3 Year Report: 2008 - 2011

NORTHERN IRELAND RADIATION MONITORING GROUP

Produced by:

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THE NORTHERN IRELAND RADIATION MONITORING SCHEME

HISTORY

1984	District Councils began monitoring radioactivity in the marine environment as a consequence of public concern about BNFL Sellafield
1988	Report entitled 'The Northern Ireland Local Authority Environmental Monitoring Programme' was presented to District Councils in the Province by Dr Stephen Harris of the University of Surrey.
June 1988	Northern Ireland Working Party of Environmental Health Officers recommended that District Councils in Northern Ireland be integrated into LARRMACC (now LARnet) and that a Joint Radiation Committee be formed in the Province comprising elected members and officers from Belfast and the four Environmental Health Groupings of Councils
Sept 1989	Inaugural meeting of the Joint Radiation Committee to become known as the 'Northern Ireland Radiation Monitoring Co-ordinating Committee' (NIRMCC)
1990 - 1996	Analytical laboratory services contracted to the University of Lancaster
April 1996	Installation of the ARGUS Continuous Monitoring Network
1996 - 1999	Analytical laboratory services contracted to the University of Southampton
1999 - 2002	Analytical laboratory services contracted to the University of Southampton
2002 - 2005	Analytical laboratory services contracted to the University of Southampton
2002	Update of Continuous Gamma Monitoring system to ARGUS 3000
2004	Introduction of a NIRMG website: www.nirmg.org.uk
2005 - 2008	Analytical laboratory services contracted to the University of Southampton
2008 - 2011	Analytical laboratory services contracted to the University of Southampton

OBJECTIVES

- To monitor levels of gamma radioactive contamination of marine biota and sediments in the Irish Sea as a consequence of routine radioactive discharges from the UK mainland and to ensure that doses due to Caesium-137 continue to fall.
- To monitor levels of actinides in sediments from Northern Ireland coastline and in fish/shellfish from the Irish Sea.
- To monitor levels of the beta emitter ^{99}Tc in shellfish and seaweeds from the Irish Sea.
- To monitor levels of contamination from gamma emitters in freshwater and terrestrial environments in Northern Ireland as a consequence of airborne releases of radioactivity such as that from Chernobyl.
- To provide independent information and data on radioactivity in the environment in order to address public concerns in Northern Ireland.
- To provide a system of radiation monitoring which is capable of adaptation to cope with abnormal/emergency releases and/or situations.

PARTICIPATING LOCAL AUTHORITIES

Northern Group
Ballymena
Coleraine
Carrickfergus
Moyle

Southern Group
Dungannon
Newry & Mourne

Eastern Group
Ards
Down
Lisburn

Western Group
Derry
Fermanagh
Limavady

Belfast City Council

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SUMMARY

This report for the Northern Ireland Radiation Monitoring Group (NIRMG) is a compilation of radiochemical data for foodstuffs and environmental samples collected by the participating authorities during the contract period April 2008 to March 2011. Over the three-year period samples were collected from the marine, estuarine and terrestrial environment that included a variety of locally produced foodstuffs.

An important objective of the NIRMG Scheme is to provide background information for the area over a period of time so that any fluctuations in the radioactive content of environmental materials derived from man-made sources can quickly be identified. The relative proximity of the Sellafield nuclear site with its reported discharges highlights the interest for continuing monitoring, as this is the greatest source of radioactivity concerning Northern Ireland.

The subject of radioactivity monitoring is a complex one and it is occasionally necessary to use technical language although this report endeavours to present the subject in a clear manner by providing regular explanations and a glossary of terms.

The measurements involved a detailed radiochemical analysis of environmental samples collected by the participating local authorities for a wide range of alpha, beta and gamma emitting isotopes. This approach makes a measurement of individual sample types and provides information on most man-made radioactive elements that exist in any given sample and gives a good indication of the nature and magnitude of environmentally significant radioactivity.

Very small levels of anthropogenic (man-made or artificial) radionuclides have been identified in many of the materials examined although none of the levels found is expected to be hazardous to the public. The concentrations found represent a tiny fraction of the national regulatory (cautionary) limits of radiation dose to members of the public. The maximum dose likely to be experienced by an adult living in Northern Ireland, derived from artificial sources of radioactivity, is low and within expected natural variations.

It is notable that the overall trend for most man-made radioactive contamination has been progressively downward since the 1980s.

MAIN CONCLUSIONS FOR RESULTS APRIL 2008 – MARCH 2011

The results obtained are briefly discussed below and a full set of data is given in the section NORTHERN IRELAND DATA.

Although anthropogenic (man-made or artificial) radionuclides have been identified in many of the materials examined, none of the levels found is expected to be hazardous to the public. The levels represent a small fraction of the national legislative (cautionary) limits of radiation dose to members of the public. All the contamination values are well below the Investigation Levels (i.e. 10% GDL*; HPA).

INTERPRETATION OF GAMMA SPECTROMETRY RESULTS

The results from all environmental samples show the region to be one of low radiological significance as far as anthropogenic (man-made or artificial) radioactive materials are concerned. Anthropogenic radioisotopes of caesium and americium are seen in minute quantities in some samples from the marine environment. These are probably derived from a combination of the Chernobyl accident, weapons' testing and Sellafield Ltd (Appendix D).

Caesium isotopes in terrestrial samples (soils and vegetation) are due to past depositions from the Chernobyl cloud and weapons' testing. The levels are extremely low in all samples examined.

INTERPRETATION OF ALPHA SPECTROMETRY RESULTS

Transuranic radionuclides, plutonium and americium, originating from Sellafield discharges and from weapons' tests are all found to be low and should be of no radiological concern. This conclusion is clearly shown by comparing the Generalised Derived Limit (GDL) data with the measured sample activity data (NORTHERN IRELAND DATA). The highest levels of contamination are found in fine-grained marine sediments.

INTERPRETATION OF TECHNETIUM-99 ANALYSES

The technetium results in samples of edible materials (lobsters, prawns and dulse seaweed) do not show any levels of ^{99}Tc that would lead to any radiological concerns. The main concentrators of technetium are the seaweeds *Fucus vesiculosus* and *Ascophyllum nodosum* (Table 5 Appendix C). The magnitude of the activity concentration for any particular species reflects the age of the plant, the contact time with contaminated seawater and the trends of marine currents from the eastern Irish Sea. Dulse, which is consumed by some people, is not a significant concentrator of 99Tc. It is known that lobsters can concentrate technetium (Table 5 Appendix C) but the results so far do not indicate any significant radiological problems.

INTERPRETATION OF CARBON-14 ANALYSES

Carbon-14 has been analysed in marine fish since 2002. The results do not indicate any significant problem and compare well with data given in the Radioactivity in food and the Environment (RIFE) reports.

COMPARATIVE RADIOMETRIC DATA

Reliability and consistency are checked by comparing data from different monitoring groups or agencies (Appendix C). Quality assurance is evaluated by participating in inter-comparison exercises with international and UK national organisations (e.g.: IAEA and NPL Appendix F).

Notes:

* GDLs are explained in Appendix E

LONG TERM TRENDS

A selected set of data are given in Figure 1 to evaluate some long-term trends with samples taken from the Northern Ireland environment. This shows variation in the activity of ^{137}Cs with time for sediments, periwinkles and seafish. Data are in Bq/kg. The significant decline in ^{137}Cs activities is a result of improved clean-up of effluents for the Sellafield Site by SIXEP (Site Ion-eXchange Plant) and EARP (Enhanced Actinide Recovery Plant). The trend for ^{99}Tc in seaweed (Figure 2a) shows there was a significant increase in activity since 1994 but that it is currently decreasing. This reflects the reported increase and subsequent decrease in discharges of ^{99}Tc from Sellafield (Figure 2b).

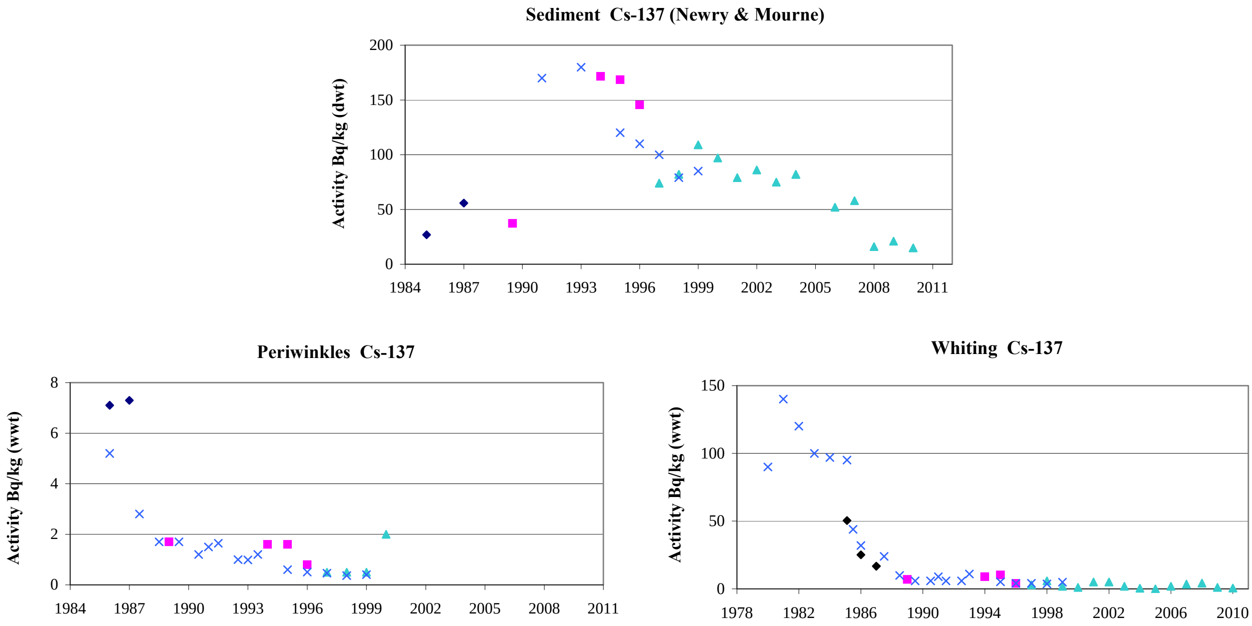


FIGURE 1: Variations in the activity of Cs-137 with time. (◆ - Surrey, ■ - Lancaster, ▲ - Southampton, × - MAFF)
(data taken from MAFF, Surry University, Lancaster University, and University of Southampton reports)

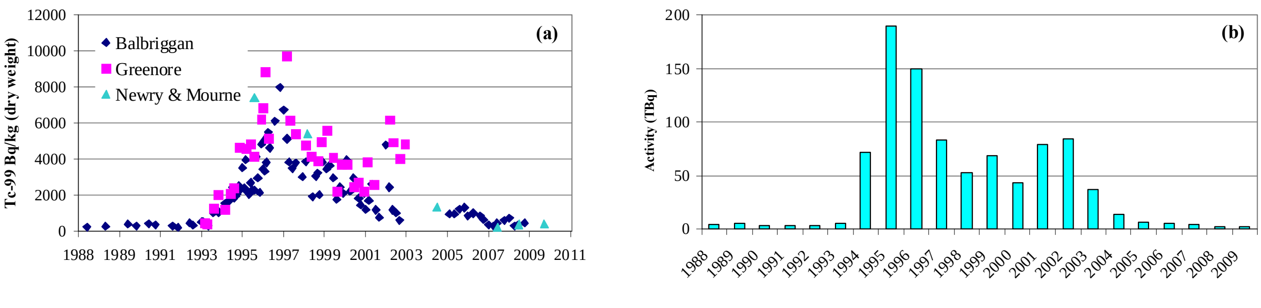


FIGURE 2a and 2b

2a: ^{99}Tc activity concentrations in *Fucus vesiculosus* sampled at Balbriggan and Greenore (Eastern Ireland) in the period 1988 – 2007. (Adapted from Smith *et al* (1997)[@]. Additional data supplied by RPII., (www.rpii.ie) for Balbriggan and Greenore, and from this and previous Northern Ireland Radiation Monitoring Group Reports for Newry & Mourne.

2b: Sellafield discharges of ^{99}Tc to the Irish Sea 1988 – 2009 (BNFL 2009)

Notes:

[@] Smith V., Ryan R.W., Pollard D., Mitchell P.I., & Ryan T.P. Temporal and geographical distribution of ^{99}Tc in inshore waters around Ireland following increased discharges from Sellafield. Radioprotection - Colloques, 32, 71-77 (1997)

GENERAL INFORMATION
TO ASSIST IN UNDERSTANDING DATA TABLES

The data tables that follow contain information on the numerous samples that have been taken during the year, as to the type of sample, where they were taken, their radiological content and the sampling authority. There is also information drawn from other sampling bodies and compared with results found in this report.

The tables are set out as follows:-

1. **NORTHERN IRELAND DATA: Results April 2008 - March 2011**

   This Appendix sets out the results for the year April 2008 - March 2011. A sample catalogue shows the type of samples submitted by each Local Authority, and the gamma spectrometry results are ordered by sample type for the terrestrial and marine environment.

2 **APPENDIX C: Selected Comparative Data**

   This Appendix sets out monitoring and sampling results from the Northern Ireland Radiation Monitoring Group for this year and compares them with results from sampling undertaken by the Food Standards Agency and British Nuclear Fuels plc (BNFL) at Sellafield.

All tables of results give the sample type, the date of sample collection and the measured level of radiological activity from man-made sources either in Becquerels per kilogram (Bq/kg) or Becquerels per litre (Bq/l). Data showing a dash are below detection limits, whereas data with a less than value (e.g. < 1 Bq/kg) are at the detection limit and a signal is seen but is too small to quantify.

A Becquerel describes the rate at which radioactive decay takes place and corresponds to the decay or disintegration of one radioactive atom per second. It is an extremely small measure of radioactivity.

A radionuclide is an unstable form of an element that emits radioactivity. The following radionuclides are referred to in the tables (with the abbreviations used given after):

ANTHROPOGENIC

^{134}Caesium	-	^{134}Cs
^{137}Caesium	-	^{137}Cs
^{57}Cobalt	-	^{60}Co
^{58}Cobalt	-	^{60}Co
^{60}Cobalt	-	^{60}Co
^{54}Manganese	-	^{54}Mn
^{65}Zinc	-	^{65}Zn
^{131}Iodine	-	^{131}I
^{238}Plutonium	-	^{238}Pu
^{239,240}Plutonium	-	^{239,240}Pu
^{241}Americium	-	^{241}Am
^{99}Technetium	-	^{99}Tc

Note

Other conventions may be used in other literature e.g. ^{99}Technetium may also be referred to as Technetium-99 or Tc-99.

To assist with understanding the significance of the radiological levels reported, Generalised Derived Limits (GDLs) are included after the tables, where appropriate. A full explanation of GDLs and summarised values are given in Appendix E but they are basically cautionary indicators of levels that should not be exceeded for specific materials and particularly foodstuffs.

SAMPLE CATALOGUE BY AUTHORITY

** Belfast City Council

* Belfast

09/06/2008	Sediment
01/06/2009	Sediment
03/06/2010	Sediment

** Eastern Group Environmental Health Committee

* Ards

05/06/2008	Dulse
05/09/2008	Whiting
05/09/2008	Mixed Seaweed
05/09/2008	Silt
22/06/2009	Seaweed
22/06/2009	Silt
21/09/2009	Whiting
02/02/2010	Whiting
03/06/2010	Dulse
03/06/2010	Silt
19/09/2010	Whiting

* Down

05/06/2008	Haddock
05/06/2008	Mussels
06/06/2008	Lobster
09/08/2008	Silt
08/09/2008	Honey
08/09/2008	Venison
18/06/2009	Lobster
22/06/2009	Haddock
22/06/2009	Mussels
22/09/2009	Silt
07/10/2009	Venison
01/06/2010	Haddock
01/06/2010	Lobster
01/06/2010	Mussels
18/09/2010	Venison
21/09/2010	Mussels
22/09/2010	Silt

* Lisburn

10/06/2008	Water
22/06/2009	Water
07/06/2010	Water

** Northern Group Environmental Health Committee

* Ballymena

09/09/2008	Water
22/09/2009	Water
20/09/2010	Water

* Coleraine

13/09/2010	Heather honey

** Northern Group Environmental Health Committee

* Carrickfergus

06/06/2008	Coastal silt
06/06/2008	Mussels
05/09/2008	Silt
17/06/2009	Silt
22/06/2009	Silt
22/06/2009	Mussels
03/06/2010	Silt
03/06/2010	Mussels
17/09/2010	Silt

* Moyle

06/06/2008	Dulse
09/06/2008	Lobster
05/09/2008	Salmon
05/09/2008	Whiting
06/09/2008	Fucus vesiculosus
05/06/2009	Fucus vesiculosus
08/06/2009	Lobster
17/09/2009	Dulse
05/06/2010	Seaweed
07/06/2010	Lobster
24/09/2010	Whiting
24/09/2010	Duse

** Southern Group Environmental Health Committee

* Dungannon

09/06/2008	Water
23/06/2009	Water
07/06/2010	Water

* Newry & Mourne

06/06/2008	Haddock
07/06/2008	Fucus vesiculosus
07/06/2008	Mussels
07/09/2008	Heather honey
08/09/2008	Whiting
08/09/2008	Haddock
08/09/2008	Silt
08/09/2008	Lobster
19/06/2009	Haddock
21/06/2009	Fucus vesiculosus
21/06/2009	Mussels
17/09/2009	Heather Honey
21/09/2009	Silt
21/09/2009	Mussels
21/09/2009	Lobster (Meat)
21/09/2009	Lobster (Pancreas)
21/09/2009	Lobster (Other)
04/06/2010	Haddock
04/06/2010	Whiting
04/06/2010	Lobster
07/06/2010	Mussels
19/09/2010	Fucus vesiculosus
19/09/2010	Silt
20/09/2010	Heather Honey

SAMPLE CATALOGUE BY AUTHORITY

** Western Group Environmental Health Committee

* Derry

08/09/2008	Whiting
08/09/2008	Haddock
08/09/2008	Mussels
08/09/2008	Water
23/06/2009	Haddock
23/06/2009	Whiting
23/06/2009	Mussels
23/06/2009	Water
22/09/2009	Water
07/06/2010	Haddock
07/06/2010	Whiting
07/06/2010	Mussels
07/06/2010	Water
20/09/2010	Mussels
20/09/2010	Water
22/09/2010	Haddock
22/09/2010	Whiting

* Fermanagh

03/09/2008	Venison
03/09/2008	Honey
17/09/2009	Venison

* Limavady

09/06/2008	Fucus vesiculosus
09/06/2008	Silt
08/09/2008	Fucus vesiculosus
08/09/2008	Silt
23/06/2009	Fucus vesiculosus
23/06/2009	Silt
22/09/2009	Fucus vesiculosus
22/09/2009	Silt
07/06/2010	Fucus vesiculosus
07/06/2010	Silt
07/06/2010	Silt
20/09/2010	Fucus vesiculosus

TABLE 1
MONITORING THE TERRESTRIAL ENVIRONMENT

Date	Authority	Type	Locality	^{131}I	^{54}Mn	^{65}Zn	^{57}Co	^{58}Co	^{60}Co	^{134}Cs	^{137}Cs
				Activity (Bq/ Kg)							
*** Honey**											
*** Eastern Group Environmental Health Committee**											
08/09/2008	Down	-	Dundrum	-	-	-	-	-	-	-	-
*** Northern Group Environmental Health Committee**											
13/09/2010	Coleraine	Heather Honey	Garvagh	-	-	-	-	-	-	-	114
*** Southern Group Environmental Health Committee**											
07/09/2008	Down/Newry & Mourne	Heather Honey	Mournes	-	-	-	-	-	-	-	19
17/09/2009	Down/Newry & Mourne	Heather Honey	Mournes	-	-	-	-	-	-	-	2
20/09/2010	Newry & Mourne	Heather Honey	Mournes	-	-	-	-	-	-	-	18
*** Western Group Environmental Health Committee**											
03/09/2008	Fermanagh	-	Fermanagh	-	-	-	-	-	-	-	-
HONEY DERIVED LIMIT assuming 50kg consumption p.a.											**1700**

Date	Authority	Type	Locality	^{131}I	^{54}Mn	^{65}Zn	^{57}Co	^{58}Co	^{60}Co	^{134}Cs	^{137}Cs
				Activity (Bq/ Kg wet weight)							
*** Meat**											
*** Eastern Group Environmental Health Committee**											
08/09/2008	Down	Venison	Downpatrick	-	-	-	-	-	-	-	-
07/10/2009	Down	Venison	Downpatrick	-	-	-	-	-	-	-	-
18/09/2010	Down	Venison	Downpatrick	-	-	-	-	-	-	-	-
*** Western Group Environmental Health Committee**											
03/09/2008	Fermanagh	Venison	Brookeborough	-	-	-	-	-	-	-	-
17/09/2009	Fermanagh	Venison	Colebrook	-	-	-	-	-	-	-	1

Date	Authority	Type	Locality	^{134}Cs	^{137}Cs
				Activity (Bq/Litre)	
*** Water**					
*** Eastern Group Environmental Health Committee**					
10/06/2008	Lisburn	Borehole	Lambeg	-	-
22/06/2009	Lisburn	Borehole	Knockmore Hill	-	-
07/06/2010	Lisburn	Borehole	Knockmore Hill	-	-
*** Northern Group Environmental Health Committee**					
09/09/2008	Ballymena	Borehole	100 Railway St,	-	-
22/09/2009	Ballymena	Borehole	100 Railway Street	-	-
20/09/2010	Ballymena	Borehole	Railway Street	-	-
*** Southern Group Environmental Health Committee**					
09/06/2008	Dungannon	Borehole	Fivemiletown	-	-
23/06/2009	Dungannon	Private Supply	Fivemiletown	-	-
07/06/2010	Dungannon	Private Supply	Fivemiletown	-	-
*** Western Group Environmental Health Committee**					
08/09/2008	Derry	Borehole	Claudy	-	-
23/06/2009	Derry	Spring Well	Claudy	-	-
22/09/2009	Derry	Spring Well	300 Longland Road	-	-
07/06/2010	Derry	Spring Well	300 Longland Road	-	-
20/09/2010	Derry	Spring Well	Longland Road	-	-

Note:: - below limit of detection

TABLE 2
MONITORING THE MARINE ENVIRONMENT

Date	Authority	Type	Locality	Activity (Bq/Kg wet weight) ^{134}Cs	^{137}Cs
*** Fish**					
*** Eastern Group Environmental Health Committee**					
05/06/2008	Down	Haddock	Irish Sea	-	-
05/09/2008	Ards	Whiting	Irish Sea	-	6
05/09/2008	Moyle	Salmon	North Channel	-	-
22/06/2009	Down	Haddock	Irish Sea	-	-
21/09/2009	Ards	Whiting	Irish Sea	-	1
02/02/2010	Ards	Whiting	Irish Sea	-	1
01/06/2010	Down	Haddock	Irish Sea	-	<1
19/09/2010	Ards	Whiting	North Atlantic	-	<1
*** Northern Group Environmental Health Committee**					
05/09/2008	Moyle	Whiting	Irish Sea	-	2
24/09/2010	Moyle	Whiting	North Channel	-	1
*** Southern Group Environmental Health Committee**					
06/06/2008	Newry & Mourne	Haddock	Irish Sea	-	5
08/09/2008	Newry & Mourne	Whiting	Irish Sea	-	7
08/09/2008	Newry & Mourne	Haddock	Irish Sea	-	3
19/06/2009	Newry & Mourne	Haddock	Irish Sea	-	<1
04/06/2010	Newry & Mourne	Haddock	Irish Sea	-	<1
04/06/2010	Newry & Mourne	Whiting	Irish Sea	-	<1
*** Western Group Environmental Health Committee**					
08/09/2008	Derry	Whiting	Malin Head	-	2
08/09/2008	Derry	Haddock	Malin Head	-	-
23/06/2009	Derry	Haddock	Malin Head	-	<1
23/06/2009	Derry	Whiting	Malin Head	-	-
07/06/2010	Derry	Haddock	Malin Head	-	-
07/06/2010	Derry	Whiting	Malin Head	-	<1
22/09/2010	Derry	Haddock	Malin Head	-	<1
22/09/2010	Derry	Whiting	Malin Head	-	-
GENERALISED DERIVED LIMITS					**700**

Date	Authority	Type	Locality	Activity (Bq/Kg wet weight) ^{131}I	^{54}Mn	^{65}Zn	^{57}Co	^{58}Co	^{60}Co	^{134}Cs	^{137}Cs
*** Seaweed**											
*** Eastern Group Environmental Health Committee**											
05/06/2008	Ards	Dulse	Ballywalter	-	-	-	-	-	-	-	5
05/09/2008	Ards	Mixed	Ballyhalbert	-	-	-	-	-	-	-	<1
22/06/2009	Ards	Dulse	Millisle	-	-	-	-	-	-	-	6
03/06/2010	Ards	Dulse	Ballywalter	-	-	-	-	-	-	-	4
*** Northern Group Environmental Health Committee**											
06/06/2008	Moyle	Dulse	Unknown	-	-	-	-	-	-	-	4
06/09/2008	Moyle	Fucus vesiculosus	Ballintoy	-	-	-	-	-	-	-	-
05/06/2009	Moyle	Fucus vesiculosus	Ballintoy	-	-	-	-	-	-	-	<1
17/09/2009	Moyle	Dulse	Ballintoy	-	-	-	-	-	-	-	2
05/06/2010	Moyle	Seaweed	Ballintoy	2	-	-	-	-	-	-	-
24/09/2010	Moyle	Dulse	Murlough Bay	-	-	-	-	-	-	-	2
*** Southern Group Environmental Health Committee**											
07/06/2008	Newry & Mourne	Fucus vesiculosus	Warrenpoint	-	-	-	-	-	-	-	<1
21/06/2009	Newry & Mourne	Fucus vesiculosus	Warrenpoint	-	-	-	-	-	-	-	1
19/09/2010	Newry & Mourne	Fucus vesiculosus	Warrenpoint	-	-	-	-	-	-	-	<1
*** Western Group Environmental Health Committee**											
09/06/2008	Limavady	Fucus vesiculosus	Ball’s Point	-	-	-	-	-	-	-	<1
08/09/2008	Limavady	Fucus vesiculosus	Ball’s Point	-	-	-	-	-	-	-	<1
23/06/2009	Limavady	Fucus vesiculosus	Ball’s Point	-	-	-	-	-	-	-	<1
22/09/2009	Limavady	Fucus vesiculosus	Ball’s Point	-	-	-	-	-	-	-	<1
07/06/2010	Limavady	Fucus vesiculosus	Ball’s Point	-	-	-	-	-	-	-	<1
20/09/2010	Limavady	Fucus vesiculosus	Ball’s Point	-	-	-	-	-	-	-	<1

Note: – below limit of detection

TABLE 2
MONITORING THE MARINE ENVIRONMENT

Activity (Bq/ Kg dry weight)

* Sediment

Date	Authority	Type	Locality	^{241}Am	^{54}Mn	^{65}Zn	^{57}Co	^{58}Co	^{60}Co	^{134}Cs	^{137}Cs
*** Belfast City Council**											
09/06/2008	Belfast	Silt	Belfast Lough	-	-	-	-	-	-	-	20
01/06/2009	Belfast	Silt	Belfast Lough	10	-	-	-	-	-	-	20
03/06/2010	Belfast	Silt	Belfast Lough	7	-	-	-	-	-	-	13
*** Eastern Group Environmental Health Committee**											
05/09/2008	Ards	Silt	Millisle	-	-	-	-	-	-	-	7
09/08/2008	Down	Silt	Killough Harbour	-	-	-	-	-	-	-	6
22/06/2009	Ards	Silt	Millisle	-	-	-	-	-	-	-	4
22/09/2009	Down	Silt	Killough Harbour	1	-	-	-	-	-	-	4
03/06/2010	Ards	Silt	Millisle	<1	-	-	-	-	-	-	3
22/09/2010	Down	Silt	Killough Harbour	1	-	-	-	-	-	-	6
*** Northern Group Environmental Health Committee**											
06/06/2008	Carrickfergus	Coastal silt	Carrickfergus	-	-	-	-	-	-	-	5
05/09/2008	Carrickfergus	Silt	Carrickfergus	-	-	-	-	-	-	-	5
22/06/2009	Carrickfergus	Silt	Carrickfergus	-	-	-	-	-	-	-	5
17/06/2009	Carrickfergus	Silt	Carrickfergus	1	-	-	-	-	-	-	3
03/06/2010	Carrickfergus	Silt	Carrickfergus	2	-	-	-	-	-	-	4
17/09/2010	Carrickfergus	Silt	Carrickfergus	2	-	-	-	-	-	-	3
*** Southern Group Environmental Health Committee**											
08/09/2008	Newry & Mourne	Silt	Warrenpoint	-	-	-	-	-	-	-	16
21/09/2009	Newry & Mourne	Silt	Warrenpoint	2	-	-	-	-	-	-	21
19/09/2010	Newry & Mourne	Silt	Warrenpoint	2	-	-	-	-	-	-	15
*** Western Group Environmental Health Committee**											
09/06/2008	Limavady	Silt	Carrickhugh Bridge	-	-	-	-	-	-	-	3
08/09/2008	Limavady	Silt	Carrickhugh Bridge	-	-	-	-	-	-	-	-
23/06/2009	Limavady	Silt	Carrickhugh Bridge	-	-	-	-	-	-	-	2
22/09/2009	Limavady	Silt	Carrickhugh Bridge	5	-	-	-	-	-	-	6
07/06/2010	Limavady	Silt	Carrickhugh Bridge	2	-	-	-	-	-	-	5
07/06/2010	Limavady	Silt	Lough Foyle	-	-	-	-	-	-	-	-
GENERALISED DERIVED LIMITS										**2000**	**5000**

Activity (Bq/ Wet weight)

* Shellfish

Date	Authority	Type	Locality	^{131}I	^{54}Mn	^{65}Zn	^{57}Co	^{58}Co	^{60}Co	^{134}Cs	^{137}Cs
*** Eastern Group Environmental Health Committee**											
05/06/2008	Down	Mussels	Killough Harbour	-	-	-	-	-	-	-	3
06/06/2008	Down	Lobster	Killough Harbour	-	-	-	-	-	-	-	-
18/06/2009	Down	Lobster	St. John’s Point	-	-	-	-	-	-	-	-
22/06/2009	Down	Mussels	Killough Harbour	-	-	-	-	-	-	-	<1
01/06/2010	Down	Lobster	Portavogie	-	-	-	-	-	-	-	-
01/06/2010	Down	Mussels	Killough Harbour	-	-	-	-	-	-	-	-
21/09/2010	Down	Mussels	Dundrum Bay	-	-	-	-	-	-	-	-

GENERALISED DERIVED LIMITS

		^{134}Cs	^{137}Cs
	Molluscs	**3000**	**4000**
	Crustacea	**3000**	**4000**

Note:
- below limit of detection

TABLE 2
MONITORING THE MARINE ENVIRONMENT

Date	Authority	Type	Locality	^{131}I	^{54}Mn	^{65}Zn	^{57}Co	^{58}Co	^{60}Co	^{134}Cs	^{137}Cs
				Activity (Bq/ Wet weight)							
* Shellfish											
* Northern Group Environmental Health Committee											
06/06/2008	Carrickfergus	Mussels	Carrickfergus	-	-	-	-	-	-	-	-
09/06/2008	Moyle	Lobster	Northern Channel	-	-	-	-	-	-	-	3
22/06/2009	Carrickfergus	Mussels	Carrickfergus	-	-	-	-	-	-	-	-
08/06/2009	Moyle	Lobster	North Channel	-	-	-	-	-	-	-	<1
03/06/2010	Carrickfergus	Mussels	Carrickfergus	-	-	-	-	-	-	-	<1
07/06/2010	Moyle	Lobster	North Channel	-	-	-	-	-	-	-	-
* Southern Group Environmental Health Committee											
07/06/2008	Newry & Mourne	Mussels	Warrenpoint	-	-	-	-	-	-	-	-
08/09/2008	Newry & Mourne	Lobster	Irish Sea	-	-	-	-	-	-	-	2
21/06/2009	Newry & Mourne	Mussels	Warrenpoint	-	-	-	-	-	-	-	<1
21/09/2009	Newry & Mourne	Mussels	Warrenpoint	-	-	-	-	-	-	-	<1
21/09/2009	Newry & Mourne	Lobster	Irish Sea	-	-	-	-	-	-	-	<1
21/09/2009	Newry & Mourne	Lobster	Irish Sea	-	-	-	-	-	-	-	-
04/06/2010	Newry & Mourne	Lobster	Irish Sea	-	-	-	-	-	-	-	<1
07/06/2010	Newry & Mourne	Mussels	Warrenpoint	-	-	-	-	-	-	-	-
* Western Group Environmental Health Committee											
08/09/2008	Derry	Mussels	Longfield	-	-	-	-	-	-	-	-
23/06/2009	Derry	Mussels	Longfield	-	-	-	-	-	-	-	-
07/06/2010	Derry	Mussels	Longfield	-	-	-	-	-	-	-	-
20/09/2010	Derry	Mussels	Longfield	-	-	-	-	-	-	-	<1
GENERALISED DERIVED LIMITS											
		Molluscs								**3000**	**4000**
		Crustacea								**3000**	**4000**

Note:
- below limit of detection

TABLE 3
RESULTS OF TRANSURANIC ELEMENT DETERMINATIONS

Date	Authority	Type	Locality	Activity (Bq/kg) ^{238}Pu	$^{239,240}Pu$	^{241}Am
*** Belfast City Council**						
09/06/2008	Belfast	Silt	Belfast Lough	1.73	9.74	10.80
01/06/2009	Belfast	Silt	Belfast Lough	1.73	8.33	12.00
03/06/2010	Belfast	Silt	Belfast Lough	1.60	9.06	14.18
*** Eastern Group Environmental Health Committee**						
05/06/2008	Down	Mussels	Killough Harbour	0.03	0.16	0.19
05/09/2008	Ards	Silt	Millisle	0.42	2.60	3.54
22/06/2009	Ards	Silt	Millisle	0.17	1.25	0.96
22/06/2009	Down	Mussels	Killough Harbour	-	0.13	0.10
03/06/2010	Ards	Silt	Millisle	0.43	1.58	2.51
01/06/2010	Down	Lobster	Portavogie	<0.02	0.33	0.13
01/06/2010	Down	Mussels	Killough Harbour	0.13	0.67	0.20
*** Northern Group Environmental Health Committee**						
06/06/2008	Carrickfergus	Silt	Carrickfergus	0.40	2.96	3.59
06/06/2008	Carrickfergus	Mussels	Carrickfergus	0.05	0.32	0.57
22/06/2009	Carrickfergus	Silt	Carrickfergus	0.48	3.20	2.30
22/06/2009	Carrickfergus	Mussels	Carrickfergus	0.08	0.35	0.49
03/06/2010	Carrickfergus	Silt	Carrickfergus	0.54	3.41	5.18
03/06/2010	Carrickfergus	Mussels	Carrickfergus	0.08	0.48	0.78
*** Southern Group Environmental Health Committee**						
07/06/2008	Newry & Mourne	Mussels	Warrenpoint	0.02	0.10	0.13
08/09/2008	Newry & Mourne	Sediment	Warrenpoint	0.64	3.72	2.71
21/06/2009	Newry & Mourne	Mussels	Warrenpoint	0.03	0.14	-
21/06/2009	Newry & Mourne	Fucus vesiculosus	Warrenpoint	0.06	0.21	0.02
21/09/2009	Newry & Mourne	Silt	Warrenpoint	0.58	5.94	2.88
21/09/2009	Newry & Mourne	Mussels	Warrenpoint	0.02	0.12	0.08
19/09/2010	Newry & Mourne	Silt	Warrenpoint	0.73	3.62	3.66
07/06/2010	Newry & Mourne	Mussels	Warrenpoint	<0.01	0.11	0.12
*** Western Group Environmental Health Committee**						
08/09/2008	Derry	Mussels	Longfield	0.04	0.13	0.16
08/09/2008	Limavady	Silt	Carrickhugh Bridge	0.05	0.11	0.96
23/06/2009	Derry	Mussels	Longfield	-	0.03	0.10
22/09/2009	Limavady	Silt	Carrickhugh Bridge	0.64	4.29	5.89
07/06/2010	Limavady	Silt	Carrickhugh Bridge	0.56	1.70	3.05
20/09/2010	Derry	Mussels	Longfield	0.03	0.14	0.20

Note:

- below limit of detection
- All biota data are on a wet weight basis.
- Silt/sediment reported as dry weight

TABLE 4
ANALYSIS FOR TECHNETIUM-99

Date	Authority	Type	Locality	Activity (Bq/kg) ^{99}Tc
*** Eastern Group Environmental Health Committee**				
05/06/2008	Down	Mussels	Killough Harbour	12
05/06/2008	Down	Lobster	St John's Point	34
05/06/2008	Ards	Dulse	Ballywalter	14
05/09/2008	Ards	Seaweed	Ballyhalbert	80
22/06/2009	Ards	Silt	Millisle	1
18/06/2009	Down	Lobster	St. John's Point	3
22/06/2009	Down	Mussels	Killough Harbour	2
22/06/2009	Ards	Dulse	Millisle	-
03/06/2010	Ards	Silt	Millisle	<5
01/06/2010	Down	Lobster	Portavogie	53
01/06/2010	Down	Mussels	Killough Harbour	8
03/06/2010	Ards	Dulse	Ballywalter	<8
*** Northern Group Environmental Health Committee**				
06/06/2008	Moyle	Dulse	Unknown	25
09/06/2008	Moyle	Lobster	Northern Channel	39
06/06/2008	Carrickfergus	Mussels	Carrickfergus	156
06/09/2008	Moyle	Seaweed	Ballintoy	115
22/06/2009	Carrickfergus	Silt	Carrickfergus	2
22/06/2009	Carrickfergus	Mussels	Carrickfergus	19
08/06/2009	Moyle	Lobster	North Channel	10
05/06/2009	Moyle	Fucus vesiculosus	Ballintoy	7
17/09/2009	Moyle	Dulse	Ballintoy	4
03/06/2010	Carrickfergus	Mussels	Carrickfergus	56
07/06/2010	Moyle	Lobster	North Channel	5
05/06/2010	Moyle	Seaweed	Ballintoy	26
24/09/2010	Moyle	Dulse	Murlough Bay	<7
*** Southern Group Environmental Health Committee**				
07/06/2008	Newry & Mourne	Mussels	Warrenpoint	63
07/06/2008	Newry & Mourne	Fucus vesiculosus	Warrenpoint	215
08/09/2008	Newry & Mourne	Lobster	Irish Sea	159
21/06/2009	Newry & Mourne	Mussels	Warrenpoint	11
21/06/2009	Newry & Mourne	Fucus vesiculosus	Warrenpoint	385
21/09/2009	Newry & Mourne	Lobster (Pancreas)	Irish Sea	165
04/06/2010	Newry & Mourne	Lobster	Irish Sea	65
07/06/2010	Newry & Mourne	Mussels	Warrenpoint	28
19/09/2010	Newry & Mourne	Fucus vesiculosus	Warrenpoint	423
*** Western Group Environmental Health Committee**				
09/06/2008	Limavady	Fucus vesiculosus	Ball's Point	10
08/09/2008	Limavady	Fucus vesiculosus	Ball's Point	9
08/09/2008	Derry	Mussels	Longfield	3
23/06/2009	Derry	Mussels	Longfield	2
23/06/2009	Limavady	Fucus vesiculosus	Ball's Point	4
22/09/2009	Limavady	Fucus vesiculosus	Ball's Point	43
07/06/2010	Derry	Mussels	Longfield	7
20/09/2010	Derry	Mussels	Longfield	5
07/06/2010	Limavady	Fucus vesiculosus	Ball's Point	11
20/09/2010	Limavady	Fucus vesiculosus	Ball's Point	7

Note:

- below limit of detection
- All biota data are on a wet weight basis.
- Silt/sediment reported as dry weight

TABLE 5
ANALYSIS FOR CARBON-14

Date	Authority	Type	Locality	Activity (Bq/kg wet weight) ^{14}C
*** Eastern Group Environmental Health Committee**				
05/06/2008	Down	Haddock	Irish Sea	75
22/06/2009	Down	Haddock	Irish Sea	24
01/06/2010	Down	Haddock	Irish Sea	31
*** Northern Group Environmental Health Committee**				
05/09/2008	Moyle	Salmon	North Channel	24
24/09/2010	Moyle	Whiting	North Channel	35
*** Southern Group Environmental Health Committee**				
06/06/2008	Newry & Mourne	Haddock	Irish Sea	145
08/09/2008	Newry & Mourne	Haddock	Irish Sea	25
19/06/2009	Newry & Mourne	Haddock	Irish Sea	25
04/06/2010	Newry & Mourne	Haddock	Irish Sea	30
*** Western Group Environmental Health Committee**				
08/09/2008	Derry	Haddock	Irish Sea	12
23/06/2009	Derry	Haddock	Malin Head	20
07/06/2010	Derry	Haddock	Malin Head	29

Notes:
Measurements given in ‘Radioactivity in Food and the Environment, 2001’ for fish in the Irish Sea are in range 41 - 120 Bq/kg wet weight

TABLE 6
INSTANTANEOUS GAMMA MONITORING

The following data were collected with samples submitted for gamma and alpha analysis.

				Doserate µGy/hr
*** Belfast City Council**				
01/06/2009	Belfast	Silt	Belfast Lough	0.082
03/06/2010	Belfast	Silt	Belfast Lough	0.081
*** Eastern Group Environmental Health Committee**				
05/09/2008	Ards	Sediment	Millisle	0.067
22/06/2009	Ards	Silt	Millisle	0.063
03/06/2010	Ards	Silt	Millisle	0.106
*** Southern Group Environmental Health Committee**				
08/09/2008	Newry & Mourne	Sediment	Warrenpoint	0.096
21/06/2009	Newry & Mourne	Silt	Warrenpoint	0.09
21/09/2009	Newry & Mourne	Silt	Warrenpoint	0.09
07/06/2010	Limavady	Silt	Carrickhugh	0.095
19/09/2010	Limavady	Silt	Warrenpoint	0.1
*** Western Group Environmental Health Committee**				
08/09/2008	Limavady	Sediment	Carrickhugh Bridge	0.076
23/06/2009	Limavady	Silt	Carrickhugh Bridge	0.056
22/09/2009	Limavady	Silt	Carrickhugh Bridge	0.053
07/06/2010	Limavady	Silt	Carrickhugh Bridge	0.06

NORTHERN IRELAND SAMPLE SITES

Map no.	Details	Locality	Grid reference
Belfast City Council			
1	Belfast	Belfast Lough	J 350 794
Eastern Group Environmental Health Committee			
2	Ards	Millisle	J 601 755
3	Ards	Ballywalter	J 635 690
4	Ards	Ballyhalbert	J 661 620
*	Ards	Irish Sea	V11a
5	Down	Dundrum	J 409 373
6	Down	St John's Point	J 530 330
7	Down	Killough Harbour	J 538 366
8	Down	Ballyhornan	J 580 380
*	Down	Downpatrick	J347347
9	Down	Mount Panther Estate	J 410 377
10	Down	Killough Harbour	J539368
11	Lisburn	Lambeg	J 283 664
Northern Group Environmental Health Committee			
12	Ballymena	Ballymena	D 105 024
13	Carrickfergus	Carrickfergus	J 429 882
14	Carrickfergus	Carrickfergus	J 375 842
15	Moyle	Cushendall	D 244 285
16	Moyle	North Channel	D 010 550
17	Moyle	Ballintoy	D 037 457
18	Moyle	Waterfoot	D 248 265
19	Moyle	Northern Channel	D 260 410
*	Moyle	*	*
20	Moyle	Cushendall	D 234 275
Southern Group Environmental Health Committee			
*	Armagh	*	*
*	Banbridge	Long Seefin	*
*	Dungannon	Fivemiletown	*
*	Dungannon	*	*
*	Craigavon	*	*
*	Newry & Mourne	*	*
*	Newry & Mourne	Irish Sea	*
21	Newry & Mourne	Warrenpoint	J 142 180
22	Newry & Mourne	Warrenpoint	J 153 183
23	Newry & Mourne	Ballyedmond	J 212 145
Western Group Environmental Health Committee			
*	Derry	*	*
24	Derry	Longfield Bank	C 545 235
25	Derry	Derry	C 545 245
26	Derry	Claudy	C 553 043
*	Derry	*	*
27	Limavady	Carrickhugh Bridge	C 603 230
28	Limavady	Ball's Point	C 644 300

* grid reference unknown

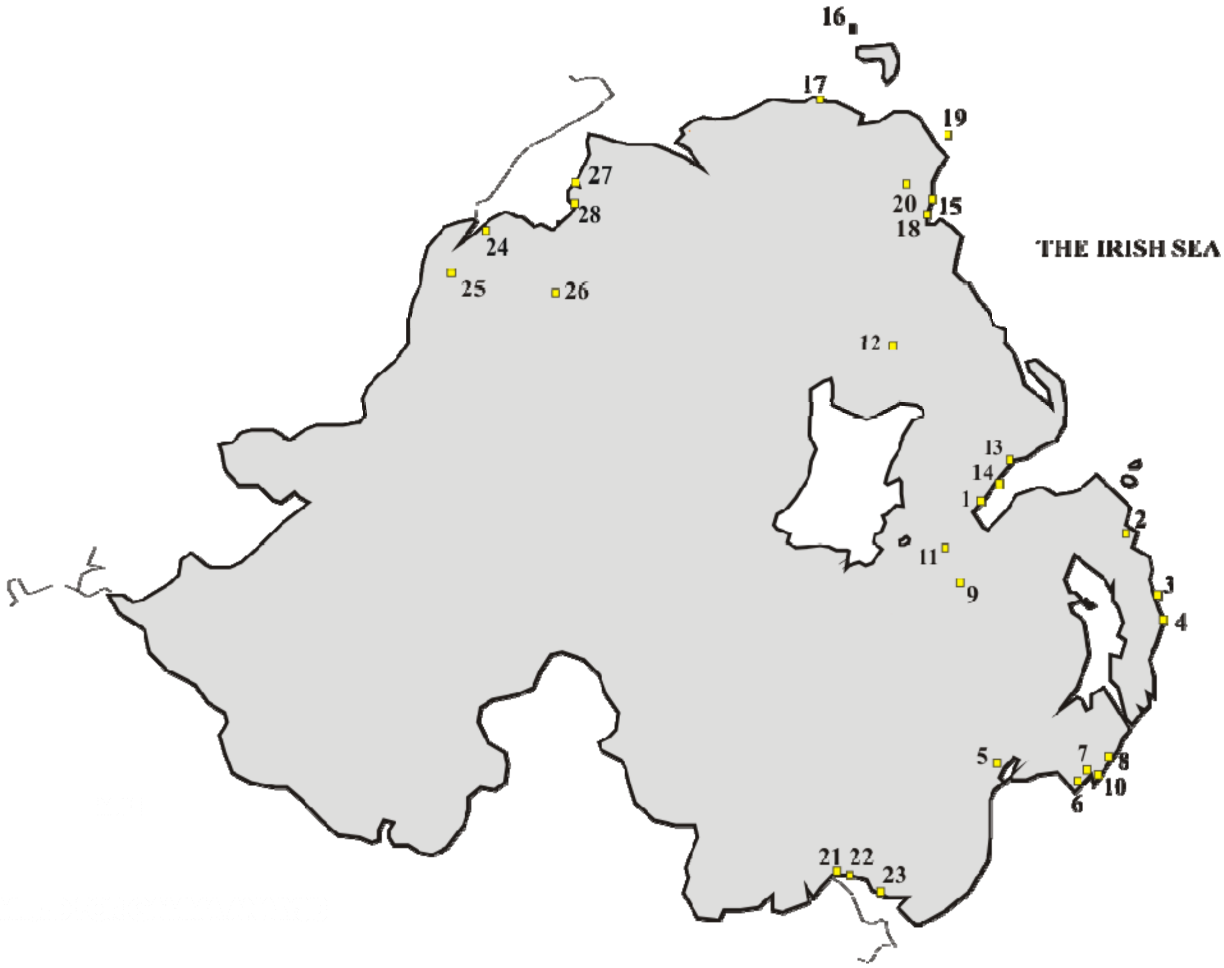


FIGURE A.1

NORTHERN IRELAND SAMPLING SITES
APRIL 2008 – MARCH 2011

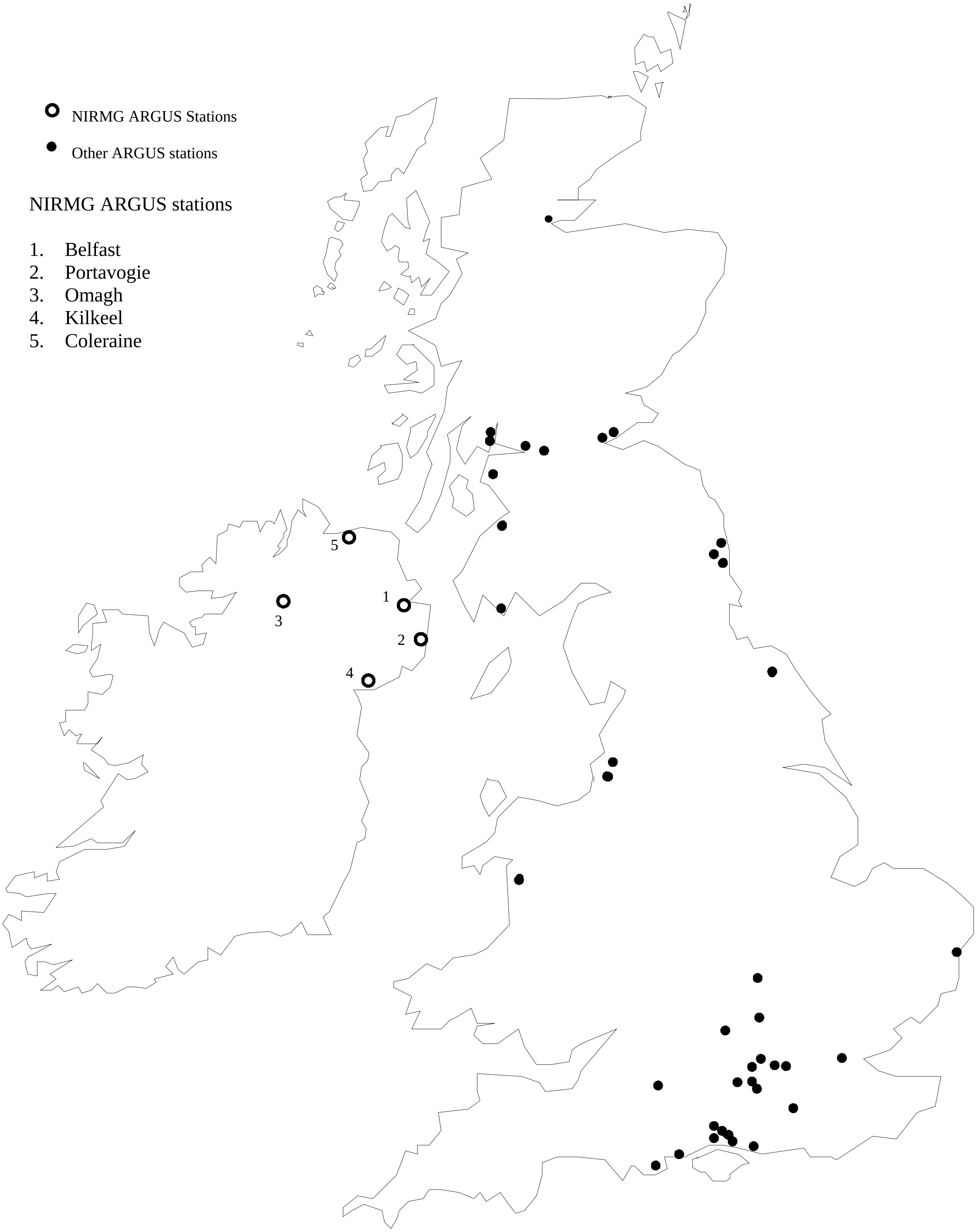


FIGURE B.1: THE UK NETWORK OF ARGUS CONTINUOUS GAMMA MONITORING STATIONS (www. environment.org.uk)

NORTHERN IRELAND CONTINUOUS MONITORING ARGUS NETWORK

In 1994, the Northern Ireland Radiation Monitoring Group (NIRMG) investigated the feasibility of installing a network of gamma radiation monitoring stations within district councils in Northern Ireland. These unattended stations would be required to provide reliable regularly updated information about background gamma radiation and, in the event of an increase in background, would be required to provide an automatic comprehensive alert warning.

Representatives from NIRMG visited a number of sites in the North-East of England where a variety of installed systems were available in a geographically small area. It was recognised that, in addition to providing information on background gamma radiation and alerting in an emergency, provision of an automated system would significantly reduce the staff resources required for the manual operation of the Mini 6-80 instruments for instantaneous gamma monitoring of background.

Following a report, of this visit, a specification of the equipment needed for a networked system was prepared and quotations were sought from prospective suppliers in Great Britain. A detailed assessment of each system was undertaken together with costs and a recommendation made to NIRMG that Argus be employed to install a network of five outstations in Northern Ireland linked to a host computer based in Belfast.

In April 1996, the equipment was installed and made operational at the sites named below and a 24-hour communications procedure was established to provide notification of an alert from any outstation to a designated contact officer.

Authority	Site of Outstation
Belfast City Council	Linenhall Street, Belfast
EGEHC	Harbour Master's Office, Portavogie
WGEHC	Mountjoy Road, Omagh
SGEHC	Sports Centre, Kilkeel
Northern Group Systems	Cloonavin, Coleraine

The Belfast Argus site was shut down in May 2010 to allow for its relocation (in June 2011) from Dunbar Street to the Cecil Ward Building, 4-10 Linenhall Street, Belfast, BT2 8BP.

Argus Data Logging

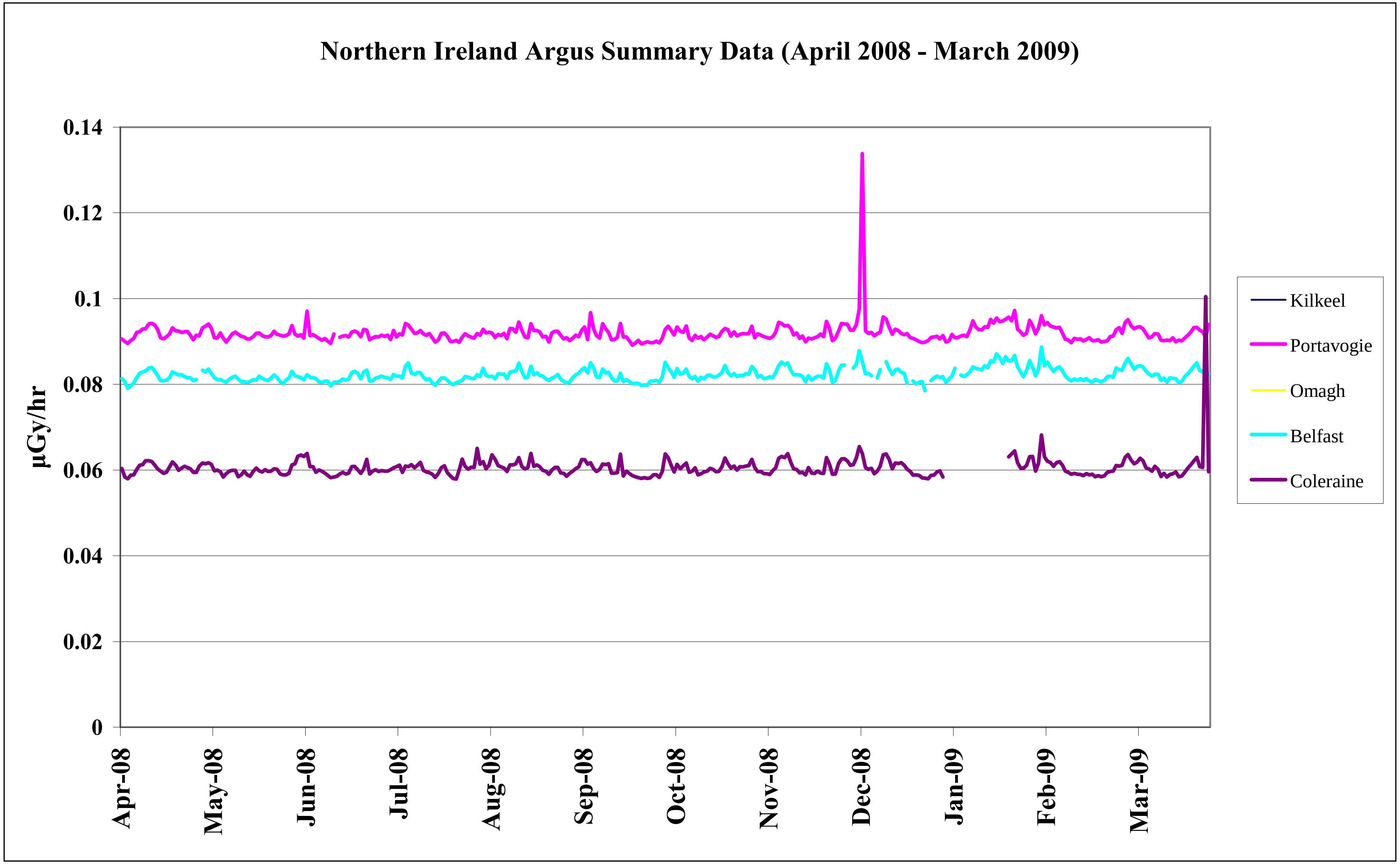
In the original ARGUS installation each outstation had its own remote station management software allowing access to background gamma readings accumulated over successive ten-minute periods. The stations also transferred results to the host computer in Belfast by modem connection. Using a Windows-based software package, ADVENT, data accessed remotely by PC could be viewed for each outstation. Local data were downloaded into spreadsheet or as a graph plotting average readings at two hourly intervals in nanograys/hour. The host computer in Belfast also checked and maintained each outstation at all times, ensuring optimum reliability and data integrity.

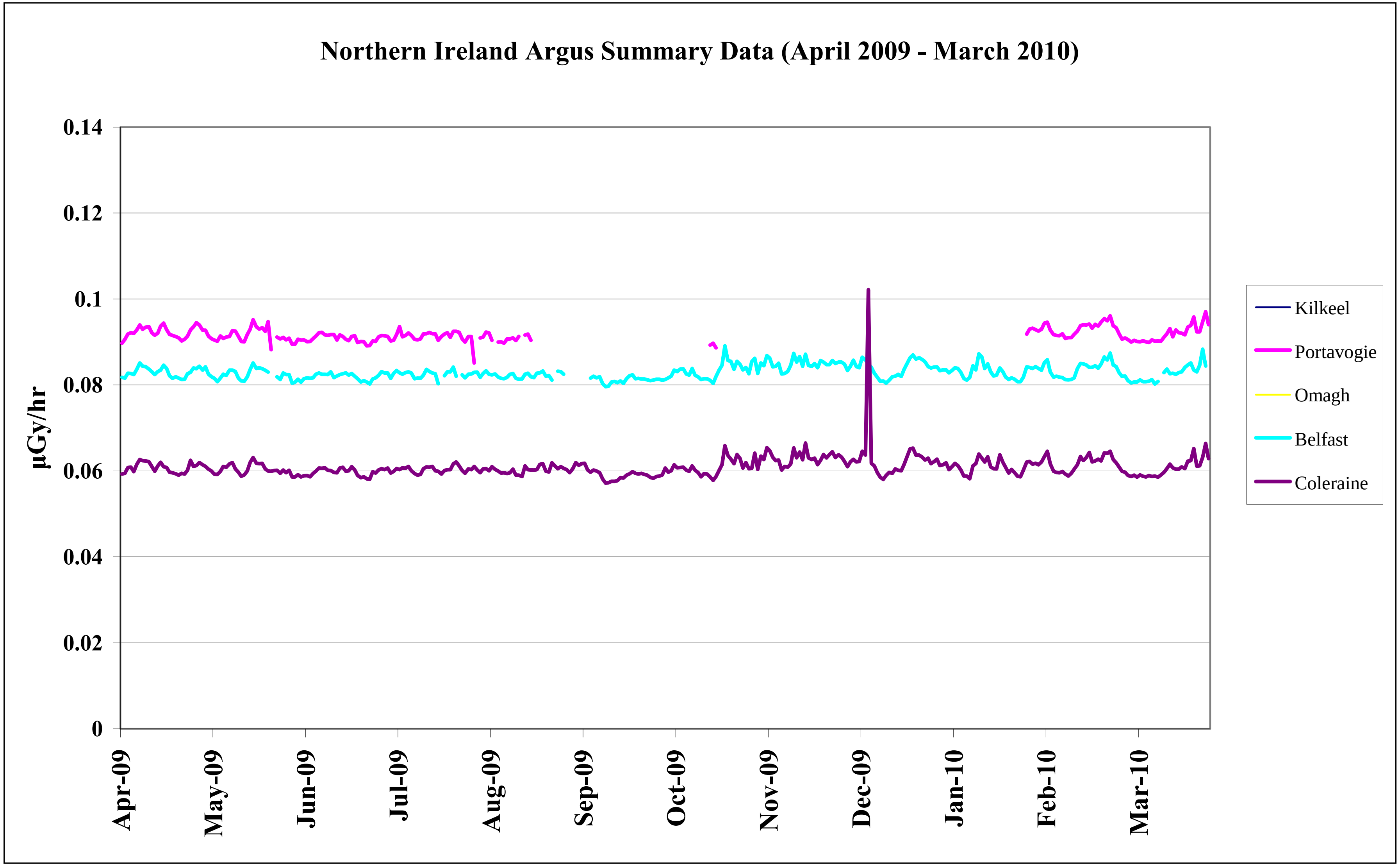
ARGUS 3000

An updated ARGUS system is now available via the Internet (www.environment.org.uk). After 24 hours all data are available on the Internet through a standard web browser. Parameters for alert levels may be updated by individual station owners, text messages sent to nominated phones and up-to-the-minute data may be viewed on a secure private website. The system is built with standard PC components and consequently it can be maintained by in-house IT personnel. Any software updates and improvements will be available from the Internet. In addition, all Northern Ireland monitoring sites have been upgraded to full meteorological stations providing weather data (wind speed and direction, atmospheric pressure, ambient temperature and rainfall) as well as a gamma detector.

Data for January 2008 – December 2010

Data downloaded from the central database at www.environment.org.uk are summarised in the following three graphs. The major peaks shown in the Portavogie and Coleraine data are the result of equipment being calibrated.


Northern Ireland Argus Summary Data (April 2008 - March 2009)
µGy/hr
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Jan-09
Feb-09
Mar-09
Kilkeel
Portavogie
Omagh
Belfast
Coleraine


Northern Ireland Argus Summary Data (April 2009 - March 2010)
µGy/hr
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
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Mar-10
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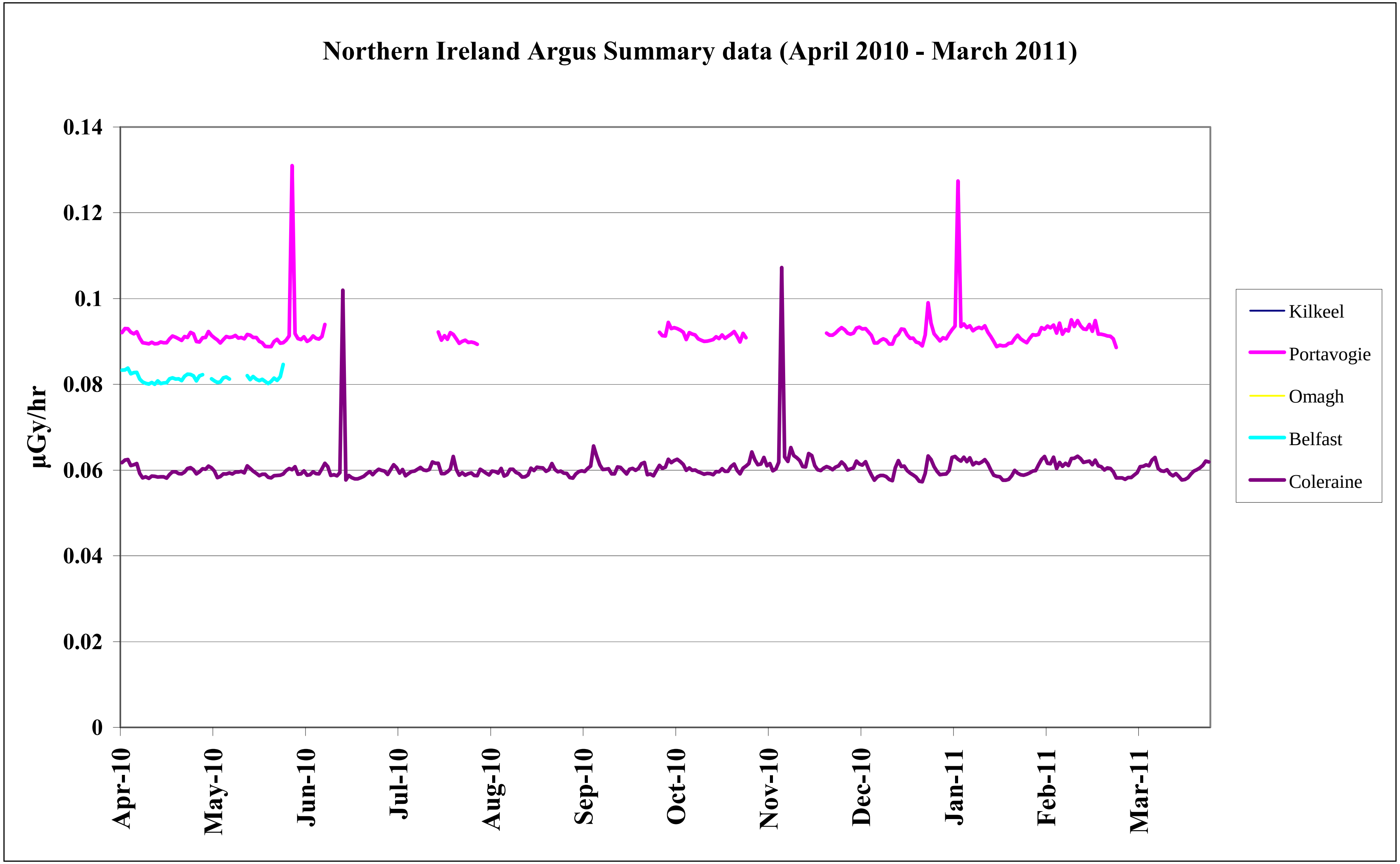
Portavogie
Omagh
Belfast
Coleraine


Northern Ireland Argus Summary data (April 2010 - March 2011)
µGy/hr
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10
Dec-10
Jan-11
Feb-11
Mar-11
Kilkeel
Portavogie
Omagh
Belfast
Coleraine

Northern Ireland Argus Summery Data (April 2008 - March 2011)

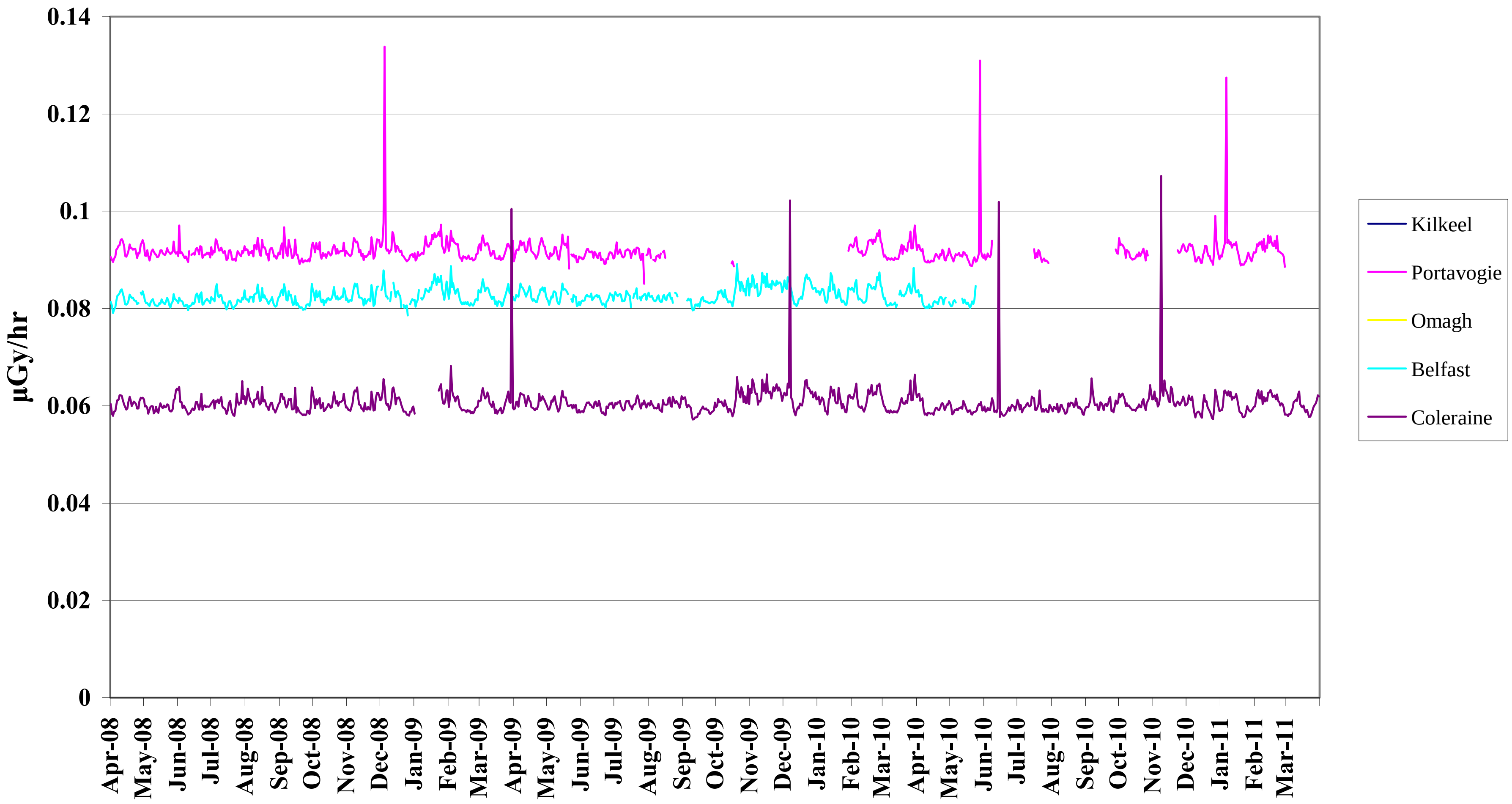


TABLE C.1

SELECTED GAMMA DOSERATE COMPARATIVE DATA

	Ground type	Locality	Activity ($nGyh^{-1}$)
1.	Silt	Belfast Lough (06/09)	82
	Sediment	Ards, Millisle (09/08)	67
	Silt	Newry & Mourne, Warrenpoint (06/09)	90
	Silt	Limavady, Carrickhugh (06/09)	56
	Silt	Limavady, Warrenpoint (09/10)	100
2.	Sand	Sellafield (2004 – mean of 4 measurements)	78
	Salt marsh	Ravenglass - Carlton Marsh (2004 – mean of 4 measurements)	170
	Mud/sand	Ravenglass - Raven Villa (2004 - mean of 4 measurements)	110
	Mussel bed	Drigg Barn Scar (2004 - mean of 4 measurements)	83
	Sand	Whitehaven – outer harbour (2005)	110
	Sand	Sellafield beach (2005 – mean of 2 measurements)	83
	Salt marsh	Ravenglass - Carleton Marsh (2005)	160
	Salt marsh/mud	Ravenglass - Raven Villa (2005 - mean of 7 measurements)	140
	Mussel bed	Drigg Barn Scar (2005 - mean of 4 measurements)	85
	Sand	Sellafield beach (2006 – mean of 2 measurements)	90
	Salt marsh/mud	Ravenglass - Carlton Marsh (2006 - mean of 2 measurements)	150
	Salt Marsh/Mud	Ravenglass - Raven Villa (2006 – mean of 3 measurements)	150
	Mussel bed	Drigg Barn Scar (2006 - mean of 4 measurements)	83
	Sand	Whitehaven – outer harbour (2006 - mean of 3 measurements)	100
	Mud	Ravenglass - Ford (2009 – mean of 2 measurements)	120
	Salt Marsh	Ravenglass – Raven Villa (2009 – mean of 3 measurements)	160
	Salt Marsh	Ravenglass - Carlton Marsh (2009)	140
	Mud/Sand	Ravenglass – salmon garth (2009)	120
	Mud	Ravenglass - Ford (2010)	110
	Salt Marsh	Ravenglass – Raven Villa (2010 – mean of 3 measurements)	150
	Salt Marsh	Ravenglass - Carlton Marsh (2010)	140
	Mud/Sand	Ravenglass – salmon garth (2010)	110
3	Silt	Belfast Lough (1/97)	70
	Silt	Warrenpoint, Newry & Mourne (6/97)	88
	Silt	Derry (9/97)	68
	Silt	Millisle (11/97)	55
	Silt	Carrickhugh, Limavady (1/98)	50
	Silt	Warrenpoint, Newry & Mourne (6/98)	80
	Silt	Longfield Bank, Limavady (11/99)	40
	Silt	Warrenpoint, Newry & Mourne (3/00)	80
	Silt	Culmore Point, Derry (3/00)	50
	Sand	Butterlump Rock, Ballyhalbert (4/01)	100
	Silt	Warrenpoint, Newry & Mourne (9/02)	90
	Silt	Warrenpoint, Newry & Mourne (9/02)	90
	Silt	Belfast Lough (6/03)	70
	Silt	Limavady (6/04)	70
	Silt	Limavady (9/05)	48
4.	Mud/Silt	Ravenglass (2004 – mean of 4 measurements)	150
	Mud/silt	Whitehaven - outer harbour (2004 – mean of 12 measurements)	140
	Dunes & grass banks	Sellafield (2004)	110
	Saltmarsh	Ravenglass - Raven Villa (2006 – mean of 5 measurements)	200
	Mud/silt	Whitehaven - outer harbour (2006 – mean of 12 measurements)	130
	Sand	Sellafield (2006 – mean of 12 measurements)	140
	Saltmarsh	Ravenglass - Raven Villa (2008 – mean of 2 measurements)	180
	Mud/silt	Whitehaven - outer harbour (2008 – mean of 10 measurements)	120
	Sand	Sellafield (2008 – mean of 11 measurements)	160
	Saltmarsh	Ravenglass - Raven Villa (2009 – mean of 2 measurements)	180
	Mud/silt	Whitehaven - outer harbour (2009 – mean of 11 measurements)	130
	Sand	Sellafield (2009 – mean of 12 measurements)	130

Notes:
1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

TABLE C.2
SELECTED GAMMA COMPARATIVE DATA FOR THE TERRESTRIAL ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{137}Cs
MEAT			
1.	Venison	Downpatrick (09/08)	-
	Venison	Downpatrick (09/10)	-
	Venison	Brookeborough (09/08)	-
	Venison	Colebrook (09/09)	1
3.	Venison	Bangor (10/99)	<1
	Venison	Fermanagh (10/99)	<1
	Venison	Fermanagh (10/00)	31
	Venison	Colebrook(10/01)	<1
	Venison	Ballymena (01/02)	-
	Venison	North Down (6/02)	<1
	Venison	Craigavon (6/02)	<1
	Venison	Fermanagh (6/03)	8
	Venison	Craigavon (9/05)	-
	Venison	Down (9/06)	-
	Venison	Craigavon (9/06)	69
	Venison	Craigavon (6/07)	27
4.	Beef	Braystones (2004)	0.26
	Mutton	Braystones (2004)	3.2
	Venison	Calder Bridge (2004)	24
GENERALISED DERIVED LIMITS			
		Sheep	**3000**
		Cattle	**2000**

Notes:
The GDLs quoted include revised limits (January 1996). A full explanation of GDLs is given in Appendix D.

1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield (2004 & 2006)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed
nr not recorded.

TABLE C.3
SELECTED GAMMA COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{137}Cs	^{60}Co	^{131}I
FISH					
1	Salmon	North Channel (09/08)	-	nr	nr
	Haddock	Irish Sea (06/08)	5	nr	nr
	Whiting	Irish Sea (09/09)	1	nr	nr
	Haddock	Malin Head (09/10)	<1	nr	nr
	Whiting	Malin Head (09/10)	-	nr	nr
2.	Plaice	Sellafield coastal area (2004 - mean of 7 measurements)	5.0	<0.11	Nr
	Cod	Northern Ireland N Coast (2004 – mean of 3 measurements)	2.2	<0.06	nr
	Whiting	Northern Ireland Portavogie (2004– mean of 3 measurements)	1.4	<0.05	nr
	Plaice	Sellafield coastal area (2005 - mean of 5 measurements)	4.8	<0.11	nr
	Whiting	Northern Ireland Kilkeel (2005– mean of 4 measurements)	0.42	<0.12	nr
	Cod	Northern Ireland North Coast (2005– mean of 2 measurements)	1.8	<0.05	nr
	Plaice	Sellafield coastal area (2006 - mean of 4 measurements)	4.5	<0.18	nr
	Whiting	Northern Ireland Kilkeel (2006)	0.36	<0.06	nr
	Cod	Northern Ireland Kilkeel (2006– mean of 3 measurements)	2.9	<0.07	nr
	Plaice	Sellafield coastal area (2009 - mean of 4 measurements)	3.3	<0.10	nr
	Cod	Northern Ireland Kilkeel (2009– mean of 4 measurements)	1.2	<0.06	nr
	Haddock	Northern Ireland Kilkeel (2009– mean of 4 measurements)	0.88	<0.07	nr
	Plaice	Sellafield coastal area (2010 - mean of 4 measurements)	2.7	<0.06	nr
	Cod	Northern Ireland Kilkeel (2010– mean of 4 measurements)	2.1	<0.06	nr
	Haddock	Northern Ireland Kilkeel (2010– mean of 4 measurements)	0.83	<0.09	nr
3.	Whiting	Kilkeel (01/98)	3	-	-
	Ling	Kilkeel (03/99)	8	<1	-
	Whiting	Unknown (03/01)	5	-	-
	Whiting	Unknown (10/99)	<1	-	-
	Whiting	Unknown (10/01)	1	-	-
	Whiting	Irish Sea (01/02)	5	-	-
	Whiting	Irish Sea (01/02)	<1	-	-
	Haddock	Northern Ireland (09/03)	<1	-	-
	Cod	Northern Ireland (06/02)	1	-	-
	Haddock	North Channel (09/03)	<1	-	-
	Whiting	North Channel (09/04)	<1	-	-
	Haddock	Irish Sea (06/05)	<1	nr	nr
	Whiting	North Channel (09/05)	<1	nr	nr
	Haddock	Irish Sea (05/06)	1	nr	nr
	Whiting	Irish Sea (09/06)	2	nr	nr
	Haddock	Irish Sea (06/07)	3	nr	nr
	Cod	North Channel (09/07)	5	nr	nr
4.	Plaice	St Bees (2004)	4.1	<0.20	nr
	Cod	St Bees (2004)	6.0	<0.25	nr
	Plaice	Sellafield Coastal Area (2006)	3.6	nr	nr
	Cod	Sellafield Coastal Area (2006)	6.3	nr	nr
	Plaice	Sellafield Coastal Area (2008)	4.9	nr	nr
	Cod	Sellafield Coastal Area (2008)	10	nr	nr
	Plaice	Sellafield Coastal Area (2009)	3.9	0.06	nr
	Cod	Sellafield Coastal Area (2009)	7.1	nr	nr
GENERALISED DERIVED LIMITS			**800**	**1290***	**500**

Notes:
The GDLs quoted include revised limits (January 1996). A full explanation of GDLs is given in Appendix D.
* Calculated from NRPB-GS7. They are for an adult critical group assuming a consumption rate of 50kg/year and an effective dose limit of 1mSv/year.

1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed
nr not recorded.

TABLE C.3 (Cont)
SELECTED GAMMA COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{137}Cs	^{60}Co	^{131}I
SEAWEED					
1.	Dulse	Ballywalter (06/08)	5	-	-
	Dulse	Millisle (06/09)	6	-	-
	Fucus vesiculosus	Ballintoy (06/09)	<1	-	-
	Fucus vesiculosus	Warrenpoint (06/09)	1	-	-
	Dulse	Murlough Bay (09/10)	2	-	-
	Fucus vesiculosus	Ball's Point (09/10)	<1	-	-
2.	Fucus vesiculosus	Sellafield (2004 – mean of 4 measurements)	6..9	12	nr
	Fucus vesiculosus	Northern Ireland, Ardglass (2004 – mean of 2 measurements)	0.89	<0.07	nr
	Fucus serratus	Northern Ireland, Portrush (2004 – mean of 4 measurements)	<0.10	<0.25	nr
	Seaweed	Sellafield (2005– mean of 2 measurements)	16	29	nr
	Fucus vesiculosus	Northern Ireland, Ardglass (2005 – mean of 3 measurements)	0.49	<0.20	nr
	Fucus serratus	Northern Ireland, Portrush (2005 – mean of 4 measurements)	<0.08	<0.07	nr
	Seaweed	Sellafield (2006 – mean of 2 measurements)	5.8	8.7	nr
	Fucus vesiculosus	Northern Ireland, Ardglass (2006 – mean of 2 measurements)	0.84	<0.20	nr
	Fucus spp	Northern Ireland, Portrush (2006 – mean of 4 measurements)	<0.07	<0.08	nr
	Fucus vesiculosus	Northern Ireland, Ardglass (2009 – mean of 3 measurements)	0.52	<0.10	nr
	Fucus spp	Northern Ireland, Portrush (2009 – mean of 3 measurements)	0.15	<0.08	nr
	Seaweed	Sellafield (2009 – mean of 2 measurements)	7.3	2.1	nr
	Fucus vesiculosus	Northern Ireland, Ardglass (2010 – mean of 3 measurements)	0.32	<0.08	nr
	Fucus spp	Northern Ireland, Portrush (2010 – mean of 4 measurements)	0.07	<0.05	nr
	Seaweed	Sellafield (2010 – mean of 2 measurements)	4.4	1.8	nr
3.	Fucus vesiculosus	Warrenpoint (11/99)	2	-	34
	Fucus serratus	Ballycastle Bay (4/01)	<1	-	-
	Fucus vesiculosus	Warrenpoint (11/00)	1	-	<1
	Fucus serratus	Warrenpoint (3/00)	2	-	-
	Dulse	Killough (03/00)	1	-	<1
	Fucus serratus	Ballycastle Bay (04/01)	<1	-	-
	Fucus vesiculosus	Killough Harbour (01/02)	<1	-	-
	Fucus vesiculosus	Warrenpoint (6/02)	1	-	
	Dulse	Ballycastle (09/03)	2	-	<1
	Dulse	Colliery Bay (09/04)	-	-	<1
	Dulse	Ballywalter (06/05)	1	-	-
	Fucus vesiculosus	Ball's Point (09/05)	6	-	-
	Fucus vesiculosus	Warrenpoint (05/06)	<1	-	-
	Fucus vesiculosus	Ballyhalbert (09/06)	<1	-	-
	Fucus serratus	Warrenpoint (06/07)	1	-	-
	Fucus vesiculosus	Ball's Point (10/07)	-	-	-
4.	Fucus vesiculosus	Seascale (2004)	3.9	6.3	nr
	Fucus vesiculosus	Nethertown (2006)	5.1	9.8	nr
	Fucus vesiculosus	Nethertown (2008)	4.5	1.4	nr
	Fucus vesiculosus	Nethertown (2009)	5.3	1.4	nr

1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed
nr not recorded.

TABLE C.3 (Cont)

SELECTED GAMMA COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{137}Cs	^{60}Co
SEDIMENT				
1.	Silt	Killough Harbour (08/08)	6	-
	Sediment	Ards, Millisle (09/08)	7	-
	Silt	Belfast Lough (06/09)	20	-
	Silt	Warrenpoint (09/09)	21	-
	Silt	Carrickfergus (06/10)	4	-
	Silt	Carrickhugh (06/10)	5	-
	Silt	Lough Foyle (06/10)	-	-
2	Sand	Sellafield (2004 – mean of 4 measurements)	82	4
	Mud	Ravenglass, Carleton Marsh (2004 – mean of 4 measurements)	380	3.4
	Sand	Northern Ireland, Portrush (2004 – mean of 2 measurements)	<0.6	<0.46
	Sand	Sellafield (2005 – mean of 4 measurements)	60	4.5
	Mud	Ravenglass, Carleton Marsh (2005 – mean of 3 measurements)	2000	27
	Sand	Northern Ireland, Portrush (2005 – mean of 2 measurements)	<0.4	0.70
	Sand	Sellafield (2006 – mean of 4 measurements)	59	3.4
	Mud	Ravenglass, Carleton Marsh (2006 – mean of 4 measurements)	460	24
	Sand	Northern Ireland, Portrush (2006 – mean of 2 measurements)	<0.6	<0.39
	Sand	Northern Ireland, Portrush (2009 – mean of 2 measurements)	0.78	<0.34
	Sand	Sellafield Beach (2009 – mean of 2 measurements)	71	<1.0
	Sand	Northern Ireland, Portrush (2010 – mean of 2 measurements)	<0.4 6	<0.42
	Sand	Sellafield site of former pipeline (2010 – mean of 2 measurements)	46	<1.1
3	Silt	Belfast Lough(10/99)	44	-
	Silt	Millisle(10/99)	8	-
	-	Belfast Lough (11/00)	-	-
	-	Warrenpoint (3/01)	-	-
	-	Warrenpoint(01/02)	86	-
	-	Coshowen(01/02)	86	-
	Silt	Belfast Lough (09/02)	33	-
	Silt	Millisle (06/02)	6	-
	-	Belfast Lough (06/03)	26	-
	-	Warrenpoint (09/03)	75	-
	-	Carrickhugh (06/04)	5	-
	-	Carrickfergus (09/04)	6	-
	Silt	Carrickfergus (06/05)	5	-
	Silt	Limavady (09/05)	18	-
	Silt	Belfast Lough (05/06)	18	-
	Silt	Belfast Lough (09/06)	18	<1
	Silt	Carrickfergus (06/05)	5	-
	Intertidal silt	Warrenpoint (09/07)	58	-
4.	silt	Ravenglass - Raven Villa (2004)	200	23
	silt	Whitehaven - Outer 2 South (2004)	150	<3.7
	silt	Ravenglass - Raven Villa (2006)	160	12
	silt	Whitehaven - Outer harbour north (2003)	140	<3.1
	silt	Ravenglass - Raven Villa (2008)	190	5.4
	silt	Whitehaven - Outer harbour South (2008)	140	<1.0
	silt	Ravenglass - Raven Villa (2009)	110	4.8
	silt	Whitehaven - Outer harbour South (2009)	90	1.1
GENERALISED DERIVED LIMITS			**5000**	

Notes:
The GDLs quoted include revised limits (January 1996). A full explanation of GDLs is given in Appendix D.

1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed
nr not recorded.

TABLE C.3 (Cont)
SELECTED GAMMA COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

Category		Locality	Activity (Bq/kg wet weight)	
			^{137}Cs	^{60}Co
SHELLFISH				
1.	Lobster	Northern Channel (06/08)	3	-
	Mussels	Longfield (09/08)	-	-
	Mussels	Carrickfergus (06/09)	<1	-
	Lobster	St. John's Point (06/09)	-	-
	Mussels	Warrenpoint (09/09)	<1	-
	Lobster	Portavogie (06/10)	-	-
	Mussels	Dundrum Bay (09/10)	-	-
	Lobster	Irish Sea (06/10)	<1	-
	Mussels	Killough Harbour (06/10)	-	-
2	Mussels	Northern Ireland, Carlingford Lough (2004 – mean of 2 measurements)	0.78	<0.13
	Winkles	Northern Ireland, Ards Peninsula (2005 – mean of 4 measurements)	<0.34	<0.16
	Winkles	Sellafield coastal area (2005 – mean of 4 measurements)	8.1	17
	Mussels	Northern Ireland, Carlingford Lough (2006 – mean of 2 measurements)	0.62	<0.09
	Mussels	Sellafield coastal area (2006– mean of 4 measurements)	3.2	1.8
	Winkles	Northern Ireland, Ards Peninsula (mean of 4 measurements)	<0.34	<0.13
	Winkles	Sellafield coastal area (2006– mean of 4 measurements)	7.3	4.7
	Mussels	Northern Ireland, Carlingford Lough (2009 – mean of 2 measurements)	0.50	<0.10
	Mussels	Sellafield coastal area (2009 – mean of 4 measurements)	3.8	0.66
	Winkles	Northern Ireland, Minerstown 2009 (mean of 4 measurements)	0.31	<0.14
	Winkles	Sellafield coastal area (2009 – mean of 8 measurements)	6.8	1.9
	Mussels	Northern Ireland, Carlingford Lough (2010 – mean of 2 measurements)	0.32	<0.12
	Mussels	Sellafield coastal area (2010 – mean of 4 measurements)	2.8	1.1
	Winkles	Northern Ireland, Minerstown 2010 (mean of 2 measurements)	0.36	<0.05
	Winkles	Sellafield coastal area (2010 – mean of 8 measurements)	5.2	1.8
3	Mussels	St Johns Point (06/03)	<1	-
	Mussels	Shingle Bay (05/04)	-	-
	Lobster	Colliery Bay (06/04)	-	-
	Lobster	Waterfoot (06/05)	<1	-
	Winkles	Ballyhalbert (09/05)	-	-
	Lobster	Irish Sea (09/06)	3	-
	Mussels	Boneybefore (06/07)	-	-
	Mussels	Warrenpoint (09/07)	2	-
4.	Mussels	St Bees (2004)	2.4	8.3
	Winkles	St Bees (2004)	8.9	12
	Mussels	Sellafield coastal area (2006)	2.4	3.2
	Winkles	Sellafield coastal area (2006)	6.2	6.2
	Mussels	Sellafield coastal area (2008)	2.4	1.6
	Winkles	Sellafield coastal area (2008)	8.3	2.4
	Mussels	Sellafield coastal area (2009)	1.6	1.2
	Winkles	Sellafield coastal area (2009)	4.7	1.8
GENERALISED DERIVED LIMITS			**4000**	**20000***

Notes:
The GDLs quoted include revised limits (January 1996). A full explanation of GDLs is given in Appendix D.
* Calculated from NRPB-GS7. They are for an adult critical group assuming a consumption rate of 50kg/year and an effective dose limit of 1mSv/year.

1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed
nr not recorded.

TABLE C.4

SELECTED ALPHA COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Locality	Activity (Bq/kg dry weight)		
		^{238}Pu	$^{239,240}Pu$	^{241}Am
SEDIMENT				
1.	Warrenpoint (09/08)	0.64	3.72	2.71
	Carrickfergus (06/09)	0.48	3.20	2.30
	Belfast Lough (06/09)	1.73	8.33	12.00
	Carrickhugh(06/10)	0.56	1.70	3.05
	Millisle (06/10)	0.43	1.58	2.51
2	Ballymacormick (2004 – mean of 2 measurements)	1.8	12	18
	Sellafield (2004 – mean of 4 measurements)	na	na	170
	Ravenglass – Raven Villa (2004 – mean of 4 measurements)	na	na	1300
	Ballymacormick (2005 – mean of 2 measurements)	1.5	8.5	13
	Sellafield (2005 – mean of 4 measurements)	na	na	160
	Ravenglass – Raven Villa (2005 – mean of 4 measurements)	na	na	1600
	Carlingford Lough (2006 – mean of 2 measurements)	2.1	14	9.3
	Whitehaven Outer Harbour (2006 – mean of 4 measurements)	8.6	47	300
	Ravenglass - Raven Villa (2006 – mean of 4 measurements)	na	na	810
	Ballymacormick (2009 – mean of 2 measurements)	na	na	12
	Carlingford Lough (2009 – mean of 2 measurements)	1.7	11	6.9
	Sellafield Beach (2009 – mean of 2 measurements)	na	na	150
	Ballymacormick (2010)	na	na	12
	Carlingford Lough (2010 – mean of 2 measurements)	2.2	13	8.6
	Sellafield site of former pipeline (2010 – mean of 2 measurements)	na	na	130
3	Carrickfergus (06/03)	0.66	3.66	3.26
	Warrenpoint (09/03)	1.11	7.79	7.28
	Belfast Lough (06/04)	1.44	10.92	88.51
	Carrickfergus (05/04)	0.52	2.77	2.40
	Belfast Lough (06/05)	1.65	8.73	10.32
	Millisle (09/05)	0.18	1.51	1.78
	Carrickfergus (05/06)	0.74	3.05	4.89
	Millisle (09/06)	0.33	2.63	0.91
	Boneybefore (06/07)	0.50	3.03	5.85
	Belfast Lough (10/07)	0.37	2.95	3.77
		Total Pu		
4.	Whitehaven - Outer 2, South (2004)	120		150
	Ravenglass - Raven Villa (2004)	490		560
	Whitehaven - Outer harbour north (2006)	120		150
	Ravenglass - Raven Villa (2006)	310		340
	Whitehaven - Outer harbour South (2008)	63		90
	Ravenglass - Raven Villa (2008)	350		550
	Whitehaven - Outer harbour South (2009)	110		130
	Ravenglass - Raven Villa (2009)	270		480
GENERALISED DERIVED LIMITS		**100000**	**90000**	**90000**

Notes:
The GDLs quoted include revised limits (1998). A full explanation of GDLs is given in Appendix D.
Results for transuranic element determinations are reported on a wet basis except for sediment.

1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed

TABLE C.5
SELECTED ^{99}Tc COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{99}Tc
SEAWEED			
1.	Dulse	Ballywalter (06/08)	14
	Seaweed	Ballyhalbert (09/08)	80
	Seaweed	Ballintoy (09/08)	115
	Dulse	Millisle (06/09)	-
	Fucus vesiculosus	Ballintoy(06/09)	7
	Fucus vesiculosus	Warrenpoint (06/09)	385
	Fucus vesiculosus	Ball's Point (06/10)	11
2	Fucus vesiculosus	Sellafield (2004 – mean of 4 measurements)	7100
	Fucus vesiculosus	Ardglass (2001 – mean of 3 measurements)	530
	Rhodymenia spp.	Strangford Lough (2004 – mean of 3 measurements)	28
	Seaweed	Sellafield (2005 – mean of 2 measurements)	6900
	Fucus vesiculosus	Ardglass (2002 – mean of 3 measurements)	310
	Rhodymenia spp.	Strangford Lough (2005 – mean of 3 measurements)	24
	Seaweed	Sellafield (2006 – mean of 2 measurements)	3900
	Fucus vesiculosus	Ardglass (2006 – mean of 2 measurements)	1100
	Rhodymenia spp.	Strangford Lough (2006 – mean of 3 measurements)	16
	Fucus vesiculosus	Ardglass (2009 – mean of 3 measurements)	220
	Rhodymenia spp.	Strangford Lough (2009 – mean of 4 measurements)	4.9
	Seaweed	Sellafield (2009 – mean of 2 measurements)	940
	Fucus vesiculosus	Ardglass (2010 – mean of 3 measurements)	80
	Rhodymenia spp.	Strangford Lough (2010 – mean of 4 measurements)	5.3
	Seaweed	Sellafield (2010 – mean of 2 measurements)	1300
3	Fucus vesiculosus	Warrenpoint (11/99)	990
	Fucus vesiculosus	Carrickhugh Bridge (3/00)	423
	Fucus spiralis	Ards (10/99)	450
	Fucus vesiculosus	Warrenpoint (3/01)	4774
	Fucus vesiculosus	Ards (4/01)	1528
	Fucus vesiculosus	Ballyhalbert (01/02)	3685
	A.nodosum	Warrenpoint (01/02)	3635
	Fucus vesiculosus	Warrenpoint (06/02)	1011
	Fucus vesiculosus	Carrickhugh Bridge (06/02)	220
	Dulse	Ballycastle (06/03)	20
	Dulse	Ballywater (06/05)	4
	Fucus vesiculosus	Ball's Point (09/05)	36
	Dulse	Ballywater (05/06)	22
	Fucus vesiculosus	Ball's Point (09/06)	34
	Fucus serratus	Warrenpoint (06/07)	48
	Fucus vesiculosus	Ball's Point (09/07)	52
4.	Fucus vesiculosus	Seascale (2004)	25000
	Fucus vesiculosus	Nethertown (2004)	9800
	Fucus vesiculosus	Nethertown (2006)	2500
	Fucus vesiculosus	Nethertown (2008)	1500
	Fucus vesiculosus	Nethertown (2009)	1300

Notes
1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed

TABLE C.5 (Cont)
SELECTED ^{99}Tc COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{99}Tc
SHELLFISH			
1.	Lobster	Irish Sea (09/08)	159
	Mussels	Longfield (09/08)	3
	Lobster	North Channel (06/09)	10
	Mussels	Carrickfergus (06/10)	56
	Mussels	Killough Harbour (06/10)	8
	Lobster	Portavogie (06/10)	53
	Mussels	Warrenpoint (06/10)	28
2.	Lobster	Sellafield coastal area (2004 - mean of 8 measurements)	100
	Lobster	Kilkeel (2004 - mean of 4 measurements)	160
	Mussels	Carlingford Lough (2004 - mean of 2 measurements)	20
	Lobster	Sellafield coastal area (2005 - mean of 8 measurements)	1800
	Mussels	Carlingford Lough (2005 - mean of 2 measurements)	18
	Lobster	Kilkeel (2005, mean of 4 measurements)	150
	Lobster	Sellafield coastal area (2006 - mean of 8 measurements)	1000
	Mussels	Carlingford Lough (2006 - mean of 2 measurements)	20
	Lobster	Kilkeel (2006, mean of 2 measurements)	100
	Mussels	Carlingford Lough (2009 - mean of 2 measurements)	6.2
	Lobster	Kilkeel (2009, mean of 4 measurements)	14
	Lobster	Sellafield coastal area (2009 - mean of 8 measurements)	250
	Mussels	Carlingford Lough (2010 - mean of 2 measurements)	13
	Lobster	Kilkeel (2010, mean of 4 measurements)	25
	Lobster	Sellafield coastal area (2010 - mean of 8 measurements)	240
3.	Lobster	Down (10/99)	57
	Nephrops	(11/99)	96
	Crab	Fairhead (3/00)	60
	Lobster	Down (10/00)	442
	Lobster	Newry & Mourne (10/00)	253
	Lobster	Ballyhornan (10/01)	520
	Nephrops	Unknown (09/01)	103
	Lobster	Down (05/02)	201
	Lobster	Newry & Mourne (09/02)	374
	Mussels	Larne (06/03)	65
	Mussels	Derry (09/04)	103
	Lobster	Newry & Mourne (09/04)	162
	Lobster	St John's Point (06/05)	3
	Mussels	Derry (09/05)	5
	Lobster	North Channel (05/06)	69
	Mussels	Longfield (09/06)	6
	Mussels	Carrickfergus (06/07)	65
	Lobster	Irish Sea (09/07)	85
4.	Lobsters	St Bees (2004)	2700
	Mussels	St Bees (2004)	1900
	Lobsters	Sellafield coastal area (2006)	560
	Mussels	Sellafield coastal area (2006)	200
	Lobsters	Sellafield coastal area (2008)	420
	Mussels	Sellafield coastal area (2008)	150
	Lobsters	Sellafield coastal area (2009)	220
	Mussels	Sellafield coastal area (2009)	120

Notes
1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

\- below the limit of detection
<1 activity seen but near the detection limit
na not analysed

TABLE C.6
SELECTED ^{14}C COMPARATIVE DATA FOR THE MARINE ENVIRONMENT

	Category	Locality	Activity (Bq/kg wet weight) ^{14}C
SEAFISH			
1.	Salmon	North Channel(09/08)	24
	Haddock	Malin Head(06/098)	20
	Haddock	Irish Sea (06/10)	31
	Whiting	North Channel(09/10)	35
2	Plaice	Sellafield offshore (2004)	140
	Cod	Kilkeel (2004 – mean of 4 measurements)	50
	Plaice	Sellafield offshore (2005 – mean of 2 measurements)	300
	Cod	Kilkeel (2005 – mean of 4 measurements)	26
	Plaice	Sellafield offshore (2006)	200
	Cod	Kilkeel (2006 – mean of 3 measurements)	55
	Plaice	Sellafield offshore (2009 – mean of 2 measurements)	140
	Cod	Kilkeel (2009 – mean of 4 measurements)	40
	Plaice	Sellafield offshore (2010– mean of 2 measurements)	150
	Cod	Kilkeel (2010 – mean of 4 measurements)	49
3	Whiting	Northern Ireland (2003)	na
	Haddock	Down (2003)	28
	Haddock	North Channel (2003)	47
	Cod	Craigavon (2004)	23
	Haddock	Derry (2004)	13
	Haddock	Irish Sea (06/05)	42
	Dogfish	North Channel (09/05)	23
	Haddock	Irish Sea (05/06)	32
	Haddock	Irish sea (06/06)	70
	Haddock	North Channel (09/07)	49
4.	Plaice	St Bees (2004)	200
	Cod	St Bees (2004)	140
	Cod	Sellafield coastal area (2006)	150
	Plaice	Sellafield coastal area (2006)	130
	Cod	Sellafield coastal area (2008)	91
	Plaice	Sellafield coastal area (2008)	160
	Cod	Sellafield coastal area (2009)	110
	Plaice	Sellafield coastal area (2009)	170

Notes
1. Results from Northern Ireland Radiation Monitoring Group (2008 - 2010)
2. Results from 'Radioactivity in Food & the Environment, Food Standards Agency (2004- 2006, 2009 & 2010)
3. Results from previous Northern Ireland Radiation Monitoring Group Reports
4. Results from Annual Report of BNFL Sellafield and Sellafield Ltd (2004, 2006, 2008, & 2009)

- below the limit of detection
<1 activity seen but near the detection limit
na not analysed

THE NUCLEAR ENVIRONMENT, INCIDENTS AND EVENTS

Radioactivity in Northern Ireland is derived mainly from weapons testing, Chernobyl and BNFL Sellafield. This Appendix contains information on the activities at Sellafield and brief summaries of recent nuclear incidents and events.

BNFL SELLAFIELD

Sellafield Ltd (formerly British Nuclear Fuels plc, BNFL) is concerned mainly with the design and production of fuel for nuclear reactors and its reprocessing after irradiation. The company also operates a solid waste disposal site and nuclear power plant that supplies electricity to the national grid. Regular monitoring is carried out of the environmental consequences of discharges of radioactive waste from four nuclear sites in England, namely Sellafield, Drigg, Springfields and Capenhurst. These nuclear sites are responsible for significant discharges of radioactive material and are the prime focus of CEFAS (Centre for Environment, Fisheries and Aquaculture Science, formerly MAFF) & EA monitoring. Most sampling and direct monitoring is conducted in the site's immediate vicinity. However, because of the ability to detect the effects of the discharges of liquid effluent from BNFL Sellafield in many parts of north-European waters, the MAFF programme for this site extend beyond national boundaries.

Operations and facilities at Sellafield include fuel element storage and decommissioning, the Magnox and oxide fuel reprocessing plants and the Calder Hall Magnox nuclear power station. Radioactive waste discharges include a very minor contribution from the adjoining UKAEA Windscale facilities. The most significant discharges are made from the BNFL fuel element storage ponds and the reprocessing plants, through which pass irradiated Magnox and oxide fuel from the UK nuclear power programme, and some fuel from abroad. [1]

Authorisation for discharge is given by the Environment Agency. At the end of 1999 the discharge limit for Tc-99 was reduced from 200TBq/y to 90TBq/y. A review of all discharges from Sellafield commenced in April 2000 after initial public consultation. In November 2000, the Agency started consultation on proposals for future discharge of Tc-99 to the sea and in 2006 the limit was further reduced to 10 TBq/y.

Discharges of Tc-99 decreased significantly during 2003 due to trials with tetraphenylphosphonium bromide (TPPBr). This reacts with the Tc-99 to form a salt which is subsequently retained and encapsulated. This treatment will continue with all medium active concentrate (MAC)[2].

Notes:
1 Taken from 'Radioactivity in Food & the Environment 1995', Food Standards Agency.
2 Taken from BNFL Annual Report 2003.

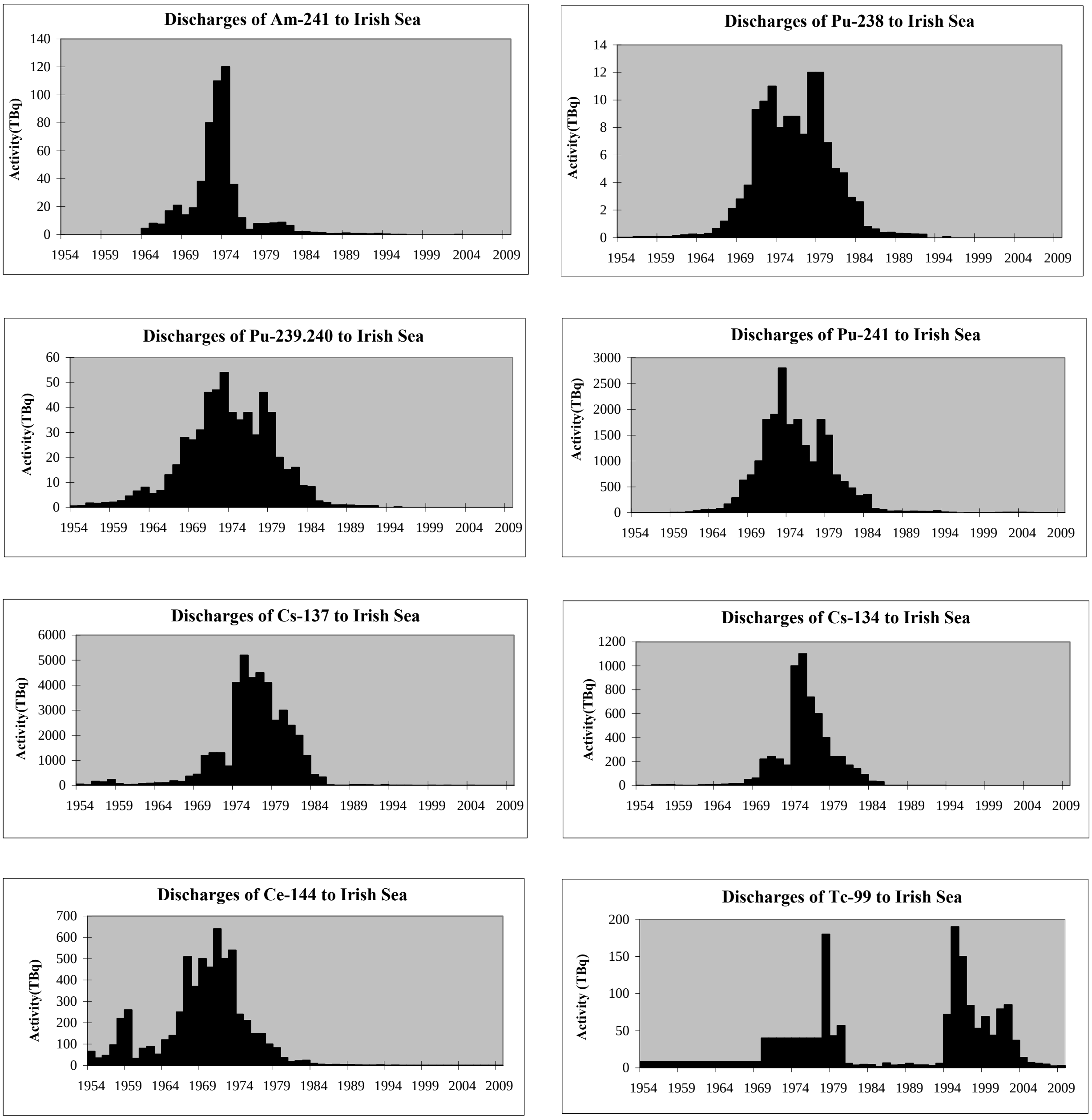


FIGURE D.1: SELLAFIELD DISCHARGES TO THE IRISH SEA, 1954 – 2009 (BNFL 2009)

TABLE D.1
SELLAFIELD DISCHARGES TO THE IRISH SEA, 1998 - 2009 (BNFL 2009)

Nuclide	Annual discharge (Terabecquerel) **												Authorised Limit (TBq) [a]
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Tritium	2300	2500	2300	2600	3300	3900	3200	1600	1100	600	780	1500	20,000
Americium-241	0.05	0.03	0.03	0.04	0.04	0.06	0.04	0.03	0.05	0.02	0.03	0.05	0.3
Antimony-125	0.05	7.9	7.8	13	17	23	29	12	8.0	5.1	3.1	3.8	-
Caesium-134	0.32	0.34	0.23	0.48	0.49	0.39	0.40	0.16	0.15	0.14	0.12	0.14	1.6
Caesium-137	7.5	9.1	6.9	9.6	7.7	6.2	9.7	6.0	6.0	7.0	5.1	4.3	34
Carbon-14	3.7	5.8	4.6	9.5	13.0	17	16	5.0	11	4.7	7.2	8.2	21
Cerium-144	0.76	0.60	0.55	0.79	0.97	0.88	0.82	0.54	0.60	0.40	0.40	0.50	4
Cobalt-60	2.4	0.89	1.2	1.2	0.89	0.43	0.78	0.70	0.14	0.05	0.07	0.08	3.6
Curium-242	0.006	0.003	0.003	0.006	0.003	0.003	0.006	0.004	0.002	0.001	0.001	c	-
Curium-243+244	0.003	0.002	0.003	0.006	0.02	0.01	0.01	0.004	0.002	0.003	0.003	0.005	0.05
Europium-152	0.16	0.11	0.07	0.11	0.13	0.23	0.22	0.17	0.11	0.13	0.11	0.07	-
Europium-154	0.10	0.05	0.06	0.08	0.13	0.22	0.17	0.11	0.08	0.09	0.10	0.06	-
Europium-155	0.09	0.04	0.05	0.07	0.10	0.19	0.14	0.12	0.06	0.07	0.10	0.09	-
Iodine-129	0.55	0.48	0.47	0.63	0.73	0.55	0.65	0.30	0.20	0.10	0.20	0.25	2
Iron-55	0.01	0.02	0.04	0.02	0.03	0.02	0.04	0.02	0.03	0.02	0.03	c	-
Manganese-54	0.07	0.04	0.01	0.03	0.02	0.02	0.01	0.01	0.007	0.007	0.009	c	-
Neptunium-237	0.04	0.04	0.03	0.04	0.06	0.05	0.06	0.05	0.05	0.04	0.04	0.05	1
Nickel-63	0.4	0.58	0.43	0.27	0.46	0.39	0.34	0.90	1.9	0.41	0.80	c	-
Niobium-95	0.35	0.08	0.09	0.35	0.08	0.09	0.10	0.07	0.07	0.05	0.05	0.08	3.8*
Plutonium alpha	0.14	0.11	0.11	0.16	0.34	0.36	0.29	0.20	0.15	0.11	0.11	0.12	0.7
Plutonium-241	3.5	2.9	3.2	4.6	10	10	8.1	5.0	3.6	2.8	2.4	2.9	25
Promethium-147	0.39	0.41	0.35	0.42	0.79	0.67	0.35	0.30	0.17	0.06	d	c	-
Ruthenium-103	0.15	0.13	0.11	0.15	0.18	0.18	0.19	0.12	0.13	0.11	0.09	c	-
Ruthenium-106	5.6	2.7	2.7	3.9	6.0	12	4.4	1.8	3.5	1.5	1.4	3.2	63
Silver-110m	0.12	0.09	0.08	0.12	0.09	0.08	0.12	0.07	0.07	0.07	0.08	c	-
Strontium-89	0.88	0.60	0.64	0.76	0.52	0.56	1.7	1.1	0.50	0.45	0.23	c	-
Strontium-90	18	31	20	26	20	14	18	13	5.0	5.0	1.7	2.9	48
Sulphur-35	0.43	0.32	0.36	0.43	0.32	0.36	0.12	0.08	0.06	0.05	0.05	c	-
Technetium-99	53	69	44	79	85	37	14	7.0	6.0	4.9	2.4	3.1	10
Zinc-65	0.14	0.07	0.03	0.05	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	-
Zirconium-95	0.30	0.10	0.10	0.13	0.17	0.14	0.13	0.09	0.09	0.07	0.07	0.11	3.8*
Total alpha [b]	0.17	0.13	0.12	0.20	0.35	0.4	0.29	0.25	0.21	0.12	0.13	0.15	1
Total beta [b]	0.86	110	77	120	110	83	73	43	29	25	14	18	220
Uranium (kg)	550	540	610	390	440	480	440	370	440	300	280	410	2,000

Notes:

** million million becquerel, 10^{12}Bq,

* Niobium-95 and Zirconium-95 have a combined authorised limit of 3.8TBq

[a] Limits as quoted in BNFL report 2009. Different limits applied in previous years.

[b] Total alpha and total beta are overall control measures that do not reproduce precisely the contributions of individual nuclides.

c Not measured in 2009.

d Not measured in 2008.

TRANSPORT OF DISSOLVED RADIOACTIVITY IN WESTERN EUROPEAN AND ARCTIC WATERS

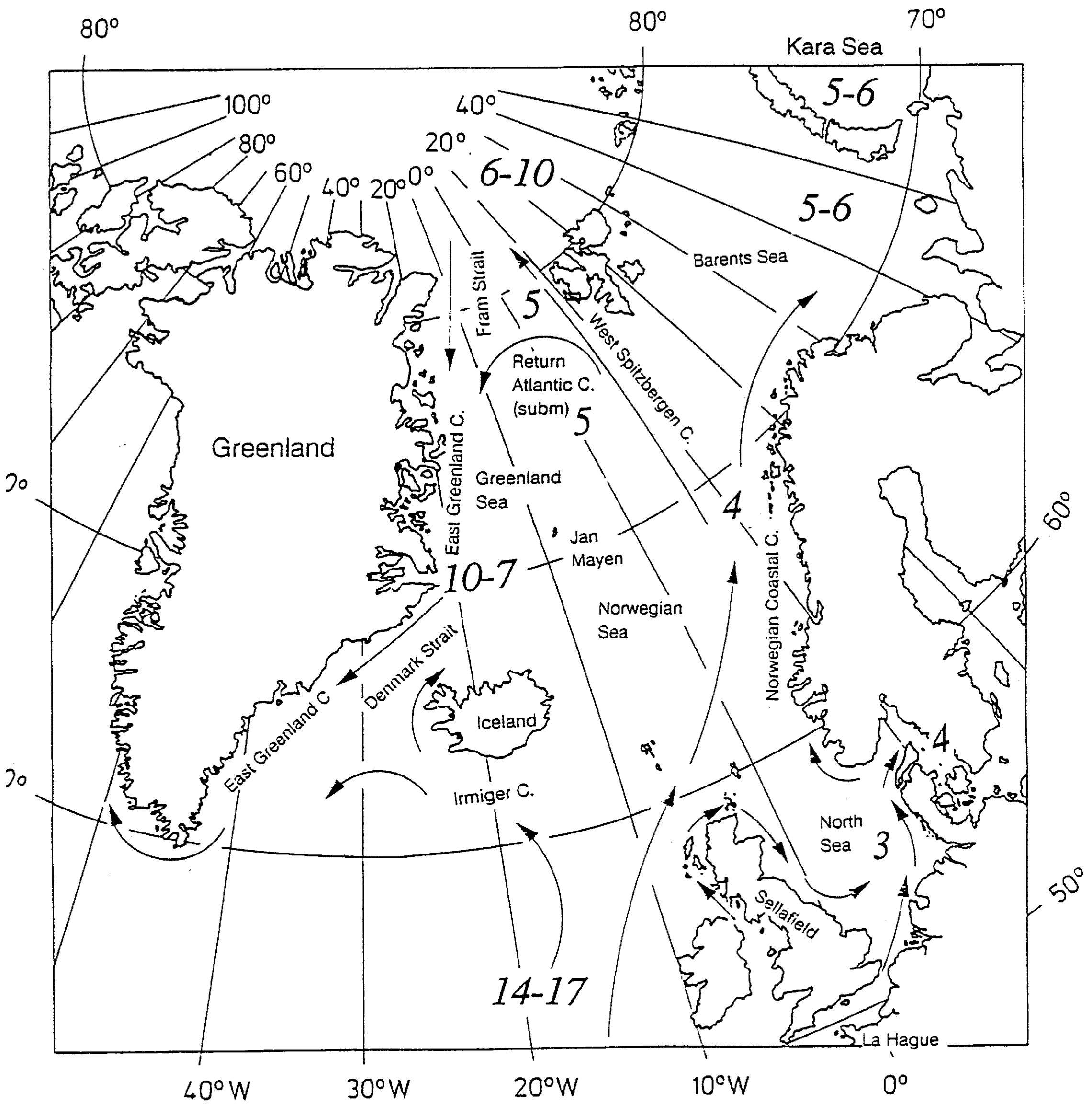
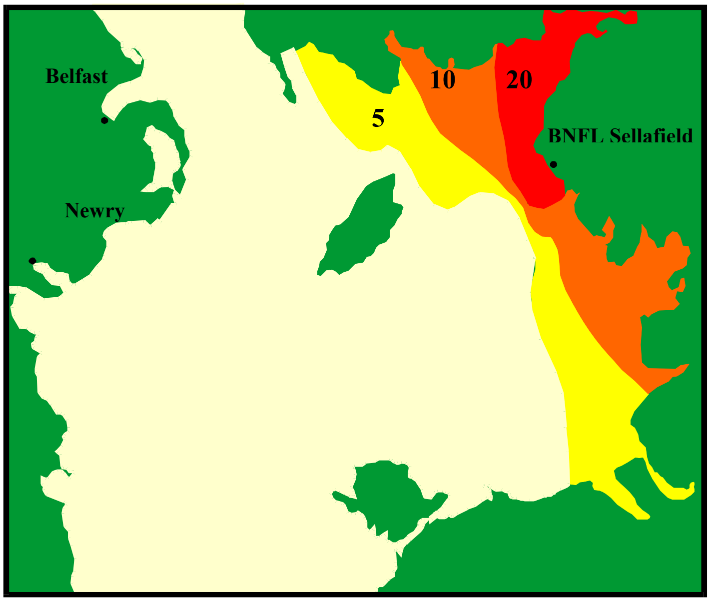


FIGURE D.2

Major surface currents and transit times in years from Sellafield to different areas.
(Extract from Marine Pollution Bulletin Vol 32, 1995 – H. Dahlgaard, Q. Chan, J. Herrman, H. Nies, R.D. Ibbett, P. J. Kershaw (1995) on the background level of 99Tc, ^{90}Sr and ^{137}Cs in the North Atlantic, J Mar. Sys 6, 571-578)

Contours of ^{99}Tc (mBq/litre) in the Irish Sea

Pre-EARP 1992



Post-EARP 1994

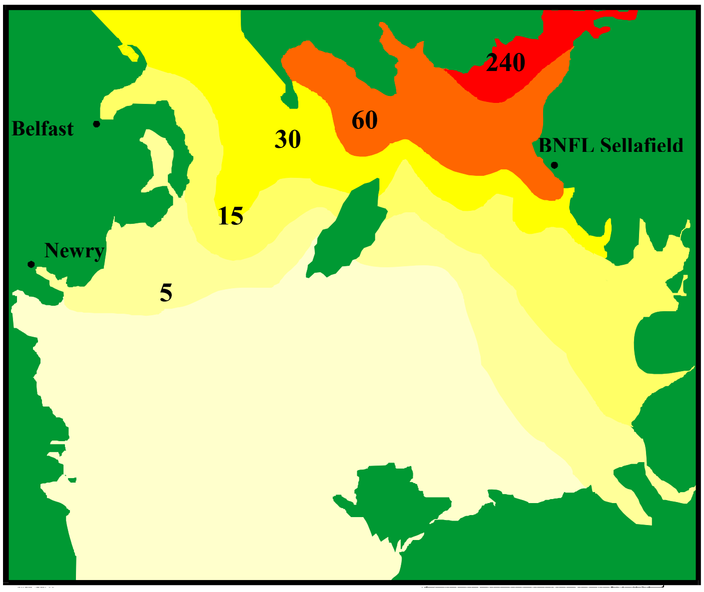


FIGURE D.3

Adapted from K.S. Leonard, D. McCubbin, J. Brown, R. Bonfield, T. Brooks, 1997. A summary report of the distribution of ^{99}Tc in UK Coastal Waters. Radioprotection – Colloques, 32, C2-109-114.

Note: EARP is the Enhanced Actinide Recovery Plant at Sellafield

RADIATION MONITORING IN THE UNITED KINGDOM

In the United Kingdom all sites where ionising radiation is used (e.g. hospitals, universities, nuclear establishments) have a statutory responsibility to monitor their environment and keep records of any disposals. The means of monitoring are diverse and often complex radiological protection instrumentation capable of measuring specific isotopes or kinds of radiation are deployed. For example, specific measuring systems dedicated to the monitoring of Plutonium isotopes and ^{131}Iodine exist around and within nuclear sites.

Public concern following the Chernobyl incident stimulated many local authorities to engage in some kind of local radiological assessment. In some cases the authorities conduct monitoring themselves although generally an independent third party is used (university, hospital, commercial laboratories). Over two hundred local authorities became involved in some kind of independent radiation monitoring. This has now largely ceased because of financial constraints.

The responsibility for authorising and monitoring discharges of radioactive material into the environment rests with the Environment Agency (EA) and the Scottish Environment Protection Agency (SEPA), NIEA – IPRI. Individual sites monitor their local environment e.g. UKAEA Winfrith reports. In recent times, following Chernobyl, a more wide ranging assessment of other areas has also been undertaken (e.g. Radioactivity in Food and the Environment). The levels permitted are determined from a detailed consideration of the likely pathways of the radionuclides, their physical lifetime and the possible radiation doses that might affect the *critical group*. This is the group of people who are likely to receive the highest radiation exposure as a result of the discharges. The *critical group* is usually identified after a careful survey of the eating habits of the local population has been undertaken. The nuclear establishment and the government department that issue the authorisations are strongly of the opinion that radiation doses to the public are well below internationally agreed limits in all UK sites. Indeed, the Health Protection Agency (formerly National Radiological Protection Board, NRPB), on the basis of comprehensive monitoring around the Sellafield site have evaluated that exposure to the general public from effluent discharges is within their guidance level of 0.5 milli-Sieverts/year.

The following article was originally published in the Journal EHP : Higgins A. and Croudace I.W. (2006) Lessons forgotten - radiological monitoring in the U.K. 20 years after Chernobyl. Environmental Health Practioner., 114, 12-13.

The current status and future of local authority funded radiological monitoring 20 years after Chernobyl

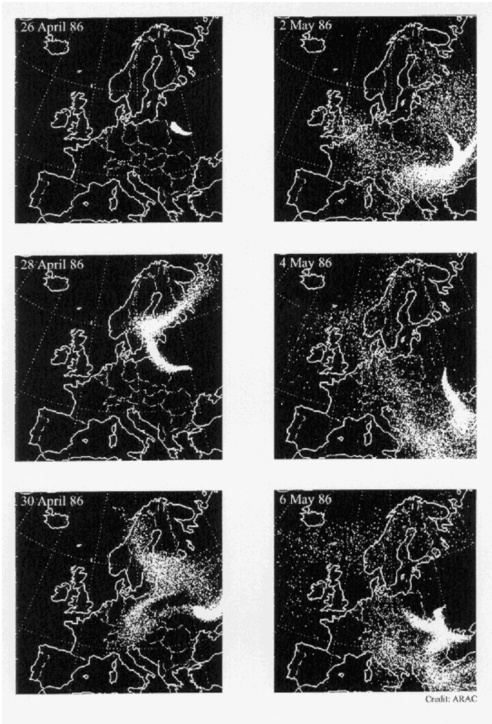
Alan Higgins (President CIEH) and Dr Ian Croudace (SERMG Project Manager)

In the aftermath of the Chernobyl accident many UK local authorities developed a capability for radiological monitoring to provide rapidly available local information to their electorate. However, 20 years after the event many of the schemes are beginning to cease operation due to financial pressures on local authorities and the loss of champions. The potential impact of this demise is discussed by Alan Higgins, President of the Chartered Institute of Environmental Health who played a significant role in setting up LARRMACC, the Local Authority Radiation and Radioactivity Monitoring and Collation Centre (later renamed LARNet), along with Dr Ian Croudace of Southampton University, established one of the largest UK Local authority radiation monitoring schemes in England.

Over twenty years have passed since the No 4 Chernobyl Reactor suffered an explosion which led to one of the world's worst civil catastrophes (26th April 1986). Contamination from various volatile radionuclides (such as ^{137}Cs) was dispersed across Europe in a pattern largely controlled by prevailing weather systems. Much of the UK was affected but upland areas where rainfall was heaviest suffered the worst contamination. The catastrophe spawned the development of a small radioactivity monitoring industry in the UK.

In 1986 UK national agencies were unprepared for a Chernobyl-type accident. Government organisations were prompted into action and had to respond as best they could but progress was slow. The general inadequacy of existing systems led many Local Authorities to form their own independent consortia where economies of scale could operate.

The suppliers of high technology radiation detectors experienced a mini-boom and small research laboratories expanded to provide a range of monitoring expertise and analytical services. The impact of the accident served to turn many in the West against nuclear energy since they feared, arguably unjustly, that the design inadequacies of the Russian reactors were a feature of all nuclear reactors.



THE TRANSPORT PATHWAY FOR THE CHERNOBYL RADIOACTIVE CLOUD IN EUROPE OVER TIME

Many Local Authorities, mostly through their Environmental Health Departments, sought advice and information from independent and credible sources of expertise such as universities, hospitals and Public Analyst laboratories. These organisations were also unprepared but several rose to the challenge to develop a radiometric capability and provide information to the LA-managed public protection professionals. Several regional schemes formed that were able to supply key information relatively quickly and certainly as quickly as the various Government agencies, but with the added perception of independence. Some of the larger schemes that are still in existence include SERMG (Southern England), NIRMG (Northern Ireland), RADMIL (Lancashire), and WSERMS (western Scotland) and these produce quarterly and annual reports to inform the public of the local impact of Chernobyl and other sources of radioactive contamination. Local Authorities as a whole combined through the Local Authority Associations to form LARRMACC, whose primary role was to deliver consistency across the range of local authority individual and consortia radiological monitoring. They also linked into the Government's new monitoring network for international radiological incidents, RIMNET. In fact Local Authorities provided the main source of long term monitoring of radiological background across a range of environmental materials and foodstuffs.

Moving forward 20 years how has the landscape changed? The impact from Chernobyl has largely drifted from the public interest but occasional interest in radioactivity is sparked with threats of dirty bombs. The many reactors in Western and Eastern Europe still exist and are now twenty years older. National systems for monitoring emergencies have improved significantly and the UK is better prepared for major incidents with the formation of new and re-organised agencies, such as the National Response Agency (for nuclear accidents), the Food Standards Agency, the Health Protection Agency and the Environment Agency. The new raft of Government designed measures (as outlined in www.ukresilience.info) would also provide information.

However, what has happened to the LA-centred radiation expertise? Several of the schemes funded by LAs have died away because of funding problems and the loss of individuals who were involved in the initial set up of the schemes. Some of the larger schemes have continued to exist but their membership has dwindled. Even though the costs of schemes are relatively trivial to individual Local Authorities, the pressure to cut costs led to many non-essential services suffering, such as radiation monitoring. Unless their initial champions were prepared to fight for the LA schemes they frequently lost funding. In fact the original champions have commonly retired or moved on. Even LARNet, the successor to LARRMACC which was formed primarily to ensure appropriate and consistent quality measures were used by laboratories serving the numerous Las, will soon to cease to exist.

So if another major radiometric incident occurred (e.g. a reactor accident or a dirty bomb) where would local authorities be? The new national support systems would hopefully work well in the early stages of identifying and responding to the emergency. However, their focus is primarily on dealing with the immediate after-effects of an incident and there is a significant focus on likely terrorist incidents. It is not clear that they are capable of supplying the long-term support and information for which the public would be looking, given that they are mainly designed to respond to the immediate emergency and not the long term monitoring requirement. Additionally, the public would still expect to know the situation for their immediate local areas and depending upon the nature of the incident and the spread of contamination this may not be available except in a regional or national context. Local Authority Public Protection and Emergency Planning Officers would be in the best position to provide such local information but only if radiation monitoring capabilities are maintained or if they can be bought in from existing sources. The schemes established in the late 1980s took up to a year to become effective in the immediate aftermath of Chernobyl and there were few resources available to be bought in.

Local Authorities should consider whether they go for crisis management or pay a relatively modest insurance premium to maintain a LA-centred independent capability. Such a capability can be cost-effective if local authorities (including Emergency Planning Offices) continue to organise themselves into and support the existing consortia. Without this support many of these consortia are likely to cease to exist in the near future and local authorities will be back to square one in respect of radiation monitoring capability.

Fukushima Accident

Almost 25 years after the Chernobyl accident another serious nuclear accident occurred in Japan. The accident was initiated by a combination of extreme natural events (i.e. an earthquake and a tsunami). The impact on the UK was virtually insignificant but the incident did cause concern about nuclear safety. It is notable that the reactor systems damaged were of an early vintage and this has been used as an argument by the nuclear industry to deny the likelihood of a similar accident occurring with modern systems. The unusual location of the Fukushima reactors (i.e. on an active seismic zone) is also seen as a highly undesirable feature. Such a combination of risks is seen as highly unlikely to affect UK nuclear plants.

- Following a major earthquake, a 15-metre tsunami disabled the power supply and cooling of three Fukushima Daiichi reactors, causing a nuclear accident on 11 March. All three cores largely melted in the first three days.
- The accident was rated 7 on the INES scale, due to the high radioactive releases in the first few days. All four reactors are written off.
- There have been no deaths or cases of radiation sickness from the nuclear accident.

  http://www.world-nuclear.org/info/fukushima_accident_inf129.html

DOSE LIMITS: ORIGINS AND USES

Radiation dose limits are those that should not be exceeded in order that a normal member of society is not exposed to an unacceptable risk. These dose limits are determined from a wide range of criteria such as epidemiological studies (especially from Japanese bomb survivors) and are set in the first instance by the ICRP (International Commission for Radiological Protection). In radiological practice the dose limit is considered to be a precautionary limit and not a danger limit. That is, if the limit is exceeded a situation should not arise that was irremediable. Thus, the risk associated with an increase in dose by several times the dose limit may only cause a very slight increase in the real risk of, for example, death from cancer. Another radiological principle recommended by the ICRP and accepted by the UK establishment is that doses should be as low as reasonably achievable, the ALARA principle. This means that it is not sufficient to merely ensure that dose limits are complied with but that all efforts should be made to minimise them to the lowest practicable levels.

The annual dose limit for radiation exposure is 1 mSv for man-made sources. For authorised discharges there is a single source constraint of 0.3mSv/y and a site constraint of 0.5 mSv/year regardless of the number of owners or operators at that site. These guidelines apply to existing plants and where compliance is not possible, then the ALARA principle should hold and the operation should be within dose limits. (CM 2919, 1995)

The inference to be drawn from this proposal is that there are no sites in the UK that constitute any appreciable radiological hazard to members of the public. To place these dose limits into perspective the average annual dose, from all sources is 2.6 mSv (i.e. natural and made-made sources).

DERIVED LIMITS AND ANNUAL LIMITS OF INTAKE, ALI

The primary dose limit for members of the public is set at 1 mSv per year for artificial sources of radiation. This does not include medical exposure but does include any possible incorporation, via ingestion or inhalation, of radioactive substances. In the latter case where incorporation may take place over some time it is difficult to make any direct measurement of the dose received. In order to comply with the limits, therefore, the ICRP has calculated the CED (committed effective dose) which enables the dose taken into the body to be estimated. In order to do this the Commission has calculated dose factors for the whole body and for each organ or tissue, which expresses the total dose received per unit of activity intake. These factors can then be used to calculate the total activity of a particular radionuclide taken into the body. These calculations take into consideration the physical, chemical and metabolic properties (assimilation, organ concerned, retention period in the organ etc) of the nuclide in question.

i THE USE OF ANNUAL LIMITS OF INTAKE, ALIs

Annual limits of intake of radioactive substances (an ICRP concept) should be used with caution. For example, with the isotope ^{137}Caesium, it is possible to calculate the mass concentration that should be tolerated in foods liable to be consumed on a daily basis by the population. The figure calculated represents the acceptable concentration for the consumption of the contaminated food, day after day, year after year throughout the lifetime of the individual *critical group* member in order to comply with the ICRP dose limit. However, consumption is rarely continuous and therefore measured concentrations may be much in excess of the calculated figure. Thus, although a particular isotope may be found having an elevated level in a particular foodstuff, its long-term radiological significance may be less serious than is evident at first seen if measures are taken to counteract the observed levels. As with all radiological data, caution should be exercised in their interpretation and an understanding of their limitations should be borne in mind.

ii GENERALISED DERIVED LIMITS AND DERIVED LIMITS

Generalised derived limits (GDLs) and derived limited (DLs) are values expressed as an activity per unit weight or unit volume. The GDL is a generally applicable value based on detailed habit surveys. DLs may have a more restricted significance but are based on similar considerations. They are secondary standards set and used to ensure virtual certainty that a critical group will not be exposed to a radiation dose in excess of the recommended limit, at present 1mSv per annum. They are calculated generally only for those environmental materials which are considered important to a particular critical group. GDLs and DLs are calculated using data published by the ICRP, presented as the committed effective dose (CED). From these data the Annual Limits of Intake ALIs are calculated (which may be quoted for three main age groups, *viz* infants, children or adults). From this information, a GDL or DL may be determined by dividing the ALI by the mass of food consumed, volume of air inhaled etc. The following scheme shows the sequence involved in their calculation.

a. Obtain CED from tabulations e.g. ICRP-72
b Calculate ALI by dividing 1 mSv by the CED,
c. Calculate GDL or DL by dividing ALI by the consumption factor.

N.B. In all calculations, the units should be consistent.

In Northern Ireland, the effluent discharges from Sellafield are the current main source of environmentally significant radioisotopes. In all cases no levels of these nuclides have been measured which either exceed or even approach closely the GDLs or DLs.

RADIATION FROM NATURAL SOURCES

The HPA (previously the NRPB) maintains surveillance on levels of radiation affecting the general public, and others, in the UK and publishes reports. The data used to construct the graphs in Figures 1 and 2 are extracted from a review conducted during 1993 (NRPB R263 - Radiation Exposure of the UK Population 1993 Review). The dose to the average person in the UK is from all sources but there can be wide variations based on geographical location. These are fully described in the report NRPB R311 that has superseded NRPB R263.

Annual exposure of the UK population from all sources of radiation

Total dose = 2.6mSv

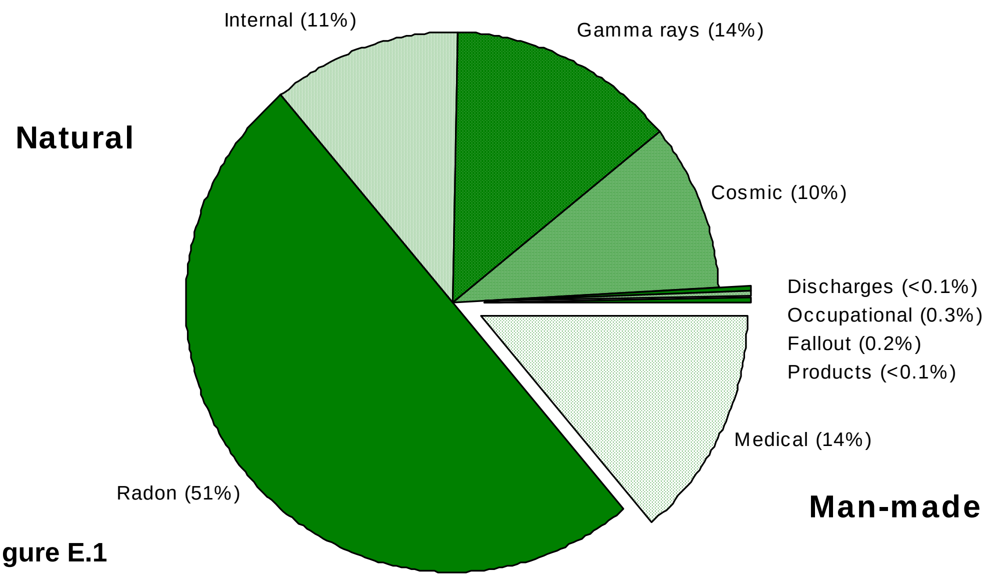


Figure E.1

Man-made sources of radiation

Total annual dose = approx. 0.285mSv

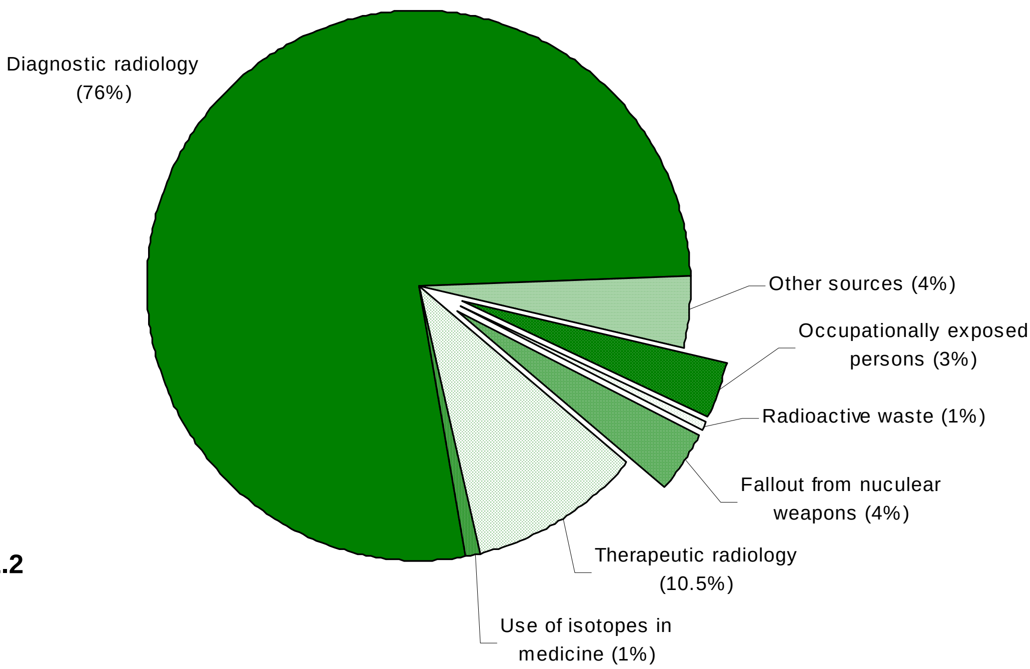


Figure E.2

OTHER GUIDELINES

World Health Organisation (WHO) Guidelines for drinking water

Guideline values recommended by the WHO propose a total alpha activity level of 100Bq/m^3. These values 'are specified assuming that only the most toxic radionuclides are present in significant quantities', and the recommendations conclude with the statement 'A value in excess of the guideline figure does not in itself imply that the water is unsuitable for consumption'.

Soil and other solids

The level of activity in unspecified soil, or other solid materials, below which no special precautions need to be considered in the disposal of that material is given as 400 Bq/kg (0.4 kBq/kg) in 'A review of Cmnd 884: The Control of Radioactive Wastes'. Certain elements have been exempted - see Statutory Instrument 1002 (June 1986).

Radiation Exposure

The principal limit for radiation exposure is now an effective dose of 1 mSv per year. The site constraint to be used in Waste Discharge Agreements with the EA is 0.5 mSv/year. This is based on the annual risk being less than the risk corresponding to an annual effective dose of 0.5 mSv i.e. a mortality risk of 5×10^{-6} per annum, based on 1977 ICRP values.

RIMNET : The national radiation monitoring network and emergency response system

Following the Chernobyl accident in 1986, the UK Government developed a National Response Plan to ensure that any future similar emergency could be effectively managed. The National Response Plan was, and remains, a multi departmental and agency response plan, with the now Department for Energy and Climate Change (DECC) as nominated Lead Government Department for overseas nuclear response.

RIMNET lies at the heart of the National Response Plan and over the years has developed as a multi-purpose response tool and as a platform for the effective coordination of emergency response. RIMNET now supports the UK response to any radiological event and has the potential to be used in non-radiological events.

RIMNET is managed by the Met Office, working in partnership with DECC and Defra on behalf of all government departments and agencies who would be involved in a radiological/nuclear incident, including those leading on non-overseas nuclear events.

RIMNET has a network of 94 fixed gamma dose rate monitoring sites across the UK, automatically measuring, analysing and informing on background radiation levels 24/7. All measurement and reference data is stored in the UK National Nuclear Database.

www.metoffice.gov.uk/publicsector/cbrn

REFERENCE LEVELS FOR RADIOACTIVE MATERIALS IN THE ENVIRONMENT

GENERALISED DERIVED LIMITS

Generalised Derived Limits (GDLs) are derived and published by the National Radiological Protection Board (NRPB) (now the Health Protection Agency, HPA) for the radioactive isotopes of a small number of elements. GDLs represent a cautionary indicator taking into account the various environmental pathways to man. The limits given below apply to uniform conditions over a year and are based on the limiting age group, which is adults for all foods, except as indicated in the tables. The GDLs/DLs for food products are expressed as fresh mass (for ingestion); for grass and sediments are expressed as dry mass (for external irradiation).

	Activity (Bq/kg)				
	^{137}Cs	^{134}Cs	^{60}Co	^{65}Zn	^{131}I
TERRESTRIAL					
Fresh water sediment	20000[4]	8000[4]			
Eggs	3000	2000			400
Freshwater Fish	4000	3000			2000
Fruit	1000	700			200[2]
Grass	3000	2000			700[2]
Honey	1700[3]	1200[3]			
Meat					
Pig	2000	1000			800[4]
Cattle	2000	1000			600[2]
Sheep	3000	2000			2000
Offal	4000	3000			1000[2]
Poultry	2000	2000			1000[2]
Milk (Bq/L)	100	100			20
Milk products	1000	900			100[2]
Soil	1000	600			
Vegetables					
Rootcrop	600	400			100[2]
Other	900	700			400[2]
Marine					
Seafish	700	500	1290[1]	2300[1]	500
Sediment	5000	2000			
Shellfish					
Molluscs	4000	3000	20000[1]	36000[1]	2000
Crustacea	4000	3000	7900[1]	14200[1]	2000

Notes

1 Not GDLs but derived limits calculated from NRPB-GS7 and NRPB-GS8. They are for the adult critical group consumers assuming an effective dose equivalent limit of lmSv.

2 For infants aged 1 year

3 Not GDLs but derived limits calculated from NRPB-GS7. They are for an adult critical group assuming an intake of 25 kg/yr and an effective dose equivalent limit of lmSv.

4 For children aged 10 years

	Activity (Bq/kg)		
	^{238}Pu	^{239,240}Pu	^{241}Am
Freshwater Fish[2]	20	200	200
Sediment			
Marine	100000	90000	80000
Freshwater	400000[3]	300000[3]	300000[3]
Seafish[2]	40	40	50
Shellfish			
Molluscs[2]	200	200	200
Crustacea[2]	200	200	200
Soil	5000	5000	5000

Notes

1 For infants of 1 year.

2 Only the edible fraction included.

3 For children aged 10 years.

NB These radioisotopes are considered to be the only ones that need to be considered in Northern Ireland at present.

METHODOLOGY USED IN GAMMA RAY SPECTROMETRY OF ENVIRONMENTAL MATERIALS

Radiation detection is possible using a variety of techniques and the method chosen depends on the kind of information sought and the level of sensitivity required. There are numerous detectors ranging from technically simple photographic emulsions through to very sophisticated and expensive electronic devices such as that used in the present scheme. A distinction can be made between those detectors that provide general information about radiation doses or the existence of radiation emitters and those which are spectrometric. Radiation spectrometers are generally designed to measure a specific kind of radiation, i.e. alpha, beta or gamma radiation. Spectrometric devices can identify the emitters (i.e. specific isotopes) and are an essential part of a radiation monitoring scheme concerned with determining the possible extent of environmental contamination.

The current scheme operating at the National Oceanography Centre, Southampton involves the counting of environmental materials using high-resolution gamma ray and alpha spectrometers.

GAMMA RAY SPECTROMETRY

All laboratory measurements are made using Canberra Industries gamma ray spectrometers (30% efficiency P-type HPGe, high purity germanium) linked to associated pulse processing NIM modules (Nuclear Instrument Modules). The counting electronics are of the latest Canberra design (AIM & ICB) and run under control from Genie-PC. The radiation detectors are housed in purpose-built lead shields in order to reduce the contribution from background radioactivity. There are several orders of magnitude reduction in the intensity of such isotopes as ^{40}K and uranium and thorium decay chain products (i.e. isotopes occurring in the immediate environment which exist naturally) when using such a well-shielded set-up. Specially selected 'low background' lead is used in the shields and they consist of a closed cylinder having a wall thickness of 100 mm.

Samples are generally counted in 0.5 or 1 litre Marinelli beakers. Most samples have been counted for approximately 12 hours.

TABLE F.1: NOMINAL DETECTION LIMITS FOR GAMMA-EMITTING RADIONUCLIDES

Radionuclide	Detection Limit	Isotope	Detection Limit
^{54}Mn	1 Bq/kg	^{60}Co	1 Bq/kg
^{51}Cr	10 Bq/kg	^{65}Zn	2 Bq/kg
^{59}Fe	2 Bq/kg	^{131}I	1 Bq/kg
^{57}Co	1 Bq/kg	^{134}Cs	1 Bq/kg
^{58}Co	1 Bq/kg	^{137}Cs	1 Bq/kg

Notes

1. Detection limits are calculated for a 60,000 second count.
2. Detection limits are calculated according to Currie (Analytical Chemistry Vol 40 1968).
3. Detection limits should be viewed with respect to the Generalised Derived Limits (GDL) given for a particular material. In all cases, the detection limits are well below the GDLs (see comparative table of results).
4. The detection limits shown are those for a particular sample type and may be higher or lower for other samples. For example, the detection limits for milk will be slightly lower than those shown above

SPECTRAL DATA REDUCTION

Gamma ray spectra are processed using a sophisticated PC software package FITZPEAKS (JF Computing Services, Stanford in the Vale, Oxon). It uses sophisticated mathematical fitting routines to derive a reliable indicator that is proportional to the activity of an isotope. Numerous other features are available which correct for decay and aid in the identification of the isotopes. The ultimate assigning of isotopes is always accompanied by a close visual inspection of each gamma spectrum to ensure that no errors have occurred.

DETECTOR EFFICIENCY CALIBRATION [1]

The calibration of a gamma ray spectrometer for activity measurements requires considerable care if reliable low-level data are to be obtained. The need for such a calibration is due to the non-uniform response of HPGe radiation detectors to gammas of different energy and because the detector does not record all nuclear decays. A mixed radionuclide solution of known and certified activity was obtained from Amersham International (code QCY.44) or the National Physical Laboratory (Teddington) and was carefully diluted in a polythene bottle. Carefully weighed portions of this solution were then weighted into PTFE beakers and about 2 grams of a mixture of 200-400 mesh cation exchange resin (in equilibrium with distilled water) and chromatographic cellulose were added. The mixture was stirred for about 1 hour and the solution was then slowly evaporated to dryness. The resulting dry residue containing the radionuclides was ground with a portion of one of several matrices (powdered shale, alcohol-washed and sieved dried fish and cellulose powder). The remaining part of the chosen matrix (which had been previously found to be sufficient to occupy the counting beaker) was then shaken for about 30 minutes in a large plastic tub with the radionuclide bearing powder. Care was taken to ensure that no activity remained in any container at any stage of the preparation. This was achieved by counting the empty containers in the gamma ray spectrometer to confirm that all activity was quantitatively transferred. Each kind of sample was counted and its activity determined using a calibration standard of equivalent composition and geometrical form.

SAMPLE PREPARATION FOR GAMMA SPECTROSCOPY

Generally, large samples of biological materials contain low levels of radionuclides. Sample preparation is concerned with fitting the maximum amount of material into a fixed geometry after minimum pre-treatment. Most biological materials have a very high water content (50-90% body weight). Thus, for samples of biological origin, volume reduction is achieved by dehydration using freeze-drying.

Solid biological materials - vegetation, fish, shellfish and meat - are chopped into strips/cubes prior to freezing on stainless steel trays. In the case of consumable produce (such as root crop, fish and shellfish) only the edible fractions are frozen. The frozen products are loaded onto heater mats within the vacuum chamber of the freeze-drying apparatus. The chamber is evacuated to a set minimum pressure, at which heat is supplied from the heater mats to the frozen samples. Under these conditions, ice within the samples is changed directly from the solid to the vapour state. The evolved water vapour is trapped within the condenser of the refrigerator unit. The dry tissues are removed from the trays and set aside for counting. Where necessary, materials undergo further chopping to ensure a homogenous distribution within the counting receptacle.

Non-biological samples (i.e. soils and sediment) are oven-dried at 80^{o}C.

The dried materials can be stored almost indefinitely at room temperature without the addition of a preservative.

[1] I. W. Croudace (1991) A reliable and accurate procedure for preparing low-activity efficiency calibration standards for germanium gamma-ray spectrometers. J. Radioanal.Nucl.Chem.Lett. 153, 151-162.

ALPHA SPECTROMETRY & THE TRANSURANIC ELEMENTS

The large-scale introduction of transuranic elements into the environment arose initially from the detonation of nuclear weapons in the atmosphere in the 1950s. A test-ban treaty on atmospheric testing was agreed between the USSR, USA and the UK in 1963; China, France, India and Pakistan are still not signatories. In addition the burn-up on re-entry of satellite power packs for example a SNAP-9, has added to the inventory. The radionuclide content of these events has resulted in widespread low-level contamination. Another major source of transuranics has been the deliberate, controlled discharge of low-level effluents from the nuclear power industry. Accidental releases of transuranics to the environment have occurred from nuclear plant operations and from the transport of nuclear weapons (i.e. Windscale Fire 1957; Three Mile Island 1978; Chernobyl 1986; Palomares, Spain 1966 and Thule, Greenland 1968).

TABLE F.2: TRANSURANIUM ELEMENTS RELEASED TO THE ATMOSPHERE

Nuclide	Amount, TBq	Half life, years
^{238}Pu	890	87.7
^{239}Pu	5.7 x 10^3	2.41 x 10^4
^{240}Pu	7.7 x 10^3	6.57 x 10^3
^{241}Pu*	3.6 x 10^5	14.1
^{241}Am#	1.2 x 10^4	433

Notes
* Largely decayed to ^{241}Am
# Derived from ^{241}Pu by decay
1 TBq = 10^{12}Bq

RECOGNITION OF TRANSURANIC SOURCES

^{239,240}Plutonium and ^{241}Americium are the main transuranics produced from nuclear weapons testing, whereas ^{238}Plutonium and ^{241}Americium will be the main isotopes from nuclear reactor operations. The ratio, ^{238}Plutonium/^{239,240}Plutonium, can be used to elucidate the origin of Plutonium in the environment. The various potential sources of Plutonium and some typical ratios associated with these operations are listed in Table 3.

TABLE F.3: TYPICAL ^{238}PLUTONIUM/^{239,240}PLUTONIUM RATIOS

Source	Ratio
Atmospheric fallout from nuclear weapons testing	0.036 - 0.076
Satellite re-entries	0.5 - 2.0
Nuclear fuel reprocessing	0.2 - 3.0
Nuclear power stations	0.4 - 0.8

COMPARATIVE DATA

The major repositories of transuranics in the environment are in soils and sediments. Some typical activity values are listed in Table 4 in order to put our data in perspective.

TABLE F.4: PLUTONIUM IN SOILS AND SEDIMENTS

Source and Location	Amount Bq/kg
Nuclear weapon testing	
Global fallout[1]	0.02 - 0.7
Chemical reprocessing	
Irish Sea (sediment)[1]	10 - 2000
Winfrith (silt)	1.12 - 1.34
Channel Islands (sediment)[2]	0.371 - 2.49

Notes
[1] Allard et. al. 1984
[2] MAFF aquatic environment monitoring report No 19 1988.

CHEMICAL SEPARATION PROCEDURES

Since alpha particles have very short penetration depths it is necessary to apply complex means to identify their presence. They have to be isolated from all other elements and presented to the detector as an ultra-thin layer (via electrode position, for example) if high quality data are to be obtained. The critical factor in the determination of transuranic elements by alpha spectrometry is how effectively a chosen separation scheme can eliminate not only the interfering natural alpha emitters i.e. uranium, thorium and polonium but also stable elements such as iron, rare earth elements, manganese etc. These elements can impair the alpha spectra when they are electrodeposited together with the transuranics onto the counting planchettes. Consequently an adequate scheme of sequential procedures for the separation of transuranic elements should eliminate all these interferences. The radiochemical scheme for the separation of transuranic elements preferred at Southampton is outlined below.

The scheme can be divided into 4 parts

i) Pre-treatment (freeze-drying, ashing, etc)
ii) Fusion or acid leaching
iii) Chemical Separation
iv) Electrodeposition

Inspection of the alpha spectra of plutonium and americium shows that the separation scheme used performs satisfactorily. The chemical yield ranges normally between 30-100%. The electrode position of the plutonium and americium (plated separately) takes place in an ammonium oxalate-HCl medium at a pH of 2-3, onto a stainless steel disc under an electric current of 300mA (nominally 10 V for 2.5 hours).

Internal tracers are used in each sample to facilitate activity determinations and to monitor the chemical efficiency of the procedure. ^{242}Pu and ^{243}Am are used as tracers because of their long half-lives, thereby not requiring any decay corrections and also because their respective peaks can be easily resolved from the nuclides of interest. Blank analyses are also made to monitor the effect of reagent impurities. Results so far indicate that this represents less than 1% of the recorded activity. Cross contamination of glassware etc is avoided by the use of good laboratory practices, namely the soaking of all glassware in acid, then Decon for 24 hours, followed by washing in hot water and distilled water.

In many analytical techniques a lower limit of detection is defined in terms of the background. Since there is zero background in alpha spectrometry this is not possible. Any background that is present is non-random and is due mostly to the contamination of the detectors. In alpha spectrometry the question is, whether a peak is real or not and thus it is necessary to define a threshold value for peak recognition. This value is set arbitrarily at 10 counts over a 200,000 second counting time and the detection limits for isotopes is 0.01Bq.

ALPHA SPECTROMETRY

The electroplated discs are counted with Passivated Implanted Planar Silicon (PIPS) detectors (Canberra Industries), with active areas of 450 mm^2 (res. <20 keV), installed in a Canberra Quad® chamber connected through ICB ADC and mixer-routers. A GENIE-PC system controls the system hardware. A counting time of at least 300000 seconds is used to count the very low activity levels of transuranics found in the samples examined to date.

The alpha spectrometers are calibrated for their energy response and counting efficiency. All the detectors are calibrated to have an energy response that places the various alpha-energies in the same relative positions. The counting efficiency is essentially the geometrical efficiency of the detector relative to the source position for accepting alpha particles from the source. It is determined from counts for a source that has a known activity but the quantification of the sample activities does not depend on this efficiency.

BETA ANALYSIS OF ENVIRONMENTAL MATERIALS

Technetium-99 (^{99}Tc) is a low energy, pure beta emitter that concentrates in some marine biota. The element is highly volatile in certain oxidation states and to prevent loss of Tc controlled conditions have to be applied throughout the methodology to ensure complete chemical recovery along with ensuring good decontamination from interfering isotopes. Isotopes, which will interfere with the beta analysis, such as Ruthenium isotopes, have to be completely eliminated along with stable elements such as iron and calcium which will adversely affect the determination of Tc.

The final measurement of the samples is performed using Liquid Scintillation Counting (LSC). ^{99m}Tc as pertechnetate is used as a yield monitor.

The analytical scheme can be divided into four parts

i)	Preliminary treatment	Ashing, acid digestion)
ii)	Purification	Precipitation, solvent extraction)
iii)	Final measurement	Liquid scintillation Counting

BETA ANALYSIS OF ENVIRONMENTAL MATERIALS (cont)

The samples are ashed under controlled conditions after the ^{99m}Tc yield monitor has been added. An acid digestion stage follows which solubilises the Tc present. A precipitation step is carried out to remove any iron and calcium that can cause interferences and reduce the solvent extraction efficiency. ^{99}Tc is purified by a combination of anion exchange and solvent extraction.

The organic phase is mixed directly with a commercially available scintillant and ^{99m}Tc determined by gamma spectrometry. The sample was stored for a week to allow the ^{99m}Tc to completely decay and the ^{99}Tc activity is determined by LSC.

References

F Wigley, P E Warwick, I W Croudace, J Caborn & A.L. Sanchez (1999) Optimised method for the routine determination of Technetium-99 in environmental samples by liquid scintillation counting. Analytica Chimica Acta 380, 73 - 82

ASSESSMENT OF DATA QUALITY

The activity data quoted in the appendices are reported without any uncertainties or confidence limits. The reason for this is to prevent needless clutter or confusion. However, data quality assessments are made regularly by the following means:-

a. measuring certified reference materials (e.g. those produced by the International Atomic Energy Authority, IAEA

b. measuring reference samples produced by other independent laboratories

c. producing multiple standards using certified and traceable activity standards (e.g.. as supplied through Amersham International and the National Physical Laboratory.)

Results of inter-laboratory measurements and detection limits allow some assessment of data accuracy and precision without the need for quoting confidence limits with all the reported data.

The following tables present radioanalytical data produced in various quality assessment exercises.

QUALITY ASSURANCE - GAMMA

An assessment of the accuracy of sample activities can be achieved in a number of ways. One means is to count a sample measured in one or more independent laboratories and to compare the results.

The method used to check data accuracy involves using a range of natural matrix reference materials, NMRMs or prepared standards. (See tables 5 - 7).

Data from inter-comparison exercises are presented in Table 10.

TABLE F.5: QUALITY ASSURANCE ASSESSMENTS (Bq/kg) – GAMMA

IAEA[1] Sample	Isotope	Recommended or Certified Value	Measured at Southampton	Measured at ITE[3]
Fish F72	^{137}Cs	14.2	15.3	16.0
	^{40}K	-	340	330
Sediment S36	^{60}Co	11.5	10.8	12.2
	^{137}Cs	13.9	14.6	14.1
Sediment S71	^{137}Cs	-	52.7	55.0
Sediment S43	^{137}Cs	53.7	54.9	52.8
Seaweed A17	^{54}Mn	19.7	nd	nd
	^{60}Co	1360	1340	1396
	^{137}Cs	16.7	17.0	15.8
Pine needles CLV-1[2]	^{137}Cs	110	112	-

Notes

1 IAEA International Atomic Energy Authority reference samples.
2 CLV-1 Pine needles reference samples supplied by the Canadian National Uranium Tailings Program.
3 ITE Institute of Terrestrial Ecology, Merelwood Laboratory, Grange-over-Sands, Cumbria.

TABLE F.6: QUALITY ASSURANCE DATA - GAMMA

	Sample CLV-1[1]	Measured at Southampton	Provisional Value[2]
1.[3]	^{137}Cs	0.115 Bq/g	0.11 Bq/g
	U (via ^{234}Th)	1.12 Bq/g	1.07 ± 0.06 Bq/g
2.[3]	^{137}Cs	0.112 Bq/g	0.11 Bq/g
	U (via ^{234}Th)	1.11 Bq/g	1.07 ± 0.06 Bq/g

Notes

1 CLV-1 Pine needles reference samples supplied by the Canadian National Uranium Tailings Program.

2 Values taken from 'Vegetative radionuclide reference materials' by L Dalton and W S Bowman (1986), NUTP-4E, ISBN 0-660-12231-6.

3 Samples 1 and 2 were prepared using different weighed portions of CLV-1 independently as two samples in different counting geometries.

TABLE F.7: PROFICIENCY TESTING SCHEME

Sample	Isotope	AEA Target Value	Measured at Southampton	All Laboratory Range
Milk	^{137}Cs	182	217 226	162 - 279
Cabbage	^{137}Cs	63.5	73	58 - 85

QUALITY ASSURANCE - ALPHA

In any chemical procedure continuous quality control is required which is able to assess both the precision and accuracy of the methods used. The precision or reproducibility of a method can be monitored by including a suitably reliable 'in-house' reference sample with each batch of samples. Accuracy is more difficult to assess and is partly controlled by the reliability of the isotopic tracer used. The use of natural matrix reference materials (NMRM) provides a way of assessing the accuracy (Table 8).

TABLE F.8: ANALYSIS OF REFERENCE SAMPLES (Bq/kg) – ALPHA EMITTERS

IAEA[1] Sample	Isotope	Recommended or Certified Value	Measured at Southampton
IAEA-307	^{238}Pu	0.025	0.03
(Sea-plant)	$^{239,240}Pu$	0.72	0.69
(Posidonia oceanica)	^{241}Am	-	0.2
IAEA-308	^{238}Pu	0.017	1) 0.03
(Mediterranean seaweed)	$^{239,240}Pu$	0.5	1) 0.48
	^{241}Am	0.17	1) 0.3
IAEA-134	$^{239,240}Pu$	15	15
(Cockles)	^{241}Am	38	36
IAEA-135	$^{239,240}Pu$	213	187
	^{241}Am	318	318
IAEA-367	$^{239,240}Pu$	38	34
	^{241}Am	26.4	24
IAEA-384	^{238}Pu	38.1 – 40.1	36.70
(Sediment)	$^{239,240}Pu$	105 - 110	103.35
	^{241}Am	6.7 – 7.6	24

Notes

1 IAEA International Atomic Energy Authority reference samples.
- not counted

QUALITY CONTROL - BETA

Quality control in the analysis of Technetium-99 is aimed at ensuring the precision of the measurement. A spiked sample is analysed along with each batch of samples. The background and counting efficiency of the samples are determined for each batch of samples counted. Participation in inter-comparison exercises helps estimate the accuracy of the procedure (see Tables 9 & 10).

With reference to results in Table 10, for the National Physical Laboratory (NPL) Inter-comparison in 1995, only spiked water samples were supplied and the validation was limited. For the NPL exercise in 2007, analyses were again performed on spiked aqueous samples. The MAFF/FSA exercise of 2000 supplied samples more appropriate for the assessment of analysis of environmental and food material.

TABLE F.9: TECHNETIUM 99 CALIBRATION EXERCISE (SURRC 1998)

	Measured at Southampton: Bq kg^{-1}			
Sample	**A**	**B**	**C**	**D**
	3.9	35.7	4.21	16.3
	6.8	36.9	4.32	16.5
		33.8	4.17	17.7
			4.13	15.2
Mean	**5.3**	**36.7**	**4.21**	**16.4**

	Measured at all laboratories (8): Bq kg^{-1}			
Sample	**A**	**B**	**C**	**D**
Mean	8.0	61.3	5.3	18.2
High	18.8	88.5	15.7	23.2
Low	1.8	36.7	2.99	12.8

TABLE F.10: INTERCOMPARISON EXERCISES

Sample	Isotope	Recommended Activity (Bq/kg)	Measured Activity
NPL (2002)	^{22}Na	2.024 ± 0.010	1.95 ± 0.07
Comparison exercise	^{57}Co	2.024 ± 0.020	1.99 ± 0.06
(high-level activity - N.B. Bq/g)	^{60}Co	2.008 ± 0.008	1.97 ± 0.06
BGH009/02	^{95}Zr	1.943 ± 0.032	1.89 ± 0.12
ABH006/002	^{106}Ru	2.012 ± 0.011	1.92 ± 0.18
	^{134}Cs	2.025 ± 0.016	1.90 ± 0.06
	^{137}Cs	2.015 ± 0.015	1.98 ± 0.06
	^{154}Eu	2.081 ± 0.017	1.92 ± 0.06
	^{155}Eu	2.041 ± 0.024	2.01 ± 0.15
	^{238}Pu	2.000 ± 0.016	2.02 ± 0.04
	^{239}Pu	1.991 ± 0.023	2.00 ± 0.04
UK-NPL (2003)			
(Inter-comparison exercise)			
BGL/03/***	^{60}Co	2.247 ± 0.007	2.39 ± 0.35
(ABL/03/***)	^{90}Sr	11.942 ± 0.035	11.72 ± 0.51
	^{134}Cs	3.937 ± 0.029	3.93 ± 0.35
	^{137}Cs	2.522 ± 0.021	2.88 ± 0.40
	^{238}Pu	2.763 ± 0.011	2.59 ± 0.10
	^{239}Pu	3.293 ± 0.016	3.16 ± 0.12
	^{241}Am	3.058 ± 0.023	2.37 ± 0.08
UK-NPL (2005)	^{14}C	160 ± 10	161 ± 21
	^{90}Sr	10189 ± 16	9425 ± 443
	^{238}U	1059 ± 24	1031 ± 179
	^{238}Pu	2607 ± 9	2765 ± 174
	$^{239,240}Pu$	6060 ± 30	6388 ± 257
	^{241}Am	3691 ± 13	3569 ± 355
UK-NPL (2007)	^{60}Co	11.72 ± 0.04	12.3 ± 0.4
	^{90}Sr	17.06 ± 0.03	17.4 ± 0.8
	^{98}Tc	6.501 ± 0.015	6.2 ± 0.5
	^{129}I	372 ± 4	360 ± 10
	^{134}Cs	4.07 ± 0.03	4.5 ± 0.3
	^{137}Cs	8.84 ± 0.06	9.4 ± 0.4
	^{238}Pu	17.13 ± 0.08	18 ± 1
	^{239}Pu	19.48 ± 0.12	20 ± 1
	^{241}Am	10.07 ± 0.04	9.4 ± 0.4
UK-NPL (2010)	^{238}Pu	18.08 ± 0.06	16.32 ± 1.01
	^{239}Pu	17.29 ± 0.08	15.84 ± 0.99
	^{14}C	0.1398 ± 0.0009	0.16 ± 0.02
	^{7}Be	4.24 ± 0.08	4.23 ± 0.45
	^{60}Co	3.427 ± 0.008	3.53 ± 0.17
	^{95}Zr	1.878 ± 0.015	1.87 ± 0.12
	^{95}Nb	4.08 ± 0.04	4.32 ± 0.21
	^{134}Cs	5.81 ± 0.05	6.03 ± 0.29
	^{137}Cs	10.43 ± 0.07	10.72 ± 0.50
	^{152}Eu	11.78 ± 0.13	11.93 ± 0.58
	^{154}Eu	1.94 ± 0.04	2.10 ± 0.07

Notes

* IAEA International Atomic Energy Agency reference sample (see report IAEA/AL/026 1990).

QUALITY CONTROL - UKAS ACCREDITATION

The GAU operates a Quality Management System which is accredited to ISO17025:2005 (which also meets the requirements of ISO 9001). The quality of data produced is constantly monitored in compliance with the strict requirements of this accreditation. Specific methods are also accredited to ISO17025 : 2005 and the GAU is continuing to add methods to the accreditation in accordance with GAU's policy of continuous improvement. Further information regarding GAU's accreditation can be obtained from the UKAS website at http://www.ukas.com.

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GLOSSARY OF TERMS

Activation Products	Activation products are the radioactive atoms formed by the absorption of neutrons in and around the reactor core. For example, some of the trace quantities of cobalt and zinc in the water passed through the core become ^{60}Co and ^{65}Zn.
Activity	Attribute of an amount of a radionuclide. Describes the rate at which decays occur in it. The unit Becquerel, Bq corresponds to the decay of one radionuclide atom per second.
Alpha particle	A particle consisting of 2 protons plus 2 neutrons, which is effectively a helium nucleus. They are emitted generally by heavy radionuclides.
Annual limits of intake, ALIs	These values are calculated from the committed effective dose equivalent, CEDE. They represent activity data that are equivalent to the annual dose limit produced by a particular radioisotope. This is an ICRP concept.
Becquerel	Unit of amount of radioactivity, Bq (see activity). 1 nuclear disintegration per second.
CED	Committed effective dose. The dose equivalents which relate to a 50 year integration period.
Decay	The spontaneous transformation of a radionuclide. The decrease in the activity of a radioactive substance.
Decay product	A nuclide or radionuclide produced by decay. It may be formed directly from a radionuclide or as a result of a series of successive decays through several radionuclides.
Derived limits	See Generalised Derived Limits.
Dose	General term for quantity of radiation. Frequently used for effective dose equivalent.
Fallout	The global deposition of very fine particulate material following testing of nuclear weapons in the atmosphere during the period 1952-1963 or due to nuclear accidents.
Fission Products	Fission is the division of a nucleus (e.g. ^{235}U) into two (usually unequal) radioactive parts. These nuclei are called fission products.
Gamma ray	A discrete quantity of electromagnetic radiation emitted during radioactive decay that originates from the nucleus.
Germanium gamma ray Spectrometer	A semiconductor detector that is most often used to measure gamma emitters because it offers the best energy resolution of any device.
Generalised derived limits	These are general secondary standards, derived from the primary dose limits, which are used as cautionary indicators for materials of environmental significance. They are quoted for specific radionuclides and are expressed in activity units per unit mass, unit volume or unit time. They express a value that will virtually guarantee compliance with legislation dose limits. Fractional GDLs are summed for different radioisotopes to give an assessment of the overall effective dose equivalent.
Gray	A measure of absorbed dose being the amount of energy imparted to unit mass of matter such as tissue. Symbol Gy. 1Gy = 1 joule per kilogram.
Half-life	The time taken for the activity of a radionuclide to lose half its value by decay. Symbol t ½.
ICRP	International Commission on Radiological Protection.
Nuclide	A species of atom characterised by the number of protons and neutrons and, in some cases, by the energy state of the nucleus.
Radiation	The process of emitting energy as waves or particles. The energy thus radiated. Frequently used for ionising radiation in the text.
Radioactive	Possessing radioactivity.
Radioactivity	The property of radionuclides of spontaneously emitting ionising radiation normally associated with nuclear decay to another nuclide.
Radon	An unstable, chemically inert, radioactive, heavy gas produced during the decay of natural uranium and thorium. Radon and its daughters accumulate in soil and may be drawn into dwellings through slight under-pressure. Radon activity generally represents the main contribution to the dose received by members of the public.
Sievert	An S.I. unit of radiation dose.