial	Farming	2 400	2 600
F	Terrestrial	Gardening	780	1 460
F	Terrestrial	Collect wild foods	-	2
HIGH GROUP				
G	Terrestrial	Shooting	132	40
G	Terrestrial	Walking	-	520
H	Terrestrial	Gardening	780	117
H	Terrestrial	Collect wild foods	-	5
I	Terrestrial	Shooting	132	84

8.3.2 Aquatic/intertidal activities

No individual re-surveyed undertook any activities in or on water. Fewer changes in the length of time individuals undertook activities in the intertidal zone were reported in Phase 2 (Table 8.5) than for terrestrial activities. The largest change was reported

by individual A whilst dog walking, with the annual total hours falling from 1 095 h y^{-1} to 344 h y^{-1} in Phase 2. Walking on the beach was a new activity reported by two individuals (F & H) in the Phase 2 survey. Conversely, individual B reported walking on the beach in the Phase 1 survey but not in Phase 2. Individual D stated they initially spent time sitting on a beach but none when re-surveyed in Phase 2.

Table 8.5 Survey comparison of intertidal activity times

			CHANGES:	
Survey ID	**Category**	**Activity**	**Phase 1**	**Phase 2**
LOW GROUP			**(h y^{-1})**	**(h y^{-1})**
A	Intertidal	Dog walking	1 095	344
B	Intertidal	Walking	4.00	-
MEDIUM GROUP				
D	Intertidal	BBQ/Picnicking/Sitting	365	-
D	Intertidal	Walking	365	330
D	Intertidal	Beachcombing	365	330
F	Intertidal	Walking	-	3
HIGH GROUP				
G	Intertidal	Playing	20	4
H	Intertidal	Walking	-	2

8.3.3 Handling equipment/sediment

No individual re-surveyed in phase two reported undertaking activities that involved handling equipment, as was reported by all individuals in Phase 1. Individual D reported a significant fall in the number of hours spent beachcombing or sitting on the beach at Sandside which involved handling sediment. Individual G initially reported handling sediment for 20 h y^{-1} whilst playing on the beach, in Phase 2 the individual reported no handling sediment activities.

8.4 Living & Working within 1 km

Only one of the individuals re-surveyed (individual E) lived and worked within 1 km of the Dounreay nuclear licensed site and they reported no change in occupancy times either indoors or outdoors.

9 Dose Assessment

9.1 Phase 1 Survey Results: Aquatic Radiation Pathways

9.1.1 Internal exposure

The retrospective dose arising from internal exposure (via food sources from the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 3.4E-3 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5th) is 3.3E-3 mSv y^{-1}. In the case of the most exposed person the dose arises from the consumption of locally obtained fish (40 kg y^{-1}) and crustaceans (35 kg y^{-1}).

9.1.2 External exposure

The retrospective dose arising from external exposure (via people's habit activities in and on the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 4.3E-3 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5th) is 4.2E-3 mSv y^{-1}. In the case of the most exposed person the dose arises from the handling of sediment (730 h y^{-1}) and walking over sandy areas in intertidal regions (1095 h y^{-1}).

9.2 Phase 1 Survey Results: Terrestrial Radiation Pathways

9.2.1 Internal exposure

The retrospective dose arising from internal exposure (via food sources from the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 9.2E-2 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5th) is 8.9E-2 mSv y^{-1}. In the case of the most exposed person the dose arises from the consumption of venison (43 kg y^{-1}) and game birds (6.8 kg y^{-1}).

9.2.2 External exposure

The retrospective dose arising from external exposure (via people's habit activities in the terrestrial environment) was used to determine the representative person from this

pathway. The retrospective dose to the most exposed person from this exposure pathway is 2.4E-2 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5th) is 2.3E-2 mSv y^{-1}. The most exposed person's external terrestrial dose was derived from 8 030 and 730 h y^{-1}, spent living indoors and spending time immediately outdoors of their house within 1 km of the site respectively.

9.2.3 Overall combined radiation exposure

The retrospective dose arising from all exposure pathways (e.g. via people's habit activities in and on the aquatic, intertidal or terrestrial environments and the consumption of all foodstuffs derived locally from the aquatic or terrestrial environments) has been used to determine the representative person. The dose rate to the most exposed person from all exposure pathways is 9.3E-2 mSv y^{-1}. The retrospective dose to the representative person (97.5th) is 9.0E-2 mSv y^{-1}. In the case of the most exposed person, the dose was derived from consumption of locally obtained fish (13 kg y^{-1}), venison (43 kg y^{-1}) and game birds (7 kg y^{-1}). These doses are all small in comparison with the 1 mSv public dose limit.

Table 9.1 contains some summarised dose information based on the average doses to different people based on age profile.

Table 9.1 Average dose estimates (mSv y^{-1}) to stylised people averaged by age (Phase 1 survey).

Age Category	Dose (mSv y^{-1})
Infant	7.5E-4
Child	4.1E-4
Adult	3.4E-3
All	3.1E-3

9.3 Phase 2 Survey Results: Dose Assessment

9.3.1 Introduction

The Phase 2 surveys were undertaken in the winter of 2018 and were re-analysed to determine the dose from each radiation exposure pathway using the same approach

and data groups as for the Phase 1 survey to allow comparisons to be drawn between the two survey periods. The results are described below.

9.2 Phase 2 Survey Results: Aquatic Radiation Pathways

9.4.1 Internal exposure

The retrospective dose arising from internal exposure (via food sources from the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the Phase 1 and Phase 2 most exposed person from this exposure pathway is 2.8E-3 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5^{th}) is 2.7E-3 mSv y^{-1}. In the case of the most exposed person, the dose arises from the consumption of locally obtained fish (94 kg y^{-1}).

9.4.2 External exposure

The retrospective dose arising from external exposure (via people's habit activities in and on the aquatic environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 1.9E-3 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5^{th}) is 1.9E-3 mSv y^{-1}. In the case of the most exposed person, the dose arises from the time spent over sand in intertidal areas and spending time doing activities in the water (660 and 330 h y^{-1} respectively).

9.3 Phase 2 Survey Results: Terrestrial Radiation Pathways

9.5.1 Internal exposure

The retrospective dose arising from internal exposure (via food sources from the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 1.4E-1 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5^{th}) is 1.4E-1 mSv y^{-1}. In the case of the most exposed person the dose arises from the consumption of game birds and venison (7 kg y^{-1} and 67 kg y^{-1} respectively).

9.5.2 External exposure

The retrospective dose arising from external exposure (via people's habit activities in the terrestrial environment) was used to determine the representative person from this pathway. The retrospective dose to the most exposed person from this exposure pathway is 1.5E-2 mSv y^{-1}. The dose to the (hypothetical) representative person (97.5th) is 1.5E-2 mSv y^{-1}. The most exposed person's external terrestrial dose was derived from living (4 044 and 1 011 h y^{-1} indoors and outdoors respectively) and working within 1km (1 001 and 2 022 h y^{-1} indoors and outdoors respectively) of the site.

9.5.3 Overall combined radiation exposure

The retrospective dose arising from all exposure pathways (e.g. via people's habit activities in and on the aquatic, intertidal or terrestrial environments and the consumption of all foodstuffs derived locally from the aquatic or terrestrial environments) has been used to determine the representative person (Table 9.2). The dose rate to the most exposed person from all exposure pathways is 1.4E-1 mSv y^{-1}. The retrospective dose to the (hypothetical) representative person (97.5th) is 1.4E-1 mSv y^{-1}. In the case of the most exposed person, the dose was derived from consumption of game birds and venison (7 kg y^{-1} and 67 kg y^{-1} respectively).

Table 9.2 Average dose estimates (mSv y^{-1}) to stylised people averaged by age (Phase 2 survey).

Age Category	Dose (mSv y^{-1})
Infant	Not surveyed
Child	Not surveyed
Adult	2.5E-2
All	2.5E-2

These doses are all small in comparison with the 1 mSv public dose limit.

9.5.4 Dose comparison of Phase 1 and Phase 2 surveys

The doses calculated for the different exposure pathways from data in the Phase 1 and Phase 2 surveys are provided in Table 9.3. For the internal terrestrial pathway,

and the total from all pathways, the doses for the Phase 2 survey are higher than those for Phase 1. All doses are still well within the 1 mSv y^{-1} public dose limit.

Table 9.3 Comparison of doses calculated from the Phase 1 and Phase 2 survey data

	Phase 1 survey		**Phase 2 survey**	
Pathway	**97.5th Percentile Dose mSv y^{-1}**	**Maximum Dose mSv y^{-1}**	**97.5th Percentile Dose mSv y^{-1}**	**Maximum Dose mSv y^{-1}**
Internal Aquatic	3.3E-3	3.4E-3	2.7E-3	2.8E-3
External Aquatic	4.2E-3	4.3E-3	1.9E-3	1.9E-3
Internal Terrestrial	8.9E-2	9.2E-2	1.4E^{-1}	1.4E^{-1}
External Terrestrial	2.3E-2	2.4E-2	1.5E-2	1.5E-2
All pathways	**9.0E-2**	**9.3E-2**	**1.4E-1**	**1.4E-1**

The Phase 2 surveys provide significant added value in either validating or refining dose estimates attributable to more extreme habits and any changes in the individual's habits following the Phase 1 survey.

10 Comparisons with the Previous Survey

10.1 Introduction

The results from the 2018 Dounreay Habits Survey have been reported in chapters 4-7 for both the postal survey and the face-to-face Phase 1 survey. These results can be compared with results from the previous habits survey, undertaken in Dounreay in 2013 by the Centre for Environment Fisheries and Aquaculture Science (CEFAS). The 2018 survey also presents data based on a postal survey undertaken in 2018, which did not form part of the 2013 survey.

The aquatic and terrestrial face-to-face survey area in the 2018 survey extended (for the aquatic survey) from intertidal areas and waters of the Pentland Firth from Armadale Bay in the west to Dunnet Head in the east, and for the terrestrial survey, the area within a 5 km radius from the Dounreay nuclear licensed site boundary. The postal survey area covered a 20 km radius from the Dounreay site.

10.2 Aquatic Survey

10.2.1 Phase 1 - Adult consumption rates – Internal exposure

In 2018 the mean consumption rate for the adult high-rate group in the face-to-face interviews is substantially increased for fish, crustaceans and molluscs compared with 2013. The main species of fish consumed by the adult high-rate group were haddock, cod, bass, plaice, lemon sole and hake in 2018. In addition to the species being consumed in 2018, the 2013 adult high-rate group were also found to consume dab, mackerel, pollock, salmon, sea trout, brill, flounder, saith, ling and turbot. The main crustaceans consumed by the adult high-rate group in 2018 were common lobster and brown crab which is consistent with the findings in 2013. Mollusc consumption in 2018 consisted of mussels, scallops and whelks by the adult high-rate group compared to only winkles being consumed by the adult high-rate group in 2013. No wildfowl was consumed in 2018 or 2013 from the aquatic survey area. The consumption of marine/intertidal plant/algae (seaweed) by adults was identified in 2018 but not in 2013.

A comparison between 2013 and 2018 adult consumption rates of aquatic foods in the face-to-face interviews is presented in Table 10.1. The table also provides the mean

consumption rates from national data (Smith and Jones, 2003) for comparison. Refer to Section 5.9.1 for further details.

Table 10.1 Comparison between 2013 and 2018 adult consumption rates of aquatic foods.

	2013			2018			National
Food Group	Number of people in the high-rate group	Maximum consumption rate (kg y^{-1})	Mean consumption rate (kg y^{-1})	Number of people in the high-rate group	Maximum consumption rate (kg y^{-1})	Mean consumption rate (kg y^{-1})	Mean (kg y^{-1})
Fish	24	35.4	17.8	4	93.6	66.3	15.0
Crustaceans	12	16.6	13.6	6	35.0	26.2	4.00
Molluscs	1	0.30	0.30	2	21.3	21.3	4.00

10.2.2 Phase 1 - Children and infant consumption rates – Internal exposure

The consumption of fish within the children's high-rate group had increased in 2018 compared to 2013. The children's high-rate group consumed pollock, cod and mackerel in 2018. In addition to the species consumed in 2018 turbot, ling and bass were consumed in 2013. Mollusc consumption in 2018 consisted of mussels and whelks comparing with no mollusc consumption being identified in 2013. No children were found to consume crustaceans or wildfowl in both the 2018 and 2013 habits survey. No consumption of fish, crustaceans, molluscs or marine plants/algae was found in 2018 compared with fish and crustacean consumption being found in 2013.

A comparison between 2013 and 2018 of children and infants' consumption rates of aquatic foods in the face-to-face interviews is presented in Table 10.2.

Table 10.2 Comparison between 2013 and 2018 children and infants' consumption rates of aquatic foods. NC = not consumed

Food group	2013			2018		
	Number of people in the high-rate group	Maximum consumption for the high-rate group (kg y^{-1})	Mean consumption for the high-rate group (kg y^{-1})	Number of people in the high-rate group	Maximum consumption for the high-rate group (kg y^{-1})	Mean consumption rate for the high-rate group (kg y^{-1})
Child (6 - 15 years old)						
Fish	5	11.8	7.90	2	42.1	42.1
Molluscs	NC	-	-	2	0.50	0.50
Infant (0 - 5 years old)						
Fish	1	1.10	1.10	NC	-	-
Crustaceans	1	2.50	2.50	NC	-	-

10.2.3 Phase 1 - Adult intertidal/aquatic occupancy – External exposure

External exposure was divided into five groups: intertidal activities, aquatic in water activities, aquatic on water activities, handling of equipment, and handling of sediment.

In 2018 the highest total intertidal occupancy was 1 460 h y^{-1} (on sand substrate only). The highest occupancy on sand in 2018 was 1 460 h y^{-1} (this was same individual as for the total intertidal occupancy) which was comparable to the highest occupancy in 2013 with 1 500 h y^{-1}. The highest occupancy on rock in 2018 was 1107 h y^{-1} which increased compared to 550 h y^{-1} in 2013. The highest occupancy on sand and stones in 2018 was 117 h y^{-1} compared to 104 h y^{-1} in 2013. The highest occupancy on stones in 2018 was 273.75 h y^{-1}.

The highest occupancy on water for an adult was 2 051 h y^{-1} in 2018 which was decreased from 2 200 y^{-1} in the 2013 survey. The highest occupancy in the water for an adult was 754 h y^{-1} which increased from 250 h y^{-1} in 2013.

10.2.4 Phase 1 – Children and infant intertidal/aquatic occupancy – External exposure

As with the adult intertidal/aquatic occupancy, external exposure was divided into five groups: intertidal activities, aquatic in water activities, aquatic on water activities, handling of equipment, and handling of sediment.

In 2018 the highest total intertidal occupancy for children and infants was determined. The highest total intertidal occupancy for a child was 156 h y^{-1} in 2018 (on a sand substrate only) and the highest total intertidal occupancy for an infant was 107 h y^{-1} (on a sand substrate only). The highest occupancy on sand in 2018 for a child was 156 h y^{-1} (this was same individual as for the total intertidal occupancy) which decreased from 260 h y^{-1} in 2013. In 2018 the highest occupancy on sand for an infant was 107 h y^{-1} which decreased from 219 h y^{-1} in 2013. The highest occupancy on rock for a child in 2018 was 3 h y^{-1} which decreased from 78 h y^{-1} in 2013. There was no occupancy for an infant in 2018 on rock compared to an infant in 2013 on rock for 16 h y^{-1}.

The highest occupancy on water for a child was 60 h y^{-1} in 2018 which was increased from 15 h y^{-1} in the 2013 survey. No infant was found to undertake on water activities in 2018 compared to 15 h y^{-1} in 2013. The highest occupancy in the water for a child was 507 h y^{-1} which increased from 48 h y^{-1} in 2013. No infants were found to undertake in water activities in 2018 compared to 12 h y^{-1} in 2013.

10.2.5 Phase 1 – Handling equipment and handling sediment

Handling of equipment by adults within the 2018 survey area was determined. These activities included handling of boats and boating equipment, handling clothes and overalls and handling fishing gear. In 2018 a total of 1 945 h y^{-1} for handling of equipment was determined as a mean occupancy handling rate for the adult high-rate group. This was higher than 1 414 h y^{-1} determined in the 2013 survey. Handling of

sediment in 2018 was determined as 730 h y^{-1} for the mean for the high-rate group in 2018. This was slightly higher than 432 h y^{-1} determined in the 2013 survey.

In 2018 a total of 69 h y^{-1} for handling of equipment was determined as a mean occupancy handling rate for the child high-rate group. There was no comparison with the 2013 survey as this was not identified. The mean for the high-rate group in 2018 for handling of sediment was determined for children as 90 h y^{-1} which increased from 5 h y^{-1} determined in the 2013 survey. For infants, 106 h y^{-1} was determined for the high-rate group for handling sediment in 2018. This was not identified in the 2013 survey therefore there is no comparison.

10.3 Terrestrial Survey

10.3.1 Phase 1 – Adult consumption rates – Internal exposure

Consumption rates of locally produced food items have increased in the 2018 survey in the root vegetables, domestic fruit, beef, game birds, venison, sheep meat, pig meat (pork) and eggs food groups in comparison to the 2013 survey.

Consumption rates decreased in the 2018 survey in the green vegetables, other vegetables, potatoes, wild fungi, poultry and honey food groups in comparison to the 2013 survey. The decreased honey consumption is assumed to be due to several beekeepers having given up beekeeping and some hives not surviving the winter as reported from individuals during the survey.

A comparison between the 2013 and 2018 mean consumption rates for adult consumption of the terrestrial food groups is presented in Table 10.3. The table also provides the mean consumption rates from national data (Smith and Jones, 2003) for comparison.

Table 10.3 Comparison between 2013 and 2018 mean consumption rates of local terrestrial food groups for adults (kg y^{-1} or l y^{-1}). NC = Not Consumed

	2013	2018	
Food group	**Mean consumption rate for the high-rate group kg y^{-1} or l y^{-1})**	**Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})**	**National**
Vegetables – Green	44.9	39.9	15.0
Vegetables – Other	29.4	25.7	20.0
Vegetables – Root	20.0	33.6	10.0
Vegetable - Potatoes	80.9	77.0	50.0
Fruit- Domestic	71.1	166	20.0
Fruit – Wild	1.00	1.00	7.00
Fungi – Wild	5.10	5.00	3.00
Meat – Beef	39.4	52.0	15.0
Meat – Game birds	NC	6.75	-
Meat– Venison	26.5	43.3	-
Meat - Poultry	31.8	NC	10.0
Meat – Sheep	22.6	26.0	8.00
Meat – Pork	19.0	40.0	15.0
Eggs	20.9	42.4	25.0
Honey	5.90	0.20	2.50

10.3.2 Phase 1 – Children and infant consumption rates - Internal exposure

Consumption rates of locally produced food items consumed in the 2018 survey were found in the green vegetables, root vegetables, potatoes, domestic fruit and eggs food groups. Only domestic fruit was found to be consumed in 2013. Domestic fruit

consumption significantly increased in 2018, there is no explanation for this. The mean consumption rates for children are presented in Table 10.4.

Infants were found to consume root vegetables, potatoes and game birds in 2018 whilst potatoes, domestic fruit and eggs were found to be consumed in 2013. Potato consumption in 2018 was comparable to that in 2013, though slightly decreased. The mean consumption rates for infants are presented in Table 10.5.

Table 10.4 Comparison between 2013 and 2018 mean consumption rates of local terrestrial food groups for children (kg y^{-1} or l y^{-1}). NC = Not Consumed

	2013	**2018**
Food group	**Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})**	**Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})**
Vegetables – Green	NC	4.20
Vegetables – Root	NC	1.00
Vegetables - Potatoes	NC	13.9
Fruit - Domestic	0.30	23.9
Eggs	NC	5.57

Table 10.5 Comparison between 2013 and 2018 mean consumption rates of local terrestrial food groups for infants (kg y^{-1} or l y^{-1}). NC = Not Consumed

	2013	**2018**
Food group	**Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})**	**Mean consumption rate for the high-rate group (kg y^{-1} or l y^{-1})**
Vegetables – Root	NC	1.00
Vegetables - Potatoes	6.3	6.00
Fruit - Domestic	1.4	NC
Eggs	8.9	NC
Meat – Game birds	NC	0.50

10.4 Direct Radiation Survey

Comparison of the occupancy rates for individuals living and working within 1 km of the Dounreay nuclear licensed site and the time spent indoors and outdoors of their home and for those who work and spend time indoors and outdoors within 1 km of the Dounreay nuclear licensed site was determined (Dounreay site workers were not included in this survey). Table 10.6 presents the comparisons between the 2013 and 2018 survey occupancy rates within the direct radiation survey area (h y^{-1}). In 2018 the total occupancy was comparable with 2013 though slightly increased, indoor occupancy was comparable though slightly decreased and outdoor occupancy decreased from 2013. There was no comparison for individuals working within 1 km of the Dounreay nuclear licensed site.

Table 10.6 Comparison between 2013 and 2018 occupancy rates for people living and working within the direct radiation area (h y^{-1}).

Occupancy	2013	2018
Highest total	8 724	8 760
Highest indoor at home	8 720	8 395
Highest outdoor at home	4 351	1 225
Highest indoor at work	-	730
Highest outdoor at work	-	3 650

11 Recommendations and Suggestions for Monitoring Programme Changes.

11.1 Introduction

The Habits Survey presents results for occupancy, activity and food consumption from three main sources of community engagement: (i) postal questionnaire (n = 193); (ii) face-to-face surveys (n = 398); and (iii) a number of meetings and informal contacts. These data have been supplemented with radiometric surveys including: (i) a car-borne and hand-held gamma spectrometry survey (n = 45 969); (ii) *in-situ* gamma dose rate (n = 31 intertidal; n = 6 inland); and, (iv) beta skin dose assessments (n = 27).

11.2 Ongoing Monitoring

Radioactivity in Food and the Environment (RIFE) report demonstrates a comprehensive set of monitoring undertaken annually around the Dounreay site encompassing a range of food types and environmental substrates. The gamma dose rates reported by RIFE are generally higher than those reported here because the RIFE data include the cosmic contribution to dose. This assessment reports the terrestrial gamma dose rate only. When taking this into account, the results are similar. Samples taken and reported by SEPA are provided within the RIFE Report 2015 (published 2016:pp103^{-1}04) and covered cod, crabs, winkles, mussels, *Fucus vesiculosus*, sediment, sea water, spume, beef muscle, beef offal, broccoli, cabbage, eggs, honey, lamb muscle, mint, potatoes, rabbit, rosehips, turnips, wild mushrooms, grass, soil and freshwater.

11.3 Conclusions and Recommendations

Of all the pathways identified and considered, the highest retrospective dose for all exposure pathways was 9.3E-2 mSv y^{-1} from the Phase 1 survey data. The highest retrospective dose for all exposure pathways from the Phase 2 survey data was higher at 1.4E-1 mSv y^{-1}. The doses from the Phase 2 survey were higher than those from the Phase 1 survey for the internal terrestrial pathway and all pathways.

For the Phase 2 survey, the highest dose from internal exposure associated with the terrestrial food pathway was 1.4E-1 mSv y^{-1} arising from the consumption of locally sourced venison and game birds. The highest dose from external exposure was from

doses received by people spending time in the terrestrial environment (1.5E-2 mSv y^{-1}). The highest dose from internal exposure associated with the aquatic food pathway was 2.8E-3 mSv y^{-1} arising from the consumption of locally sourced fish. The highest dose from external exposure in the aquatic environment was from doses received by people spending time in water (1.9E-3 mSv y^{-1}).

These are small compared with the 1 mSv annual public dose limit.

It is recommended that consideration is given to the following areas for future monitoring:

- It is recommended that apples within the domestic fruit food group be sampled annually at Forss and Reay annually within the SEPA monitoring programme. Consumption of local apples was identified as being the highest contribution within the domestic fruit food group, as was also determined within the 2013 survey;
- Despite no winkle pickers being identified in the 2018 survey, winkle pickers were reported to be operating in the survey area. It is therefore recommended that winkles remain part of the monitoring programme;
- It is recommended that pig meat be sampled and incorporated into SEPA's routine monitoring programme due to consumption of locally sourced pig meat within the survey area;
- It is recommended that venison be added and sampled annually from Shebster and Sandside within the SEPA monitoring programme. The highest consumption of locally derived meat within the survey area was venison sourced from around Shebster and Sandside; and,
- Within the wild/free food groups, the following are highlighted as having the highest consumption rates of locally sourced wild foods: (a) blackberries sourced from around Borlum walk within the survey area; and (b) nettles and meadow sweet were sourced from within the Achvarasdal area. Consideration should be given to the inclusion of these additional food items within the routine sampling campaigns at the associated areas indicated.

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Appendices

Appendix A

Appendix A1 Raw Data

Table 1. Phase 1 Adult crustacean consumption

Unique ID	Food type	kg y^{-1}
99	Brown crab	0.90
246	Brown crab	1.00
136	Brown crab	0.34
326	Brown crab	1.00
123	Brown crab	7.80
234	Brown crab	0.60
310	Brown crab	0.60
223	Brown crab	7.80
120	Brown crab	7.80
222	Brown crab	18.2
221	Brown crab	18.2
220	Brown crab	15.6
249	Brown crab	8.00
216	Brown crab	0.90
341	Brown crab	8.00
277	Brown crab	0.10
271	Brown crab	2.40
393	Brown crab	0.45
335	Brown crab	5.40
21	Brown crab	0.22
9	Brown crab	0.22
209	Brown crab	0.35
270	Brown crab	0.35
186	Brown crab	0.46
278	Brown crab	0.46
177	Brown crab	0.34
104	Brown crab	15.6
337	Brown crab	5.00
395	Brown crab	0.25
35	Brown crab	0.25
133	Brown crab	15.0
18	Brown crab	1.84
290	Brown crab	3.00

Unique ID	Food type	kg y^{-1}
394	Brown crab	1.00
396	Brown crab	1.84
159	Brown crab	1.00
40	Brown crab	2.76
252	Brown crab	8.00
319	Brown crab	2.00
251	Brown crab	8.00
320	Brown crab	1.00
250	Brown crab	8.00
253	Brown crab	5.00
271	Common lobster	0.50
219	Common lobster	2.00
394	Common lobster	0.50
341	Common lobster	16.8
133	Common lobster	20.0
249	Common lobster	16.8
290	Common lobster	3.00
253	Common lobster	10.0
337	Common lobster	10.0
252	Common lobster	16.8
251	Common lobster	16.8
250	Common lobster	15.0
320	Common lobster	1.00
159	Common lobster	0.50
335	Prawns (langoustines)	0.90
61	Prawns (langoustines)	0.50
342	Prawns (langoustines)	0.50

Table 2. Phase 1 Adult fish consumption

Unique ID	Food type	kg y^{-1}
272	Bass	2.40
81	Bass	4.50
290	Bass	2.08
65	Bass	0.30
277	Bass	0.35
333	Bass	20.0
38	Bass	7.80
37	Bass	7.80

Unique ID	Food type	kg y^{-1}
34	Bass	7.80
28	Bass	9.00
358	Bass	0.30
212	Bass	0.35
391	Bass	31.2
210	Bass	2.40
198	Cod	0.25
238	Cod	9.10
82	Cod	15.6
298	Cod	8.00
295	Cod	18.8
293	Cod	8.40
210	Cod	2.404
290	Cod	2.08
221	Cod	18.2
96	Cod	7.80
97	Cod	7.80
272	Cod	2.40
271	Cod	3.00
251	Cod	4.00
161	Cod	2.90
252	Cod	4.00
133	Cod	10.0
254	Cod	3.00
199	Cod	0.25
123	Cod	9.10
273	Cod	1.00
95	Cod	26.0
197	Cod	0.25
407	Cod	18.8
249	Cod	4.00
104	Cod	18.2
163	Cod	3.60
250	Cod	4.00
390	Cod	7.80
21	Cod	5.10
359	Cod	0.30
81	Cod	15.6
359	Cod	20.8
28	Cod	15.6

Unique ID	Food type	kg y^{-1}
30	Cod	2.00
336	Cod	3.00
344	Cod	7.80
40	Cod	0.89
341	Cod	4.00
65	Cod	0.30
9	Cod	5.10
393	Cod	15.6
300	Cod	10.4
313	Cod	15.6
301	Cod	10.4
66	Cod	20.8
273	Flounder	4.00
121	Flounder	2.10
216	Haddock	18.2
161	Haddock	2.90
18	Haddock	15.6
163	Haddock	3.60
17	Haddock	7.20
177	Haddock	4.00
215	Haddock	2.10
199	Haddock	3.00
197	Haddock	3.00
9	Haddock	6.75
212	Haddock	18.2
5	Haddock	15.6
198	Haddock	3.00
393	Haddock	15.6
210	Haddock	2.40
203	Haddock	1.25
209	Haddock	18.2
4	Haddock	31.25
12	Haddock	15.6
97	Haddock	3.00
81	Haddock	15.6
82	Haddock	15.6
86	Haddock	1.39
78	Haddock	15.6
87	Haddock	1.25
94	Haddock	31.2

Unique ID	Food type	kg y^{-1}
77	Haddock	10.4
66	Haddock	20.8
65	Haddock	0.30
96	Haddock	3.00
27	Haddock	8.40
51	Haddock	15.6
142	Haddock	0.30
99	Haddock	18.2
28	Haddock	15.62
104	Haddock	18.2
113	Haddock	1.392
119	Haddock	8.392
120	Haddock	18.2
123	Haddock	9.09
95	Haddock	6.00
21	Haddock	6.75
133	Haddock	15.0
136	Haddock	36.7
61	Haddock	5.40
318	Haddock	10.0
248	Haddock	17.0
336	Haddock	3.00
249	Haddock	4.00
277	Haddock	18.2
335	Haddock	15.6
251	Haddock	4.00
326	Haddock	17.0
252	Haddock	4.00
320	Haddock	1.00
246	Haddock	17.0
319	Haddock	2.00
250	Haddock	4.00
254	Haddock	3.00
310	Haddock	18.2
261	Haddock	4.19
270	Haddock	18.2
271	Haddock	6.00
272	Haddock	2.40
221	Haddock	18.2
293	Haddock	4.19

Unique ID	Food type	kg y^{-1}
286	Haddock	1.75
253	Haddock	20.0
244	Haddock	2.00
223	Haddock	18.2
234	Haddock	18.2
238	Haddock	9.09
391	Haddock	15.6
243	Haddock	10.0
359	Haddock	20.8
358	Haddock	0.30
345	Haddock	15.6
342	Haddock	5.40
341	Haddock	4.00
337	Haddock	20.0
245	Haddock	2.00
66	Hake	20.8
271	Hake	15.6
359	Hake	20.8
163	Halibut	3.60
335	Lemon sole	0.30
272	Lemon sole	2.40
4	Lemon sole	31.2
210	Lemon sole	2.40
95	Ling	3.00
313	Mackerel	7.80
34	Mackerel	9.10
298	Mackerel	4.50
95	Mackerel	1.00
336	Mackerel	1.00
390	Mackerel	7.80
295	Mackerel	4.50
299	Mackerel	4.50
318	Mackerel	4.00
11	Mackerel	1.50
316	Mackerel	0.17
38	Mackerel	9.10
341	Mackerel	0.75
337	Mackerel	3.00
16	Mackerel	4.00
58	Mackerel	0.174

Unique ID	Food type	kg y^{-1}
57	Mackerel	0.34
19	Mackerel	1.50
344	Mackerel	7.80
40	Mackerel	0.89
37	Mackerel	9.10
198	Mackerel	0.25
253	Mackerel	3.00
252	Mackerel	0.75
290	Mackerel	2.07
250	Mackerel	0.75
189	Mackerel	0.34
133	Mackerel	5.00
197	Mackerel	0.25
251	Mackerel	0.75
199	Mackerel	0.25
245	Mackerel	0.50
202	Mackerel	0.17
244	Mackerel	0.50
243	Mackerel	4.00
239	Mackerel	0.34
249	Mackerel	0.75
254	Mackerel	1.00
96	Mackerel	1.00
124	Mackerel	0.17
273	Mackerel	3.00
97	Mackerel	1.00
223	Monk fish	11.7
120	Monk fish	11.7
4	Plaice	31.2
290	Plaice	2.07
295	Pollock	18.8
245	Pollock	1.00
199	Pollock	0.25
21	Pollock	3.40
124	Pollock	1.00
244	Pollock	1.00
197	Pollock	0.25
243	Pollock	4.00
9	Pollock	3.40
202	Pollock	1.00

Unique ID	Food type	kg y^{-1}
254	Pollock	2.00
318	Pollock	4.00
298	Pollock	18.8
273	Pollock	12.0
299	Pollock	18.8
58	Pollock	1.00
336	Pollock	2.00
133	Pollock	10.0
198	Pollock	0.25
124	Salmon	1.00
290	Salmon	2.07
58	Salmon	1.00
202	Salmon	1.00
161	Salmon	2.90
88	Sea trout	4.00
121	Sea trout	2.00
58	Sea trout	0.75
124	Sea trout	0.75
107	Sea trout	4.00
202	Sea trout	0.75
163	Whiting	3.60

Table 3. Phase 1 Children fish consumption

Unique ID	Food type	kg y^{-1}
69	Bass	15.6
237	Cod	3.00
296	Cod	18.8
297	Cod	18.8
69	Haddock	15.68
200	Mackerel	0.348
201	Mackerel	0.348
237	Mackerel	3.00
296	Mackerel	4.50
297	Mackerel	4.50
296	Pollock	18.8
297	Pollock	18.8
90	Sea trout	4.00

Table 4. Phase 1 Adult mollusc consumption

Unique ID	Food type	kg y^{-1}
21	Mussels	20.0
397	Mussels	0.33
9	Mussels	20.0
159	Mussels	0.40
119	Scallops	4.80
57	Scallops	0.375
189	Scallops	0.38
270	Scallops	0.15
209	Scallops	0.15
9	Scallops	1.00
27	Scallops	4.80
16	Scallops	0.60
61	Scallops	0.38
342	Scallops	0.38
104	Scallops	1.20
221	Scallops	1.20
310	Scallops	0.20
234	Scallops	0.20
316	Scallops	0.08
239	Scallops	0.08
326	Scallops	0.20
246	Scallops	0.20
21	Scallops	1.00
21	Whelks	0.34
9	Whelks	0.34
397	Whelks	0.17
159	Whelks	0.40

Table 5. Phase 1 Children mollusc consumption

Unique ID	Food type	kg y^{-1}
8	Mussels	0.33
3	Mussels	0.33
201	Scallops	0.38
200	Scallops	0.38
8	Whelks	0.17
3	Whelks	0.17

Table 6. Phase 1 Adult in water activities

Unique ID	In water activity	h y^{-1}
241	Body boarding	28.0
351	Body boarding	28.0
357	Body boarding	12.0
257	Cliff/rock jumping	4.00
329	Cliff/rock jumping	1.00
194	Coast guard training	15.0
329	Coasteering	1.00
327	Diving	3.00
328	Diving	4.25
328	Diving	29.0
328	Diving	4.25
104	Horse swimming	0.40
104	Horse swimming	0.40
6	Outdoor swimming	6.50
17	Outdoor swimming	0.50
53	Outdoor swimming	26.0
54	Outdoor swimming	26.0
88	Outdoor swimming	1.00
117	Outdoor swimming	13.0
220	Outdoor swimming	3.00
220	Outdoor swimming	3.00
169	Outdoor swimming	10.0
169	Outdoor swimming	10.0
169	Outdoor swimming	1.00
189	Outdoor swimming	3.00
318	Outdoor swimming	2.00
397	Outdoor swimming	1.00
398	Outdoor swimming	1.00
133	RNLI duties	4.00
329	RNLI duties	9.00
273	Snorkelling	10.0
273	Snorkelling	10.0
26	Surfing	39.0
26	Surfing	234
26	Surfing	234
26	Surfing	234
88	Surfing	39.0
131	Surfing	4.00

Unique ID	In water activity	h y^{-1}
131	Surfing	4.00
131	Surfing	4.00
131	Surfing	4.00
133	Surfing	9.00
133	Surfing	9.00
133	Surfing	9.00
162	Surfing	34.0
162	Surfing	34.0
164	Surfing	12.0
166	Surfing	12.0
167	Surfing	12.0
173	Surfing	39.0
189	Surfing	12.0
273	Surfing	39.0
273	Surfing	78.0
273	Surfing	39.0
273	Surfing	78.0
274	Surfing	104
274	Surfing	104
274	Surfing	312
274	Surfing	26.0
274	Surfing	208
276	Surfing	2.00
276	Surfing	8.00
276	Surfing	2.00
276	Surfing	2.00
276	Surfing	8.00
303	Surfing	16.8
303	Surfing	16.8
303	Surfing	16.8
303	Surfing	237
303	Surfing	16.8
303	Surfing	16.8
303	Surfing	16.8
304	Surfing	237
304	Surfing	16.8
304	Surfing	16.8
304	Surfing	16.8
304	Surfing	16.8
304	Surfing	16.8

Unique ID	In water activity	h y^{-1}
304	Surfing	16.8
354	Surfing	405
354	Surfing	34.0
354	Surfing	34.0
354	Surfing	34.0
354	Surfing	34.0
357	Surfing	6.00
357	Surfing	6.00

Table 7. Phase 1 Children in water activities

Unique ID	In water activity	h y^{-1}
170	Body boarding	13.0
242	Body boarding	42.0
353	Body boarding	39.0
3	Outdoor swimming	1.00
8	Outdoor swimming	1.00
55	Outdoor swimming	26.0
56	Outdoor swimming	26.0
69	Outdoor swimming	39.0
200	Outdoor swimming	3.00
201	Outdoor swimming	3.0
170	Surfing	52.0
200	Surfing	12.0
201	Surfing	12.0
353	Surfing	39.0
353	Surfing	234
353	Surfing	39.0
353	Surfing	39.0
353	Surfing	39.0
353	Surfing	39.0
353	Surfing	39.0

Table 8. Phase 1 Adult on water activities

Unique ID	On water activity	h y^{-1}
17	Being on a dive boat	24.0
327	Being on a dive boat	8.00
328	Being on a dive boat	60.0

Unique ID	On water activity	h y^{-1}
9	Boat maintenance	4.00
159	Boat maintenance	16.0
215	Boat maintenance	65.0
317	Boat maintenance	1924
328	Boat maintenance	104
394	Boat maintenance	365
395	Boat maintenance	195
189	Canoeing	60.0
256	Commercial fishing/creeling	65.0
257	Commercial fishing/creeling	60.0
329	Commercial fishing/creeling	65.0
337	Commercial fishing/creeling	1643
341	Commercial fishing/creeling	1643
394	Commercial fishing/creeling	1600
9	Commute via boat	6.00
16	Commute via boat	1.00
17	Commute via boat	0.50
356	Commute via boat	0.25
215	Creel fishing/Handling	8.00
319	Creel fishing/Handling	24.0
39	Jet skiing	50.0
86	kayaking	97.5
100	kayaking	54.0
100	kayaking	54.0
100	kayaking	54.0
100	kayaking	54.0
113	kayaking	97.5
163	kayaking	6.00
163	kayaking	6.00
163	kayaking	1.00
163	kayaking	1.00
163	kayaking	1.00
205	kayaking	27.0
205	kayaking	36.0
205	kayaking	27.0
205	kayaking	27.0
205	kayaking	27.0
258	kayaking	26.0
258	kayaking	52.0
258	kayaking	36.0

Unique ID	On water activity	h y^{-1}
269	kayaking	26.0
269	kayaking	36.0
269	kayaking	52.0
276	kayaking	48.0
390	kayaking	6.00
398	kayaking	6.00
276	Kite surfing	2.00
276	Kite surfing	2.00
276	Kite surfing	2.00
16	Power boating	20.0
17	Power boating	26.0
133	RNLI duties	82.0
317	RNLI duties	120
330	RNLI duties	78.0
256	RNLI Rescue	30.0
257	RNLI Rescue	6.75
317	RNLI Rescue	6.50
329	RNLI Rescue	30.0
16	Rowing	8.00
17	Rowing	26.0
17	Safety boat duties	26.0
16	Sailing	20.0
17	Sailing	26.0
159	Sailing	18.0
161	Sailing	104
9	Sea angling	30.0
21	Sea angling	3.00
88	Sea angling	5.00
95	Sea angling	104
95	Sea angling	104
121	Sea angling	5.00
121	Sea angling	5.00
133	Sea angling	72.0
173	Sea angling	5.00
192	Sea angling	2.00
193	Sea angling	2.00
195	Sea angling	2.00
196	Sea angling	2.00
197	Sea angling	312
215	Sea angling	8.00

Unique ID	On water activity	h y^{-1}
220	Sea angling	24.0
221	Sea angling	24.0
222	Sea angling	24.0
235	Sea angling	72.0
256	Sea angling	15.0
257	Sea angling	30.0
273	Sea angling	54.0
274	Sea angling	25.0
295	Sea angling	54.0
298	Sea angling	54.0
311	Sea angling	72.0
318	Sea angling	36.0
318	Sea angling	18.0
319	Sea angling	10.0
329	Sea angling	15.0
336	Sea angling	48.0
337	Sea angling	80.0
390	Sea angling	42.0
26	Stand-up paddle boarding	2.00
26	Stand-up paddle boarding	2.00
26	Stand-up paddle boarding	2.00
256	Training	156
257	Training	104
329	Training	156
337	Wildlife tours	24.0
40	Working on a boat	1600

Table 9. Phase 1 Children on water activities

Unique ID	On water activity	h y^{-1}
200	Canoeing	60.0
201	Canoeing	60.0
3	kayaking	6.00
8	kayaking	6.00
296	Sea angling	54.0
297	Sea angling	54.0

Table 10. Phase 1 Adult intertidal activities

Unique ID	Intertidal activity	h y^{-1}
22	Bait digging	6.50
22	Bait digging	13.0
95	Bait digging	13.0
121	Bait digging	2.00
121	Bait digging	2.00
318	Bait digging	1.50
318	Bait digging	1.50
4	BBQ/Picnicking/Sitting	365
59	BBQ/Picnicking/Sitting	4.00
63	BBQ/Picnicking/Sitting	3.00
86	BBQ/Picnicking/Sitting	13.0
86	BBQ/Picnicking/Sitting	13.0
86	BBQ/Picnicking/Sitting	13.0
102	BBQ/Picnicking/Sitting	0.30
113	BBQ/Picnicking/Sitting	13.0
113	BBQ/Picnicking/Sitting	13.0
113	BBQ/Picnicking/Sitting	13.0
142	BBQ/Picnicking/Sitting	2.00
174	BBQ/Picnicking/Sitting	3.00
184	BBQ/Picnicking/Sitting	0.30
212	BBQ/Picnicking/Sitting	1.00
212	BBQ/Picnicking/Sitting	2.00
273	BBQ/Picnicking/Sitting	4.00
273	BBQ/Picnicking/Sitting	12.0
277	BBQ/Picnicking/Sitting	1.00
277	BBQ/Picnicking/Sitting	2.00
281	BBQ/Picnicking/Sitting	22.5
281	BBQ/Picnicking/Sitting	22.5
281	BBQ/Picnicking/Sitting	22.5
281	BBQ/Picnicking/Sitting	22.5
282	BBQ/Picnicking/Sitting	22.5
282	BBQ/Picnicking/Sitting	22.5
282	BBQ/Picnicking/Sitting	22.5
282	BBQ/Picnicking/Sitting	22.5
300	BBQ/Picnicking/Sitting	3.00
300	BBQ/Picnicking/Sitting	3.00
300	BBQ/Picnicking/Sitting	3.00
300	BBQ/Picnicking/Sitting	3.00
301	BBQ/Picnicking/Sitting	3.00
301	BBQ/Picnicking/Sitting	3.00

Unique ID	Intertidal activity	h y^{-1}
301	BBQ/Picnicking/Sitting	3.00
301	BBQ/Picnicking/Sitting	3.00
343	BBQ/Picnicking/Sitting	4.00
378	BBQ/Picnicking/Sitting	3.00
273	Beach Clean	4.00
4	Beachcombing	365
17	Beachcombing	2.00
103	Beachcombing	1.00
103	Beachcombing	1.00
103	Beachcombing	1.00
190	Beachcombing	1.00
190	Beachcombing	1.00
190	Beachcombing	1.00
191	Beachcombing	1.00
191	Beachcombing	1.00
191	Beachcombing	1.00
393	Beachcombing	365
381	Bird/Nature watching	10.0
381	Bird/Nature watching	10.0
383	Bird/Nature watching	10.0
383	Bird/Nature watching	10.0
390	Boat maintenance	24.0
390	Boat maintenance	26.0
194	Coastguard ropeworks	15.0
159	Collecting mussels	1.00
318	Collecting mussels	6.00
271	Collecting seaweed	1.00
318	Collecting seaweed	4.00
159	Collecting whelks	1.00
12	Dog walking	548
13	Dog walking	365
14	Dog walking	1.00
32	Dog walking	104
33	Dog walking	1.50
57	Dog walking	365
61	Dog walking	548
65	Dog walking	2.00
65	Dog walking	2.00
66	Dog walking	104
66	Dog walking	730

Unique ID	Intertidal activity	h y^{-1}
84	Dog walking	52.0
85	Dog walking	52.0
92	Dog walking	104
110	Dog walking	14.0
111	Dog walking	70.0
123	Dog walking	7.80
125	Dog walking	621
126	Dog walking	0.50
126	Dog walking	6.00
128	Dog walking	12.0
129	Dog walking	12.0
130	Dog walking	195
133	Dog walking	26.0
135	Dog walking	24.0
137	Dog walking	2.00
138	Dog walking	2.00
145	Dog walking	24.0
148	Dog walking	2.00
149	Dog walking	2.00
150	Dog walking	18.0
150	Dog walking	610
151	Dog walking	156
152	Dog walking	9.00
153	Dog walking	156
154	Dog walking	7.00
159	Dog walking	52.0
165	Dog walking	17.0
165	Dog walking	17.0
165	Dog walking	102
171	Dog walking	548
171	Dog walking	548
172	Dog walking	78.0
172	Dog walking	78.0
178	Dog walking	0.50
178	Dog walking	6.00
180	Dog walking	0.50
181	Dog walking	621
183	Dog walking	2.00
187	Dog walking	52.0
187	Dog walking	52.0

Unique ID	Intertidal activity	h y^{-1}
210	Dog walking	110
226	Dog walking	6.00
226	Dog walking	6.00
227	Dog walking	365
239	Dog walking	7.00
247	Dog walking	48.0
247	Dog walking	130
247	Dog walking	130
260	Dog walking	0.50
261	Dog walking	1.00
261	Dog walking	52.0
261	Dog walking	52.0
265	Dog walking	365
272	Dog walking	1010
280	Dog walking	36.0
280	Dog walking	36.0
281	Dog walking	183
290	Dog walking	2.00
290	Dog walking	120
292	Dog walking	2.00
292	Dog walking	120
292	Dog walking	468
316	Dog walking	7.00
319	Dog walking	104
327	Dog walking	260
334	Dog walking	26.0
339	Dog walking	1.00
342	Dog walking	548
345	Dog walking	36.0
347	Dog walking	26.0
358	Dog walking	2.00
358	Dog walking	2.00
359	Dog walking	104
359	Dog walking	730
376	Dog walking	6.00
376	Dog walking	6.00
378	Dog walking	6.00
378	Dog walking	6.00
379	Dog walking	147
379	Dog walking	147

Unique ID	Intertidal activity	h y^{-1}
380	Dog walking	147
380	Dog walking	147
391	Dog walking	208
392	Dog walking	183
392	Dog walking	183
392	Dog walking	183
393	Dog walking	730
397	Dog walking	17.5
398	Dog walking	17.5
22	Fishing	9.75
22	Fishing	117
30	Fishing	12.0
30	Fishing	12.0
30	Fishing	12.0
58	Fishing	6.00
88	Fishing	78.0
105	Fishing	6.00
107	Fishing	78.0
121	Fishing	27.0
121	Fishing	117
121	Fishing	117
159	Fishing	8.00
162	Fishing	2.00
189	Fishing	4.00
197	Fishing	12.0
239	Fishing	3.00
318	Fishing	60.0
333	Fishing	8.00
333	Fishing	8.00
333	Fishing	8.00
345	Fishing	52.0
350	Fishing	24.0
350	Fishing	312
350	Fishing	274
351	Fishing	156
290	Groundhog Operator	24.0
290	Groundhog Operator	64.0
290	Groundhog Operator	1080
258	Guides & Brownies	2.00
104	Horse riding	208

Unique ID	Intertidal activity	h y^{-1}
104	Horse riding	312
139	Horse riding	104
150	Horse riding	1.50
122	Jogging	4.00
276	Jogging	183
301	Jogging	8.58
303	Jogging	34.3
303	Jogging	34.3
263	Metal detecting	2.00
32	Paddling	1.00
32	Paddling	1.00
32	Paddling	1.00
34	Paddling	3.00
59	Paddling	0.90
92	Paddling	1.00
92	Paddling	1.00
92	Paddling	1.00
103	Paddling	1.00
103	Paddling	1.00
103	Paddling	1.00
134	Paddling	26.0
136	Paddling	0.75
136	Paddling	1.50
142	Paddling	1.00
177	Paddling	0.75
177	Paddling	1.50
190	Paddling	1.00
190	Paddling	1.00
190	Paddling	1.00
191	Paddling	1.00
191	Paddling	1.00
191	Paddling	1.00
234	Paddling	0.25
285	Paddling	0.17
287	Paddling	0.17
310	Paddling	0.25
343	Paddling	0.90
361	Paddling	0.72
368	Paddling	2.00
369	Paddling	2.00

Unique ID	Intertidal activity	h y^{-1}
392	Painting	6.00
393	photography	12.0
12	Playing	10.0
173	Playing	1.00
212	Playing	3.00
212	Playing	6.00
277	Playing	3.00
277	Playing	6.00
346	Playing	10.0
361	Playing	26.0
361	Playing	78.0
365	Playing	10.0
367	Playing	10.0
368	Playing	8.00
369	Playing	8.00
370	Playing	10.0
371	Playing	10.0
375	Playing	10.0
382	Playing	20.0
385	Playing	20.0
362	Praying	12.0
17	Research/education	4.00
333	Research/education	4.00
333	Research/education	4.00
333	Research/education	4.00
333	Research/education	4.00
335	Research/education	13.0
335	Research/education	26.0
335	Research/education	169
9	Rock pooling	8.00
17	Rock pooling	4.00
111	Rock pooling	3.00
154	Rock pooling	3.00
333	Rock pooling	4.00
4	Walking	365
6	Walking	26.0
6	Walking	26.0
6	Walking	26.0
6	Walking	26.0
7	Walking	104

Unique ID	Intertidal activity	h y^{-1}
7	Walking	104
9	Walking	40.0
22	Walking	234
28	Walking	13.0
28	Walking	19.5
30	Walking	10.0
30	Walking	25.0
39	Walking	52.0
39	Walking	52.0
59	Walking	21.0
60	Walking	1.00
62	Walking	1.00
63	Walking	3.00
64	Walking	0.25
67	Walking	0.25
68	Walking	1.00
68	Walking	1.00
81	Walking	13.0
81	Walking	19.5
88	Walking	39.0
101	Walking	4.00
103	Walking	1.33
103	Walking	1.33
103	Walking	1.33
107	Walking	39.0
117	Walking	26.0
117	Walking	26.0
117	Walking	26.0
117	Walking	26.0
127	Walking	5.00
134	Walking	26.0
136	Walking	1.00
136	Walking	6.00
142	Walking	2.00
156	Walking	1.00
157	Walking	1.00
158	Walking	52.0
161	Walking	6.00
161	Walking	6.00
174	Walking	3.00

Unique ID	Intertidal activity	h y^{-1}
177	Walking	1.00
177	Walking	6.00
179	Walking	5.00
183	Walking	1.00
185	Walking	1.00
186	Walking	3.60
188	Walking	1.00
190	Walking	1.33
190	Walking	1.33
190	Walking	1.33
191	Walking	1.33
191	Walking	1.33
191	Walking	1.33
182	Walking	2.00
193	Walking	2.00
194	Walking	15.9
195	Walking	2.00
196	Walking	2.00
197	Walking	12.0
198	Walking	12.0
209	Walking	4.00
209	Walking	8.00
211	Walking	1.00
212	Walking	13.0
212	Walking	13.0
219	Walking	4.00
234	Walking	24.0
234	Walking	52.0
235	Walking	20.0
240	Walking	1.00
241	Walking	3.00
243	Walking	40.0
255	Walking	0.45
258	Walking	9.00
263	Walking	1.00
268	Walking	2.00
269	Walking	9.00
270	Walking	4.00
270	Walking	8.00
271	Walking	104

Unique ID	Intertidal activity	h y^{-1}
273	Walking	78.0
275	Walking	1.00
276	Walking	52.0
277	Walking	13.0
277	Walking	13.0
278	Walking	3.60
279	Walking	2.00
285	Walking	1.00
285	Walking	1.00
286	Walking	3.30
286	Walking	3.30
287	Walking	1.00
287	Walking	1.00
288	Walking	1.00
289	Walking	1.00
300	Walking	65.0
301	Walking	65.0
307	Walking	4.00
310	Walking	24.0
310	Walking	52.0
311	Walking	20.0
312	Walking	2.00
315	Walking	3.00
318	Walking	40.0
331	Walking	4.00
331	Walking	4.00
331	Walking	9.00
335	Walking	15.6
338	Walking	0.45
340	Walking	1.00
343	Walking	21.0
346	Walking	8.00
352	Walking	208
356	Walking	0.25
360	Walking	0.25
362	Walking	1.50
363	Walking	26.0
364	Walking	1.00
365	Walking	8.00

Table 11. Phase 1 Children intertidal activities

Unique ID	Intertidal activity	h y^{-1}
114	BBQ/Picnicking/Sitting	3.00
115	BBQ/Picnicking/Sitting	3.00
213	BBQ/Picnicking/Sitting	1.00
213	BBQ/Picnicking/Sitting	2.00
214	BBQ/Picnicking/Sitting	1.00
214	BBQ/Picnicking/Sitting	1.00
283	BBQ/Picnicking/Sitting	22.5
283	BBQ/Picnicking/Sitting	22.5
283	BBQ/Picnicking/Sitting	22.5
283	BBQ/Picnicking/Sitting	22.5
305	BBQ/Picnicking/Sitting	3.00
305	BBQ/Picnicking/Sitting	3.00
305	BBQ/Picnicking/Sitting	3.00
305	BBQ/Picnicking/Sitting	3.00
306	BBQ/Picnicking/Sitting	3.00
306	BBQ/Picnicking/Sitting	3.00
306	BBQ/Picnicking/Sitting	3.00
306	BBQ/Picnicking/Sitting	3.00
155	Dog walking	7.00
175	Dog walking	156
176	Dog walking	156
348	Dog walking	26.0
349	Dog walking	26.0
90	Fishing	78.0
114	Paddling	3.00
114	Paddling	4.00
115	Paddling	3.00
170	Paddling	13.0
373	Paddling	2.00
3	Playing	52.0
8	Playing	52.0
213	Playing	3.00
213	Playing	6.00
214	Playing	1.00
214	Playing	1.00
373	Playing	8.00
155	Rock pooling	3.00

Unique ID	Intertidal activity	h y^{-1}
69	Walking	1.00
69	Walking	1.00
70	Walking	1.00
70	Walking	1.00
71	Walking	1.00
71	Walking	1.00
90	Walking	39.0
242	Walking	3.00

Table 12. Phase 1 Infant intertidal activities

Unique ID	Intertidal activity	h y^{-1}
116	BBQ/Picnicking/Sitting	3.00
284	BBQ/Picnicking/Sitting	22.5
284	BBQ/Picnicking/Sitting	22.5
284	BBQ/Picnicking/Sitting	22.5
284	BBQ/Picnicking/Sitting	22.5
146	Dog walking	24.0
147	Dog walking	24.0
75	Paddling	1.50
93	Paddling	1.00
93	Paddling	1.00
93	Paddling	1.00
116	Paddling	3.00
374	Paddling	2.00
375	Paddling	2.00
75	Playing	26.0
75	Playing	78.0
93	Playing	104
374	Playing	8.00
375	Playing	8.00
384	Playing	20.0
386	Playing	20.0
118	Walking	26.0
118	Walking	26.0
118	Walking	26.0
118	Walking	26.0

Table 13. Phase 1 Adult handling sediment activities

Unique ID	Activity	h y^{-1}
22	Bait digging	19.5
95	Bait digging	13.0
121	Bait digging	4.00
318	Bait digging	3.00
4	BBQ/Picnicking/Sitting	365
59	BBQ/Picnicking/Sitting	4.00
63	BBQ/Picnicking/Sitting	3.00
86	BBQ/Picnicking/Sitting	39.0
102	BBQ/Picnicking/Sitting	0.30
113	BBQ/Picnicking/Sitting	39.0
142	BBQ/Picnicking/Sitting	2.00
174	BBQ/Picnicking/Sitting	3.00
184	BBQ/Picnicking/Sitting	0.30
212	BBQ/Picnicking/Sitting	3.00
273	BBQ/Picnicking/Sitting	16.0
277	BBQ/Picnicking/Sitting	3.00
281	BBQ/Picnicking/Sitting	90.0
282	BBQ/Picnicking/Sitting	90.0
300	BBQ/Picnicking/Sitting	12.0
301	BBQ/Picnicking/Sitting	12.0
343	BBQ/Picnicking/Sitting	4.00
378	BBQ/Picnicking/Sitting	3.00
273	Beach Clean	4.00
4	Beachcombing	365
17	Beachcombing	2.00
103	Beachcombing	3.00
190	Beachcombing	3.00
191	Beachcombing	3.00
393	Beachcombing	365
159	Collecting mussels	1.00
318	Collecting mussels	6.00
271	Collecting seaweed	1.00
318	Collecting seaweed	4.00
159	Collecting whelks	1.00
258	Guides & Brownies	2.00
263	Metal detecting	2.00
32	Paddling	3.00
34	Paddling	3.00
59	Paddling	0.90
92	Paddling	3.00

Unique ID	Activity	h y^{-1}
103	Paddling	3.00
134	Paddling	26.0
134	Paddling	2.25
142	Paddling	1.00
177	Paddling	2.25
190	Paddling	3.00
191	Paddling	3.00
234	Paddling	0.25
285	Paddling	0.17
287	Paddling	0.17
310	Paddling	0.25
343	Paddling	0.90
361	Paddling	0.72
368	Paddling	2.00
369	Paddling	2.00
12	Playing	10.0
173	Playing	1.00
212	Playing	9.00
277	Playing	9.00
346	Playing	10.0
361	Playing	104
365	Playing	10.0
366	Playing	10.0
367	Playing	8.00
369	Playing	8.00
370	Playing	10.0
371	Playing	10.0
372	Playing	10.0
382	Playing	20.0
385	Playing	20.0
17	Research/education	4.00
333	Research/education	16.0
335	Research/education	208
9	Rock pooling	8.00
17	Rock pooling	4.00
111	Rock pooling	3.00
154	Rock pooling	3.00
333	Rock pooling	4.00

Table 14. Phase 1 Children handling sediment activities

Unique ID	Activities	h y^{-1}
213	BBQ/Picnicking/Sitting	3.00
114	BBQ/Picnicking/Sitting	3.00
306	BBQ/Picnicking/Sitting	12.0
305	BBQ/Picnicking/Sitting	12.0
283	BBQ/Picnicking/Sitting	90.0
214	BBQ/Picnicking/Sitting	2.00
115	BBQ/Picnicking/Sitting	3.00
114	Paddling	7.00
115	Paddling	3.00
170	Paddling	13.0
373	Paddling	2.00
3	Playing	52.0
373	Playing	8.00
214	Playing	2.00
8	Playing	52.0
213	Playing	9.00
155	Rock pooling	3.00

Table 15. Phase 1 Infant handling sediment activities

Unique ID	Activities	h y^{-1}
116	BBQ/Picnicking/Sitting	3.00
284	BBQ/Picnicking/Sitting	90.0
75	Paddling	1.50
93	Paddling	3.00
116	Paddling	3.00
374	Paddling	2.00
375	Paddling	2.00
75	Playing	104
93	Playing	104
374	Playing	8.00
375	Playing	8.00
384	Playing	20.0
386	Playing	20.0

Table 16. Phase 1 Adult handling equipment activities

Unique ID	Activities	h y^{-1}
17	Being on a dive boat	24.0
327	Being on a dive boat	8.00
328	Being on a dive boat	60.0
9	Boat maintenance	4.00
159	Boat maintenance	16.0
215	Boat maintenance	65.0
317	Boat maintenance	1924
328	Boat maintenance	104
390	Boat maintenance	50.0
394	Boat maintenance	365
395	Boat maintenance	195
16	Boats and boating equipment	12.0
17	Boats and boating equipment	12.0
100	Boats and boating equipment	12.0
133	Boats and boating equipment	10.0
163	Boats and boating equipment	0.50
197	Boats and boating equipment	56.0
273	Boats and boating equipment	20.0
273	Boats and boating equipment	1.44
295	Boats and boating equipment	13.0
298	Boats and boating equipment	9.0
319	Boats and boating equipment	12.0
328	Boats and boating equipment	7.50
337	Boats and boating equipment	50.0
341	Boats and boating equipment	40.0
357	Boats and boating equipment	3.00
16	Clothes and overalls	1.00
17	Clothes and overalls	3.25
86	Clothes and overalls	52.0
121	Clothes and overalls	17.2
133	Clothes and overalls	10.0
161	Clothes and overalls	6.50
163	Clothes and overalls	1.44
189	Clothes and overalls	1.00
215	Clothes and overalls	0.30
258	Clothes and overalls	5.00
269	Clothes and overalls	5.00
295	Clothes and overalls	1.50

Unique ID	Activities	h y^{-1}
298	Clothes and overalls	1.50
337	Clothes and overalls	3.00
256	Commercial fishing/creeling	65.0
257	Commercial fishing/creeling	60.0
329	Commercial fishing/creeling	65.0
337	Commercial fishing/creeling	1643
341	Commercial fishing/creeling	1643
394	Commercial fishing/creeling	1600
215	Creel fishing/Handling	8.00
319	Creel fishing/Handling	24.0
327	Diving gear	4.00
328	Diving gear	7.50
22	Fishing	127
30	Fishing	36.0
58	Fishing	6.00
88	Fishing	78.0
105	Fishing	6.00
107	Fishing	78.0
121	Fishing	261
159	Fishing	8.00
162	Fishing	2.00
189	Fishing	4.00
197	Fishing	12.0
239	Fishing	3.00
318	Fishing	60.0
333	Fishing	24.0
345	Fishing	52.0
350	Fishing	610
351	Fishing	156
22	Fishing gear	9.75
95	Fishing gear	13.0
121	Fishing gear	0.18
189	Fishing gear	3.00
239	Fishing gear	0.25
295	Fishing gear	0.50
298	Fishing gear	0.50
311	Fishing gear	1.50
318	Fishing gear	1.50
319	Fishing gear	1.00
336	Fishing gear	10.0

Unique ID	Activities	h y^{-1}
337	Fishing gear	1.00
345	Fishing gear	6.26
9	Sea angling	30.0
21	Sea angling	3.00
88	Sea angling	5.00
95	Sea angling	208
121	Sea angling	10.0
133	Sea angling	72.0
173	Sea angling	5.00
192	Sea angling	2.00
193	Sea angling	2.00
195	Sea angling	2.00
196	Sea angling	2.00
197	Sea angling	312
215	Sea angling	8.00
220	Sea angling	24.0
221	Sea angling	24.0
222	Sea angling	24.0
235	Sea angling	72.0
256	Sea angling	15.0
257	Sea angling	30.0
273	Sea angling	54.0
274	Sea angling	25.0
295	Sea angling	54.0
298	Sea angling	54.0
311	Sea angling	72.0
318	Sea angling	54.0
319	Sea angling	10.0
329	Sea angling	15.0
336	Sea angling	48.0
337	Sea angling	80.0
390	Sea angling	42.0

Table 17. Phase 1 Children handling equipment activities

Unique ID	Activities	h y^{-1}
296	Boats and boating equipment	9.00
297	Boats and boating equipment	9.00
200	Clothes and overalls	1.00

Unique ID	Activities	h y^{-1}
201	Clothes and overalls	1.00
296	Clothes and overalls	1.50
297	Clothes and overalls	1.50
353	Clothes and overalls	40.0
90	Fishing	78.0
296	Fishing gear	0.50
297	Fishing gear	0.50
296	Sea angling	54.0
297	Sea angling	54.0

Table 18. Phase 1 Adult terrestrial activities

Unique ID	Terrestrial activity	h y^{-1}
331	At work	658
399	Bee keeping	52.0
20	Bird/nature watching	365
48	Bird/nature watching	365
288	Bird/nature watching	0.25
289	Bird/nature watching	0.25
120	Collecting wild produce	0.40
223	Collecting wild produce	0.40
399	Crofting	1095
47	Crofting	730
47	Crofting	1460
50	Crofting	1460
50	Crofting	730
58	Crofting	730
58	Crofting	821
120	Crofting	260
223	Crofting	2400
226	Crofting	1095
270	Crofting	1300
270	Crofting	780
291	Crofting	730
34	Cycling	4.50
34	Cycling	9.75
122	Cycling	65.0
122	Cycling	6.00
132	Cycling	195

Unique ID	Terrestrial activity	h y^{-1}
171	Cycling	156
273	Cycling	1.00
291	Cycling	48.0
300	Cycling	13.0
399	Dog walking	183
10	Dog walking	365
13	Dog walking	365
27	Dog walking	730
46	Dog walking	365
47	Dog walking	365
50	Dog walking	365
101	Dog walking	130
104	Dog walking	26
104	Dog walking	26
112	Dog walking	195
119	Dog walking	730
123	Dog walking	548
125	Dog walking	438
135	Dog walking	195
140	Dog walking	60.0
141	Dog walking	60.0
145	Dog walking	78.0
160	Dog walking	260
168	Dog walking	260
171	Dog walking	417
172	Dog walking	35.0
172	Dog walking	35.0
172	Dog walking	35.0
181	Dog walking	438
215	Dog walking	39.0
215	Dog walking	39.0
219	Dog walking	130
226	Dog walking	365
267	Dog walking	416
267	Dog walking	1095
272	Dog walking	730
272	Dog walking	730
274	Dog walking	2.00
332	Dog walking	365
387	Dog walking	26.0

Unique ID	Terrestrial activity	h y^{-1}
387	Dog walking	183
389	Dog walking	26.0
389	Dog walking	183
333	Education/Research	6.00
36	Farming	832
46	Farming	2190
49	Farming	4745
53	Farming	1560
53	Farming	1820
54	Farming	1820
54	Farming	1560
87	Farming	3120
98	Farming	1170
99	Farming	2400
204	Farming	260
206	Farming	260
246	Farming	1560
265	Farming	3560
309	Farming	170
309	Farming	340
325	Farming	2912
326	Farming	2080
332	Farming	24.0
366	Farming	3650
377	Farming	3640
58	Fishing	6.00
9	Gardening	385
9	Gardening	4.00
10	Gardening	509
11	Gardening	780
13	Gardening	509
18	Gardening	365
19	Gardening	780
20	Gardening	183
21	Gardening	385
21	Gardening	4.00
27	Gardening	39.0
27	Gardening	390
34	Gardening	26.0
34	Gardening	104

Unique ID	Terrestrial activity	h y^{-1}
41	Gardening	78.0
43	Gardening	183
46	Gardening	104
48	Gardening	183
101	Gardening	130
106	Gardening	13.0
120	Gardening	156
134	Gardening	1095
135	Gardening	348
136	Gardening	730
140	Gardening	720
145	Gardening	348
160	Gardening	104
168	Gardening	104
219	Gardening	130
271	Gardening	365
272	Gardening	183
318	Gardening	821
387	Gardening	183
389	Gardening	183
171	Geocaching	182
172	Geocaching	182
10	Golfing	4.00
34	Golfing	104
34	Golfing	312
43	Golfing	624
44	Golfing	780
45	Golfing	156
151	Golfing	24.0
165	Golfing	260
194	Golfing	64.0
123	Grass strimming	6.00
123	Green-keeping	1976
39	Groundworks	120
53	Horse riding	104
122	Horse riding	365
139	Horse riding	365
224	Horse riding	364
226	Horse riding	156
332	Horse riding	104

Unique ID	Terrestrial activity	h y^{-1}
122	Jogging	22.0
224	Looking after horses	364
135	Photography	24.0
169	Photography	6.00
9	Playing	20.0
33	Rambling/walking	104
34	Rambling/walking	52.0
37	Rambling/walking	52.0
44	Rambling/walking	104
44	Rambling/walking	104
86	Rambling/walking	4.00
89	Rambling/walking	18.0
101	Rambling/walking	78.0
106	Rambling/walking	39.0
107	Rambling/walking	18.0
112	Rambling/walking	4.00
134	Rambling/walking	1095
136	Rambling/walking	78.0
165	Rambling/walking	26.0
177	Rambling/walking	31.2
209	Rambling/walking	52.0
219	Rambling/walking	78.0
234	Rambling/walking	2.00
266	Rambling/walking	274
270	Rambling/walking	52.0
281	Rambling/walking	4.00
282	Rambling/walking	4.00
286	Rambling/walking	0.50
310	Rambling/walking	2.00
43	Running	26.0
45	Running	26.0
88	Running	1.00
173	Running	1.00
2393	Shooting	44.0
239	Shooting	44.0
239	Shooting	44.0
385	Shooting	44.0
385	Shooting	44.0
385	Shooting	44.0
122	Sports	48.0

Unique ID	Terrestrial activity	h y^{-1}
271	Wood sculpting	1095

Table 19. Phase 1 Children terrestrial activities

Unique ID	Terrestrial activity	h y^{-1}
302	Crofting	24.0
314	Crofting	24.0
143	Dog walking	183
55	Farming	80.0
55	Farming	96.0
56	Farming	80.0
56	Farming	96.0
322	Farming	24.0
323	Farming	24.0
324	Farming	24.0
302	Mucking out donkeys	104
314	Mucking out donkeys	104
2	Playing	20.0
24	Playing	20.0
302	Playing	473
314	Playing	473
388	Playing	20.0
90	Rambling/walking	18.0
108	Rambling/walking	39.0
109	Rambling/walking	39.0
283	Rambling/walking	4.00

Table 20. Phase 1 Infant terrestrial activities

Unique ID	Terrestrial activity	h y^{-1}
146	Dog walking	36.0
147	Dog walking	36.0
284	Rambling/walking	4.00

Table 21. Phase 1 Adult green vegetable consumption

Unique ID	Vegetable	kg y^{-1}
28	Broccoli	1.40
82	Broccoli	1.40
318	Broccoli	10.5
79	Broccoli	2.80
243	Broccoli	10.5
29	Broccoli	2.80
81	Broccoli	1.40
19	Broccoli	14.0
271	Broccoli	10.5
11	Broccoli	14.0
243	Brussel sprouts	3.00
271	Brussel sprouts	3.00
318	Brussel sprouts	3.00
9	Brussel sprouts	5.00
21	Brussel sprouts	5.00
13	Brussel sprouts	2.00
10	Brussel sprouts	2.00
318	Cabbage	12.5
270	Cabbage	22.5
209	Cabbage	22.5
271	Cabbage	12.5
19	Cabbage	7.50
11	Cabbage	7.50
243	Cabbage	2.25
19	Calabrese	2.50
11	Calabrese	2.50
271	Cauliflower	1.05
318	Cauliflower	1.05
243	Cauliflower	1.05
19	Chard	5.00
28	Chard	0.30
82	Chard	0.30
11	Chard	5.00
81	Chard	0.30
9	Herbs	0.22
21	Herbs	0.22
19	Herbs	2.50
11	Herbs	2.50

Unique ID	Vegetable	kg y^{-1}
140	Kale	1.50
271	Kale	10.0
318	Kale	6.00
13	Kale	2.00
10	Kale	2.00
243	Kale	6.00
19	Kale	1.00
11	Kale	1.00
141	Kale	1.50
81	Lettuce	1.35
140	Lettuce	2.70
141	Lettuce	2.70
19	Lettuce	5.00
160	Lettuce	2.50
389	Lettuce	6.75
168	Lettuce	2.50
28	Lettuce	1.35
387	Lettuce	6.75
79	Lettuce	1.35
11	Lettuce	5.00
29	Lettuce	1.35
82	Lettuce	1.35
49	Rhubarb	1.80
4	Rhubarb	1.30
134	Rhubarb	11.5
46	Rhubarb	1.80
19	Rhubarb	4.00
11	Rhubarb	4.00
10	Rhubarb	20.0
13	Rhubarb	20.0
318	Spinach	0.86
19	Spinach	2.50
11	Spinach	2.50
389	Spinach	7.014
271	Spinach	0.86
387	Spinach	7.01
243	Spinach	0.86

Table 22. Phase 1 Children green vegetable consumption

Unique ID	Vegetable	kg y^{-1}
144	Kale	1.50
143	Kale	1.50
144	Lettuce	2.70
143	Lettuce	2.70

Table 23. Phase 1 Adult other vegetable consumption

Unique ID	Vegetable	kg y^{-1}
5	Broad bean	1.87
9	Broad bean	6.00
10	Broad bean	6.00
11	Broad bean	10.0
13	Broad bean	6.00
19	Broad bean	10.0
21	Broad bean	6.00
29	Broad bean	3.00
77	Broad bean	1.87
79	Broad bean	3.00
243	Broad bean	12.0
271	Broad bean	12.0
318	Broad bean	12.0
11	French bean	7.50
19	French bean	7.50
29	French bean	1.66
79	French bean	1.66
5	Pea	2.70
9	Pea	8.65
10	Pea	8.65
11	Pea	6.50
12	Pea	1.66
13	Pea	8.65
19	Pea	6.50
21	Pea	8.65
28	Pea	3.33
29	Pea	4.33
77	Pea	2.70
78	Pea	1.665
79	Pea	4.32

Unique ID	Vegetable	kg y^{-1}
81	Pea	3.33
82	Pea	3.33
112	Pea	1.99
243	Pea	3.99
271	Pea	3.99
318	Pea	3.99
9	Runner Bean	4.50
21	Runner Bean	4.50
243	Runner Bean	10.8
271	Runner Bean	10.8
318	Runner Bean	10.8

Table 24. Phase 1 Adult root vegetable consumption

Unique ID	Vegetable	kg y^{-1}
9	Beetroot	2.60
10	Beetroot	2.60
13	Beetroot	2.60
21	Beetroot	2.60
28	Beetroot	0.39
29	Beetroot	1.30
79	Beetroot	1.30
81	Beetroot	0.39
82	Beetroot	0.39
243	Beetroot	5.20
271	Beetroot	5.20
318	Beetroot	5.20
5	Carrot	0.93
9	Carrot	3.00
11	Carrot	15.0
14	Carrot	3.75
19	Carrot	15.0
21	Carrot	3.00
28	Carrot	0.90
29	Carrot	1.50
79	Carrot	3.75
77	Carrot	0.93
79	Carrot	1.50

Unique ID	Vegetable	kg y^{-1}
81	Carrot	0.90
82	Carrot	0.90
209	Carrot	15.0
270	Carrot	15.0
11	Celeriac	7.50
19	Celeriac	7.50
5	Garlic	0.10
11	Garlic	1.50
19	Garlic	1.50
77	Garlic	0.10
243	Garlic	0.75
271	Garlic	0.75
318	Garlic	0.75
5	Leek	1.04
9	Leek	3.33
10	Leek	3.33
11	Leek	7.14
13	Leek	3.33
19	Leek	7.14
21	Leek	3.33
77	Leek	1.04
243	Leek	4.76
271	Leek	4.76
318	Leek	4.76
5	Onion	0.66
9	Onion	16.6
10	Onion	2.66
11	Onion	2.66
12	Onion	1.59
13	Onion	2.66
19	Onion	2.66
21	Onion	16.6
28	Onion	1.33
77	Onion	0.66
78	Onion	1.59
81	Onion	1.33
82	Onion	1.33
243	Onion	3.30
271	Onion	1.99
318	Onion	3.32

Unique ID	Vegetable	kg y^{-1}
9	Parsnip	3.40
21	Parsnip	3.40
5	Radish	0.16
9	Radish	0.33
21	Radish	0.33
77	Radish	0.16
140	Radish	0.66
141	Radish	0.66
160	Radish	2.50
168	Radish	2.50
5	Shallot	0.16
9	Shallot	1.30
10	Shallot	0.20
13	Shallot	0.20
21	Shallot	0.20
9	Spring Onion	0.052
10	Spring Onion	0.21
13	Spring Onion	0.21
21	Spring Onion	0.052
160	Spring Onion	2.50
168	Spring Onion	2.50
243	Sweet potatoes	1.12
271	Sweet potatoes	1.12
318	Sweet potatoes	1.12
5	Turnip	0.83
9	Turnip	2.00
14	Turnip	3.33
21	Turnip	2.00
76	Turnip	3.33
77	Turnip	0.83
87	Turnip	2.00
203	Turnip	2.00
204	Turnip	2.00
206	Turnip	2.00
209	Turnip	20.0
243	Turnip	8.00
270	Turnip	20.02
271	Turnip	8.00
318	Turnip	8.00

Table 25. Phase 1 Children root vegetable consumption

Unique ID	Vegetable	kg y^{-1}
143	Radish	0.16
144	Radish	0.16
207	Turnip	1.00

Table 26. Phase 1 Infant root vegetable consumption

Unique ID	Vegetable	kg y^{-1}
208	Turnip	1.00

Table 27. Phase 1 Adult potato consumption

Unique ID	Vegetable	kg y^{-1}
5	Potatoes	3.08
9	Potatoes	16.1
10	Potatoes	4.62
11	Potatoes	25.0
12	Potatoes	15.4
13	Potatoes	4.62
14	Potatoes	77.0
19	Potatoes	25.0
20	Potatoes	5.00
21	Potatoes	16.1
28	Potatoes	23.1
29	Potatoes	9.24
48	Potatoes	5.00
76	Potatoes	77.0
77	Potatoes	3.08
78	Potatoes	15.4
79	Potatoes	9.24
81	Potatoes	23.1
82	Potatoes	23.1
87	Potatoes	26.0
112	Potatoes	15.4
123	Potatoes	9.24
134	Potatoes	4.62
140	Potatoes	13.8
141	Potatoes	13.8

Unique ID	Vegetable	kg y^{-1}
203	Potatoes	26.0
204	Potatoes	13.0
206	Potatoes	13.0
209	Potatoes	50.0
238	Potatoes	9.24
243	Potatoes	19.2
270	Potatoes	50.0
271	Potatoes	15.4
318	Potatoes	19.2

Table 28. Phase 1 Children potato consumption

Unique ID	Vegetable	kg y^{-1}
143	Potatoes	13.8
144	Potatoes	13.8
207	Potatoes	6.00

Table 29. Phase 1 Infant potato consumption

Unique ID	Vegetable	kg y^{-1})
208	Potatoes	6.00

Table 30. Phase 1 Adult fruit consumption

Unique ID	Fruit	kg y^{-1}
10	Apple	10.0
11	Apple	25.0
13	Apple	10.0
19	Apple	25.0
28	Apple	2.00
30	Apple	20.0
81	Apple	2.00
82	Apple	2.00
140	Apple	13.5
141	Apple	13.5
243	Apple	5.00
271	Apple	40.0
318	Apple	40.0

Unique ID	Fruit	kg y^{-1}
11	Blackberry	5.00
19	Blackberry	5.00
10	Blackcurrant	1.00
11	Blackcurrant	5.00
12	Blackcurrant	9.00
13	Blackcurrant	1.00
14	Blackcurrant	13.5
19	Blackcurrant	5.00
76	Blackcurrant	13.5
78	Blackcurrant	9.00
210	Blackcurrant	3.50
243	Blackcurrant	6.75
271	Blackcurrant	18.0
272	Blackcurrant	3.50
318	Blackcurrant	6.75
28	Cherries	9.60
81	Cherries	9.60
82	Cherries	9.60
11	Courgettes	5.00
19	Courgettes	5.00
140	Courgettes	1.44
141	Courgettes	1.44
140	Cucu Melon	2.00
141	Cucu Melon	2.00
9	Cucumber	1.00
10	Cucumber	2.50
13	Cucumber	2.50
21	Cucumber	1.30
99	Cucumber	1.87
120	Cucumber	2.50
140	Cucumber	1.25
141	Cucumber	1.25
216	Cucumber	1.87
217	Cucumber	1.87
218	Cucumber	1.87
223	Cucumber	2.50
10	Gooseberry	5.00
11	Gooseberry	5.00
12	Gooseberry	4.00
13	Gooseberry	5.00

Unique ID	Fruit	kg y^{-1}
14	Gooseberry	12.0
19	Gooseberry	5.00
76	Gooseberry	12.0
78	Gooseberry	4.00
122	Gooseberry	2.80
224	Gooseberry	2.80
225	Gooseberry	2.80
243	Gooseberry	8.00
271	Gooseberry	4.00
318	Gooseberry	8.00
387	Gooseberry	0.50
389	Gooseberry	0.50
11	Loganberry	0.50
19	Loganberry	0.50
28	Pear	0.70
81	Pear	0.70
82	Pear	0.70
140	Pear	2.25
141	Pear	2.25
5	Pepper	0.50
10	Pepper	2.00
13	Pepper	2.00
77	Pepper	0.50
140	Pepper	1.00
141	Pepper	1.00
243	Pepper	7.00
271	Pepper	7.00
318	Pepper	7.00
11	Plum	0.01
19	Plum	0.01
140	Plum	1.50
141	Plum	1.50
10	Raspberry	2.50
11	Raspberry	0.50
13	Raspberry	2.50
19	Raspberry	0.50
140	Raspberry	0.50
141	Raspberry	0.50
210	Raspberry	6.00
243	Raspberry	25.0

Unique ID	Fruit	kg y^{-1}
271	Raspberry	7.00
272	Raspberry	6.00
318	Raspberry	25.0
10	Redcurrant	5.00
13	Redcurrant	5.00
122	Redcurrant	2.80
224	Redcurrant	2.80
225	Redcurrant	2.80
243	Redcurrant	10.0
271	Redcurrant	10.0
272	Redcurrant	6.00
318	Redcurrant	10.0
11	Rowan Berry	2.00
19	Rowan Berry	2.00
10	Strawberry	5.00
11	Strawberry	1.50
13	Strawberry	5.00
19	Strawberry	1.50
28	Strawberry	2.25
29	Strawberry	8.09
46	Strawberry	1.80
49	Strawberry	1.80
79	Strawberry	8.09
81	Strawberry	2.25
82	Strawberry	2.25
120	Strawberry	2.25
121	Strawberry	0.45
210	Strawberry	2.00
223	Strawberry	2.25
224	Strawberry	0.45
225	Strawberry	0.45
243	Strawberry	5.40
271	Strawberry	5.40
272	Strawberry	1.00
318	Strawberry	5.40
387	Strawberry	2.00
389	Strawberry	2.00
243	Sweetcorn	9.15
271	Sweetcorn	9.15
318	Sweetcorn	9.15

Unique ID	Fruit	kg y^{-1}
5	Tomato	4.00
10	Tomato	3.00
13	Tomato	3.00
28	Tomato	12.0
29	Tomato	24.0
77	Tomato	4.00
79	Tomato	24.0
81	Tomato	24.0
82	Tomato	12.0
99	Tomato	12.0
120	Tomato	8.00
140	Tomato	4.00
141	Tomato	4.00
160	Tomato	2.50
168	Tomato	2.50
216	Tomato	12.0
217	Tomato	12.0
218	Tomato	12.0
223	Tomato	8.00
243	Tomato	60.0
271	Tomato	60.0
318	Tomato	60.0
10	White currants	0.50
13	White currants	0.50
10	Worster berry	0.50
13	Worster berry	0.50
387	Worster berry	1.50
389	Worster berry	1.50

Table 31. Phase 1 Children fruit consumption

Unique ID	Fruit	kg y^{-1}
144	Apple	13.5
143	Apple	13.5
144	Courgettes	1.44
143	Courgettes	1.44
144	Cucu Melon	2.00
143	Cucu Melon	2.00
143	Cucumber	1.25

Unique ID	Fruit	kg y^{-1}
144	Cucumber	1.25
143	Pear	2.25
144	Pear	2.25
143	Pepper	1.00
144	Pepper	1.00
144	Plum	1.50
143	Plum	1.50
143	Raspberry	0.50
144	Raspberry	0.50
143	Tomato	2.00
144	Tomato	2.00

Table 32. Phase 1 Adult wild foods consumption

Unique ID	Wild foods	kg y^{-1}
10	Blackberry	0.50
13	Blackberry	0.50
28	Blackberry	0.30
81	Blackberry	0.30
82	Blackberry	0.30
136	Blackberry	0.25
177	Blackberry	0.25
210	Elderflower	0.21
272	Elderflower	0.21
210	Meadow Sweet	0.43
272	Meadow Sweet	0.43
10	Mushrooms	0.50
11	Mushrooms	2.50
11	Mushrooms	2.50
13	Mushrooms	0.50
19	Mushrooms	2.50
19	Mushrooms	2.50
46	Mushrooms	0.65
49	Mushrooms	0.65
99	Mushrooms	0.05
120	Mushrooms	0.25
216	Mushrooms	0.05
223	Mushrooms	0.25
243	Mushrooms	1.00

Unique ID	Wild foods	kg y^{-1}
318	Mushrooms	1.00
11	Nettle	0.50
19	Nettle	0.50
10	Raspberry	0.50
13	Raspberry	0.50
46	Raspberry	0.50
49	Raspberry	0.50

Table 33. Phase 1 Adult beef consumption

Unique ID	Meat	kg y^{-1}
120	Beef	52.0
387	Beef	1.00
389	Beef	1.00

Table 34. Phase 1 Adult lamb consumption

Unique ID	Meat	kg y^{-1}
120	Lamb	26.0
210	Lamb	5.00
272	Lamb	5.00
387	Lamb	1.00
389	Lamb	1.00

Table 35. Phase 1 Adult venison consumption

Unique ID	Meat	kg y^{-1}
11	Wild venison	5.00
19	Wild venison	5.00
72	Wild venison	1.00
73	Wild venison	1.00
74	Wild venison	1.00
91	Wild venison	21.2
120	Wild venison	5.00
223	Wild venison	5.00
223	Wild venison	7.50
227	Wild venison	5.00
228	Wild venison	5.00

Unique ID	Meat	kg y^{-1}
255	Wild venison	7.50
293	Wild venison	43.2
294	Wild venison	43.2
309	Wild venison	5.00
361	Wild venison	1.00
382	Wild venison	22.0
385	Wild venison	22.0

Table 36. Phase 1 Infant venison consumption

Unique ID	Meat	kg y^{-1}
386	Wild venison	1.00

Table 37. Phase 1 Adult game bird consumption

Unique ID	Meat	kg y^{-1}
361	Pheasant	0.8
72	Pheasant	0.8
73	Pheasant	0.8
74	Pheasant	0.8
318	Pheasant	2
318	Partridge	1.3
243	Pheasant	2
243	Partridge	1.3
293	Pheasant	6.75
294	Pheasant	6.75
385	Pheasant	2.25
382	Pheasant	2.25
385	Partridge	2
382	Partridge	2

Table 38. Phase 1 Infant game bird consumption

Unique ID	Meat	kg y^{-1}
386	Partridge	0.5
386	Pheasant	0.5

Table 39. Phase 1 Adult egg consumption

Unique ID	Eggs	kg y^{-1})
210	Duck eggs	1.82
122	Duck eggs	36.4
225	Duck eggs	10.9
272	Duck eggs	1.82
43	Eggs	9.04
120	Eggs	15.0
223	Eggs	15.8
122	Eggs	6.02
225	Eggs	9.04
300	Eggs	18.0
301	Eggs	18.0
135	Eggs	15.08
145	Eggs	12.06
210	Eggs	9.04
377	Eggs	5.56
44	Eggs	9.04
47	Eggs	10.1
50	Eggs	10.1
52	Eggs	10.1
361	Eggs	18.0
72	Eggs	18.0
28	Eggs	1.39
81	Eggs	1.39
82	Eggs	1.39
136	Eggs	1.39
177	Eggs	1.39
272	Eggs	9.04
332	Eggs	5.56

Table 40. Phase 1 Children egg consumption

Unique ID	Eggs	kg y^{-1}
322	Eggs	5.58
323	Eggs	5.56
324	Eggs	5.56

Table 41. Phase 1 Adult honey consumption

Unique ID	Honey	kg y^{-1}
28	Honey	0.20
81	Honey	0.20
82	Honey	0.20

Table 42. Phase 2 Adult crustacean consumption

Unique ID	Food type	kg y^{-1}
406	Brown crab	0.90

Table 43. Phase 2 Adult fish consumption

Unique ID	Food type	kg y^{-1}
405	Bass	26.0
407	Haddock	41.6
406	Haddock	18.1
404	Haddock	31.2
407	Kipper (herring)	2.7
405	Kipper (herring)	2.7
404	Lemon sole	31.2
404	Plaice	31.2
405	Trout (freshwater)	15.6

Table 44. Phase 2 Adult mollusc consumption

Unique ID	Food type	kg y^{-1}
407	Scallops	1.80
407	Squid	1.00

Table 45. Phase 2 Adult intertidal activity

Unique ID	Intertidal activity	h y^{-1}
404	Beachcombing	330
400	Dog walking	52.0
400	Dog walking	240
400	Dog walking	52.0
402	Playing	4.00

Unique ID	Intertidal activity	h y^{-1}
404	Walking	330
405	Walking	2.00
407	Walking	3.00

Table 46. Phase 2 Adult handling sediment

Unique ID	Activity	h y^{-1}
404	Beachcombing	330
402	Playing	4.00

Table 47. Phase 2 Adult terrestrial activities

Unique ID	Terrestrial activity	h y^{-1}
403	Bee keeping	52.0
405	Collecting wild produce	5.00
407	Collecting wild produce	2.00
403	Crofting	1095
400	Cycling	52.0
400	Cycling	52.0
400	Dog walking	91.2
401	Dog walking	91.2
400	Dog walking	52.0
403	Dog walking	183
400	Dog walking	52.0
406	Farming	2600
404	Gardening	117
401	Gardening	195
407	Gardening	1460
405	Gardening	117
400	Geocaching	39.0
400	Geocaching	39.0
400	Geocaching	39.0
402	Rambling/walking	520
404	Rambling/walking	183
408	Shooting	21.0
408	Shooting	21.0
408	Shooting	21.0
402	Shooting	20.0
402	Shooting	20.0

Unique ID	Terrestrial activity	h y^{-1}
408	Shooting	21.0

Table 48. Phase 2 Adult green vegetable consumption

Unique ID	Vegetable	kg y^{-1}
405	Broccoli	2.10
407	Broccoli	7.00
405	Cabbage	5.00
407	Cabbage	5.00
407	Kale	3.00
407	Lettuce	2.70
404	Rhubarb	3.00
407	Spinach	0.50

Table 49. Phase 2 Adult other vegetable consumption

Unique ID	Vegetable	kg y^{-1}
407	French bean	1.16

Table 50. Phase 2 Adult root veg consumption

Unique ID	Vegetable	kg y^{-1}
405	Garlic	1.40
407	Garlic	1.00
405	Leek	9.96
405	Onion	5.32
407	Onion	2.66

Table 51. Phase 2 Adult potato consumption

Unique ID	Vegetable	kg y^{-1}
407	Potatoes	15.4

Table 52. Phase 2 Adult fruit consumption

Unique ID	Fruit	kg y^{-1}
405	Apple	40.0
407	Apple	40.0
402	Apple	5.00
405	Blackberry	13.5
405	Blackcurrant	18.0
407	Blackcurrant	45.0
406	Cucumber	1.25
405	Gooseberry	14.0
402	Plum	2.00
407	Raspberry	5.00
407	Tomato	40.0
406	Tomato	8.00

Table 53. Phase 3 Adult wild foods consumption

Unique ID	Wild food	kg y^{-1}
407	Blackberry	0.50
405	Mushrooms	1.00
407	Mushrooms	1.00
406	Mushrooms	0.10
405	Rowanberry	0.50
407	Rowanberry	2.50

Table 54. Phase 2 Adult poultry consumption

Unique ID	Meat	kg y^{-1}
402	Duck	4.00

Table 55. Phase 2 Adult venison consumption

Unique ID	Meat	kg y^{-1}
4021	Wild venison	150
405	Wild venison	1.50
408	Wild venison	67.2

Table 56. Phase 1 Occupancy rates of those individuals working or living within 1 km of Dounreay

Unique ID	Indoors at home ($h\ y^{-1}$)	Outdoors at home ($h\ y^{-1}$)	Indoors at work ($h\ y^{-1}$)	Outdoors at work ($h\ y^{-1}$)
366	4 380	730	0	3 650
15	8 395	365	-	-
25	8 030	730	-	-
41	8 030	78	-	-
42	8 395	0	-	-
31	3 650	365	730	3 650
83	3 650	365	730	3 650
84	3 580	358	-	-
85	3 580	358	-	-
99	4 044	1 011	101	2 022
216	4 044	337	-	-
394	4 200	1 225	-	-
321	4 200	104	-	-
18	3 640	728	-	-
396	4 550	208	-	-

Appendix A2 Postal Survey

The postal survey produced an independent data set from a broader cross section of the population living in the area potentially providing the means to identify new or missed habits that might provide useful focus to target some of the face-to-face surveys or meetings with local groups.

The postal survey helped refine and revise the face-to-face survey tools and identify the optimal areas to target the face-to-face surveys. It also provided additional information on sites to be identified for the collection of observation data and indicated the optimum timings to visit each site. Further information and contacts were obtained with regard to both individuals and a wider range of activities that might merit further investigation in the later survey work.

Appendix A3 The Mobile Gamma Spectrometry System

The Mobile Gamma Spectrometry System (MoGSS) deploys 76 mm x 76 mm and large volume (4 or 8 litre) NaI(Tl) detectors for real time data acquisition gamma ray spectra. One second spectra were acquired whilst driving with the detector mounted in the roof box of the survey vehicle to characterise the heterogeneity in the radiation environment around the Dounreay site and further afield to identify exposure pathways that might otherwise be missed through conventional point measurements. Acquisition rate is limited by road and traffic conditions but aims to achieve on average better than one measurement per 20 m (45 mph), although speeds are likely to vary between 5 and 60 mph depending on the road conditions. MoGSS comprises a real time differential GPS system providing < 0.6 m positional accuracy, controlled by bespoke software through a tablet computer. Spectra were collected with 1 second integration times and data are presented as counts per second (gross counts or counts in the window >350 keV). MoGSS was deployed to identify anomalies in the radiation field to help target follow-up *in-situ* dosimetry surveys and identify the likely source of the radioactive anomaly and spatially extrapolate any anomalous observations identified.

This approach provided a better understanding of the underlying natural background and any anthropogenic contribution to the radiation environment. The MoGSS system was deployed in vehicular mode to undertake a car borne survey along the road network and in hand-held mode to map the site perimeter and the spillway.

Survey area

Two systems operating MoGSS were deployed in order to cover the area in sufficient spatial detail:

Firstly, two large volume sodium iodide detectors were mounted in a roof box on top of a car, which was driven along all the major roads within the area of interest. The system, owing to the size of detectors, produced high efficiency and data, although data could only be collected from roads. A backpack system was used on smaller areas not accessible by vehicle, principally the beaches in the survey area. All major beaches and coastal stream sections from Armadale to Dunnet beach were covered using the backpack system (Figure A3i). This system comprised of a 76 × 76 mm sodium iodide detector. Both MoGSS units produced differential energy spectra recorded at 1 Hz alongside high accuracy (<0.6 m) differential GPS readings.

Conversion of detector count rate (counts s^{-1}) to activity (Bq kq^{-1}) was performed using Monte Carlo calibrations and a conventional window stripping routine derived from concrete calibration pads. Cosmic background was measured on Loch Lomond and stripped from all spectral data. Prior to stripping, the Noise Adjusted Singular Value Decomposition was used on individual instruments to smooth window counts using counts above 400 keV. A spatial Gaussian kernel was then used to further smooth data. Finally, dose (nGy hr^{-1}) was calculated using International Commission on Radiation Units and Measurements (ICRU) conversion factors (ICRU, 1994).

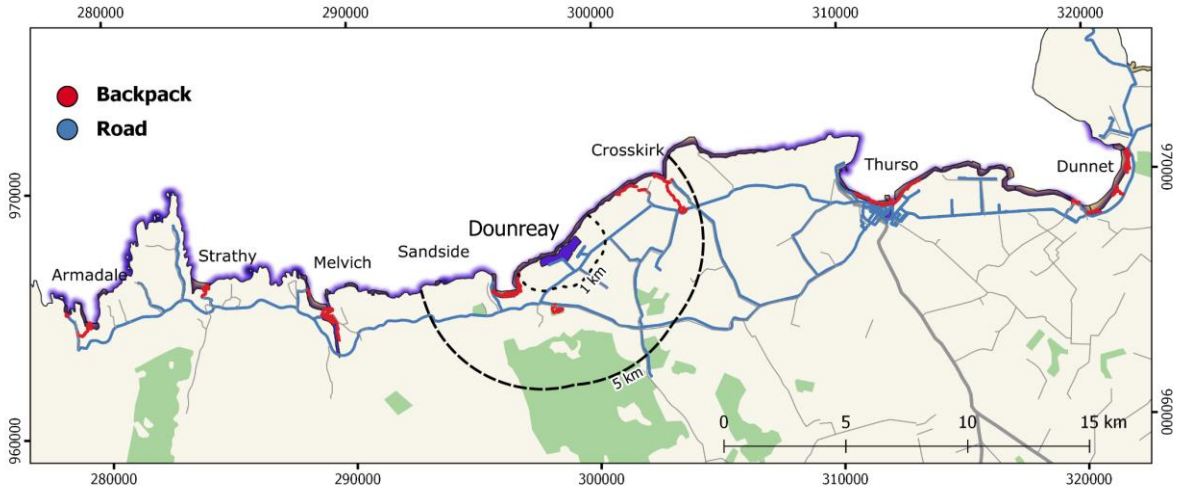

Figure A3i MoGSS coverage of Dounreay survey area. Red points demonstrate the area covered using the backpack system and blue points represent roads covered by the road car-borne system. The purple outline highlights the aquatic zone.

Appendix A4 *In-Situ* Gamma Dose Rate Measurements

The protocol requires the detector to be maintained at 1 m above the surface and counts acquired over a 600 second integration time and the cosmic and intrinsic component to the measurement subtracted. The protocol also requires no persons operating the detector to be within 5 m of the probe during the count. Both instruments are calibrated with ^{226}Ra and ^{137}Cs. Here, gamma dose rates were dominated by the natural background, so all results are reported with the ^{226}Ra calibration and reported as μGy h^{-1}.

For the dose assessment tool, gamma dose rates were converted to Effective Dose (μSv hr^{-1}) using a conversion factor of 0.85, which assumes an individual is standing and exposed to terrestrial derived gamma radiation. This conversion factor is used for most statutory monitoring programmes (Punt *et al*., 2011). All survey measurements are reported as terrestrial gamma dose measurements and have had the cosmic and intrinsic component subtracted.

Appendix A5 Beta Skin Dosimetry Measurements

The instrument was calibrated under UKAS accreditation against strontium-90 (^{90}Sr) and yttrium-90 (^{90}Y); chlorine-36 (^{36}Cl) and carbon-14 (^{14}C) (and put inside a file poly-pocket to protect the system from the weather). A 12 mm Perspex shield was used to shield out any beta emissions and so enable the gamma contribution to the instrument to be established. All measurements were made with a 20 second integration time and in duplicate, with and without the 12 mm Perspex shield, enabling the net beta contribution to skin dose rate to be estimated (effective dose, or ambient dose equivalent) and reported in μSv h^{-1}. The system is estimated to have a lowest detection limit of around 0.2 μSv h^{-1}.

Appendix A6 GPS Tracking Device

To ensure consistency in data a wearable GPS tracking device was considered the most suitable device for the Dounreay Habits Survey.

The devices used were iGOTU GT600 trackers (Figure A6i), which have a capacity to record 262 000 waypoints, at user defined intervals. The battery life varies depending on the sampling rate, which was set to record once every 6 seconds, giving 30 hours of use on a single charge. This battery life could be extended by enabling motion detection, whereby the device sleeps until an on-board accelerometer detects motion and then enables the GPS tracking (which has a bigger battery cost), therefore motion detection was disabled so that the tracker logged continuously.

Figure A6i iGOTU GPS tracker

The devices require specialist software to download the trajectory data, and all units were password protected to maintain data security and privacy. The participants were informed that the tracker worked best when positioned on their wrist, or on a bag/belt strap, where they had a clear line of sight to the sky. The participants were asked to take the device with them whenever they left their home and instructions were given regarding use and recharging of the device.

With the 6 second sample rate, the device was able to store the last 16 days of position data on board. Participants were asked to stop charging the unit on the last day of use before collection, to ensure it would run out of power and stop logging position data.

Appendix A7 - Postal Survey Results

A7.1 Terrestrial External Exposure

A number of households reported undertaking a range of terrestrial activities within 5 km of the Dounreay site (Figure A7i). No other sports or stalking/shooting activities were reported by any respondents.

Within 1 km of the site walking/rambling was the most popular activity (five respondents) and running/jogging (three respondents). Single respondents reported undertaking the following activities within 1 km: bird/nature watching; cycling; dog walking; farming; horse riding; sitting/BBQ/picnicking; and working.

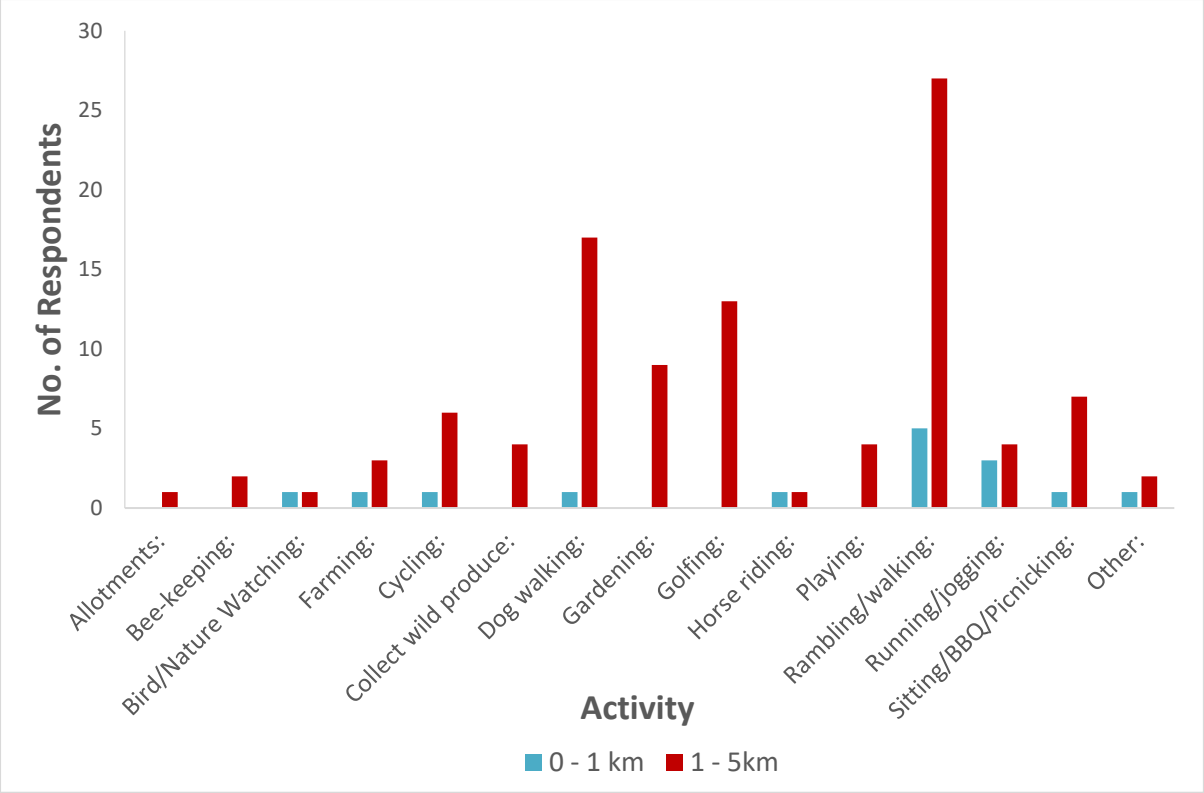

Figure A7i. Overview of the number of households participating in terrestrial activities in the 1 km and 5 km survey areas.

Within 5 km of the site rambling/walking was also the most popular activity (a total of 29 respondents), followed by dog walking (17 respondents) and golf (13 respondents). One beekeeper was identified as being active whilst the survey also identified a respondent who spent time enjoying photography. Gardening, sitting/BBQ/picnicking, cycling and running all appeared to be relatively popular within 5 km.

Table A7i Summary of where respondents undertook terrestrial activities within 5 km.

Upper Dounreay	Reay	Shebster	Dounreay
Bee Keeping	Bird/nature watching	Bee Keeping	Farming
Farming	Cycling	Cycling	Cycling
Cycling	Collect wild produce	Collect wild produce	Dog walking
Dog walking	Dog walking	Dog walking	Horse riding
Gardening	Gardening	Gardening	Walking/rambling
Horse riding	Golf	Walking/rambling	Running/jogging
Playing	Horse riding	Running/jogging	Sitting/BBQ/picnicking
Running/jogging	Walking/rambling	Photography	Working
Sitting/BBQ/picnicking	Running/jogging		

Achvarasdal	Crosskirk	West Shebster	Stemster
Allotments	Bird/nature watching	Bird/nature watching	Bird/nature watching
Bird/nature watching	Farming	Cycling	Dog walking
Collect wild produce	Dog walking	Dog walking	Walking/rambling
Dog walking	Walking/rambling	Walking/rambling	Sitting/BBQ/picnicking
Playing	Working		
Walking/rambling			
Sitting/BBQ/picnicking			

Lybster	Sandside Bay	Achreamie	Balmore
Bird/nature watching	Bird/nature watching	Cycling	Farming
Gardening	Dog walking	Dog walking	Cycling
Walking/rambling	Playing	Gardening	Running/jogging
Running/jogging	Walking/rambling	Running/jogging	Sitting/BBQ/picnicking
Sitting/BBQ/picnicking	Sitting/BBQ/picnicking		

Sandside harbour	A836	Isauld	Buldoo
Collect wild produce	Cycling	Cycling	Horse riding
Dog walking	Walking/rambling	Dog walking	Sitting/BBQ/picnicking
Walking/rambling	Running/jogging		

Milton Moss	Sandside	Forests within 5km Dounreay	Red Point
Cycling	Gardening	Running/jogging	Walking/rambling
Walking/rambling	Walking/rambling		

Loch na Moine	Bridge of Forss	All Over 5 km zone	Stemster Hill Wind Farm
Photography	Walking/rambling	Bird/nature watching	Walking/rambling

The location where the range of activities were reported are listed in Table A7i. Upper Dounreay and Reay reported the widest range of activities with nine differing activities at each location. Walking/rambling and dog walking were the two activities undertaken at more sites than any other activity, 16 and 12 locations respectively. One unusual location was photography undertaken at Loch na Moine, a small lochan, 2.5 km west of Sandside bay near Red Point. Four farmers reported some agricultural activity.

A7.2 Aquatic External Exposure

A number of households reported they engaged in aquatic activities within the survey area. The total number of respondents undertaking each aquatic activity, either in or on the water and the distance from the Dounreay site are presented in Figure A7ii.

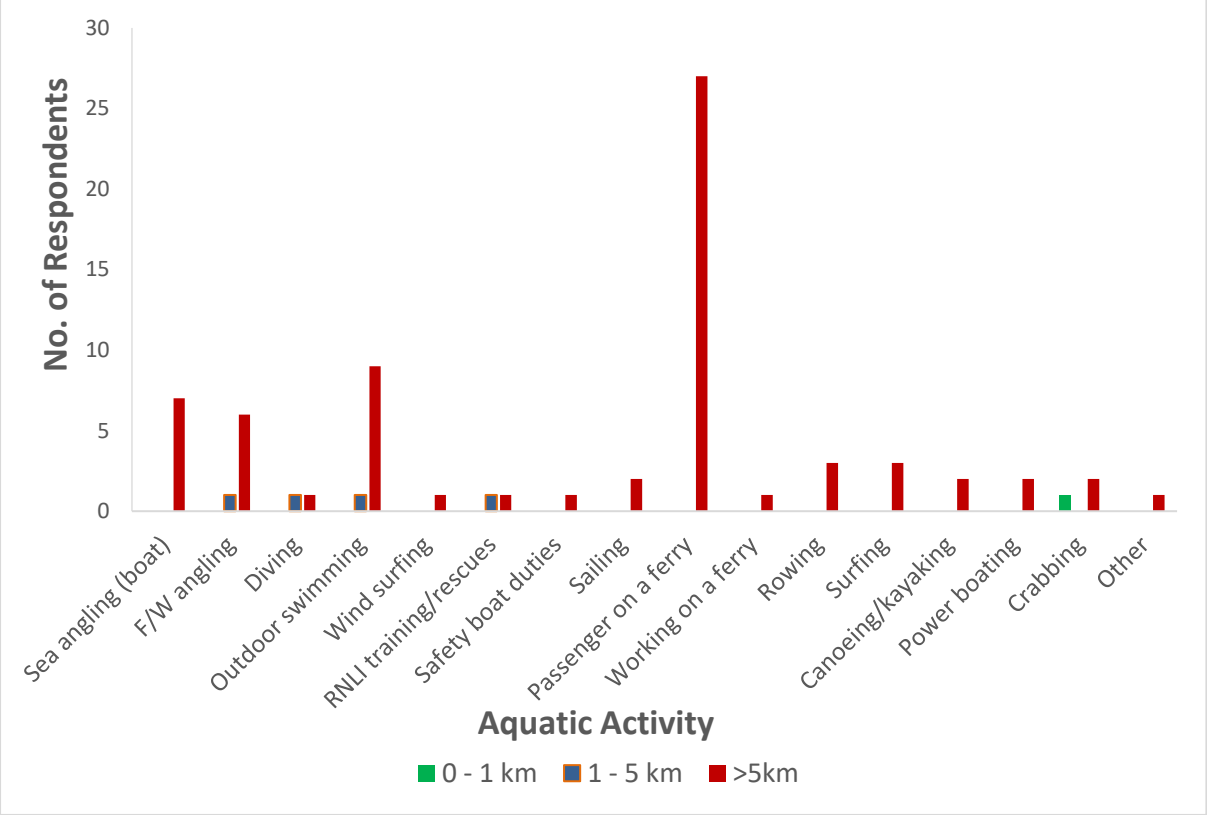

Figure A7ii. Summary of the number of households undertaking aquatic activities.

Across the whole aquatic survey area, travelling as a passenger on the ferry from Scrabster to Stromness was the most popular (27 respondents) followed by outdoor swimming (10 respondents) and sea angling from a boat (seven respondents). Only one respondent reported undertaking an activity, crabbing, within 1 km of the Dounreay site. It is unclear if this is on a commercial scale or not. Within 1 - 5 km one

respondent reported freshwater angling, one respondent diving and a further one respondent outdoor swimming. No respondents reported commercial fishing, creeling, jet skiing, water skiing, being on a dive boat, working on a boat or boat maintenance.

In terms of activity locations, respondents reported undertaking higher numbers of activities in Scrabster Bay and off East Thurso, both part of the wider Thurso Bay (Table A7ii). Dunnet Bay was also a popular location for aquatic activities and reflected the close proximity to the town of Thurso and holiday facilities (Dunnet Bay). No activities were reported at Armadale Bay, Port a' Chinn or Castletown harbour.

Table A7ii Summary of where respondents undertook aquatic activities.

Scrabster Bay	East Thurso	Dunnet Bay	Holborn Head
Sea angling (boat)	Sea angling (boat)	Sea angling (boat)	Sea angling (boat)
Safety boat duties	Outdoor swimming	Outdoor swimming	Diving
Sailing	Surfing	Surfing	RNLI Rescue/Training
Passenger on a ferry	Rowing	Canoeing/Kayaking	Crabbing
Working on a ferry	Canoeing/Kayaking		
Rowing	Crabbing	**Dunnet Head**	**Strathy Bay**
Canoeing/Kayaking		Sea angling (boat)	Sea angling (boat)
		Outdoor swimming	Outdoor swimming

Crosskirk	Thurso Bay	Murkle Bay	Melvich Bay
Diving	Sea angling (boat)	Wind surfing	Sea angling (boat)
Surfing	Working	Crabbing	Diving
Rowing	Crabbing		
Canoeing/Kayaking			

Sandside Bay	River Thurso	Portskerra	Brims Ness
RNLI Rescue/Training	F/W angling	Sea angling (boat)	Sea angling (boat)
Surfing	Outdoor swimming	Diving	

Scrabster beach	Sandside Bay	Dounreay	Dwarwick Head
Outdoor swimming	Outdoor swimming	Crabbing	Wind surfing

Strathy Point	River Forss	River Halladale	Thurso beach
Diving	F/W angling	F/W angling	Outdoor swimming

A7.3 External Intertidal Exposure

A number of households carry out activities in the intertidal zone within the survey area. The total number of respondents undertaking each intertidal activity and the

distance from the Dounreay site are presented in Figure A7iii with the highest number of respondents walking/rambling (47 respondents) or dog walking (36 respondents) across all locations.

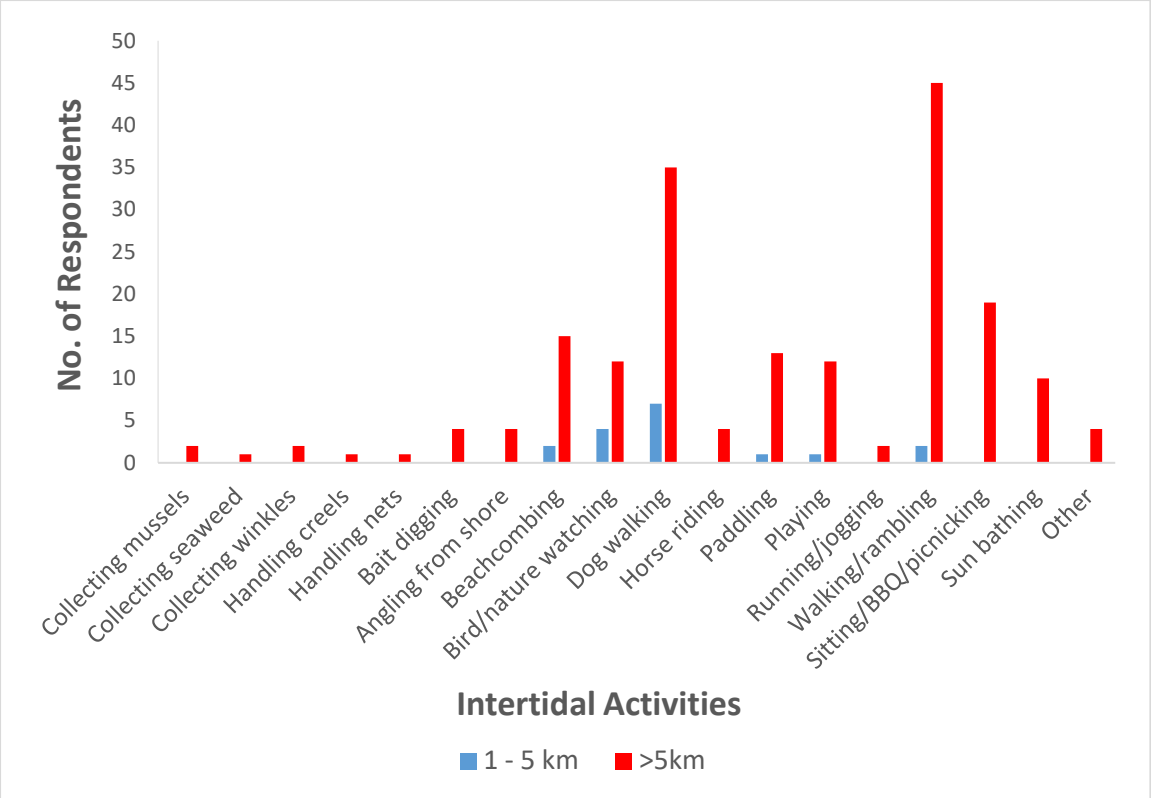

Figure A7iii Summary of number of households undertaking intertidal activities.

Between 1 and 5 km, dog walking and bird/nature watching proved the more popular (seven and four respondents respectively). Photography and model airplane flying were identified as unusual activities on the shoreline. No activities were reported within 1 km of the site reflecting the limited access onto the shoreline close to the site (though the shoreline is largely inaccessible, it is possible to access it). No respondent reported undertaking the following activities: boat maintenance; fixing moorings; coastal net fishing; rock pooling; and research/education or wildfowling.

Intertidal activities were reported throughout the survey zone (Table A7iii). Dunnet Bay reported the highest number of differing activities with other bays and beaches also proving relatively popular including Strathy and Sandside Bays.

Table A7iii Summary of where respondents undertook Intertidal activities.

Dunnet Bay	Strathy Bay	Sandside Bay	East Thurso
Bait digging	Beachcombing	Beachcombing	Beachcombing
Bird/nature watching	Bird/nature watching	Bird/nature watching	Bird/nature watching
Dog walking	Dog walking	Dog walking	Dog walking
Paddling	Paddling	Paddling	Paddling
Walking/rambling	Walking/rambling	Walking/rambling	Walking/rambling
Sitting/BBQ/picnicking	Sitting/BBQ/picnicking	Sitting/BBQ/picnicking	Sitting/BBQ/picnicking
Collecting winkles	Running/jogging	Horse riding	Playing
Handling nets	Shore angling	Playing	Sun bathing
Horse riding	Sun bathing	Work	
Playing	Sketching & painting		
Running/jogging			
Shore angling			
Sun bathing			
Sketching & painting			
Model airplane flying			

Thurso beach	Murkle Bay	Melvich Bay	Armadale
Beachcombing	Bait digging	Beachcombing	Beachcombing
Bird/nature watching	Beachcombing	Bird/nature watching	Bird/nature watching
Dog walking	Dog walking	Dog walking	Dog walking
Paddling	Paddling	Paddling	Walking/rambling
Sitting/BBQ/picnicking	Walking/rambling	Walking/rambling	Sitting/BBQ/picnicking
Collecting mussels	Collecting mussels	Sitting/BBQ/picnicking	Shore angling
Running/jogging	Collecting seaweed	Playing	
Shore angling	Running/jogging	Sun bathing	

Thurso Bay	Scrabster beach	Holborn Head	Castletown Harbour
Dog walking	Beachcombing	Bird/nature watching	Bait digging
Paddling	Bird/nature watching	Walking/rambling	Bird/nature watching
Walking/rambling	Dog walking	Collecting winkles	Walking/rambling
Collecting winkles	Walking/rambling		
Handling nets	Sitting/BBQ/picnicking		

Scrabster harbour	West Dunnet	Strathy Point	Crosskirk
Sitting/BBQ/picnicking	Beachcombing	Bird/nature watching	Bird/nature watching
Handling nets			
Harbour master			

A7.4 Internal Terrestrial Exposure

Households were asked to provide information on where they sourced their food. A summary of the results (Figure A7iv) shows the origins of where respondents sourced their food as a percentage. Results show that the respondents bought most of their food sourced from outwith the zoned areas from local shops or supermarkets. This was consistent across all food groups.

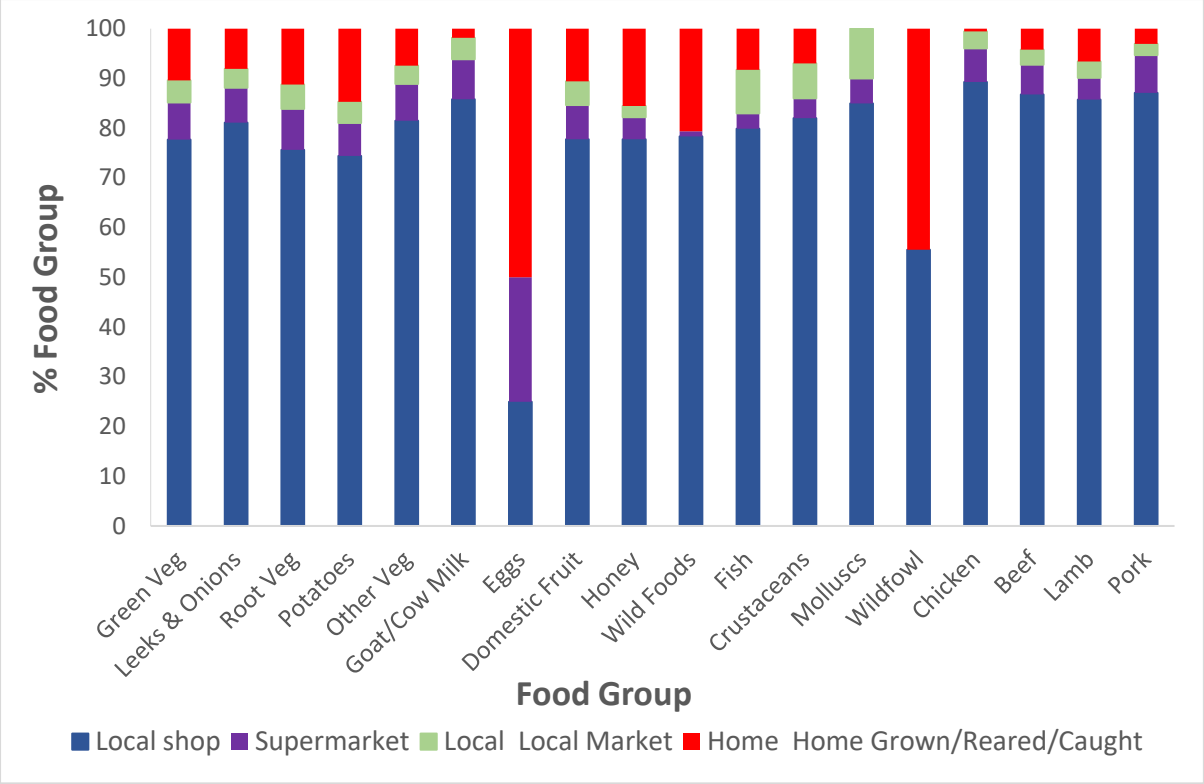

Figure A7iv Source of food consumed by postal survey respondents.

Food bought from the local shop tended to be the most common place with fewer people reporting buying their food at supermarkets or a local market in Thurso. However, anecdotal evidence suggests that where people reported buying food from their local shop, they in fact meant a supermarket in Thurso or Wick. A small proportion of respondents reported growing some of their own fruit and vegetables, in season, but in insufficient quantities to provide an annual supply (Table A7iv). Thus, they also reported buying food from local shops or supermarkets for some part of the year. One or two respondents consumed meat from animals reared on their own farm or who sourced some meat from a local farmer. Several people sourced their meat from outwith the survey area (Weydale, Wick or Halkirk, Bettyhill) or did not provide a specific location. Three people reported consuming milk from a local source (two respondents from Castletown and one respondent from Halkirk), however there are no dairy farms operating within 5 km of Dounreay therefore any milk consumption would be outwith the terrestrial survey area.

Table A7iv. Summary of locally produced food (grown/reared or caught).

Food Group	No. People	Local
Green Veg	19	Portskerra, Thurso, Scrabster, Melvich, Shebster
Leeks & Onions	13	Thurso, Scrabster, Castletown
Root Veg	22	Portskerra, Thurso, Murkle, Lyth, Skaill,
Potatoes	27	Thurso, Reay, Portskerra, Scrabster, Lyth, Skaill, Murkle, Castletown
Other Veg	7	Thurso, Melvich, Castletown
Goat/Cow Milk	2	Castletown
Eggs	1	Thurso
Dom Fruit	18	Reay, Castletown, Thurso, Portskerra
Honey	4	Reay, Dounreay, Shebster
Wild Foods	11	Reay, Achvarasdal, Portskerra, Thurso
Fish	5	Thurso Bay, Thurso river, Forss river, Scrabster, Castletown
Crustaceans	4	Castletown, Scrabster, Thurso Bay
Wildfowl		None confirmed from survey area
Chicken	1	1x own farm near Thurso
Beef	4	1 x farm near Thurso, 1 x Melvich, 2x local farm within 5km
Lamb	3	1x own farm, 1 x farm near Thurso, 1x local farm within 5km
Pork	2	1x own farm, 1 x farm near Thurso,

* Where given

Several respondents reported consuming some fish they had caught from either Thurso Bay area or Castletown including two freshwater rivers. No individual reported collecting locally caught molluscs. It was unclear if those who bought molluscs locally were sourced within the survey area.

Several respondents reported buying food types from outwith the survey area or provided no location (Table A7v). No individual reported buying locally sourced chickens.

Table A7v Summary of food sourced from outwith survey area.

Food Group	No. People	Local but not in main survey area (no. people)	No location Provided
Green Veg	1	Halkirk	
Leeks & Onions	1	Halkirk	
Root Veg	1	Halkirk	
Potatoes	3	Halkirk(2), John O' Groats(1),	
Other Veg	1	Halkirk	
Goat/Cow Milk	1	Halkirk	
Eggs			1
Dom Fruit	2	Halkirk	
Honey	2	Halkirk	1
Wild Foods	2	Wick(1), Halkirk(1),	5
Fish	3	Pentland Firth(2), Home(1),	2
Crustaceans	1	1x Pentland Firth(1)	2
Wildfowl		Bettyhill(1), Caithness(1), Halkirk(1), Local estates(1)	
Chicken			
Beef	1	Weydale(1)	2
Lamb	1	Weydale(1)	2
Pork			3

Appendix A8 Site descriptions and observations

A8.1 Armadale Bay to Port Skerra

Armadale Bay (Figure A8i) is the most western site within the survey area. Access to this site was from a footpath leading from the road or via a footpath through a field at the western side of the beach. The beach is a large sandy beach backed by a field with cliffs on either side. To the west of Armadale Bay is Port a' Chinn, a stony little cove with a sandy foreshore at low tide. This small cove is accessed via a field and down steep grassy slope. Outwith the school holiday period only one walker and one

individual swimming were observed on Armadale beach. Continuing east Strathy Point is a grassy headland with a lighthouse which was popular with birdwatchers. The area was surrounded by steep cliffs with access to the rocks difficult, no individuals were observed on the rocks outwith the school holiday period. The coastline remains fairly steep towards Strathy Bay which was accessed from a car park and a walk through relatively large, steep dunes down to the sandy beach. The River Strathy entered the sea to the west side of the beach at Strathy Bay. One dog walker and three walkers were observed on the beach at Strathy Bay outwith the school holiday period. There is no current access down a private road to Port Ghrantaich, between Strathy Point and Strathy Bay, and no evidence of current fishing.

Within the school holiday period, there were no marine activities observed at Port a' Chinn with one small motorboat observed to be pulled up onto the rocks. Activities observed at Armadale Bay were five individuals surfing. Observations at Strathy Bay were one dog walker and nine individuals walking. One sailing yacht was observed on the water.

Within this section of coastline no spume was observed outwith or within the school holiday period.

Figure A8i. Armadale Bay (2018)

A8.2 Port Skerra to Sandside Bay

Port Skerra (Figure A8ii) has a small rocky cove which is difficult to access via a field from the road with a steep climb down a grassy slope into the rocky cove. Despite the steep terrain there are two styles over fencing which allows access. There are cliffs on either side of the rocky cove and evidence of a lobster pot marked by a buoy in the bay. The harbour is situated to the east of the bay and is a small natural harbour with easy access via the road. One commercial creel boat and a rowboat were observed to be moored in the water at the harbour. Continuing east towards Melvich Bay is Port Skerra Pier with access to the water via a slipway. There was no evidence of fishing boats or equipment. The substrate at this site was predominantly large rocks with several patches of sand visible and rocks covered with seaweed at low tide. There were no observations of individuals or aquatic activities outwith the school holiday period at this site. The coastline continues to be rocky towards Melvich Bay, a sandy

beach backed with grassy sand dunes rising to grassy slopes on the eastern side of the beach. This was a popular beach outwith the school holiday period with five dog walkers, six individuals playing, 15 individuals sitting/picnicking, 11 individuals sunbathing, four individuals swimming and three individuals walking. It was reported to the survey team that bait diggers have been observed at Melvich beach though none were observed during the survey period.

Within the school holiday period at Port Skerra Harbour one fisherman was preparing to go out fishing, one pleasure fisherman was preparing to launch their boat to take out four individuals sea fishing, one dog walker, two sightseers on the slip and four individuals walking on the rocks. One commercial creel boat and rowboat were moored in the water at the harbour at Port Skerra Harbour. There were no marine activities observed at Port Skerra Pier. Within the school holiday period Melvich Bay was very quiet with only five surfers and one dog walker observed.

Spume was noted at Port Skerra Pier and Melvich Bay outwith the school holiday period. Spume was noted at Port Skerra Harbour only within the holiday period.

Figure A8ii. Port Skerra, west of Port Skerra harbour (2018)

A8.3 Sandside Bay to Crosskirk Bay

Sandside Bay is a sandy beach with rocky outcrops on both eastern and western sides. It is backed by grassy coverage on sand dunes with the road behind it leading to Sandside Harbour (Figure A8iii), a small harbour to the west of Sandside Bay. Three fishing boats were moored on the water (one being a commercial creel boat) at the harbour and one boat was on the hard standing. To the west of Sandside Harbour there is a small sandy beach which gives access to Sandside Head. Activities observed outwith the school holiday period at Sandside Bay were two birdwatchers, three individuals walking on the beach and six individuals (families) sitting and playing in the sand. There were two walkers and one cyclist noted on the road behind Sandside Bay, two individuals at the harbour car park and one individual working on a boat on the hard standing of Sandside Harbour. From the eastern rocky outcrops on Sandside Bay it continues with steep rocky cliffs along the coastline with no access down to the coast. The Dounreay nuclear licensed site is situated as the coastline

continues east of Sandside Bay (Chapter 2). The coastline continues to be inaccessible due to the steep rocky cliffs and a 2 km stretch that is fenced off from public access along the coast at Dounreay.

Within the school holiday period activities observed at Sandside Harbour were two individuals undertaking boat maintenance, three individuals fishing from the harbour, four individuals walking, two individuals gardening and one individual horse-riding from Sandside Head down to the road. Activities observed at Sandside Beach were two groundhog operators, nine dog walkers and eight walkers. No aquatic activities were observed.

It was reported to the survey team that commercial winkle and whelk pickers operate at Sandside beach and sell them at Scrabster.

No spume was noted at any of these sites outwith or within the school holiday period.

Figure A8iii. Sandside Harbour looking over to Dounreay (2018)

A8.4 Crosskirk Bay to Holborn Head

Continuing east the coastline becomes accessible at Crosskirk Bay (Figure A8iv). Access to the coast is via a farm road and a walk along a public path through farmland leading to a rocky/stony bay with cliffs to either side. The river, called Forss Water, enters the sea to the western side of Crosskirk Bay. Outwith the school holiday period activities at this site were four walkers, two photographers and one individual sitting. The only accessible point between Crosskirk Bay and Holborn Head is a site called Brims Ness with access through farmland. No aquatic or terrestrial activities were noted at this site outwith the school holiday period though it was reported to be popular with surfers.

Within the school holiday period activities observed were seven individuals walking on the rocky foreshore, two individuals walking on the path and one farmer working in the field. No aquatic or terrestrial activities were noted at Brims Ness within the school holiday period though one campervan was parked down near the shore. No individuals were present to interview.

No spume was observed outwith or within the school holiday period at either of these sites.

Figure A8iv. Crosskirk Bay (2018)

A8.5 Holborn Head to Thurso

Continuing along the coast, Holborn Head is an elevated piece of headland with extremely steep vertical cliffs allowing no access to the shore. The steep coastline continues to Scrabster lighthouse just north of Scrabster Harbour with access only via steep rocky platforms. Scrabster Harbour is the main fishing port and hosts a ferry terminal taking passengers north to the Orkney Isles. The lifeboat station is situated at Scrabster Harbour. Scrabster beach (Figure A8v) is situated to the eastern side of the harbour and is a long narrow sandy beach backed by a sea wall with defence boulders and rocky substrate on the eastern side of the beach. Outwith the school holiday period activities observed at Scrabster beach were five walkers, one dog walker and one individual sunbathing.

Within the school holiday survey period Scrabster beach activities observed were three dog walkers, five walkers, two outdoor swimmers and one individual paddling.

No spume was observed at either site outwith or within the school holiday period.

Figure A8v. Scrabster beach (2018)

A8.6 Thurso to Castletown

Continuing east the coastline is rocky to Thurso beach which presents as a large sandy beach backed by a sea wall with sea defence boulders on either side of the beach. The beach front consists of a café and residential dwellings. Thurso beach (Figure A8vi) was observed to be very popular with individuals and families outwith the school holiday period. Activities observed were 21 dog walkers, 24 walkers, 37 individuals sitting/picnicking, nine individuals playing, 13 individuals (adults and children) swimming, 14 individuals paddling, three individuals sitting, an organised activity group of eight children and two adults playing in the sand, two individuals fishing from the rocks and one group of 15 kayakers (from the kayak club situated to the western end of Thurso beach) preparing to go out onto Thurso Bay. One boat was observed to be moored on the water. Continuing east the River Thurso enters the sea which separates Thurso beach and Thurso East Mains beach. No boats were observed to be moored

on the River Thurso though the Thurso Sea Cadets launch boats onto the river and undertake boating activities in the River Thurso and in Thurso Bay. A group of approximately ten children were observed to spend time jumping off the pier into the River Thurso. This was reported to be undertaken regularly in agreeable weather. Thurso East Mains beach substrate was rocky with boulders on the foreshore with some sand on the upper shore. Thurso East Mains beach was not as popular as Thurso beach outwith the school holiday period and activities observed were three individuals walking on the rocks and two individuals sitting on the rocks. Continuing towards Castletown the coastline was mainly rocky and inaccessible until Murkle Bay which is a small sandy beach accessed via farmland. No individuals were observed outwith the school holiday period though evidence of tyre tracks were visible on the sand and lobster pot buoys were observed in the water.

Within the school holiday period activities observed were nine dog walkers, five individuals sitting, seven individuals walking, two individuals sitting/picnicking, two individuals paddling and eleven kayakers. At Thurso pier activities observed were three individual's nature watching, two photographers and one individual fishing. At Thurso East Mains two individuals were observed sitting on the rocks. One horse-rider was observed at Murkle Bay. No marine activities were observed.

No spume was noted at these sites outwith or within the school holiday period.

Figure A8vi. Kayakers at Thurso Bay (2018)

A8.7 Castletown to Dunnet Head

The coastline towards Castletown was mainly rocky and Castletown Harbour is a small harbour with rocky substrate on either side. Outwith the school holiday period one fisherman was observed at Castletown Harbour along with four fishing boats and one boat moored on the water. A further one fishing boat and nine leisure boats were moored on the hard standing. A small sandy beach is situated along the coast from Castletown Harbour with no observations of activities noted outwith the school holiday period.

Continuing along the coast extending northwards from Castletown, Dunnet beach is a long stretch of sandy beach and sand dunes. Along this stretch there are several access points to Dunnet beach and it is a popular beach attracting many locals, visitors and activities. At the northern end of Dunnet beach there is a caravan and camping site along with a visitor centre providing locals and visitors with coastal group activities and information. Activities observed outwith the school holiday period on Dunnet

beach were 28 dog walkers, 43 walkers, 22 individuals sitting/picnicking and playing, 10 individuals paddling, eight surfers, two individuals horse riding, one individual flying a kite and one individual playing on the sand with a sand scooter (sand surfing).

To the north of Dunnet beach the coastline becomes rocky towards the vertical cliffs of Dunnet Head, a popular bird and nature watching location. Dwarwick Pier is approximately one kilometre north of Dunnet beach and is a concrete pier and slipway with public parking and picnic area. The substrate is very rocky and there is a footpath from the carpark north to access Peedie Bay (Figure A8vii). Observations noted outwith the school holiday period at Dwarwick Pier were four sea anglers fishing from the pier, two individuals walking and one surfer. Peedie Bay is a small sandy beach backed by steep rocky cliffs with rocky substrate at either side of the beach. It is accessed via a footpath from Dwarwick Pier providing an elevated walk to an access down into the bay. There were no activities observed at Peedie Bay though evidence of dog walking was apparent on the sandy beach and a lobster pot buoy was situated offshore.

Within the school holiday period, the harbour at Castletown was fairly popular with seven campervans parked on the hardstanding, three individuals sitting/picnicking on the harbour, two individuals sitting on the harbour wall and one dog walker on the rocks. The small sandy beach just south of the harbour was fairly popular too with nine dog walkers on the rocks and sand, one individual walking and one family playing. One fishing boat was on the water. Activities observed at Dunnet Bay were 11 dog walkers, 16 walkers, two individuals jogging, one individual metal detecting, one individual nature watching, three individuals surfing, three individual's body boarding and two individuals swimming. At Dwarwick Pier activities observed were three individuals dog walking on the rocks, one individual fishing off the pier, four individuals sitting/picnicking, two individuals in a small motorboat landing at the pier after fishing, two individuals swimming and five individuals surfing. At Peedie Bay one tent was pitched on the upper section of the beach next to the rockface. No aquatic activities were observed.

No spume was noted outwith or within the school holiday period at any sites.

Figure A8vii. Peedie Bay (2018)