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Radioactivity in Food and the Environment, 1996

MAFF

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MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
SCOTTISH ENVIRONMENT PROTECTION AGENCY

Radioactivity in Food and the Environment, 1996

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This is the second surveillance report in the series “Radioactivity in Food and the Environment”. It is published jointly by MAFF and SEPA and for the first time includes a complete appraisal of information relating to Scotland.

The scope of this report series comprises government surveillance previously issued in the Terrestrial Radioactivity Monitoring Report (TRAMP), the Aquatic Environment Monitoring Report (AEMR) and the Statistical Bulletin: Environmental Monitoring for Radioactivity in Scotland.

The report was compiled by the Centre for Environment, Fisheries and Aquaculture Science in Lowestoft for the Radiological Safety and Nutrition Division of the Joint Food Safety and Standards Group of MAFF and the Department of Health in London and for the Radioactive Substances Group of the Scottish Environment Protection Agency in Stirling.

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SUMMARY

1. This report continues the series which combines the results of the radioactivity monitoring programmes previously published by MAFF in two documents: the ‘Terrestrial Radioactivity Monitoring Programme (TRAMP) Report: Radioactivity in food and agricultural products in England and Wales’ and the ‘Aquatic Environment Monitoring Report: Radioactivity in surface and coastal waters of the British Isles’ (AEMR). For the first time the report includes the results of all environmental monitoring for radioactivity carried out on behalf of the regulatory authority in Scotland. These results were previously presented in the ‘Statistical Bulletin: Environmental Monitoring for Radioactivity in Scotland’ (e.g. The Scottish Office, 1996).

2. These programmes required the collection of approximately 1800 samples of foodstuffs together with approximately 3900 samples of environmental indicator materials in the United Kingdom. Dose rate measurements were made at sites throughout Great Britain. Approximately 18000 analyses or dose rate measurement were completed. A conclusion of this report is that foodstuffs produced in the United Kingdom and seafoods produced in the waters surrounding the British Isles are radiologically safe to eat.

3. The programmes are managed (other than in Scotland) by the Ministry of Agriculture, Fisheries and Food on behalf of the Welsh Office, the Department of the Environment for Northern Ireland, the Manx Government and the Channel Island States. They act as a key component of the UK Government’s strategy to protect the safety of the food chain and the marine environment. The main objective of the programmes is to verify that the level of radioactivity present in foodstuffs is acceptable and to ensure that the resulting public radiation exposure is within internationally accepted limits. The Scottish Environment Protection Agency (SEPA) is responsible for the programme in Scotland. The responsibilities of SEPA are for the protection of the environment as a whole and there the programme includes the monitoring of the environment, foodstuffs and drinking water.

4. A substantial part of the cost of the programmes is recouped from industries discharging wastes in accordance with the ‘polluter pays’ principle.

5. Disposals of liquid, gaseous and solid wastes from nuclear sites are regulated by the Environment Agency in England and Wales and by SEPA in Scotland using powers in the Radioactive Substances Act, 1993.

6. Measurements in 1996 included the analysis of samples of food and other materials from the environment and detection of beta and gamma dose rates in the environment. The results show that radionuclide concentrations and radiation dose rates were generally similar to those in 1995. However, near Sellafield, despite the general downward trend in disposals from the site during 1996, there were some increases in concentrations of technetium-99 and carbon-14 in marine foodstuffs reflecting disposals from and operations on the site in previous years. These operations included processing of stored wastes and the operation of the Enhanced Actinide Removal Plant (EARP). The Thermal Oxide Reprocessing Plant (THORP) continued its commissioning phase in 1996 and its disposals had little effect on food and the marine environment. The results of the monitoring have been interpreted in terms of public radiation exposures using data on activity levels in food and local surveys to establish potential ‘critical groups’ of people likely to be most exposed.

7. Public radiation doses received in 1996 from disposals of radioactive waste are presented in the Summary Table and in Figures 1-3. The exposures are expressed in terms of ‘committed effective dose’ calculated on the basis of the methodology in ICRP-60 and include a contribution due to previous years’ disposals. Where appropriate, doses to skin are also given. Exposures were all within the dose limit of 1 mSv for members of the public or the skin dose limit of 50 mSv as appropriate. Figures 1 and 2 present the numerical data in graphical form for aquatic and terrestrial sectors, respectively. These data include consideration of children and of the age dependent toxicities of radionuclides. Data in Figure 3 represent the total food doses for adults at each site, excluding external radiation, based on the MAFF ‘INTAKE’ methodology (Section 6).

8. The highest exposures due to the nuclear industry in the UK were from disposals of liquid radioactive wastes from Sellafield. Exposures of high-rate fish and shellfish consumers due to artificial radionuclides near Sellafield increased in 1996 (0.14 mSv), as compared with 1995 (0.12 mSv), due to increased consumption of crustaceans and increased concentrations of technetium-99. These individuals also received a dose resulting from disposals from the Albright and Wilson Ltd works at Whitehaven of 0.075 mSv. There were also small increases in exposures of people associated with fisheries at Whitehaven, Dumfries and Galloway, Morecambe Bay and Fleetwood and their families in 1996, though all such exposures were significantly less than those at Sellafield. Exposures due to Sellafield liquid disposals include a contribution due to activity discharged in years prior to 1996.

9. The most exposed group from disposals of gaseous wastes was also at Sellafield. The dose to the most exposed group of terrestrial food consumers, including a contribution from weapon test and Chernobyl fallout, was less than 0.055 mSv, a decrease from the value for 1995 (0.081 mSv), because of a reduction in radionuclide concentrations in food particularly sulphur-35 in milk. Exposures due to consumption of terrestrial foods at all nuclear sites were well within the dose limit of 1 mSv.

Summary Table: Estimates of public radiation exposure from discharges of radioactive waste in the United Kingdom, 1996

Establishment	Radiation exposure pathway[h]	Critical group	Exposure, mSv[a]
British Nuclear Fuels plc			
Sellafield and Drigg[b]	All foodstuffs	Local consumers at Sellafield	<0.034
	Fish and shellfish consumption	Local fishing community	0.14
	Terrestrial foods	Local consumers at Sellafield	<0.055
	"	" " " Drigg	<0.020
	"	" " " Ravenglass	<0.034
	External	Houseboat dwellers (River Ribble)	0.14
	External[c]	Fishermen (Whitehaven)	0.049
	"	Anglers	0.038
	External (skin)	"	0.15[d]
	Handling of fishing gear	Local fishing community	0.31[d]
	Porphyra/laverbread consumption	Consumers in South Wales	<0.005
	Trout consumption	Local consumers at Sellafield	0.010
Springfields	All foodstuffs	Local consumers	<0.018
	External	Houseboat dwellers (River Ribble)	0.14
	"	Bird warden	0.080
	" (skin)	"	4.2[d]
	"	Anglers	0.044
	" (skin)	"	2.3[d]
	Fish and shellfish consumption and external	Local fishing community	0.042
	Terrestrial foods[g]	Local consumers	<0.014[f]
Capenhurst	Inadvertent ingestion of water and sediment	Local community	<0.005
	Terrestrial foods	Local consumers	<0.005[f]
Chapelcross	All foodstuffs	Local consumers	<0.020
	Fish and shellfish consumption and external	Local fishing community	0.032
	External	Wildfowlers	0.023
	Handling of fishing gear	Local fishermen	0.038[d]
	Terrestrial foods	Local consumers	<0.024
United Kingdom Atomic Energy Authority			
Dounreay	All foodstuffs	Local consumers	<0.019
	Handling of fishing gear	Local fishermen	<0.16[d]
	Fish and shellfish consumption	Local fishing community	<0.005
	Mollusc consumption and external	Mollusc collectors	0.022
	External	Local community	0.008
	Terrestrial foods[g]	Local consumers	<0.031
Harwell	Fish consumption and external	Anglers	0.009
	Terrestrial foods	Local consumers	<0.005
Winfrith	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption	Local fishing community	<0.005
	Terrestrial foods	Local consumers	<0.005
Electricity Companies			
Berkeley and Oldbury	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption and external	Local fishing community	0.008
	Terrestrial foods	Local consumers	<0.005
Bradwell	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption and external	Houseboat dwellers	0.010
	Terrestrial foods	Local consumers	<0.005
Dungeness	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption and external	Bait diggers	0.006
	Terrestrial foods	Local consumers	<0.005
Hartlepool	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption	Local fishing community	<0.005
	Terrestrial foods	Local consumers	<0.006
Heysham	All foodstuffs	Local consumers	<0.008
	Fish and shellfish consumption and external	Local fishing community	0.082
	Terrestrial foods	Local consumers	<0.007

Summary Table: continued

Establishment	Radiation exposure pathway[h]	Critical group	Exposure, mSv[a]
Electricity Companies *continued*			
Hinkley Point	All foodstuffs	Local consumers	<0.005
	External	Local fishing community	0.006
	Terrestrial foods	Local consumers	<0.007
Hunterston	All foodstuffs	Local consumers	<0.010
	Fish and shellfish consumption and external	Local fishing community	0.023
	Terrestrial foods	Local consumers	<0.045
Sizewell	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption and external	Local fishing community	<0.005
	Terrestrial foods	Local consumers	<0.005
Torness	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption	Local fishing community	<0.005
	External	Local community	<0.005
	Terrestrial foods	Local consumers	<0.019
Trawsfynydd	Fish consumption and external	Local fishing community	0.043
	Terrestrial foods	Local consumers	<0.006
Wylfa	All foodstuffs	Local consumers	<0.005
	Fish and shellfish consumption and external	Local fishing community	0.006
	Terrestrial foods	Local consumers	<0.005
Defence Establishments			
Aldermaston	Fish consumption and external	Anglers	<0.005
	Terrestrial foods[g]	Local consumers	<0.005[f]
Barrow	External	Local community	0.022
Chatham	External	Houseboat dwellers	<0.005
Devonport	Fish and shellfish consumption and external	Local community	<0.005
Faslane	External	Local community	0.009
Holy Loch	External	Local community	0.008
Rosyth	External	Local community	0.017
Amersham International plc			
Amersham	Fish consumption and external	Anglers	<0.005
	Terrestrial foods	Local consumers	<0.005
Cardiff	All foodstuffs	Local consumers	<0.013
	Fish and shellfish consumption and external	Local fishing community	0.012
	Terrestrial foods	Local consumers	<0.014
Albright and Wilson Ltd			
Whitehaven[e]	Fish and shellfish consumption	Local fishing community	0.17

[a] *Unless otherwise stated represents committed effective dose calculated using methodology of ICRP-60 to be compared with the dose limit of 1 mSv (see section 6). Exposures due to marine pathways include the far-field effects of discharges of liquid waste from Sellafield. All exposures for terrestrial pathways include a component from radionuclides which were found to be below the limits of detection. Unless stated otherwise, the critical group for terrestrial pathways is represented is represented by the 1 year old age group*

[b] *The estimates for marine pathways include the effects of liquid discharges from Drigg, but exclude the effects of natural radionuclides. The contribution due to Drigg is negligible. The exposure due to enhanced concentrations of natural radionuclides for seafood consumers in 1996 was 0.075 mSv*

[c] *Includes a small contribution due to consumption of seafood*

[d] *Exposure to skin including a component due to natural sources of beta radiation, to be compared with the dose limit of 50 mSv (see section 6)*

[e] *These estimates include the effects of enhanced concentrations of natural radionuclides but exclude a small contribution from the effects of artificial radionuclides from other sites. They assume a gut uptake factor of 0.8 for polonium which is based on studies of seafood consumption (see section 6). The exposure due to artificial radionuclides in 1996 was 0.082 mSv*

[f] *Includes a component due to natural sources of radionuclides*

[g] *Adults*

[h] *The exposure from ingestion of all foodstuffs is based on the INTAKE methods and data (Section 6) and includes components due to liquid and gaseous discharges*

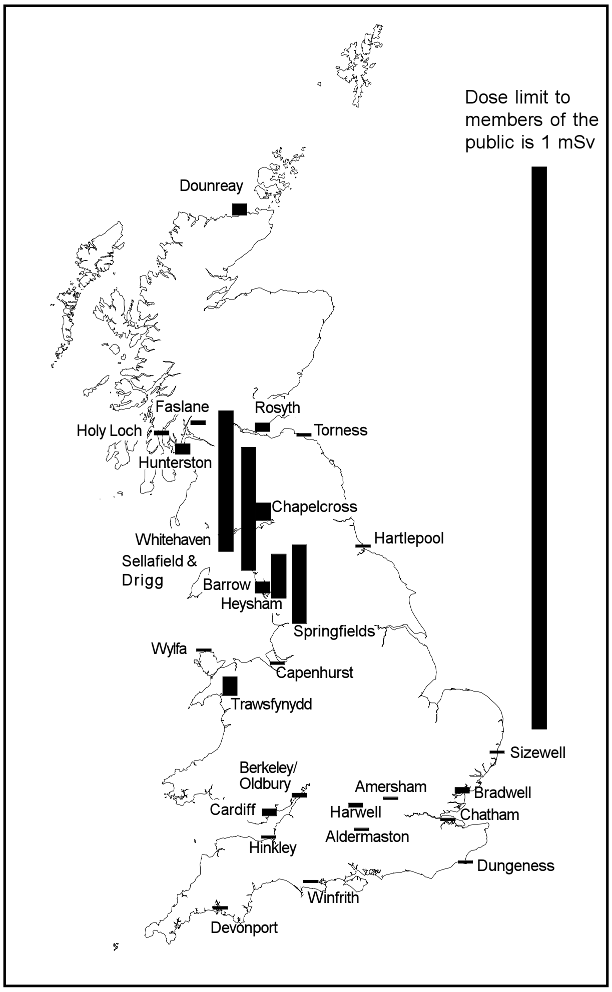

Figure 1. ***Radiation exposures in the UK due to liquid radioactive waste discharges,1996. (Historic discharges from Sellafield have a significant effect on exposures throughout the Irish Sea. Exposures at Whitehaven and Sellafield include the effects of enhanced concentrations of natural radionuclides)***

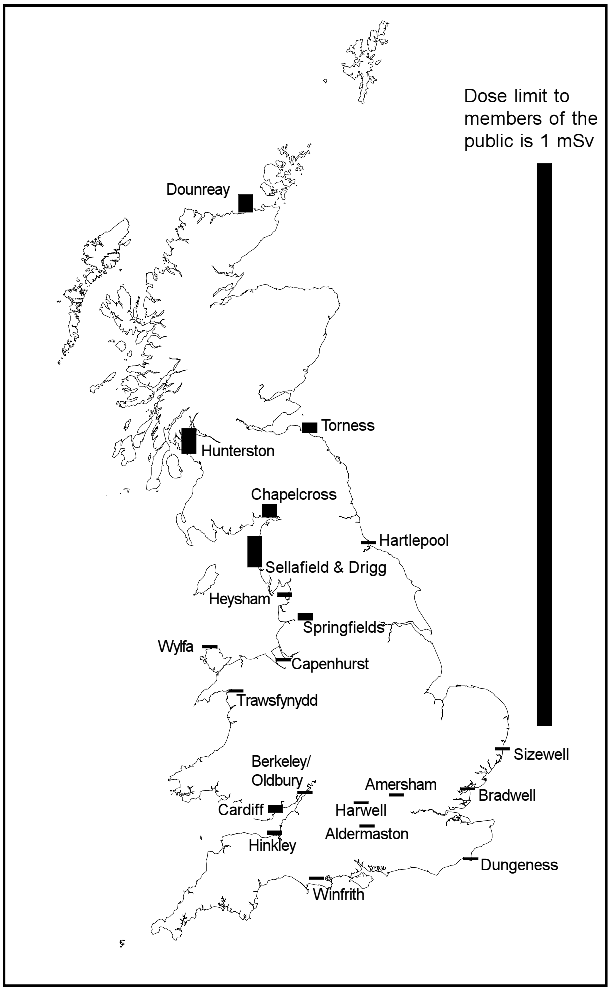

Figure 2. ***Radiation exposures in the UK due to gaseous radioactive discharges, 1996***

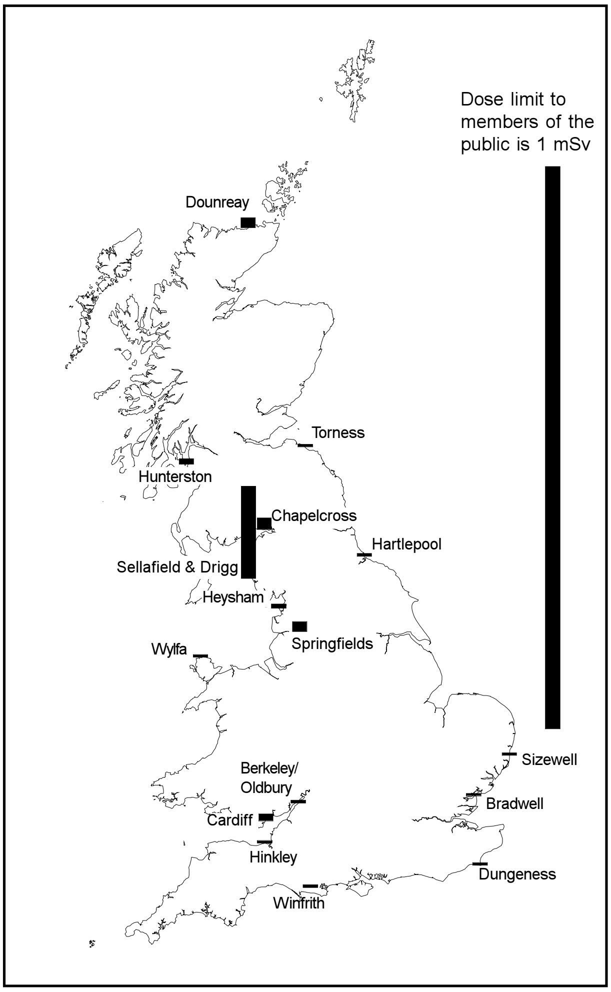

Figure 3. Radiation exposures in the UK in 1996 from food consumption calculated using the INTAKE methods and data (Historic discharges from Sellafield have a significant effect on exposures throughout the Irish Sea. Exposures at Sellafield include the effects of enhanced concentrations of natural radionuclides)

10. Those most exposed to external radiation in connection with disposals from Sellafield were a small group of houseboat dwellers in the Ribble estuary. Their dose in 1996 was 0.14 mSv, an increase from 0.091 mSv for 1995 due to increased time being spent on the boat in the estuary. In the Sellafield vicinity, the exposure of anglers who dig bait near Sellafield reduced from 0.13 mSv (1995) to 0.038 mSv due to reduced time spent on the mud and moving to areas with lower dose rates. The exposure of a fisherman living on a boat in Whitehaven harbour also reduced from 0.060 mSv (1995) to 0.049 mSv.

11. Concentrations in seafood of the significant radionuclides discharged from Whitehaven Works (Albright and Wilson Ltd) have reduced further in 1996, as expected, due to earlier reductions in liquid disposals and radioactive decay. As a consequence, exposures of the most exposed group of fish and shellfish consumers due to the enhancement of concentrations of natural radionuclides have reduced. Taking an upper estimate of the gut transfer of polonium, the dose in 1996 was cautiously estimated to be 0.17 mSv compared with 0.29 mSv in 1995. This group also received a dose from disposals from Sellafield. The total dose remained within the limit.

12. Some evidence was found for enhancement of natural radionuclides near other non-nuclear industrial sites though the data are difficult to interpret because of the high natural variability in levels in the terrestrial environment. Estimates of the exposure of the most exposed group consuming meat from cattle grazing near such sites were up to 0.18 mSv greater than those consuming cattle products from a control site. The natural variability in levels of these radionuclides in the environment make it difficult to quantify the exact dose contribution from site activities. There was also limited evidence to support the observation that tritium is to be found leaching from some landfill sites. However the radiological significance of the levels found was negligible. Further monitoring around landfill sites was carried out by the Environment Agency in England and Wales.

13. The collective dose from seafood consumption to the UK and other European populations in 1996 was 4 and 19 man-Sv respectively, the same as in 1995. The most significant waste disposals giving rise to collective dose were marine disposals of radiocaesium from Sellafield.

14. Regional monitoring showed that exposures on the Isle of Man and the Channel Islands from artificial radioactivity were low, at less than 3% of the dose limit of 1 mSv in the case of the Isle of Man and lower in the Channel Islands.

15. Analyses of general diet throughout England and Wales and foodstuffs produced remote from nuclear sites continued to demonstrate that natural radionuclides are by far the most significant source of exposure through the food chain.

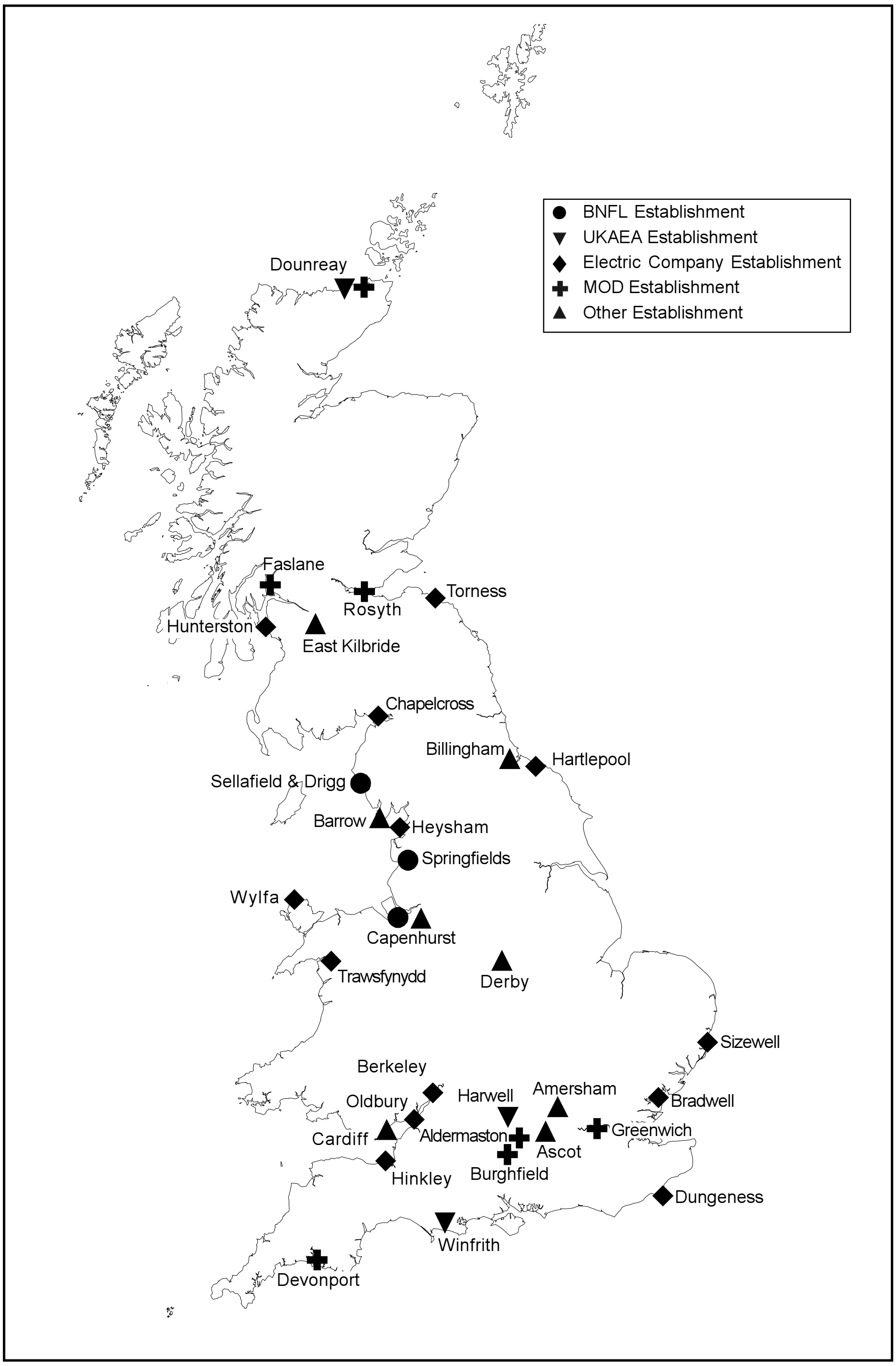

Figure 4. Principal sources of radioactive waste disposal in the UK

1. INTRODUCTION

This report continues the series which combines the results of the radioactivity monitoring programmes previously published by the Ministry of Agriculture, Fisheries and Food (MAFF) in two documents: the 'Terrestrial Radioactivity Monitoring Programme (TRAMP) Report: Radioactivity in food and agricultural products in England and Wales' (e.g. MAFF, 1995) and the 'Aquatic Environment Monitoring Report: Radioactivity in surface and coastal waters of the British Isles' (e.g. Camplin, 1995). Data from this programme pertaining to nuclear licensed sites is supplied quarterly to the Environment Agency and are available to the general public.

For the first time the report includes the results of all environmental monitoring for radioactivity carried out on behalf of the Scottish Environment Protection Agency (SEPA). These results were previously presented in the 'Statistical Bulletin: Environmental Monitoring for Radioactivity in Scotland' (e.g. The Scottish Office, 1996). This report is jointly published by MAFF and SEPA.

The data in this report are for 1996 and the results of the programmes are assessed by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of MAFF, SEPA, the Welsh Office, the Environment and Heritage Service (Northern Ireland), the Manx Government and the Channel Island States. Together with the monitoring sponsored by the Environment Agency [a] (e.g. Environment Agency, 1997), the programme supports statutory functions under the Radioactive Substances Act, 1993 (United Kingdom - Parliament, 1993) (replacing the Radioactive Substances Act, 1960 (United Kingdom - Parliament, 1960)). It is set up to verify that the levels of radioactivity present within foodstuffs are acceptable and to ensure that the resulting public radiation exposure is within internationally accepted limits. The monitoring is independent of similar programmes carried out by nuclear site operators as a condition of their authorisations to discharge radioactive wastes. The bulk of the report concerns the local effects of disposals from nuclear sites in the United Kingdom. However, data on the marine environment of the whole of the British Isles and further afield together with information on the levels of radioactivity in foodstuffs in areas of the UK remote from nuclear sites is included. Where appropriate, the monitoring data for nuclear sites are supplemented by results from other projects related to the behaviour of radioactivity in the environment. A summary of the scope of all radioactivity monitoring programmes as undertaken by nuclear site operators and local and central government can be found in Cotter *et al.* (1992).

To set the monitoring results from the programme in context, radioactive waste disposals from nuclear establishments in the United Kingdom in 1996 are first summarised. Before the results are presented, an explanatory section gives details of methods of sampling, analysis and presentation and explains how results are interpreted in terms of public radiation exposures. A glossary of terms and abbreviations is provided at Appendix 2.

2. DISPOSALS OF RADIOACTIVE WASTE

2.1 Radioactive waste disposal from, and in, sites on land

Data on radioactive waste disposals are published annually by the Department of Environment, Transport and the Regions (DoE, 1997), the latest available publication being for the year 1995. Details of the disposals from individual sites are available from public registers held by the Environment Agency and SEPA. A summary of 1996 disposals is included here and this enables the results of monitoring presented in this report to be considered in the context of the relevant disposals. The sites which are the principal sources of waste containing man-made radionuclides are shown in Figure 4. Our programme includes monitoring at each of these sites. For completeness, it should be noted that small disposals of radioactive waste are also authorised from other sites such as hospitals, chemical works and research establishments. Occasionally the impact of such disposals is detected within this programme e.g. Iodine 131 originating from hospitals is detected in marine samples. Small amounts of solid waste are also disposed of in specified landfill sites. In general these disposals are so insignificant that environmental monitoring of their effects is not required. However, this situation is reviewed from time to time, and small surveys are included in the programme where relevant.

Tables 1, 2 and 3 list the principal disposals of liquid, gaseous and solid radioactive waste respectively from nuclear establishments in the United Kingdom during 1996. The Tables also list the disposal limits which are authorised or, in the case of Crown operators, administratively agreed. In some cases, the authorisations specify limits in greater detail than can be summarised in a single table: in particular, periods shorter than one year are specified at some sites. The authorised limits are usually very much lower than the levels of activities which could be released without exceeding the dose limits which are recommended by the International Commission on Radiological Protection (ICRP), and embodied in national policy (United Kingdom - Parliament, 1995a). The

[a] *With effect from April 1996, this function was transferred from Her Majesty's Inspectorate of Pollution.*

percentages of the authorised (or agreed) limits taken up in 1996 are also stated in the Tables.

Where changes in the rates of disposal in 1996 have materially affected the levels of radioactivity in the environment, comments are made to this effect in the relevant part of the subsequent text.

2.2 Solid radioactive waste disposal at sea

In addition to receiving most of the discharges of liquid radioactive effluents , the marine environment has also, in the past, received packaged solid waste of low specific activity, mainly disposed of in an area of the deep Atlantic Ocean. Such disposals no longer take place, the last being in 1982. The environmental impact of the deep ocean disposals is determined by mathematical modelling and has been shown to be negligible (OECD (NEA), 1985). Disposals of small amounts of waste also took place from 1950 to 1963 in a part of the English Channel known as the Hurd Deep. The results of environmental monitoring of this area in 1996 are presented in Section 16, which confirms the negligible radiological significance of these disposals.

2.3 Beaufort's Dyke

During the period of the preparation of this report, documents were discovered in the Public Record Office which showed that small amounts of radioactive waste had been dumped in the area of the Irish Sea known as the Beaufort's Dyke during the 1950s. Prior to this discovery, knowledge of these operations had been lost for many years. Details were given in a written Parliamentary reply (House of Commons Official Report 1 July 1997, columns 158-160).

In the light of this new information, further searches of archive records relating to dumping of radioactive waste at sea were undertaken. These identified several other previously unrecognised sites around the UK where radioactive waste was dumped in the past, details of which were given in a further Parliamentary reply (House of Commons Official Report 30 July 1997, columns 322-324).

These areas are not specifically monitored as part of the surveillance programme, which is generally focused on areas around nuclear sites. The monitoring programme around nuclear sites and in regional seas around the British Isles gives no indications that the wastes disposed of give cause for concern in terms of doses to consumers or impact on the environment. The National Radiological Protection Board have been asked to carry out an independent assessment of the radiological significance of the disposals and to advise on the need for any additional monitoring (House of Commons Official Report 30 July 1997, columns 322-324, Scottish Office Press Release 30 July/0986/97).

3. SAMPLING PROGRAMME

The primary purpose of the MAFF programme is to monitor the safety of the food-chain. In order to assess the total radiation dose received by a member of the public, for comparison with dose limits, samples from the environment are also taken. In this context sampling is intended to imply not only collection of samples from the environment for laboratory analysis (which is mainly directed at food pathways), but also direct measurements in the environment of dose rates to assess external exposure pathways. Subsidiary objectives for the programme are: (i) to establish a baseline from which to judge the importance of accidental releases of radioactivity should they occur; (ii) to determine whether undeclared releases of radioactivity have occurred from sites; and (iii) to provide information on radioactivity in the diet of the general population and to aid calculation of collective radiation exposures. In Scotland as well as monitoring the safety of the foodchain the programme has the further aim of determining environmental levels of radioactivity and ensuring the protection of the environment as a whole.

Sampling is generally focused at nuclear sites licensed by the Health and Safety Executive under the Nuclear Installations Act, 1965 (United Kingdom - Parliament, 1965) where the programme serves to provide information to assist government bodies to fulfil their statutory duties under the Radioactive Substances Act, 1993 [b].

However, additional sampling is carried out remote from nuclear sites in order that the government bodies can establish the general safety of the foodchain and the environment as affected by, for example, atmospheric fallout from past nuclear weapon testing and the reactor accident at Chernobyl and disposals from nuclear sites in other nations.

The combined programme can be divided into four main sectors largely on the basis of the origin of radioactivity in the environment:

1. Nuclear sites
2. Other industrial and landfill sites
3. Chernobyl
4. Regional monitoring

Fallout from weapons tests is also detected although there is not a component of the programme to specifically measure this source.

The scope of these sectors is summarised in Table 4 and described in the following sub-sections.

[b] *In April 1996, the distribution of functions within government bodies was amended by the Environment Act, 1995 (United Kingdom - Parliament, 1995b).*

3.1 Nuclear sites

Nuclear sites are the prime focus of the programme as they are responsible for the largest disposals of radioactive waste. Monitoring is carried out in relation to each of the sites shown in Figure 4. Most sampling and direct monitoring is conducted in the site's immediate vicinity. However, because of the ability to detect the effects of disposals of liquid effluent from BNFL Sellafield in many parts of north-European waters, the programme for this site extends beyond national boundaries.

The main goal of the programme is to monitor the diet of consumers who live near nuclear sites and to estimate exposures for those small groups of people who are most at risk from disposals of radioactive waste. In the aquatic environment, the pathways which are most relevant to such a programme are ingestion of seafood, freshwater fish and drinking water and external exposure from contaminated materials. In the terrestrial environment they are ingestion of terrestrial foods, inhalation of airborne activity and external exposure from material in the air and deposited on land. The drinking water pathway is of interest for inland sites which are found in England and Wales. This pathway is considered as part of the Environment Agency's programme (Environment Agency, 1997). Inhalation of airborne activity and external exposure from airborne material and surface deposition are difficult to assess by direct measurement and are more amenable to assessment using environmental models. The main thrust of the monitoring is therefore directed at foodstuffs of all kinds. Measurements of external exposures on the shores of seas, rivers and lakes are an essential component of the calculation of the total dose to the critical group.

3.1.1 The aquatic programme

The general scope of the aquatic programme in 1996 is summarised in Table 5. The detailed programme can be deduced by reference to the results given later in this report. The main components were: sampling and laboratory analysis of a wide range of seafood and indicator materials and direct measurements of external dose rates in areas of known or suspected contamination and where public occupation occurs or is likely to occur. In both cases the frequency of measurement is dependent on the level of environmental impact from the source under scrutiny, the intervals between measurements varying between 1 month and 1 year. In addition, large-area contamination monitoring is carried out along beaches at selected sites to establish whether there is any unusual localised radioactivity which may be missed by the sediment sampling and measurement regime which is by definition selective.

The types of material sampled and the locations where samples are taken from are chosen to be representative of existing exposure pathways. Knowledge of such pathways is gained from local habits surveys and other sources. As a consequence the programme varies from site to site and, indeed from year to year, according to local circumstances. For example, shrimps are an important fishery at Hinkley Point and are a key foodstuff in the programme at this site. At Springfields little commercial fishing takes place and the bulk of the monitoring addresses external exposure pathways.

Measurements of indicator materials, such as sediments and seaweeds, whilst less directly relevant to dose, still perform an important function by, for example, providing information on trends in contamination levels in the environment. These materials can concentrate particular radionuclides and can offer a cost-effective means of determining levels of activity. In the case of sediments, there is an immediate use for activity concentration data in assessments. Such data can also be used to help distinguish contributions to the overall dose rates from artificial and natural radionuclides and different sources of artificial radioactivity.

Data from the aquatic programme is also used to aid the development of models for assessment of prospective doses.

3.1.2 The terrestrial programme

The general scope of the terrestrial programme in 1996 is summarised in Table 5. The main focus of this programme is the sampling and analysis of foodstuffs which may be affected by gaseous disposals although in some cases where food availability is limited, environmental indicator materials such as grass are monitored in place of food. Grass and soil are also sampled and analysed under obligations under the Euratom Treaty (see section 12).

The types of foodstuff sampled are chosen on a site-by-site basis to reflect local availability, however the basis of the choice is to provide information on the main components of diet; milk, meat and cereals, and on products most likely to be contaminated by disposals, such as leafy green vegetables or soft fruit. Minor foods such as mushrooms and honey, which are known to accumulate radioactivity in some circumstances, are also sampled when available.

For monitoring purposes cows' milk is generally the most important foodstuff as grass is an efficient collector of atmospheric contaminants and many of the more important radionuclides are rapidly passed from grass into milk. Milk is also a convenient product to regularly sample and analyse and is an important part of the diet, especially for young children and infants. In addition cows graze a large area of pasture and therefore the monitoring of milk provides a method of carrying out surveillance of large areas. For most analyses of milk weekly or monthly collections are bulked to provide four quarterly samples for analysis each year, although some analyses may be carried out more frequently. The frequency of analysis of other foodstuffs is generally annual in order to allow for as wide a range of sample types as possible. Samples are collected from locations as close to the sites as practicable as these are the most sensitive to the effects of disposals. In the case of milk, sampling may take place at several farms and these are labelled either as 'near' or 'far' in the tables of results depending on their distance from the site. The threshold for distinguishing between near and far farms is 8 km.

The analyses carried out on terrestrial samples reflect the relative magnitude of radionuclide disposals through the gaseous route and the transfer processes which exist for terrestrial pathways. Analysis of grass and soil in England and Wales is carried to fulfil requirements under Article 35 of the Euratom Treaty. Results are sent to the Joint Research Centre in Italy for incorporation into the Radioactivity Environmental Monitoring database. In Scotland grass only is analysed for this purpose except at Dounreay where soil is also analysed.

'Dry cloth' detectors, positioned around the nuclear sites are analysed for airborne radionuclides which have become entrapped in the cloth. Further details are given in section 4.3.

3.2 Industrial and landfill sites

Whilst the main focus of the combined programme is the nuclear industry, a watching brief is kept on other activities which may have a radiological impact on the food chain. This part of the programme considers the impact of disposals of natural radionuclides from other industries and of disposal into landfill sites other than at the disposal site at Drigg and Dounreay's own disposal facility.

A limited number of industrial sites are chosen for study because either they are known from previous research to have measurable impact on the environment or they represent a type of industrial activity which has potential effects on the environment. These sites do not require licensing under the Nuclear Installations Act. In 1996, the industrial sites studied were a chemical works at Whitehaven in Cumbria, where disposals of liquid effluent containing natural radionuclides have been shown to increase exposures through seafood consumption (Camplin *et al.*, 1996), at Buxton in Derbyshire (a lime kiln), Didcot in Oxfordshire (a coal-fired power station) and Hope in Derbyshire (a cement works). In the case of the Whitehaven site, the survey was directed at seafood sampling and analysis. At the other sites monitoring of grass, soil or animals took place because the main interest was any possible terrestrial food chain impact.

The landfill sites monitored were in East Sussex, Gwynedd, Cheshire and many Scottish areas. These landfill sites which are amongst those authorised to receive very low levels of radioactivity for controlled burial are studied to assess the extent, if any, of the contamination leaching from the site and re-entering the terrestrial environment and hence the foodchain. A landfill site in Devon which is not authorised to receive radioactive material was also studied to provide a control.

3.3 Chernobyl

The main effort to monitor the effects of the Chernobyl accident which occurred in 1986 was in relation to the continuing restrictions on the movement and sale of sheep in Cumbria, north Wales and parts of Scotland. Monitoring of other foodstuffs is now at a much reduced rate as levels have declined since the accident, but there remains a small scale survey of caesium radionuclides in freshwater fish taken from a few upland lakes.

3.4 Additional monitoring

In addition to the previous programmes which address specific sources of contamination in the United Kingdom, we also consider the levels of radionuclides in the environment more remotely from these sources as an indication of general contamination of the United Kingdom food supply and the environment. The component parts of this programme are:

- monitoring of the Isle of Man and the Channel Islands;
- dietary surveys;
- sampling of milk, crops, bread and meat;
- drinking water and air particulates in Scotland;
- seawater surveys.

3.4.1 Isle of Man and the Channel Islands

The programmes for the Insular States are designed to complement that for the United Kingdom and to take account of the possibility of long range transport of radionuclides.

Monitoring on the Isle of Man for terrestrial foodstuffs is carried out on behalf of the Department of Local Government and the Environment. It comprises sampling of a range of foodstuffs and analysis for Chernobyl, Sellafield and Heysham related radionuclides. Monitoring of seafood is primarily directed at the effects from Sellafield.

Channel Islands monitoring is carried out on behalf of the Channel Island States. It comprises sampling and analysis of seafood and indicator materials as a measure of the potential effects of UK and French disposals into the English Channel and also of historic disposal of solid waste in the Hurd Deep.

3.4.2 General diet

The purpose of the general diet surveys is to provide information on radionuclides in the food supply to the whole population, rather than to those in the vicinity of particular sources of contamination such as the nuclear industry. This programme provides background information which is useful in interpreting site-related data and also helps ensure that all significant sources of contamination form part of the site-related programme. Representative mixed diet samples are collected from thirteen regions throughout the United Kingdom. Each diet sample is prepared as for consumption and combined in amounts which reflect the relative importance of each food in the average UK diet. These samples are analysed for a range of components including radionuclides. The results for radionuclides are presented in this document. This data is also supplied to the European Commission as part of the 'Euratom monitoring' detailed later in this report.

3.4.3 Specific foods, freshwater and air particulates

Further background information on the relative concentrations of radionuclides is gained from the sampling and analysis of particular foods. These comprise milk, crops, bread and meat. Freshwater and air particulates in Scotland are also analysed to add to our understanding of radionuclide intakes by the population via ingestion and inhalation and as environmental indicators.

The milk sampling carried out within the United Kingdom in 1996 was in two networks: a 'sparse' network of 3 dairies where samples are determined to a significantly lower limit of detection than is routine; and a 'dense' network of 29 dairies which affords nation-wide coverage at higher limits of detection. Samples are taken monthly and are reported to the EU to allow comparison of results with those from other European countries.

Other food sampling complements the regional dairy programme. Crop samples were taken from twenty-six locations covering twenty-one areas throughout the United Kingdom. Bread and meat samples were taken from four areas, at present limited to Scotland. The results are used to give an indication of background levels of radioactive contamination from natural and anthropogenic sources (weapon tests and Chernobyl fallout) for comparison with samples collected from around nuclear sites.

Drinking water was sampled from twenty-nine locations throughout Scotland. The results of monitoring of drinking water in England and Wales have been published by the Department of the Environment, Transport and the Regions (DOE, 1997). Air particulates are sampled monthly at three locations in Scotland.

3.4.4 Seawater surveys

Seawater surveys are carried out in the Irish Sea, Scottish waters and the North Sea to provide information on radionuclide levels and fluxes in the coastal seas of northern Europe. Such information is used to support international studies of the health of the seas under the aegis of the Oslo and Paris Conventions (OSPAR, 1993a) to which the UK is a signatory. These surveys are mounted using government research vessels and are supplemented by a programme of spot sampling of seawater at coastal locations.

4. METHODS OF MEASUREMENT

There are two basic types of measurement made: (i) samples are collected from the environment and analysed for their radionuclide content in a laboratory; and (ii) dose rates are measured directly in the environment.

4.1 Sample analysis

The analyses carried out on samples vary according to the nature of the source under investigation. The types of analysis can be broadly categorised in two groups: (i) gamma-ray spectrometry; and, (ii) radiochemical methods. The former is a cost-effective method of detecting a wide range of radionuclides commonly found in radioactive wastes and is used for most samples. The latter comprise a range of analyses involving chemical treatments to isolate the radionuclides under study. They are sensitive methods but costly. They are therefore only used when there is clear expectation that information is needed on specific radionuclides which are not detectable using gamma-ray spectrometry.

Six laboratories analysed samples in the programmes described in this report. CEFAS * was responsible for analysis of dry cloths and all aquatic samples excluding drinking water, VLA and NRPB for gamma-ray spectrometry and radiochemistry of terrestrial samples excluding total uranium analysis, CARE for total uranium analysis of terrestrial samples, WRI for analysis of freshwater and UKAEA for analysis of air particulates. Each laboratory operates a quality control procedure to the standards required by MAFF or SEPA involving regular calibration of detectors and intercomparison exercises with other laboratories. The methods of measurement used are summarised in Table 6.

** Abbreviations are explained in Appendix 2.*

Corrections are made for the radioactive decay of radionuclides between the time of sample collection and measurement in the laboratory. This is particularly important for radionuclides with relatively short half-lives such as sulphur-35 and iodine-131. Where bulking of samples is undertaken, the date of collection of the bulked sample is assumed to be in the middle of the bulking period. Otherwise the actual collection date for the sample is used. In a few cases where short-lived radio-nuclides are part of a radioactive decay chain, the ingrowth of activity from their parent radionuclides after sample collection is also considered. Corrections to the activity present at the time of measurement are made to take this into account for protactinium-233 and thorium-234.

The analysis of foodstuffs is carried out on that part of the sampled material which is normally eaten and so, for example, the shells of shellfish and the pods from legumes where appropriate are usually discarded before analysis. Foodstuff samples are prepared in such a way so as to minimise losses of activity during the analytical stage. Thus most shellfish samples are boiled soon after collection to minimise losses from the digestive gland. For a few radionuclides, some activity may be lost in the cooking process during sample preparation. However, these losses are to be expected in the normal cooking process for the foodstuff.

4.2 Measurement of dose rates

Measurements of gamma dose in air over intertidal areas are normally made at 1 m above the ground using Mini Instruments [c] environmental radiation meters type 6-80 with compensated G-M tubes type MC-71. When the human activity resulting in exposure justifies it, for example for people living on boats or for wildfowlers lying on the ground, measurements at other distances from the ground may be made. External beta doses are measured on contact with the source, for example, fishing nets, using Berthold [c] LB 1210B contamination monitors. These portable instruments are calibrated against recognised reference standards.

4.3 Dry Cloths

The dry cloth programme provides a simple and cheap method of sampling airborne radioactive contamination around each of the major nuclear licensed sites. The dry cloth assembly consists of a v-shaped, dust retentive cloth mounted to pivot on a 2 metre rod. The assembly is set up in a relatively exposed, but secure, area and is free to turn in the wind to maximise collection. The cloths are changed each month and analysed for alpha, beta and gamma activity. Around 2000 cloths are analysed each year. Each set of results is carefully examined so that any unusual levels of activity can be followed up by further sampling or investigation at the site.

5. PRESENTATION OF RESULTS

The tables of monitoring results contain summarised values of observations obtained during the year under review. The data are generally rounded to two significant figures but it should be noted that values near to the limits of detection will not have the precision implied by using two significant figures. Observations of a given quantity may vary throughout the year and when levels above the limit of detection are recorded often these variations between observations are larger than the analytical uncertainty inherent in the observations. The variations may, for example, be due to changes in rates of discharge, different conditions in the receiving environment or the random fluctuations expected in the environment. The presentation of the summarised results expresses the overall results in terms of public radiation exposures as this provides the best means of comparison with agreed safety standards. The method of interpretation is described more fully in Section 6. The appropriate period for comparison with recommended limits is one year; standard practice is to combine annual rates of consumption or occupancy of the small group of people who are the most exposed (the critical group) with the arithmetic means of observed radioactivity concentrations or dose rates, respectively, during the year at the appropriate locations. The use of, for example, the single highest observed radioactivity concentration, where a series of measurements have been made over the year, with an annual consumption rate would not generally provide a realistic basis for comparison with the recommended limits. However, in the case of terrestrial foods excluding milk, such as meat and potatoes, it is recognised that the potential for storage of foods harvested at a particular time has to be taken into account. In such cases, we have presented the maximum concentration observed of each radionuclide in 1996 as well as the mean value. The maximum is labelled 'max.' in the tables and forms the basis for the assessment of dose. For milk samples, the most appropriate quantity for use in assessments is the arithmetic mean at the farm where the highest concentrations are observed. In most tables this is also labelled 'max.' to distinguish it from the values which are averaged over a range of farms. However for Scottish sites bulking of milk samples across farms is carried out prior to analysis. In these cases the 'max.' values are the maximum results from the analysis of bulks in a year.

The tables of concentrations are based on three types of results for individual samples. These are: (i) positively detected values above the detection limits; (ii) values at the minimum reporting level (MRL) or limit of detection (LoD); and (iii) results which are 'not detected' (ND) by the methods used. In the case of the latter category, an

[c] *The reference to proprietary products in this report should not be construed as an official endorsement of these products, nor is any criticism implied of similar products which have not been mentioned.*

ND result is indicated for aquatic samples when the uncertainty in the measurement due to counting statistics exceeds a threshold value. 'Less than' values are reported at the LoD or the MRL for terrestrial samples when the radionuclide is one which is likely to be discharged or when a positive result is detected in any other sample from the site in 1996. Limits of detection are governed by various factors relating to the measurement method used and these are described in earlier reports (MAFF, 1995). The minimum reporting level is a quantity related to the radiological significance of a particular concentration of activity. In certain cases, whilst a limit of detection may be relatively low, the requirements for reporting from analytical laboratories are defined at a higher level, that is the MRL. The concepts and values of MRL's are discussed further in earlier reports (e.g. MAFF, 1995).

When assembling data in the tables of concentrations from the analytical laboratories for the calculation of doses, values to be included are calculated assuming that the 'less than' activities are present in the sample at 'less than' levels for those nuclides which are specified in the discharge authorisation or have been detected in other samples from the same site. If a result is 'not detected' then the activity is taken to be nil.

Uncertainties in the results are reported in the tables where appropriate. For all samples except dry cloths, the uncertainties are due to counting statistics and are expressed at the 95% confidence interval. When results in the tables wholly comprise 'less than' or 'not determined' results, no uncertainties are quoted. However when they include such results, the combined uncertainty is calculated assuming the uncertainty for an individual sample is nil if the result for that sample is not positive. The combined uncertainties are calculated by taking the square root of the sum of squared uncertainties divided by the number of observations.

The majority of the analyses undertaken of terrestrial foodstuffs are carried out to routine LoD's and MRL's which are chosen to correspond to a small percentage of the dose limit for members of the public. In some cases it is useful to carry out analyses to below these routine levels to provide information on the actual concentrations of activity present and therefore facilitate more realistic assessment of activity intake by the local population and to illustrate geographical variations and time trends in results. Such results are labelled 'sub-sets' in the tables.

The results for certain measurements, particularly concentrations of total alpha, total beta, total gamma, carbon-14 and uranium-238 and thorium-232 decay chains and dose rates of beta and gamma radiation, include contributions due to natural radioactivity. Where appropriate, the assessment of exposures takes into account these contributions as discussed in Section 6.

The tables of results give an indication of the number of observations made for each material. For measurements of dose rates, each observation consists of the mean of a number of individual instrument readings at a given location.

The numbers of farms which are sampled to provide information on activities in milk at nuclear sites in England and Wales are indicated in the tables of results. In Scotland milk for all farms is bulked and the numbers in the tables refer to the number of bulked samples analysed at the site. Otherwise, the number of sampling observations in the tables of concentrations refers to the number of samples which were prepared for analysis during the year. In the case of small animals such as molluscs, one sample may include several hundred individual animals. The number of sampling observations does not necessarily indicate the number of individual analyses carried out for a particular radionuclide. In particular, determinations by radiochemical methods are sometimes carried out less frequently than those by gamma-ray spectrometry. However, the results are based on bulking of samples such that the resulting determination remains representative.

In keeping with normal practice, the concentrations of very short-lived (<3 days half-life) radionuclides which are supported by their parents are not reported in the tables. However, the concentrations of parents are quoted and it can be assumed that the concentrations of such daughter products are approximately equal to those of the parents. Examples of very short-lived radionuclides are yttrium-90, rhodium-103m, rhodium-106m, barium-137m and protactinium-234m which are formed by decay of, respectively, strontium-90, ruthenium-103, ruthenium-106, caesium-137 and thorium-234. Account is taken of the presence of these daughter nuclides when performing the calculations of exposure.

6. ASSESSMENT OF RESULTS

6.1 Radiation protection standards

The monitoring results in this report are interpreted in terms of radiation exposures of the public. The standards against which these exposures are judged are embodied in national policy on radioactive waste (United Kingdom - Parliament, 1995a). The National Radiological Protection Board (NRPB) advises the UK Government on appropriate standards, including the recommendations of the International Commission on Radiological Protection (ICRP). Current UK practice relevant to the general public is based on the recommendations of the ICRP as set out in ICRP Publications 26 (ICRP, 1977) and 60 (ICRP, 1991). The Euratom Directive on basic radiation safety standards

(Commission of the European Communities, 1984), with which UK legislation complies, is based on the recommendations of ICRP-26, but has been revised to take account of the changes in radiological protection criteria recommended in ICRP-60 (Commission of the European Communities, 1996); new United Kingdom legislation will be promulgated in due course. The International Atomic Energy Agency (IAEA) and its related inter-governmental organisations have now published their own, revised, Basic Safety Standards for Radiation Protection based on ICRP-60 (IAEA, 1996).

The ICRP-60 dose limitation system for practices involving radiation includes, within appropriate dose limits to individuals, the requirement that 'all exposures shall be kept as low as reasonably achievable...' (ALARA). This requirement involves consideration of collective, as well as individual, doses in radiological control procedures. Collective doses from radioactive waste disposals are kept under review as described later and by NRPB (Hughes and O'Riordan, (1993). The ICRP and the NRPB do not recommend a dose limit for populations; such a limit might be regarded as suggesting the acceptability of a higher population exposure than may be either necessary or probable.

The condition that doses should meet the ALARA objective is additional to the requirement to comply with appropriate individual dose limits. Control of individual exposures is intended to limit stochastic effects (i.e. those whose probability depends on the dose) to an acceptable level and to prevent non-stochastic or deterministic (threshold) effects. For stochastic effects, it is recommended that the risk should be equal whether the whole body is irradiated uniformly or non-uniformly; weighting factors proportional to the risk are defined for different organs. The weighted sum of organ doses is called effective dose in ICRP-60. Exposures from intakes of radioactivity can continue for a number of years, depending upon body retention time. The ICRP-60 committed effective dose represents the integrated exposure following an intake. The maximum dose to the general population from anthropogenic sources (excluding medical exposure)accepted by the UK Government (United Kingdom - Parliament, 1995a) is 1 mSv in a year; this limit applies to the sum of the effective dose resulting from external exposure during one year and the committed effective dose from that year's intake of radionuclides. ICRP-60 distinguishes between 'practices' which add exposures, can be controlled and to which the dose limits apply, and 'interventions' which reduce exposures from a pre-existing situation and to which the dose limits do not apply. However, it is accepted that exposures arising from past controlled releases should be included in any comparison with the dose limit to avoid any relaxation of the control of public exposure presently exercised. In practical terms at each site the dose limit is compared to the mean dose received by the 'critical group', which is that small group of people who, because of their habits and other aspects of behaviour which affect the doses received, are representative of those most exposed.

In this report, the committed effective doses to the most exposed groups in 1996 calculated from the monitoring data are therefore compared with the dose limit of 1 mSv. For external exposures, specific non-stochastic (deterministic) limits to individual organs may be appropriate. For example, the ICRP continues to recommend (ICRP, 1991) the limit for skin of 50 mSv in a year; this limit is applicable, for example, in the case of handling of fishing gear.

A recommendation in ICRP-60 is that optimisation of doses should be subject to appropriate constraints which apply within the overall limits. The UK Government has accepted that the dose constraint for a single new source should not exceed 0.3 mSv $year^{-1}$ and that, in general, it should be possible for existing plant to be operated so that the dose from a controlled source does not exceed 0.3 mSv $year^{-1}$. In cases where the 0.3 mSv dose constraint cannot be met the operator must demonstrate that the doses resulting from the continued operation of the plant are as low as reasonably achievable and within the range of tolerable risk. In addition, a 'site constraint' of 0.5 mSv $year^{-1}$ should apply to current and future operations from a number of sources with contiguous boundaries at a single location when the site cannot be optimised as an integral whole. The use of constraints is intended for predictive assessments which do not include the effects of past disposals, but for those based on monitoring data, which may include the effects of several sources and past operations, use of the dose limit of 1 mSv is appropriate.

6.2 Methods and data

Calculations of exposures of members of the public from waste disposal are based on the environmental monitoring data for 1996. These data provide information on two main pathways: (i) ingestion of foodstuffs; and (ii) external exposure from contaminated materials in the aquatic environment. In both cases, the assessment sets out to estimate exposures from these pathways for potential critical groups, that is the groups of people who are likely to be most exposed. There are three factors to consider in the assessment of the ingestion pathway: (i) the concentrations of radionuclides in foodstuffs; (ii) the amounts of food eaten; and (iii) the dose coefficients relating an activity intake to a dose.

6.2.1 Radionuclide concentrations in foodstuffs

In nearly all cases, the activities in foodstuffs are determined by monitoring and are given later in this report. The Sellafield, Isle of Man and Scottish terrestrial assessments are supplemented by information from models (see Appendix 1). In all cases the concentrations chosen for the assessment are intended to be representative of the intakes of the most exposed consumers in the population. All of the concentrations where a positive result was determined are included irrespective of the origin of the radionuclide. In some cases this means that the calculated exposures include contributions due to disposals from other sites as well as from weapon test fallout and activity deposited following the Chernobyl accident. For aquatic foodstuffs, the mean concentrations from the areas where harvesting of seafood near the site in question is known to take place are used. Positive determinations are often found for aquatic samples. Therefore, where a nuclide is 'not detected', it is assumed that its concentration is nil. For milk, the mean concentrations at a farm close to site are taken where possible. The farm is chosen by reference to the data on concentrations such that the highest values of any farm are used in the assessment. This procedure accounts for the possibility that any farm close to a site can act as the sole source of supply of milk to high-rate consumers. For Scottish sites, results for individual farms are generally not available. In such cases the maximum observed concentration in the bulk samples across farms is taken to provide an adequate degree of conservatism. For other foodstuffs, the maximum concentrations are selected for the assessment to allow for the possibility of storage of food harvested at a particular time when the peak levels in a year may have been present in the environment.

Whereas positive determinations are generally found for aquatic samples, this is not the case for terrestrial samples. It is therefore more important to take account of the possibility of activity being present when no positive determination is found, albeit at a level below the limit of detection or minimum reporting level. Such a possibility is taken into account by assuming that all radionuclides which are specified in the discharge authorisation, or have been detected in other samples at the site and are reported as being 'less than' a certain level, are indeed present at that level. Although this is likely to produce a slight overestimation of dose it will ensure that estimated exposures are unlikely to be understated.

6.2.2 Consumption rates

In the assessment of the effects of disposals of liquid effluents, the amounts of seafood consumed are determined by site specific habits surveys. Data are collected primarily by direct interviews with potential high-rate consumers who are often found in fishing communities. Techniques have included the use of consumption logging sheets (Leonard *et al*., 1982; Leonard, 1984) and consumption rate data have been interpreted using techniques based upon ICRP recommendations (Hunt *et al*., 1982) to select appropriate groups of high-rate consumers. Consideration of children's consumption rates has been included in this selection process (Leonard and Hunt, 1985).

In assessments of gaseous disposals, the amounts of food consumed are derived from recent national surveys of diet and are grouped for three age groups, adults, 10 year old children and 1 year old infants (Byrom *et al*., 1995). For each food type, consumption rates at the 97.5 th percentile of consumers have been taken to represent these people who consume a particular foodstuff at higher than average levels (the 'critical group' consumption rate). For foodstuffs where there is a marked variability in local availability, for example honey, or in personal preference, for example offal, diet surveys undertaken among local populations can provide additional data (Stewart *et al*., 1990). A programme of such surveys is being undertaken by MAFF around nuclear sites. However, it has been found that when the consumption rates for a variety of staple foodstuffs are examined, the contributions of cows' milk in the infant diet and vegetable consumption by young adults are generally the most important pathways for radionuclide intake.

The foodstuff consumption rates are given in Appendix 3.

The assessment of exposures due to gaseous disposals is based on the assumptions: (i) that the foodstuffs eaten by the most exposed group which are most affected by site operations are those that are sampled for the purposes of environmental monitoring; and (ii) that the consumption of such foodstuffs are sustained wholly by local sources. The two food groups resulting in the highest dose are taken to be consumed at 'critical group' consumption rates, while the remainder are consumed at average rates. The choice of two food groups at the higher consumption rates is based on statistical analysis by MAFF of national diet surveys which showed that only a very small percentage of the population were critical rate consumers in more than two food groups (Day, personal communication). Locally grown cereals are not considered in the assessment of exposures as it is considered highly unlikely that cereals will be made into locally consumed (as opposed to nationally consumed) foodstuffs and consumed at the critical group rates.

The simple addition of estimates of doses due to liquid and gaseous disposals at a site may produce unduly pessimistic estimates of total food doses. This is because the people most exposed to contamination from liquid or gaseous disposals are generally different. In order to provide a separate perspective on the total food dose, a calculation has been performed using a data base of food consumption rates for approximately 2000 adults in Great Britain (Gregory *et al*., 1990). The approach used is to calculate the dose to each individual in the data base assuming they obtain all of their food (except cereals and goat's milk) from the vicinity of the nuclear site under study. The concentrations of radionuclides in the foods are evaluated using the methodologies for aquatic and terrestrial foods described above. A program called INTAKE (MAFF, in preparation),which has been developed to allow calculation of the consumption of a range of foods and food components, is then used to evaluate the dose due to consumption of foods by each individual in the database and the distribution of the doses is evaluated. The 97.5 percentile of this distribution is then selected. This value does not necessarily correspond with any individual within the database. The value is presented in the rest of the report as the ' INTAKE food' dose

The consumption data base used to calculate the INTAKE food dose was derived from a seven day diary study for adults between the ages of 16 and 65 living in private households. The use of national survey data is believed to underestimate the consumption of seafood by those living in coastal communities. Work is underway to develop a data set applicable to such communities. Whilst separate data sets are available within the INTAKE program for age groups other than adults the underestimation of the consumption of seafoods by those living in coastal communities is more marked (e.g. the database for infants records no consumption of shellfish although this behaviour has been recorded in habit surveys). As the consumption of small amounts of shellfish can result in a significant proportion of the dose received as a result of consuming foodstuffs from the vicinity of the site this methodology has only been used for adults. It is hoped that the derivation of data sets for coastal communities will enable the methodology to be extended to these groups in the future. Similarly it is unlikely that a national survey of this size would have recorded the habits of the small groups who consume significant amounts of freshwater fish. For these reasons the methodology has only been applied to coastal sites.

The estimates of INTAKE food dose are for the foodchain only and do not include contributions due to external exposures, handling of fishing gear, etc.. These other exposure pathways need to be taken into account in a comprehensive assessment of the exposure of the critical group. Both INTAKE doses and doses calculated by the 'critical group' method are presented in this report.

6.2.3 Dose coefficients

Dose calculations for intakes of radionuclides are based on committed effective doses per unit intake (dose coefficients) taken from ICRP Publication 72 (ICRP, 1996). The dose coefficients used in this report are provided in Appendix 4 for ease of reference. In past reports (e.g. The Scottish Office 1996) the dose received by infants from the consumption of milk has been calculated using the dose per unit intake values appropriate to 3 month old infants. In this report, for uniformity with the calculations carried out for England and Wales the values appropriate to a 1 year old have been used. This should be considered when comparing the dose estimates reported for Scottish sites with those reported previously.

The dose assessments include consideration of children and the use of appropriate gut transfer factors. Where there is a choice of gut transfer factors for a radionuclide we have generally chosen the one which results in the highest predicted exposure. However, we have also taken into account specific research work of relevance to the foods considered in this report. This affects the assessments for polonium, plutonium and americium radionuclides.

The current ICRP advice for polonium is that a factor of 0.5 is appropriate for dietary intakes by adults (ICRP, 1994). A study involving the consumption of crab meat containing natural levels of polonium-210 has suggested that the factor could be as high as 0.8 (Hunt and Allington, 1993). Estimates of the exposures due to polonium intake have therefore been calculated using the conservative assumption that a factor of 0.8 applies to all seafood. We have retained a factor of 0.5 for other food.

Studies using adult human volunteers have suggested a factor of 0.0002 in connection with the consumption of plutonium and americium in winkles from near Sellafield (Hunt *et al.,* 1986, 1990). For these and other actinides in food in general, the NRPB considers a gut transfer factor of 0.0005 to be a reasonable best estimate (NRPB, 1990) to be used when data for the specific circumstances under consideration is not available. In this report, when estimating doses to consumers of winkles from Cumbria, a gut transfer factor of 0.0002 is used for plutonium and americium. For other foods and for winkles outside Cumbria the factor of 0.0005 is used for these radioelements.

6.2.4 External exposure

In the assessment of external exposure there are two factors to consider: (i) the dose rate from the source and (ii) the time spent near the source. In the case of external exposure to penetrating gamma radiation, uniform whole body exposure has been assumed. The measured quantity is air kerma rate. When interpreting this in terms of radiological effect, an air kerma rate of 1 mGy h^{-1} has been taken as producing an effective dose equivalent rate of 0.87 mSv h^{-1} (Spiers *et al.*, 1981). This factor does not change significantly for effective dose under ICRP-60 (NRPB, 1993). For external exposure of skin, the measured quantity is contamination in Bq cm^{-2}. In this case, dose rate factors in Sv $year^{-1}$ per Bq cm^{-2} are used which are calculated for a depth in tissue of 7 mg cm^{-2} (Kocher and Eckerman, 1987). The exposure of gonads from beta radiation is assessed using the methods described by Hunt (1992). The times spent near sources of external exposure are determined by site specific habits surveys in a similar manner to consumption rates of seafood. The occupancy and times spent handling fishing gear are given in Appendix 3.

6.2.5 Subtraction of 'background' levels

When assessing the man-made effect on external exposures to gamma radiation and internal exposures due to ingestion of carbon-14 and radionuclides in the uranium and thorium decay series in seafood, estimates of dose rates and concentrations, as appropriate, due to natural background levels are subtracted. Background carbon-14 concentrations in terrestrial foods are also subtracted. The estimates of background concentrations are given in Appendix 5. On the basis of measurements made previously as part of the programmes reported here, the gamma dose rate backgrounds in the aquatic environment were taken to be 0.05 $\mu Gy\ h^{-1}$ for sandy substrates, 0.07 $\mu Gy\ h^{-1}$ for mud and salt marsh and 0.06 $\mu Gy\ h^{-1}$ for other substrates. These data are compatible with those presented by McKay *et al.* (1995). However, where it is difficult to distinguish the result of a dose rate measurement from natural background, the method of calculating exposures based on the concentrations of man-made radionuclides in sediments (Hunt, 1984) has been used. Estimates of external exposures from beta radiation include a component due to natural sources because of the difficulty in distinguishing between natural and man-made contributions. Such estimates are therefore conservative when compared with the relevant dose limit which excludes natural sources of radiation.

7. BRITISH NUCLEAR FUELS PLC (BNFL)

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 plants supplying electricity to the national grid. Regular monitoring is carried out of the environmental consequences of disposals of radioactive waste from five BNFL sites, namely Sellafield, Drigg, Springfields, Capenhurst and Chapelcross.

7.1 Sellafield and Drigg, Cumbria

Operations and facilities at Sellafield include fuel element storage, the Magnox and oxide fuel reprocessing plants, decommissioning of some facilities and the Calder Hall Magnox nuclear power station. Radioactive waste disposals include a very minor contribution from the adjoining UKAEA Windscale and AEA Technology facilities. The most significant disposals 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. Small disposals are made from the Drigg site, the function of which is to receive low level solid radioactive wastes from Sellafield and other UK sites and to dispose of them in engineered vaults on land.

7.1.1 The aquatic monitoring programme

Liquid radioactive wastes from both Sellafield and Drigg are discharged under separate authorisations effectively to the same body of water on the Irish Sea coastline. The sites are therefore considered together for the purpose of aquatic environmental monitoring.

Disposals from the Sellafield pipelines during 1996 are summarised in Table 1. Total alpha and beta disposals were 0.275 and 143 TBq respectively (1995: 0.397 and 188 TBq respectively). The small reductions were mainly due to the continued operation of the Enhanced Actinide Removal Plant (EARP) and a reduction in the activities released by the processing of stored wastes. All disposals were within the limits set in the authorisations.

The main function of the Drigg site is to receive low level solid radioactive wastes from Sellafield and other UK sites and to dispose of them in engineered trenches on land. The authorisation for disposals allows for the discharge of leachate from the trenches through a marine pipeline. The limits for activity to be discharged through the marine pipeline and for concentrations of residual activity in the Drigg Stream are given in Table 1. These disposals are small compared with those discharged from the Sellafield site. MAFF marine monitoring of the Drigg site is subsumed within the Sellafield programme which is described in the remainder of this sub-section. The contribution to exposures due to Drigg disposals is negligible compared with that due to Sellafield and any effects of Drigg disposals could not be detected in 1996 above those due to Sellafield. Regulatory monitoring of the Drigg Stream is carried out by the Environment Agency (Environment Agency, 1997).

Regular monitoring of the marine environment near Sellafield continued during 1996. Important radiation exposure pathways were consumption of fish and shellfish and external exposure to gamma rays and beta particles from occupancy over sediments, with other pathways being kept under review. In 1996, as in previous recent years, there was no harvesting of *Porphyra* seaweed in west Cumbria for manufacture of laverbread, but monitoring continued because the pathway remains potentially important. A general review of radioactivity in the Irish Sea has been compiled by Kershaw *et al.* (1992). In addition, Hunt

(1995) has provided a reconstruction of exposures due to Sellafield liquid disposals from the beginning of operations in 1952 through to 1993 and Hunt *et al*. (in press) have reviewed the recent changes in disposals and effects from the site.

7.1.1.1 The fish and shellfish consumption pathway

7.1.1.1.1 Concentrations of radioactivity

Concentrations of beta/gamma activity in fish from the vicinity of the Irish Sea and from further afield are given in Table 7. Data are listed by location of sampling or landing point, in approximate order of increasing distance from Sellafield. Samples taken near other nuclear establishments which reflect Sellafield disposals are given later in this report. The 'Sellafield Coastal Area' extends 15 km north and south of Sellafield from St Bees Head to Selker and 11 km offshore; most of the local fish and shellfish consumed by the local most exposed group is taken from this area. Specific surveys are carried out in the smaller 'Sellafield Offshore Area' where experience has shown that good catch rates may be obtained. This area consists of a rectangle, one nautical mile wide by two nautical miles long, situated south of the pipelines with the long side parallel to the shoreline; it averages about 5 km from the pipeline outlet.

The results generally reflect the progressive dilution of radiocaesium with increasing distance from Sellafield. However the rate of decline of radiocaesium concentrations with distance is not as marked as was the case some years ago, because significant reductions in disposals have been achieved and the effect of the remobilisation of radiocaesium discharged in the past from sediment. Radiocaesium in fish from the Baltic is not due to Sellafield disposals but is substantially from the Chernobyl accident (Aakrog *et al.,* 1991). This is the most likely source of activity in fish sampled from a retail shop in Great Yarmouth. Concentrations of radiocaesium in fish known to have been caught in Icelandic waters remained typical of those from weapon test fallout, at a value of about 0.3 Bq kg^{-1} for caesium-137 in cod. Data for the Barents Sea are similar. In the Irish Sea, the ratios of caesium-137 to caesium-134 were generally higher than those in recent disposals from Sellafield, even allowing for residence time in the water and uptake into fish; this suggests that a significant contribution from aged radiocaesium is present, due to remobilisation from the sediment of the Irish Sea (Hunt and Kershaw, 1990). There were small increases in concentrations of carbon-14 and technetium-99 in fish from the eastern Irish Sea in 1996 reflecting increases in disposals of these radionuclides from the site in recent years.

A sample of rainbow trout from a small lake near Sellafield was again collected this year. The caesium-137 concentration in the sample, 110 Bq kg^{-1}, was less than in 1995 (480 Bq kg^{-1}), the variability of activities in samples of freshwater fish is known to be high (Camplin *et al.*, 1989). The absence of any detected caesium-134 in the sample suggests that fallout from Chernobyl, which is detected in other freshwater fish in Cumbria, is unlikely to be the source of activity nor would fallout from atmospheric weapon tests be the source at these concentrations. A trace amount of cobalt-60 which is likely to have originated from operations at Sellafield was also detected in the sample.

There were small increases in concentrations of carbon-14 and technetium-99 in fish from the eastern Irish Sea in 1996 reflecting changes in disposals from the site in recent years. However, the trend of decreasing concentrations of radiocaesium in fish in the area continued. Concentrations of caesium-134 and -137 in Baltic fish continued to reflect the effects of the Chernobyl accident in 1986.

For shellfish, a wide range of radionuclides contribute to radiation exposure of consumers owing to generally greater uptake in these organisms than in fish. Table 8 lists concentrations of beta/gamma-emitting nuclides (except plutonium-241) and total beta activity in shellfish from the Irish Sea and further afield. Crustaceans and molluscs are of particular radiological importance to the most exposed group near to Sellafield, as described later in this section. In addition to sampling by MAFF, supplies of winkles, mussels and limpets were obtained from consumers who collected them in the Sellafield Coastal Area exploited by this most exposed group near to Sellafield.

Concentrations of artificial radionuclides in shellfish, as with fish, diminish with increasing distance from Sellafield. There are substantial variations between species: for example, lobsters tend to concentrate more technetium-99 in comparison to crabs. In addition, molluscs tend to concentrate the less mobile nuclides to a greater extent than crustaceans, which in turn tend to concentrate them more than fish. The reverse behaviour has also been true for mobile nuclides in the past. However, since the importance of caesium-137 associated with sediment has increased relative to current disposals, concentrations of this nuclide in molluscs have tended to be higher than or similar to those for crustaceans. There were both increases and decreases of concentrations of beta/gamma-emitting radionuclides in shellfish in 1996. Increases occurred for carbon-14, technetium-99 and ruthenium-106 and decreases for ruthenium-103 and caesium-137. These changes reflect changes in disposals of these radionuclides but the magnitude of the change in discharge from 1995 to 1996 was not necessarily matched by an equivalent change in concentration over the same period. Such differences are caused by several factors including the timing of sampling and the rate at which biota respond to their environment.

Analyses for transuranics are labour-intensive; as in previous years, a selection of samples of fish and shellfish chosen mainly on the basis of potential radiological significance was analysed for transuranic nuclides. The data for 1996 are presented in Table 9. Transuranics are less mobile than radiocaesium in sea water; this is reflected in higher concentrations of transuranics in shellfish as compared to fish, and a rapid reduction with distance from Sellafield in concentrations of transuranics, particularly in shellfish. Over the past decade disposals of transuranic nuclides from Sellafield have reduced significantly, resulting in overall decreases in concentrations of these nuclides in fish and shellfish. However, the non-mobile nature of these nuclides causes a delayed effect in the environment (Hunt, 1985) such that a contribution to present concentrations is provided by disposals in earlier years. In 1996, concentrations of transuranic nuclides in fish and shellfish were generally similar to those observed in 1995.

Concentrations of natural radionuclides in fish and shellfish in the Sellafield area are presented in Section 13.

7.1.1.1.2 Individual dose

Table 10 summarises doses in 1996 from artificial radionuclides in seafood. The committed effective dose to the local most exposed group of seafood consumers was 0.14 mSv. The increase in dose from 0.12 mSv reported for 1995 (MAFF, 1996) is largely due to an increase in consumption of lobsters (2.2 kg in 1995, 4.8 kg in 1996) by the most exposed group and the increased concentrations of technetium-99, particularly in lobsters.

Data for natural radionuclides in fish and shellfish are discussed in Section 13; however, the effects on the Sellafield most exposed group of controlled disposals of natural radionuclides from another west Cumbrian source, Albright and Wilson Ltd, Whitehaven, are considered here to enable the total dose to be compared to the limit of 1 mSv. The exposure of the local group of seafood consumers due to the enhancement of concentrations of natural radionuclides in the Sellafield area in 1996 was 0.075 mSv using a gut uptake factor for polonium of 0.8. Most of this was due to the polonium-210 and lead-210 content of shellfish. This gives a total dose to this group of 0.22 mSv. These doses may be compared with an average dose rate of approximately 2.2 mSv year^{-1} to members of the UK public from all natural sources of radiation (Hughes and O'Riordan, 1993) and are well within the limit of 1 mSv.

Exposures of groups representative of the wider fishing communities associated with fisheries in Whitehaven, Dumfries and Galloway, Fleetwood and the Morecambe Bay area have been kept under review (Table 10). The doses received by these groups are significantly less than that for the local Sellafield group because of the lower concentrations observed further afield. There were small increases in the doses at Whitehaven, Dumfries and Galloway, Morecambe Bay and Fleetwood in 1996 when compared with those in 1995 (0.039, 0.053, 0.073 and 0.031 mSv respectively) (MAFF, 1996). This was partly due to the increased concentrations of technetium-99 in seafood. All doses were well within the dose limit for members of the public of 1 mSv.

The dose from artificial radionuclides, appropriate to a consumption rate of 15 kg year^{-1} of fish from landings at Whitehaven and Fleetwood, is also given in Table 10. This consumption rate represents an average for typical fish-eating members of the public. The dose in 1996 was <0.002 mSv, the same as that for 1995 (MAFF, 1996).

The exposure of consumers of trout from a local fish farm were also considered in 1996. Their exposure, based on consumption rate data obtained by interview, was 0.010 mSv or 1% of the dose limit of 1 mSv. This includes a contribution due to Chernobyl and weapon test fallout.

7.1.1.2 External exposure

A further important pathway leading to radiation exposure as a result of Sellafield disposals arises from uptake of gamma-emitting radionuclides by intertidal sediments in areas frequented by the public. In general, it is the fine-grained muds and silts prevalent in estuaries and harbours, rather than the coarser-grained sands to be found on open beaches, which adsorb the radioactivity more readily. Gamma dose rates currently observed in intertidal areas are mainly due to radiocaesium and natural radionuclides.

A range of coastal locations is regularly monitored, both in the Sellafield vicinity and further afield, using portable gamma-radiation dosimeters. Table 11 lists the locations monitored together with the dose rates in air at 1 m above ground. Dose rates on Irish Sea shorelines, near other nuclear establishments which reflect Sellafield disposals, are given later in this report. Variations in sediment type from place to place account for the quite marked fluctuations in dose rate, superimposed on a general decrease with increasing distance from Sellafield. Dose rates over intertidal areas throughout the Irish Sea in 1996 were similar to those data for the same locations in 1995 (MAFF, 1996). Data for the River Calder continued to show an excess above natural background and it is likely that the main cause is direct radiation from Calder Hall. However, there may also be a contribution due to radionuclides in small patches of sediments in the river. The occupancy by members of the public, for example anglers, of this section of the river is low. It is unlikely that more than a few tens of hours per year is spent near the sediment patches and, on this basis, the resulting exposures were much less than those of intertidal areas discussed subsequently in this sub-section.

Radioactivity concentrations in surface sediments are also regularly monitored, both because of relevance to dose rates and in order to keep under review distributions of adsorbed radioactivity. Concentrations of beta/gamma radioactivity and transuranics, in most cases at the same locations as the dose rate measurements, are given in Table 12. Variations due to similar causes to those of the variation in dose rates are observed, and comparison with results for 1995 (MAFF, 1996) shows similar amounts of radioactivity. Data for small patches of sediment in the River Calder are also included in Table 12. Cobalt-60 is present in these samples and this may be due to deposition of authorised disposals to air from Calder Hall.

In western Cumbria the maximum exposure in 1996 was 0.049 mSv for a fisherman who lives on a boat in Whitehaven harbour. His dose reduced from 0.060 mSv in 1995 because of reduced external dose rates on his boat. The exposure of anglers who dig bait near to Sellafield and who fish in the Cumbrian coastal area also decreased in 1996, from 0.13 mSv (1995) to 0.038 mSv. This was due to reduced occupancies and movement from higher to lower dose rate areas. Both estimates include a small contribution due to consumption of seafood. In the wider area, including Cumbria, Lancashire and the north Solway coast it is considered that houseboat dwellers in the Ribble estuary are representative of those who receive the highest external exposures from the effects of disposals from Sellafield. Making an allowance for natural background using a dose rate of 0.07 $\mu Gy\ h^{-1}$ their external exposure in 1996 was 0.14 mSv, which is more than the value for 1995 of 0.091 mSv calculated on the same basis. The increase was mainly due to an increase in occupancies on the boat. Most of the external exposure of the houseboat dwellers was due to the radioactivity already in the environment as a result of past disposals from Sellafield.

It is to be noted that inhalation of resuspended beach sediments and inadvertent ingestion of the same material give rise to only minor radiation exposures to the public compared with the external radiation pathway considered in this sub-section (Wilkins *et al.,* 1994). In areas of salt marsh and sea-washed pastures such as the Ravenglass estuary exposures from pathways other than those due to external radiation need consideration, and these are monitored regularly. Meanwhile, doses including external radiation in such areas were cautiously assessed for 1989 to be well within the dose limit of 1 mSv (Wilkins *et al.,* 1994). This would also have been the case in 1996 because relevant concentrations of activity and dose rates in such areas have reduced since 1989. Monitoring in the Ravenglass estuary is considered further in sub-section 7.1.2.

7.1.1.3 Fishing gear

During immersion in sea water, fishing gear may entrain particles of sediment on which radioactivity is adsorbed. Fishermen handling this gear may be exposed to external radiation, mainly to skin from beta particles. Fishing gear is regularly monitored using portable beta dosemeters. Results for 1996 are presented in Table 13. Measured dose rates were generally similar to those for 1995 (MAFF, 1996). Habits surveys keep under review the amounts of time spent by fishermen handling their gear; for those most exposed, a time handling nets and pots of 2500 h $year^{-1}$ was appropriate. The skin exposure from handling of fishing gear in 1996, including a component due to natural radiation, was 0.31 mSv, which is less than 1% of the dose limit appropriate for exposures to skin of members of the public. Handling of fishing gear therefore continues to be a minor radiation exposure pathway.

7.1.2 The terrestrial monitoring programme

Because of the proximity of the sites, environmental monitoring at Sellafield and Drigg are considered together in this sub-section. In addition, the programme around the Ravenglass estuary approximately 10 km south of the Sellafield is included. The purpose of that programme is primarily to investigate contamination of sea-washed land resulting from disposals of liquid waste from Sellafield.

7.1.2.1 Sellafield

Disposals of gaseous wastes from Sellafield are summarised in Table 2. They were generally similar to those in 1995.

The sampling programme for terrestrial foods in the vicinity of Sellafield was the most extensive of those for the nuclear sites in England and Wales in order to reflect the scale of the operations on the site. A wide range of foodstuffs were sampled including milk, fruit, vegetables, eggs, meat and offal, mushrooms, game, honey, cereals and indicator materials such as grass and soil. Samples were obtained from different locations around the site in order to encompass the possible variations in activity levels due to the influence of meteorological conditions on the dispersal of gaseous disposals. The analyses undertaken included gamma-ray spectrometry and specific measurements for tritium, carbon-14, sulphur-35, strontium-90, technetium-99, iodine-129, radiocaesium, polonium-210, uranium and transuranics. The polonium-210 analyses were carried out to give an indication of any historic contamination from past disposals and also to confirm that there is no continuing source of this nuclide at Sellafield.

The results of monitoring in 1996 are presented in Table 14. The concentrations of all radionuclides were low and there was no indication of widespread contamination from the site. However, small enhancements of some radionuclides were found close to the site.

The ratio of the mean concentration in milk collected from near and milk from far farms was close to 1 for all radionuclides except tritium and strontium-90 when it was 2-3. Stronger evidence was found for a site-related effect by examination of the maximum concentrations at single farms. In this case, ratios greater than 1 were also found for sulphur-35 (4), iodine-129 (2) and caesium (3). As will be shown later, taken together it is those radionuclides in milk which make the greatest contribution to exposures of consumers of locally produced food. Concentrations in milk were generally less than those in 1995 (MAFF, 1996). The decrease for sulphur-35 is probably a consequence of the levels in 1995 being increased by the enhanced levels of sulphur-35 discharged from the Calder Hall reactors during May 1995. Levels measured in 1996 are comparable to those in previous years.

Enhanced disposals of iodine-129 took place during April 1996. Contemporary milk sampling and analysis gave iodine-129 concentrations in milk of 0.05 Bq kg^{-1}, about four times the mean value for 1996. Hypothetical consumption of milk at the enhanced concentration for a full year would have given rise to a very low level of exposure of 0.004 mSv.

Samples of apples, blackberries and elderberries were analysed in 1996. All three fruits were good indicators of the local effects of disposals from Sellafield. Plutonium concentrations, whilst much lower than those found in seafood, gave isotopic ratios ((239+240)/238) less than 20. With a ratio of about 40 expected for background weapon test fallout, these data demonstrate a local source. The concentrations of plutonium in elderberries were the highest of those determined in any terrestrial food at Sellafield in 1996. The Pu-241 levels were comparable to those measured in previous years (1996 1.8 Bq kg^{-1}, 1995 2.2 Bq kg^{-1}). Concentrations of carbon-14 in fruit samples were also in excess of the concentrations assumed as representative of background values (Appendix 5). Concentrations of other radionuclides, for example tritium, sulphur-35, and strontium-90, also provided evidence of a local effect. Where it was possible to compare data for fruit in 1996 with those for 1995, similar concentrations of activity were found. However, in view of the limited number of samples obtained, no conclusion can be drawn as to whether there is a significant trend in levels of any particular radionuclide.

Levels of activity in bovine and ovine meat and offal continued to be analysed in 1996. Concentrations of radionuclides were low, with limited evidence for the effects of Sellafield disposals in data for tritium, carbon-14, sulphur-35, strontium-90 and the plutonium isotopic ratio.

Both barley and wheat were sampled as being representative of cereals in 1996. Sulphur-35 was detected in both samples, indeed cereals contained the highest levels of this radionuclide when compared with other food groups (15 Bq kg^{-1} in barley 1996 and 17 Bq kg^{-1} in 1995). In common with meat and offal samples limited evidence for the effects of Sellafield disposals was also found in data for the plutonium isotopic ratio. The vegetables sampled in 1996 were cabbage, carrots, cauliflower, potatoes and turnips. Concentrations of transuranic radionuclides in vegetables were very low and did not provide as distinct a Sellafield signal in the plutonium isotopic ratio as some other food groups. Evidence of the effects of Sellafield was also weak for other radionuclides in vegetables with the possible exception of tritium and carbon-14.

Finally, the most distinctive feature of the data for eggs, game, mushrooms and honey was that deer muscle and honey contained relatively high levels of caesium (38 and 11 Bq kg^{-1} respectively). Deer muscle was not sampled in 1995 and the level of caesium in honey was 1.1 Bq kg^{-1}. These levels of caesium are likely to include a contribution from Chernobyl fallout.

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The dose received by the most exposed group of terrestrial food consumers was calculated using the methods and data presented in Section 6. The results are presented in Table 15. Calculations were performed for three age groups (adults, 10y and 1y) and the doses received by the 1-year-old age group were found to be the highest, at <0.055 mSv (Adult: <0.040; 10y: <0.040). The most significant contributions to this dose were from carbon-14, sulphur-35, strontium-90 and ruthenium-106. The most important foodstuff was milk which accounted for 60% of the dose. The exposure is an upper estimate of the effects of Sellafield disposals because: (i) it is based on the assumption that a radionuclide which is not detected in a sample is present at a concentration equivalent to the limit of detection; (ii) the effects of the background of artificial nuclides in the area from Chernobyl and weapon test fallout are included; and (iii) it is assumed that most food consumed is locally produced.

The exposure of the most exposed group of terrestrial foodstuff consumers (infants) decreased in 1996 to <0.055 mSv (1995: <0.081 mSv) because of a general reduction in concentrations in foods.

The dose received by a typical adult consumer obtaining food from the vicinity of Sellafield, <0.021 mSv, was much less than this.

7.1.3 Total food exposures

The INTAKE food exposures, combining aquatic and terrestrial data for Sellafield, have been estimated using the method described in Section 6. In 1996, the dose to adults from food consumption, excluding contributions from intakes through inhalation and from external radiation, was <0.035 mSv or less than 5% of the dose limit of 1 mSv.

7.1.4 Drigg

No gaseous disposals are authorised from Drigg. The monitoring programme is therefore primarily directed at the potential migration of radionuclides from the waste burial site via ground water.

Results for 1996 are given in Table 16. Low concentrations of tritium which may have leached from the site were found in rabbits and mushrooms, however they were of negligible radiological significance. Other than this there was no evidence to suggest migration of activity from the site was taking place. In general concentrations of other radionuclides detected were lower than those found near Sellafield. The radiation exposure of the most exposed group, including a component due to Chernobyl or weapon test fallout was less than 0.020 mSv or 2% of the dose limit of 1 mSv.

7.1.5 Other Surveys

As part of the surveillance programme in west Cumbria samples and measurements are taken in other locations in addition to those detailed above.

7.1.5.1 Contact dose-rate monitoring of intertidal areas

Contact beta and gamma dose rates in intertidal areas are regularly monitored using purpose-built large-area detectors to locate and remove any material with unusual levels of contamination. Two items were found in 1996 with contact dose rates of 1 and 3 mSv h^{-1}. The former was a fragment of a rubber glove found in March. Analysis revealed this to be contaminated with caesium-137, strontium-90 and europium-154. In July a piece of tape contaminated with caesium-137 and strontium-90 was found. A routine programme of measurements of beta dose rates on contact with shoreline sediments continued in 1996 in order to establish the contribution to effective dose made by exposures of people, such as bait diggers, who handle sediments regularly, and to estimate their skin exposures for comparison with the non-stochastic dose limit of 50 mSv. The results of the measurements made using portable beta dosemeters are presented in Table 17.

The skin exposure of anglers who dig bait, based on a time handling sediment of 510 h $year^{-1}$, was 0.15 mSv in 1996 which is 0.3% of the appropriate dose limit. The contribution this source of exposure makes to effective dose is included in the assessment in sub-section 7.1.1.2.

7.1.5.2 Ravenglass

The main purpose of the monitoring of terrestrial foodstuffs in the Ravenglass area is to determine whether there is a significant transfer of radionuclides from sea to land. In order to investigate this samples of milk, crops, fruit, livestock and indicator materials are collected and analysed for radionuclides which are released in liquid effluent disposals from Sellafield. In addition analyses for sulphur-35 are also undertaken for comparison with results for the immediate area around Sellafield.

The results of measurements in 1996 are presented in Table 18. In general, the data are similar to those for 1995 (MAFF, 1996) and show lower concentrations than are found in the Sellafield vicinity. Evidence for sea to land transfer is limited. Technetium-99 concentrations in duck and ovine offal were the highest in any terrestrial foodstuffs sampled, albeit at very low levels, less than 1 Bq kg^{-1}. However, concentrations in grass of this nuclide reduced from 3.7 (1995) to 0.055 Bq kg^{-1}. A small amount of promethium-147 (1.9 Bq kg^{-1}) was detected in cabbages from Ravenglass though the concentrations in grass were similar to those found at Drigg. Concentrations of plutonium isotopes in some samples indicated a local source in that the plutonium-239/240 to plutonium-238 ratio was substantially less than that expected due to weapon test fallout. Taken together these observations suggest that some sea to land transfer of radionuclides takes place, though the resulting effect is minor.

The only other indication of the effects of Sellafield disposals is found in barley and carrots where a low concentration of sulphur-35 was detected. This would have been due to gaseous disposals from the site.

The exposure due to consumption of terrestrial foods from Ravenglass in 1996 is given in Table 15. The 1 year-old age group received the highest exposures. Their exposure, including contributions from Chernobyl or weapon test fallout, was less than 0.034 mSv or 3% of the dose limit of 1 mSv. This is substantially less than the value for the same age group near Sellafield. From this evidence, sea to land transfer in this area is not having a major effect on the terrestrial food chain.

7.1.5.3 Research and other surveys

In addition to the monitoring described above, which is related to the most (or potentially most) significant radiation exposure pathways as a consequence of Sellafield disposals, a number of further investigations are undertaken. Some of these are of a research nature; however, they also enable pathways of lower current importance to be kept under review.

Seaweeds are useful indicator materials; they may concentrate certain radionuclides, so they greatly facilitate measurement and assist in the tracing of these radionuclides in the environment. Table 19 presents the results of measurements in 1996 on marine plants from shorelines of the Irish Sea and further afield. Although small quantities of samphire and *Rhodymenia* (a seaweed) may be eaten, concentrations of radioactivity were of negligible radiological significance. *Fucus* seaweeds are useful indicators, particularly of fission product radionuclides other than ruthenium-106; samples of *Fucus vesiculosus* seaweed were collected both in the Sellafield vicinity and further afield, and the results are presented here. These clearly showed the effects of increases in disposals of technetium-99 from Sellafield in recent years. Such seaweeds are sometimes used as fertilisers and soil conditioners. However, the exposures from consumption of crops grown on land to which seaweed has been applied have been estimated to be low (Camplin *et al.*, in preparation). Analyses of similar samples collected in Northern Ireland are carried out on behalf of the Environment and Heritage Service (NI).

No harvesting of *Porphyra* in west Cumbria, for consumption after being made into laverbread, was reported in 1996; this pathway has therefore remained essentially dormant. However, monitoring has continued in view of its potential importance, historical significance and the value of *Porphyra* as an indicator material. Samples of *Porphyra* are regularly collected from selected locations along UK shorelines of the Irish Sea. Results of analyses for 1996 are presented in Table 19. Samples of laverbread from the major manufacturers are regularly collected from markets in South Wales and analysed. Results for 1996 are also presented in Table 19. The exposure of critical laverbread consumers in South Wales was much less than 0.005 mSv, confirming the virtual abeyance of this exposure pathway.

7.1.6 Collective dose

Collective doses, received during 1996 from consumption of fish and shellfish, have been estimated for the UK and other European countries. In general, the method used has been to combine data on actual fish and shellfish landings from relevant sea areas with average radioactivity concentrations in fish and shellfish caught in these areas. This method differs from that based on modelling of water movements and a (usually) fixed catch rate for different sea areas; the modelling method generally derives the collective dose to be received over a number of years as a result of disposals during the year under review, and the results are not readily comparable with those based on the present method. Sea areas considered in this assessment include the Irish Sea, Scottish waters, the North Sea, the English Channel, Baltic Sea, Norwegian Sea, Spitzbergen/Bear Island area and the Barents Sea. Corrections have been made for the fraction of fish or shellfish consumed. The contribution of weapon test fallout to the radioactivity concentrations has been subtracted. Consideration has been given to the pathway due to fish offal and industrial fisheries, the product of both of which is fish meal which is fed to pigs, poultry, ruminants and farm-reared fish. Consumption of food products from these animals gives rise to a small contribution to the collective dose, and this has been included.

Liquid radioactive waste disposals from Sellafield are the main source of collective dose; by comparison, the effect of liquid disposals from other establishments is very small. The small contribution due to fallout from the Chernobyl reactor accident to the Irish Sea, Scottish waters and the North Sea has been included. Most of the collective dose is due to radiocaesium in edible fish; however, approximately one quarter of the total dose is due to plutonium and americium radionuclides in shellfish. Carbon-14, strontium-90 and technetium-99 also make a small contribution to the collective dose, about 10% of the total. The results for 1996, of 4 man-Sv for the UK and 19 man-Sv for other European countries are similar to those reported for 1995. The trend of collective dose in recent years is shown in Figure 5.

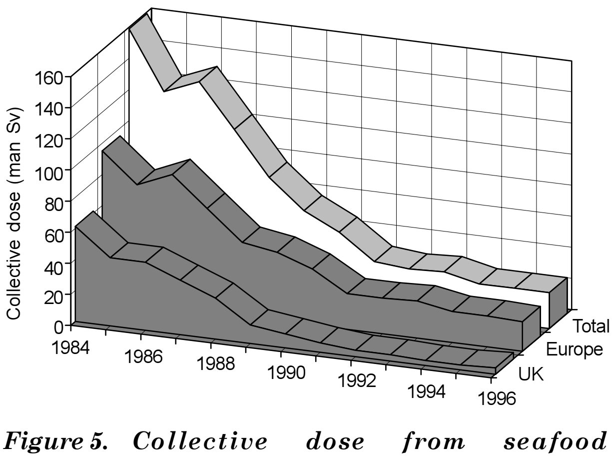

Figure 5. Collective dose from seafood consumption due to nuclear industry discharges

The collective dose to the UK population due to the effects of liquid disposals may be compared to that from other sources. In Hughes and O'Riordan (1993) the collective dose to the UK population from all sources of natural background radiation is given as 127,000 man-Sv and that from all sources of artificial radiation as 23,000 man-Sv. Therefore the UK collective dose delivered in 1996 through the seafoods pathway as a result of liquid radioactive waste disposals was less than 0.01 % of the total from all sources of radiation.

7.2 Springfields, Lancashire

This establishment is mainly concerned with the manufacture of fuel elements for nuclear reactors and the production of uranium hexafluoride. Radioactive liquid waste arisings consist mainly of thorium and uranium and their decay products; liquid disposals are made by pipeline to the Ribble estuary. Disposals of beta emitting radionuclides, which result in the greatest contribution to the radiological impact, increased in 1996 (153 TBq) as compared with 1995 (112 TBq) because of increased processing of uranium ore concentrate, but remained well within authorised limits. Disposals of gaseous effluents remained very low at a similar level to those for 1995.

Public radiation exposure in this vicinity, as a result of site disposals, is relatively low; there is, however, a contribution in the estuary due to Sellafield disposals. The most important marine pathway is external exposure, due to adsorption of radioactivity on the muddy areas of river banks and in salt marshes. The most exposed group consists of people who live on a houseboat moored in a muddy creek of the Ribble estuary. A habits survey was undertaken in 1996 and identified other activities which were found to have significant occupancies for example wildfowling and bird conservation which take place in intertidal areas and marshes bordering the estuary, and angling which is popular in the Preston area. The survey also identified consumers of seafood, particularly fish and shrimps, and they are considered as a potential critical group in this report. Gamma and beta dose rates are regularly monitored in relevant areas including muddy creeks where houseboats are moored, and some of these measurements are supported by analyses of sediments. Locally obtained fish, shellfish and samphire continued to be sampled. A study (Rollo *et al.,* 1994) has shown that exposures due to airborne radionuclides which may have come from disposals to the estuary and are subsequently remobilised are negligible.

Monitoring of terrestrial foods included sampling of milk, fruit, vegetables and duck. Indicator materials including dry cloths, grass, soil and animals faeces were also sampled.

Results for 1996 are shown in Tables 20(a) and (b). Radionuclides detected which were partly or wholly due to Springfields disposals were isotopes of thorium, uranium and their decay products. Natural sources also contributed to these activities. Other radionuclides present were mainly from Sellafield.

Gamma dose rates over intertidal areas in 1996 were similar to those in 1995. The results of beta dose rate measurements are highly variable but there was a general increase in results for 1996 due to increased disposals from the site. In 1996 the exposure of the most exposed group of houseboat dwellers including the Sellafield component was 0.14 mSv, an increase from the value for 1995 (0.091 mSv) because of an increase in occupancies on the boat. Most of this exposure was due to the radioactivity already in the environment as a result of past disposals from Sellafield. The whole-body exposure of bird conservationists, anglers and wildfowlers were assessed as being 0.080, 0.044 and 0.042 mSv respectively in 1996. A significant proportion of the dose is due to Springfields disposals. Consumption of wildfowl makes a very small contribution to the dose received by wildfowlers because of the very low concentrations of radionuclides in ducks and geese.

The most exposed group for skin irradiation was bird conservationists with skin exposures, including a component due to natural radiation, of 4.2 mSv in 1996. This is 8% of the relevant dose limit for members of the public.

Seafood consumption was found to be dominated by fish and shrimps though small quantities of cockles and samphire were also taken into account, as indeed was external exposure over the outer parts of the estuary while fishing. The exposure of seafood consumers was 0.042 mSv in 1996. Most of this was due to Sellafield disposals with only a small percentage attributable to Springfields.

The most exposed group of terrestrial food consumers were adults consuming vegetables and potatoes at high rates. Their dose in 1996, including a contribution due to weapon test and Chernobyl fallout and natural sources, was <0.014 mSv, a major part of which was due to thorium radionuclides.

The INTAKE food dose was <0.018 mSv or 2% of the dose limit of 1 mSv.

7.3 Capenhurst, Cheshire

The main functions undertaken on the Capenhurst site are enrichment of uranium and dismantling of redundant plant. The enrichment facility is operated by URENCO Capenhurst Ltd. Radioactive waste arisings of tritium, uranium and its daughter products, and technetium-99 and neptunium-237 from recycled fuel, are minor; in 1996 BNFL had authorisations to dispose of small amounts of radioactivity in gaseous wastes via stacks and in liquid wastes to the Rivacre Brook. An environmental monitoring programme is carried out related to the pathways which could be of radiological significance due to all disposal routes. Plants, animal faeces, soil and dry cloths are also sampled as indicator materials.

Results for 1996 are presented in Table 21. Concentrations of radionuclides in materials from the land and from the Rivacre Brook were similar to those for 1995. The hypothetical most exposed group for liquid disposals from the site is considered to be people who may inadvertently ingest water and sediment from the Brook. Taking pessimistic assumptions about their ingestion rates, the exposure of the group was very low, at less than 0.005 mSv in 1996. The concentrations of artificial radioactivity in marine samples are consistent with values expected at this distance from Sellafield. The exposure of the most exposed group of terrestrial food consumers was also very low, at less than 0.005 mSv in 1996.

7.4 Chapelcross, Dumfries and Galloway

At this establishment, BNFL operates a magnox-type nuclear power station. Gaseous wastes are discharged to the local environment and liquid waste is discharged to the Solway Firth under authorisation from SEPA. Disposals in 1996 were similar to those in 1995. Terrestrial monitoring comprises sampling and analysis of milk and grass. Habits surveys have been used to investigate aquatic exposure pathways. These have established that two groups of people could receive radiation exposures of potential importance. The first of these groups comprises fishermen who consume local seafood and are exposed to external radiation whilst tending stake nets. The second group are wildfowlers who are exposed whilst on salt marshes. The scope of aquatic monitoring reflects these pathways. Samples of sea water and *Fucus vesiculosus*, as useful indicators, are also analysed.

The results of monitoring in 1996 are presented in Tables 22(a) and (b). Concentrations of artificial radionuclides in marine materials in the Chapelcross vicinity are mostly due to Sellafield disposals, and the general levels of nuclides given in Table 22(a) are consistent with values expected at this distance from Sellafield. Concentrations of most radionuclides in 1996 were generally similar to, or less than, those in 1995. Concentrations of technetium-99 increased due to recent increases in disposals from Sellafield. The whole-body exposure of the critical group of fishermen who consume seafood and are exposed to external radiation over intertidal areas was 0.032 mSv in 1996 which is 3% of the dose limit of 1 mSv for members of the public. The skin exposure of local fishermen whilst handling nets, including a component due to natural radiation was, 0.038 mSv corresponding to less than 0.1% of the dose limit appropriate for exposures to skin of members of the public. Wildfowlers received a dose of 0.023 mSv. The magnitude of the Chapelcross disposals indicates that the local contribution to dose was a tiny fraction of these exposures, most of the dose being due to Sellafield disposals.

Concentrations of radionuclides in milk and grass were similar to those in 1995. The effects of the power station were detected by observation of positive values for tritium in terrestrial samples, but the radiological significance of this radionuclide is low. The exposure of the most exposed group of terrestrial food consumers, including a contribution due to weapon test and Chernobyl fallout, was estimated to be <0.024 mSv or 2% of the dose limit of 1 mSv. This estimate includes a contribution due to consumption of vegetables (Appendix 1).

The INTAKE food dose, including aquatic and terrestrial components, was <0.020 mSv in 1996.

8. UNITED KINGDOM ATOMIC ENERGY AUTHORITY

The United Kingdom Atomic Energy Authority (UKAEA) operates in England at Harwell, Winfrith and Windscale, adjacent to the BNFL Sellafield site, and in Scotland at Dounreay. All sites have reactors that are currently being decommissioned. Disposals of radioactive waste are related to decommissioning and decontamination operations and the nuclear related research that is undertaken at all sites. Some of this work is carried out by tenants such as AEA Technology. In addition, gaseous and liquid wastes are generated at Dounreay as a result of fuel reprocessing and small amounts of low level solid waste are disposed of by shallow land burial on the site. In previous years some solid waste was authorised for disposal in a shaft 55 metres deep at Dounreay, but no such disposals have been made since 1977. Solid and liquid waste disposals from Dounreay include a minor contribution from the adjoining reactor site (Vulcan Naval Reactor Test Establishment) which is operated by the Ministry of Defence (Procurement Executive) and from the minor activities on the Dounreay site divested in June 1996 to AEA Technology. Disposals from the Windscale site are negligible compared to Sellafield. Regular monitoring of the environment in relation to Dounreay, Harwell and Winfrith is undertaken and disposals from Windscale are monitored by the Sellafield programme. Disposals from Vulcan (NRTE) and AEA Technology (Dounreay) are monitored by the Dounreay programme.

8.1 Dounreay, Highland

Radioactive waste disposals from this UKAEA establishment are made under authorisation by SEPA. The quantities discharged from Dounreay in 1996 were generally similar to those in 1995 reflecting the campaigns of reprocessing of reactor fuel. The establishment is also authorised to dispose of low levels of radioactivity on site. Monitoring in 1996 continued to include sampling of ovine liver and thyroid, grass, soil and dry cloths to detect the effects of gaseous releases. Samples of leachate from the vicinity of the landfill site were also analysed. Milk is not produced in the Dounreay area. Routine marine monitoring involved sampling of fish and shellfish from the area of the Dounreay outfall in the Pentland Firth and other materials further afield, in combination with associated beta and gamma dose rate measurements. The results of SEPA's monitoring are presented in Tables 23(a) and (b). The local beach and foreshore are routinely monitored for particulate contamination by the operator. Fragments of spent fuel were found on the public beach at Dounreay. Thirteen small fragments were found with caesium-137 activities in the range of 1×10^5 to 1×10^8 Bq (these activities were measured by the operator). A fragment of spent nuclear fuel was found on a public beach in Sandside Bay in 1997. Further details will be given in a later report covering that period. On the basis of present knowledge the probability of a member of the public encountering one of these particles is assessed to be small. Consideration has been given to the health effects of these particles if encountered and has been detailed in reports jointly published by COMARE and RWMAC (COMARE 1995). The source of these particles has not yet been identified by UKAEA; once this is determined a more accurate assessment of the risk will be possible.

Habits surveys have confirmed the existence of four potentially critical exposure pathways for marine radioactivity at Dounreay, three of which involve external irradiation. The first of these is due to radioactivity adsorbed mainly on fine particulate matter becoming entrained on fishing gear which is regularly handled. This results in skin dose, mainly from beta particles, to the hands and forearms of fishermen. The most exposed group is represented by a small number of people who operate a fishery close to Dounreay. Dose rates on their fishing gear were below the limit of detection in 1996. However, an upper limit to the skin exposure of these fishermen may be assessed including a component due to natural radiation. The dose in 1996 was less than 0.16 mSv, or less than 0.5% of the dose limit of 50 mSv for skin exposures.

The second potentially critical pathway arises also from the uptake of radioactivity by particulate material which accumulates in rocky areas of the foreshore and presents a potential source of exposure, mainly to gamma radiation, of those who visit these areas. In 1996, monitoring of sludge at Oigin's Geo showed generally increased concentrations of radionuclides compared with 1995. This was in part due to an increased plant throughput during 1996. However, there is known to be significant variability in these concentrations with differing sea and weather conditions. The more important measurements of gamma dose rates above areas of the foreshore remained unchanged. Public radiation exposure via this pathway remained low, at 0.008 mSv or 0.8% of the dose limit of 1 mSv.

The third potentially critical pathway involves internal exposure of consumers of locally-collected fish and shellfish; fish, crabs, lobsters and winkles from the outfall area are sampled to enable this pathway to be kept under review. Additionally, sea water and seaweed were sampled as indicator materials. Concentrations of radionuclides in 1996 were generally similar to those for 1995, although there were some small increases of technetium-99 observed due to disposals from Sellafield. Despite these, exposures from consumption of fish and shellfish continued to be low: for high-rate consumers the radiation dose was less than 0.005 mSv or 0.5% of the dose limit of 1 mSv.

The fourth potential critical pathway is due to consumption of molluscs and external exposure during collection. Gamma dose rates were measured over collecting areas and winkles were analysed for their radioactivity content. Gamma dose rates over the main collecting areas were similar in 1996 to those measured previously and the radiation dose due to a combination of consumption of molluscs and external exposure during collection was still low at 0.022 mSv or 2% of the dose limit of 1 mSv. This pathway was the critical marine pathway at Dounreay in 1996.

A special survey in 1996 investigated the detection by UKAEA of an area of contamination below the beach surface on the Dounreay foreshore. Sediment samples were obtained and the results of the analyses are given in Table 23(a). Public access to the foreshore is very difficult and the mean levels (from a wide range of activities) of radioactivity in the sediments are similar to those found routinely within sludge in adjacent geos. On this basis, SEPA have concluded that the contamination does not represent a significant hazard, nor does it have any implication for other beaches in Caithness. The source of the contamination is still being investigated but is most probably due to migration of radionuclides from an area contaminated as a result of failures in the containment of the plant associated with effluent treatment. The UKAEA have undertaken to remove the area of historic contamination on the foreshore in early 1997 and SEPA have requested that a full report detailing areas of contaminated land bordering the site and associated remediation plan be prepared.

The results for terrestrial samples, Table 23(a), generally showed low levels of radioactivity. However although still at low levels there is a significant increase in the mean caesium-137 concentration in ovine liver from <0.56 Bq kg^{-1} in 1995 to 23 Bq kg^{-1} in 1996. This increase in mean level is due to an elevated result from an individual sample of ovine liver collected in September 1996 (68 Bq kg^{-1}). This higher activity in the sample would appear to be explained by close examination of the daily discharge data in that the sample was taken less than a week after an above-average, authorised release a few days in duration. These results, whilst remaining of relative low radiological significance, will be investigated further in 1997. Concentrations of activity in leachate from the landfill site were low. The exposure of the most exposed group of local terrestrial consumers, including a contribution due to weapon test fallout, was estimated to be <0.031 mSv or 3% of the dose limit of 1 mSv.

The INTAKE food dose, including aquatic and terrestrial components, was <0.019 mSv in 1996.

8.2 Harwell, Oxfordshire

Disposals of radioactive wastes from Harwell continued in 1996 with liquid disposals made under authorisation to the River Thames at Sutton Courtenay and to the Lydebank Brook north of the site while gaseous disposals were made to the atmosphere. The monitoring programme comprised sampling of milk, other terrestrial foodstuffs, freshwater fish and indicator materials together with measurements of gamma dose rates around the liquid discharge points. Monitoring of the aquatic environment at Newbridge is undertaken to indicate background levels remote from nuclear establishments.

The results of measurements of radioactivity concentrations and dose rates are shown in Tables 24(a) and (b). Tritium was detected in apples and blackberries collected near the site at low levels similar to those observed in local foodstuffs in previous years. The exposure of the most exposed group of terrestrial food consumers was estimated to be less than 0.005 mSv or 0.5% of the dose limit of 1 mSv.

Some nuclides, notably cobalt-60 and caesium-137, were enhanced close to the outfall for liquid wastes, but the levels were very small in terms of any radiological effect. Those found in Lydebank Brook were lower still.

Habits surveys have identified anglers as the most exposed group affected by direct disposals into the river. Their occupancy of the river bank has been assessed to estimate their external exposures. Consumption of freshwater fish was not found, but it is considered prudent to include a component in the assessment of the angler's exposure equivalent to a hypothetical consumption of fish at a rate of 1 kg $year^{-1}$. On this basis, and excluding a background dose rate of 0.06 $\mu Gy\ h^{-1}$, the radiation dose to anglers in 1996 was 0.009 mSv, or less than 1% of the dose limit of 1 mSv.

8.3 Winfrith, Dorset

Disposals of radioactive wastes from this site continued in 1996 at the low rates typical of recent years following the shutdown of the Steam Generating Heavy Water Reactor (SGHWR) in September 1990. Liquid wastes are disposed of under authorisation to deep water in Weymouth Bay. The monitoring programme comprised sampling of milk, crops, fruit, seafood and indicator materials and measurements of gamma dose rates on the foreshore. Data are presented in Tables 25(a) and (b). Results for terrestrial samples gave no indication of an effect due to gaseous disposals. Levels of carbon-14 detected were typical of the background concentrations to be expected. The most exposed group for gaseous disposals comprised the 1-year-old age group who were estimated to receive an exposure of less than 0.005 mSv or 0.5% of the dose limit of 1 mSv. Concentrations of radionuclides in the marine environment continued at the low levels attained since closure of the SGHWR. No indication of the effect of disposals from the Cap de la Hague facility in France was detected. The radiation dose to the most exposed group of fish and shellfish consumers remained low in 1996 at less than 0.005 mSv or 0.5% of the dose limit.

The INTAKE food dose was <0.005 mSv in 1996.

9. NUCLEAR POWER STATIONS OPERATED BY ELECTRICITY GENERATING COMPANIES [d]

In 1996, the electricity companies [d] were authorised to dispose of wastes from 12 locations in the United Kingdom. All locations included operational power stations with the exception of Berkeley and Trawsfynydd where the redundant power stations were undergoing decommissioning. One of the power stations at Hunterston was also being decommissioned. The Berkeley site also provides research facilities.

9.1 Berkeley, Gloucestershire and Oldbury, Avon

Berkeley Power Station ceased electricity generation in March 1989, but small amounts of radioactive wastes still need to be disposed of as part of decommissioning operations. In addition there is a component of the discharge from the adjoining Berkeley Technology Centre. The Oldbury Power Station has continued operation and because the effects of both sites are on the same area, Berkeley and Oldbury are considered together for the purposes of environmental monitoring. Liquid radioactive wastes are discharged to the Severn estuary.

Habits surveys have established that the two potentially critical pathways for public radiation exposure in the aquatic environment are internal radiation following consumption of locally-caught fish and shellfish, and external exposure from occupancy of muddy intertidal areas. Therefore, samples of fish and shellfish are analysed and gamma dose rates are monitored. In addition, measurements of external exposure are

[d] *With effect from 31 March 1996, these were Magnox Electric plc, Nuclear Electric Ltd and Scottish Nuclear Ltd.*

supported by analyses of intertidal mud, and *Fucus vesiculosus* is collected as an indicator material. The focus for terrestrial sampling remained on the tritium, carbon-14 and sulphur-35 content of milk, crops and fruit, supported by analysis of dry cloths.

Data for 1996 are presented in Tables 26(a) and (b). Gamma dose rates and concentrations in the aquatic environment were similar to those in recent years. Most of the artificial radioactivity detected was due to carbon-14, radiocaesium and sulphur-35. Concentrations of radiocaesium represent the combined effect of disposals from the sites, other nuclear establishments discharging into the Bristol Channel, weapon test and Chernobyl fallout, and possibly a small Sellafield-derived component. Most of the carbon-14 is due to disposals from the Amersham International site at Cardiff. Very small concentrations of other radionuclides were detected but, taken together, were of low radiological significance. The total exposure of the most exposed group of fish and shellfish consumers including external radiation was low, at 0.008 mSv or less than 1% of the dose limit of 1 mSv.

Tritium and sulphur-35 were detected at very low levels in some of the terrestrial food samples monitored; the most significant indications of the effects of the sites were in blackberries. Carbon-14 was detected in local milk and crops at levels generally consistent with background values. The most exposed group dose continued to be low and was estimated to be less than 0.005 mSv or 0.5% of the dose limit.

The INTAKE food dose was <0.005 mSv in 1996.

9.2 Bradwell, Essex

This power station, powered by Magnox reactors, is authorised to discharge gaseous wastes to the local environment and liquid wastes to the estuary of the River Blackwater. Terrestrial sampling is similar to that for other power stations including analyses of milk and crop samples for tritium, carbon-14 and sulphur-35. Aquatic sampling was directed at external exposure of people who live on houseboats in muddy areas of the estuary and consumption of locally-caught fish and shellfish. It included the commercial oyster fishery of importance in the northern part of the estuary. Gamma dose rate measurements are supported by analyses of intertidal sediment, and *Fucus vesiculosus* is analysed as an indicator material.

Measurements for 1996 are summarised in Tables 27(a) and (b). Gamma dose rates confirmed the importance of direct radiation from the reactors in the immediate vicinity of the site. Further afield, dose rates could not be distinguished from the natural background. Low concentrations of artificial radioactivity were detected in aquatic materials due to the combined effects of disposals from the station, Sellafield disposals, and weapon test and Chernobyl fallout. Apportionment of the effects of these sources is difficult because of the low levels detected; concentrations were similar to those for 1995 (MAFF, 1996). A calculation based on concentrations of radionuclides in sediments has been used to estimate the external exposure of the houseboat dwellers who were the most exposed group in 1996. Their exposure including the effects of consumption pathways, was small, amounting to 0.010 mSv or 1% of the dose limit of 1 mSv.

Concentrations of activity were also low in terrestrial samples. There was nevertheless an indication in local fruit that carbon-14 levels had been enhanced by the operation of the power station. Small concentrations of sulphur-35 were also detected in some samples. As it was believed that there was a possibility of iron-55 being discharged in shield cooling air, grass was analysed for this nuclide and it was detected. Despite this, the most exposed group exposure was estimated to be less than 0.005 mSv or 0.5% of the dose limit of 1 mSv, confirming that the radiological impact of authorised disposals from Bradwell was very low.

The INTAKE food dose was <0.005 mSv in 1996.

9.3 Dungeness, Kent

There are two, separate, 'A' and 'B' nuclear power stations on this site; the 'A' station is powered by Magnox reactors and the 'B' station by advanced gas-cooled reactors (AGRs). These are operated by Magnox Electric plc. and Nuclear Electric Ltd. respectively. Disposals are made via separate, but adjacent, outfalls and stacks and for the purposes of environmental monitoring are considered together.

Analyses for tritium, carbon-14 and sulphur-35 in terrestrial samples, were supplemented by a small number of analyses for strontium-90, iodine-131 and caesium-137 taken primarily for comparison with Sellafield samples. Marine monitoring included gamma and beta dose rate measurements on beaches and analysis of seafood and indicator materials.

The results for 1996 are given in Tables 28(a) and (b). Concentrations of radiocaesium in marine materials are attributable to disposals from the stations and to weapon test fallout with a contribution due to disposals from Sellafield. Apportionment is difficult at these low levels. Trace levels of cobalt-60 in some marine materials are likely to be due to the combined effects of disposals from the site and from other sites on the English Channel coast. The small concentrations of transuranics in whelks and mud were typical of levels expected at sites remote from Sellafield. Gamma and beta dose rates were difficult to distinguish from the natural background. The most exposed group in 1996 continued to be represented by local bait diggers who also eat fish and shellfish. Their radiation exposure was low at 0.006 mSv or 0.6% of the dose limit of 1 mSv.

Activity concentrations in many terrestrial foods were close to the limits of detection. Levels of carbon-14 were generally within the range of activity concentrations observed for background sources, however small enhancements were observed in legumes. Low concentrations of sulphur-35 and caesium-137 were detected in some samples; the former is due to station disposals, but the latter is likely to be due to other sources, e.g. weapon test and Chernobyl fallout. The maximum exposure due to gaseous disposals was received by the 1 year old age group. Their exposure in 1996 was estimated to be less than 0.005 mSv or 0.5% of the dose limit.

The INTAKE food dose was also <0.005 mSv in 1996.

9.4 Hartlepool, Cleveland

This station is powered by twin AGRs. The critical pathway for radiation exposure due to liquid effluent disposals is internal irradiation following consumption of local fish and shellfish. Collection of small coal, which is washed ashore along this stretch of coast, is used to represent the highest beach occupancies. The sampling and measurement programmes at Hartlepool were similar to those for other power station sites. However technetium analysis in *Fucus vesiculosus* is used as a specific indication of the far-field effects of disposals to sea from Sellafield.

Results of the monitoring programme carried out in 1996 are shown in Tables 29(a) and (b). The effects of gaseous disposals from the site were not clearly detectable in foodstuffs, though a small enhancement of carbon-14 levels in blackberries was apparent. The most exposed group exposure in 1996 was less than 0.006 mSv or 0.6% of the dose limit of 1 mSv.

Disposals of tritium in liquid effluents from the power station are discontinuous and levels in the environment vary accordingly. Camplin *et al* (1990) has observed concentrations in excess of 100,000 Bq l^{-1} immediately after a discharge. Even at this level the radiological significance of the disposals is minor because of the very low radiotoxicity of the nuclide. No such enhancements were observed in 1996. An increase in the level of technetium-99 in *Fucus vesiculosus* was apparent this year (56 Bq kg^{-1}: 1996; 30 Bq kg^{-1}: 1995). This is due to recent increased disposals of this radionuclide from BNFL Sellafield. Low levels of iodine-131 detected were likely to be from local hospitals. Concentrations of radiocaesium and transuranics were mainly due to disposals from Sellafield and to weapon test fallout. Gamma and beta dose rates were difficult to distinguish from natural background with the exception of measurements at Paddy's Hole. In this location, waste slag from a steel works can be found containing enhanced levels of gamma-emitting natural radionuclides. The radiation exposure of the most exposed group of local fish and shellfish consumers was low, at less than 0.005 mSv or 0.5% of the dose limit of 1 mSv.

The INTAKE food dose was <0.005 mSv in 1996.

9.5 Heysham, Lancashire

This establishment comprises two, separate, nuclear power stations both powered by AGRs. Disposals of radioactive waste from both stations are made under authorisation via adjacent outfalls in Morecambe Bay and stacks and for the purposes of environmental monitoring are considered together. The monitoring programme for the effects of gaseous disposals was similar to that for other power stations. That for liquid disposals was also similar, including sampling of fish, shellfish and indicator materials and measurements of gamma dose rates, but for completeness the data considered in this sub-section includes all of that for Morecambe Bay. Parts of the programme are therefore in place in order to monitor the effects of Sellafield. Samphire is also collected and analysed because of its use as a foodstuff.

The results for 1996 are given in Tables 30(a) and (b). Concentrations of carbon-14 and technetium-99 increased in marine materials due to disposals from Sellafield. Otherwise similar levels to those for 1995 (MAFF, 1996) were observed and the effect of liquid disposals from Heysham was not detectable above the Sellafield background. The radiation exposure in 1996 to the most exposed group of fishermen including a component due to external radiation was 0.082 mSv which is well within the dose limit of 1 mSv. This represents a small increase from the estimate for 1995 of 0.073 mSv (MAFF, 1996). Most of this exposure was due to the effects of disposals from Sellafield. The increased levels of carbon-14 and technetium-99 noted above made only a small contribution to the assessed dose. Concentrations of radioactivity in samphire were of negligible radiological significance.

The effects of gaseous disposals were difficult to detect in 1996. Small enhancements of concentrations of carbon-14 were apparent in blackberries and parsnips. The most exposed group dose was estimated to be less than 0.007 mSv or 0.7% of the dose limit of 1 mSv.

The INTAKE food dose was <0.008 mSv in 1996.

9.6 Hinkley Point, Somerset

At this establishment there are two, separate, 'A' and 'B' nuclear power stations; the 'A' station is powered by Magnox reactors and the 'B' station by AGRs. These are operated by Magnox Electric plc. and Nuclear Electric Ltd. respectively. Environmental monitoring covers the effects of the two power stations together. Analyses of milk and crops were undertaken to measure activity concentrations of tritium, carbon-14, sulphur-35 and gamma emitters. Analyses of seafood and marine indicators materials and measurements of external radiation over muddy intertidal areas were also carried out.

The results for 1996, presented in Tables 31 (a) and (b) indicate a small effect due to disposals of gaseous wastes. Activity concentrations of tritium and gamma emitters in terrestrial materials were all below or close to the limits of detection. Concentrations of sulphur-35 in beans and wheat showed the effects of the power stations and some of the concentrations of carbon-14 in fruit and crops were higher than the default values used to represent background levels (Appendix 5). The estimated most exposed group exposure from radioactivity in the terrestrial environment was less than 0.007 mSv or 0.7% of the dose limit of 1 mSv.

The concentrations observed in the Bristol Channel were generally similar to those in 1995. The concentration of tritium in seawater decreased in 1996 but the results of such measurements are highly variable in view of the discontinuous discharge of this radionuclide. Concentrations of other radionuclides in the aquatic environment represent the combined effects of releases from the stations, from other establishments which discharge into the Bristol Channel, from Sellafield, and from weapon test and Chernobyl fallout. Apportionment is generally difficult at the low levels detected. However the carbon-14 content in seafood was likely to have been due to disposals from Amersham International, Cardiff as the disposals from this site are significantly higher than those from the Hinkley Point power stations. The concentrations of transuranic nuclides were of negligible radiological significance. Gamma radiation dose rates over intertidal sediment, measured using portable instruments, were difficult to distinguish from the natural background with the exception of the measurements close to the station which were affected by direct radiation from the reactors. The most exposed group from liquid disposals from the site in 1996 were represented by fishermen on the River Parrett who were estimated to receive an exposure of 0.006 mSv or 0.6% of the dose limit of 1 mSv.

The INTAKE food dose was <0.005 mSv in 1996.

9.7 Hunterston, North Ayrshire

This site comprises 'A' and 'B' stations; the 'A' station was is a magnox-type reactor and the 'B' station an AGR. The 'A' station ceased power production at the end of March 1990. Liquid radioactive waste disposals are made to the Firth of Clyde under authorisation granted by SEPA. Gaseous disposals are made separately from 'A' and 'B' stations. The gaseous discharge authorisation for the 'B' station was revised in 1996 which resulted in new lower limits for control of disposals. Environmental monitoring in the area considers the effects of both sites together. The main part of the aquatic monitoring programme comprises sampling of fish and shellfish and measurement of gamma dose rate on the foreshore. Samples of sand are also analysed in support of the gamma dose rate measurements and sea water and Fucus seaweed are analysed as indicator materials. Terrestrial monitoring comprises quarterly sampling of milk and grass.

The results of monitoring in 1996 are shown in Tables 32(a) and (b). The concentrations of artificial radioactivity in the marine environment are predominantly due to Sellafield disposals, the general values being consistent with those to be expected at this distance from Sellafield. Small concentrations of activation products such as manganese-54 were probably due to disposals from the site; however, these were of negligible radiological significance. In 1996, the exposure, including external radiation, of members of the most exposed group of fish and shellfish consumers near Hunterston was low, at 0.023 mSv or 2% of the dose limit of 1 mSv.

The concentrations of radionuclides in milk and grass were generally low and similar to previous years' results. However, concentrations of sulphur-35 detected in milk, which are probably due to disposals from the 'B' station, were higher than those found at other sites The radiation exposure of the most exposed group of terrestrial food consumers, including a contribution due to weapon test and Chernobyl fallout, was therefore relatively high at <0.045 mSv. The level was nevertheless only a small fraction of the dose limit of 1 mSv.

The INTAKE food dose, including aquatic and terrestrial components, was <0.010 mSv in 1996.

9.8 Sizewell, Suffolk

At this establishment there are two stations. The 'A' station is powered by Magnox reactors whilst the 'B' station is powered by a PWR. Station 'B' began operation in 1995. These are operated by Magnox Electric plc. and Nuclear Electric Ltd. respectively. Authorised disposals of radioactive liquid effluent from both power stations are discharged via adjacent outfalls to the North Sea. Gaseous wastes are discharged via separate stacks to the local environment. Environmental monitoring for the power stations is considered in a single programme covering the area likely to be affected. The results of monitoring in 1996 are shown in Tables 33 (a) and (b).

The aquatic programme comprised analysis of seafood and indicator materials and measurements of gamma and beta dose rates in intertidal areas. Concentrations of artificial radionuclides were low and mainly due to the distant effects of Sellafield disposals and to weapon test and Chernobyl fallout. Trace levels of activation products were likely to have been due to disposals from the power stations though there was no conclusive evidence of the effects of the new 'B' station. In 1996, the radiation exposure of local fish and shellfish consumers was low, at less than 0.005 mSv or 0.5% of the dose limit of 1 mSv. Measured gamma and beta dose rates were indistinguishable from the natural background. The above assessment includes a contribution for their external exposure based on a calculation using radionuclide concentrations in sediment.

Gamma-ray spectrometry and analysis of tritium, carbon-14 and sulphur-35 in milk, crops and fruit showed very low levels of artificial radioactivity near the power stations in 1996. Trace quantities of sulphur-35 were detected in some samples. The estimated exposure of the most exposed group of consumers eating such foods was less than 0.005 mSv or 0.5% of the dose limit of 1 mSv. There has been no detectable increase in levels of radioactivity in foodstuffs due to the operation of the PWR.

The INTAKE food dose was <0.005 mSv in 1996.

9.9 Torness, East Lothian

This station, which is powered by two AGRs, came into operation at the end of 1987. Revised authorisations from the Scottish Office took effect in 1996. These introduced new lower limits for both liquid and gaseous disposals. The monitoring programme comprises sampling of milk and seafood, and samples of seawater, seaweed and grass are monitored as indicator materials. Measurements are also made of gamma dose rates over intertidal areas, supported by analyses of sediment, and beta dose rates on fishing gear.

Results of this monitoring in 1996 are shown in Tables 34(a) and (b). Concentrations of artificial radionuclides were mainly due to the distant effects of Sellafield disposals and to weapon test and Chernobyl fallout, though trace levels of activation products were likely to have been due to disposals from the station. In 1996, the group of fish and shellfish consumers and the group subject to external radiation both received very low exposures at less than 0.005 mSv, or 0.5% of the dose limit of 1 mSv. The beta radiation from fishermen's nets and pots was typical of that due to natural radiation and the most exposed group of terrestrial food consumers would have received an exposure, including a contribution due to weapon test and Chernobyl fallout, of <0.019 mSv, or 2% of the dose limit of 1 mSv. The INTAKE food dose, including aquatic and terrestrial components, was <0.005 mSv in 1996.

9.10 Trawsfynydd, Gwynedd

This station is being decommissioned. Low level disposals continued during 1996 under authorisation of the Environment Agency [+]. Disposals of liquid radioactive waste were made to a freshwater lake making the power station unique in UK terms. The aquatic monitoring programme is directed at consumers of freshwater fish caught in the lake and external exposure over the lake shoreline; the important radionuclides are those of caesium and to a lesser extent, strontium-90. Habits surveys have established that species of fish regularly consumed are brown trout, rainbow trout and a small amount of perch. Perch and most brown trout are indigenous to the lake but rainbow trout are introduced from a hatchery. Because of the limited period which they spend in the lake, introduced fish generally exhibit lower radiocaesium concentrations than those of indigenous fish.

The results of the terrestrial programme, including those for local milk, crops and indicator materials are shown in Tables 35 (a) and (b). Concentrations of activity in all terrestrial foods were low, the most significant being those of 4.2 Bq kg^{-1} and 2.1 Bq kg^{-1} of radiocaesium in ovine muscle and offal respectively. The most likely source of radiocaesium in these and other samples is fallout from Chernobyl and weapon tests though it is conceivable that a small contribution may be made by resuspension of lake activity. In recognition of this potential mechanism, monitoring of transuranic radionuclides was also carried out in crop and animal samples. In all cases, detected activities were low, and similar to observations in other areas of England and Wales, where activity was attributable to background weapon test fallout. No evidence was therefore found that resuspension of activity in sediment from the lake shore contributed to exposure from transuranic radionuclides in 1996.

The most exposed group for terrestrial foods at Trawsfynydd in 1996 received exposures of less than 0.006 mSv or 0.6% of the dose limit of 1 mSv. This assessed dose includes a contribution from the caesium activity detailed above.

In the lake itself, there remains clear evidence for the effects of disposals from the power station. Concentrations of caesium exceed 1000 Bq kg^{-1} in the mud from the bed of the lake and in peat from below the hydroelectric power station at Maentwrog though lower values tend to be found on the shoreline where occupancy by anglers is relevant. Gamma dose rates were similar to those in 1995.

There were small decreases in the concentrations of caesium-137 in lake water which remain above those for water coming into the lake via the Afon Prysor. However, there were small increases in concentrations of radio-caesium in fish in 1996. Taking this and the

[+] *Of the Welsh Office and HMIP prior to April 1996.*

results of measurements of gamma dose rates into account, the exposure of the most exposed group of anglers was 0.043 mSv in 1996, or about 4% of the dose limit of 1 mSv. In 1995, their estimated exposure was 0.035 mSv (MAFF, 1996), the increase being due to the concentrations in fish.

9.11 Wylfa, Isle of Anglesey

Gaseous and liquid wastes from this station were discharged in 1996 under authorisation of the Environment Agency +. Environmental monitoring of the effects on the Irish Sea and the local environment is carried out on behalf of the Welsh Office. Such disposals and effects are very low.

The results of the programme in 1996 are given in Tables 36 (a) and (b). The data for artificial radionuclides related to the Irish Sea continue to reflect the distant effects of Sellafield disposals though trace levels of activation products were likely to have been due to disposals from the station. The concentrations were generally similar to or less than those for 1995 though the increase in beta activity in *Fucus vesiculosus* may have been due to the sensitivity this species has as an indicator of recent increased disposals of technetium-99 from Sellafield. The exposure of the most exposed group of high-rate fish and shellfish consumers was low, at 0.006 mSv or 0.6% of the dose limit of 1 mSv. Gamma dose rates, measured using portable instruments, continued to be difficult to distinguish from the natural background, but a small contribution due to external exposure of the most exposed group has been included in the total above.

The results for terrestrial foods indicate a small effect due to the total gaseous disposals from the power station. This is seen in the data for sulphur-35 in blackberries and barley. However, the dose received by high-rate food consumers remained low at less than 0.005 mSv or 0.5% of the dose limit.

The INTAKE food dose was <0.005 mSv in 1996.

10. DEFENCE ESTABLISHMENTS

10.1 Aldermaston, Berkshire

The Atomic Weapons Establishment at Aldermaston is authorised to discharge low levels of radioactive waste to the environment. Liquid disposals are made to the River Thames at Pangbourne and to the sewage works at Silchester. The monitoring programme comprised sampling of milk, other terrestrial foodstuffs, freshwater fish and indicator materials together with measurements of gamma dose rates near the main outfall on the River Thames. Monitoring of the aquatic environment at Newbridge is undertaken to indicate background levels remote from nuclear establishments.

The results of measurements of radioactivity concentrations and dose rates are shown in Tables 37(a) and (b). The concentrations of artificial radioactivity detected in the Thames catchment were generally very low. Iodine-131 was detected in mud in Foundry Brook but the source of this nuclide is most likely to have been associated with medical applications. The gamma dose rate on the river bank at Pangbourne was difficult to distinguish from natural background. Habits surveys have established that the most exposed group affected by disposals into the river comprises anglers whose occupancy of the river bank has been assessed to estimate their external exposures. No consumption of freshwater fish has been established, however the assessment has conservatively included consumption of fish at a low rate of 1 kg $year^{-1}$. The overall radiological significance of liquid disposals was very low: the radiation dose to anglers was much less than 0.005 mSv or 0.5% of the dose limit of 1 mSv.

The concentrations of radioactivity in milk, vegetables, fruit and terrestrial indicator materials were also very low. Results for tritium, uranium and transuranic radionuclides were similar to those for 1995 (MAFF, 1996). The most likely source of the radionuclides detected was natural background or weapon test fallout. The maximum dose was assessed to be for adults. The dose in 1996, including contributions from the natural and fallout sources, was less than 0.005 mSv or 0.5% of the dose limit of 1 mSv.

10.2 Barrow, Cumbria

Whilst the site operated by Vickers Shipbuilding and Engineering Ltd at Barrow is not strictly a defence establishment, the small amounts of liquid radioactive wastes disposals to the Irish Sea are related to submarine activities and are therefore included in this section for completeness. The monitoring programme comprises measurements of gamma dose rates and analysis of sediments collected near the outfall. The results, given in Tables 38(a) and (b), show no enhancement due to site activities above the background to be expected in the Irish Sea at this distance from Sellafield. The external exposure of the most exposed group at the site was estimated to be 0.022 mSv, representing less than 3% of the dose limit of 1 mSv. Most of this exposure was due to historic disposals from Sellafield.

10.3 Chatham, Kent

Disposals of radioactive waste from Chatham no longer take place, however a small programme of gamma dose rate measurement and sediment analysis has continued

+ *Of the Welsh Office and HMIP prior to April 1996.*

in surveillance of the effects of past disposals. The results (Tables 38(a) and (b)) show that gamma dose rates continued to be indistinguishable from natural background and that low levels of radioactivity were detected in sediments. The external exposure of the most exposed group was 0.005 mSv or 0.5% of the dose limit of 1 mSv.

10.4 Devonport, Devon

Disposals of liquid radioactive waste are made by Devonport Management Ltd and the Ministry of Defence under authorisation into the Tamar Estuary. The monitoring programme in 1996 comprised measurements of gamma dose rates and analysis of seafood and indicator materials. The results (Tables 38(a) and (b)) were similar to those in 1995 (MAFF, 1996). No activity was detected in grass. Trace quantities of fission and activation products and actinides were detected in the marine environment. The detection of iodine-131 is most likely to be related to its medical uses. The exposure of the most exposed group taking account of consumption of marine foods and occupancy times was estimated to be less than 0.005 mSv or 0.5% of the dose limit of 1 mSv. The radiological significance of this, in common with other defence establishments, continued to be low.

10.5 Faslane, Argyll and Bute

Disposals of liquid radioactive waste into Gare Loch are made under letter of agreement by the Ministry of Defence. The monitoring programme in 1996 was undertaken primarily to investigate external radiation pathways. Levels of cobalt-60 detected in sediments (Table 38(a)) were attributable to local disposals but the concentrations were very low. Also present was caesium-137 at concentrations consistent with the distant effects of disposals from Sellafield and weapon test and Chernobyl fallout. Gamma dose rates were difficult to distinguish from natural background (Table 38(b)). The exposure of the most exposed group was 0.009 mSv in 1996 or 0.9% of the dose limit of 1 mSv.

10.6 Greenwich, London

In order to monitor the potential effects of the small disposals of gaseous activity from the Royal Naval College at Greenwich, grass is sampled and analysed by gamma-ray spectrometry. Four samples were analysed in 1996. The samples contained a small amount of caesium-137 above the limit of detection (0.7 ± 0.1 Bq kg^{-1}). This activity is typical of that expected due to the residual but radiologically insignificant effects of weapon tests and Chernobyl fallout in the area. Therefore there was no detected impact in the environment due to the operation of the site in 1996.

The reactor at this site is due to be shut down for decommissioning late in 1997.

10.7 Holy Loch, Argyll and Bute

A small programme of monitoring Holy Loch continued in surveillance of the effects of past disposals from the US submarine support facilities which closed in March 1992. Low levels of cobalt-60 detected in sediments from the Loch were due to these earlier operations. However, measurements of gamma dose rates in intertidal areas were difficult to distinguish from natural background (Tables 38 (a) and (b)). The external exposure of the most exposed group was 0.008 mSv in 1996 or 0.8% of the dose limit of 1 mSv.

10.8 Rosyth, Fife

Activities at the Rosyth Royal Dockyard continued to give rise to disposals of low levels of liquid radioactive waste into the Firth of Forth. New authorisations for the disposal of radioactive wastes were granted to Rosyth Royal Dockyard plc with effect from 1 April 1996, replacing those granted to Babcock Rosyth Defence Ltd on 17 August 1994. The new certificates incorporate reduced limits for liquid waste, most notably for cobalt-60 and beta activity. The monitoring programme comprised sampling and analysis of crabs and indicator materials and measurements of gamma dose rates in intertidal areas. As was the case at other defence establishments, the radioactivity levels detected were low, and in most part due to other sources. Iodine-131 detected in seaweed is likely to have been due to medical sources. Gamma dose rates were difficult to distinguish from natural background. Exposure of the most exposed group in 1996 was 0.017 mSv or 2% of the dose limit of 1 mSv.

10.9 Vulcan NRTE

The Vulcan Nuclear Reactor Test Establishment operated by the Ministry of Defence (Procurement Executive) is located adjacent to the UKAEA Dounreay site and the impact of its disposals are considered along with those from Dounreay in section 8.1.

11. AMERSHAM INTERNATIONAL PLC

This company manufactures radioactive materials for use in medicine, research and industry. The company's principal establishment is located in Amersham, Buckinghamshire and it also operates from Cardiff in South Glamorgan and on the Harwell site. Disposals from the Amersham International plc facility on the Harwell site are covered by the Harwell monitoring programme.

11.1 Amersham, Buckinghamshire

Disposals of liquid radioactive wastes are made under authorisation to the Maple Lodge sewage works; releases enter the Grand Union Canal and the River Colne. Disposals of gaseous wastes are also authorised. The monitoring programme consists of measurements of gamma dose rates on the river bank of the Grand Union Canal and analysis of fish, milk, crops and indicator materials. Monitoring at Newbridge on the Thames acts as an indication of background levels in the catchment. Monitoring of non-food pathways is carried out by the Environment Agency.

The results of the measurements are presented in Tables 39(a) and (b). The concentration of carbon-14 in fish was enhanced above the background level (25 Bq kg^{-1}) but its radiological significance was low. Concentrations of other radionuclides, e.g. cobalt isotopes, were also slightly enhanced close to the outfall. However, the gamma dose rates on the river bank were indistinguishable from natural background.

The activity concentrations in milk and crops were generally lower than the limits of detection. However, low levels of sulphur-35 and iodine-125 were detected in a few samples.

Habit surveys have identified anglers as the most exposed group affected by disposals into the canal/river system. Their occupancy of the river bank has been assessed to estimate their external exposures. Consumption of freshwater fish was also considered but none was found. Nevertheless, it is considered prudent to include a component in the assessment of the anglers' exposure and a hypothetical consumption of fish at a rate of 1 kg $year^{-1}$ was assumed. The anglers' exposure in 1996 was much less than 0.005 mSv or 0.5% of the dose limit of 1 mSv.

The exposure of the most exposed group of terrestrial food consumers was assessed as being less than 0.005 mSv or 0.5% of the dose limit.

11.2 Cardiff

A second laboratory, situated near Cardiff, produces labelled compounds used in research and diagnostic kits used in medicine for the testing of clinical samples and radiopharmaceuticals. Liquid wastes are discharged into the Severn estuary via the sewer system. Disposals from the site are also made by Johnson and Johnson Clinical Diagnostics Ltd.

Monitoring, carried out on behalf of the Welsh Office, includes consideration of consumption of food and external exposure over muddy, intertidal areas. Measurements of external exposure are supported by analyses of intertidal sediment. Indicator materials including seawater, *Fucus* seaweed, rape, silage and dry cloths provide additional information.

The results of monitoring in 1996 are presented in Tables 40(a) and (b). The main effect of liquid disposals is seen in increases of carbon-14 activities above those expected due to background. Similar values to those found in 1995 were observed (MAFF, 1996). Concentrations of other radionuclides in aquatic samples were low and can be explained by other sources such as Chernobyl and weapon test fallout and disposals from other establishments. Gamma dose rates over sediment, as measured using portable instruments, were difficult to distinguish from those expected from the natural background. The exposure of the most exposed group of fish and shellfish consumers including external radiation was 0.012 mSv or 1% of the dose limit of 1 mSv.

The main effects of gaseous disposals were seen in results for tritium and carbon-14. Concentrations of tritium, organically bound tritium and carbon-14 were found to be higher in milk sampled from farms close to the site than from farms far from the site. When compared with data for other sites, relatively high concentrations of these nuclides were also detected in other terrestrial samples e.g. 79 Bq kg^{-1} tritium and 28 Bq kg^{-1} carbon-14 in cabbage and 12 Bq kg^{-1} tritium and 24 Bq kg^{-1} carbon-14 in potatoes. High levels of tritium and carbon-14 were also measured in grass from Cardiff. However, levels in silage were significantly lower than those in grass. These results have low radiological significance as the levels measured in foodstuffs directly consumed by man were significantly lower. The concentrations of other radionuclides were low and generally close to the limits of detection.

The maximum estimated exposure from food consumption was to the 1-year-old age group. The most exposed group dose received <0.014 mSv or 1% of the dose limit of 1 mSv. The largest contribution was from carbon-14 in milk.

The INTAKE food dose was also <0.013 mSv or 1% of the dose limit of 1 mSv.

12. MINOR SITES AND EURATOM SAMPLING

Three minor sites with very low levels of discharge are monitored using a small programme of sampling indicator materials. The results, given in the following sub-sections, show that there was no detected impact on the environment in 1996 due to operation of these sites. This section also presents the results of indicator sampling around the major nuclear sites carried out in relation to the Euratom Treaty.

12.1 Imperial College Reactor Centre, Ascot, Berkshire

Four grass samples were analysed by gamma-ray spectrometry. All results in 1996 were less than the limits of detection.

12.2 Imperial Chemical Industries plc, Billingham, Cleveland

Three grass samples were analysed by gamma-ray spectrometry. All results in 1996 were less than the limits of detection with the exception of a single sample which contained a small amount of caesium-137. The mean concentration of caesium-137 was <0.6 ± 0.09 Bq kg^{-1} which is typical of that expected due to the residual but radiologically insignificant effects of weapon test and Chernobyl fallout in the area.

The reactor at this site ceased operation on 28 June 1996.

12.3 Rolls Royce plc, Derby, Derbyshire

Results of monitoring at Derby are presented in Table 41. Uranium activity detected in grass and soil samples was similar to results obtained in 1995 (MAFF, 1996). Isotopic analysis of the soil samples confirmed that the activity was not enriched in uranium-235. The activities detected are therefore due to natural sources.

12.4 Scottish Universities Research Reactor Centre, South Lanarkshire

Preparations are on-going for the decommissioning of this site and although disposals of small amounts of radioactive wastes take place the only monitoring carried out is that performed by the operator. The reactor has been defuelled and the fuel removed for storage.

12.5 Euratom sampling

In accordance with the requirements of Articles 35 and 36 of the Euratom Treaty, each member state is obliged to monitor levels of radioactivity in air, grass and soil near nuclear facilities and provide information from this programme to the Joint Research Centre of the European Commission. A programme of grass and soil monitoring to fulfil these requirements was established in 1993 in England and Wales (MAFF, 1995). The results of the programme in 1996 are presented in this sub-section. There is also a requirement on each member state to evaluate baseline exposure to members of the public and to ensure compliance with the Basic Safety Standards. The results of the monitoring carried out by SEPA for this purpose are contained within this report. This comprises sampling of air, soil, water (both fresh and drinking) and foodstuffs. Other results from Euratom sampling are contained in section 16. Supplementary information on grass and soil analyses is provided for some sites in the foregoing site-specific sub-sections.

The programme in England and Wales consists of annual sampling of paired grass and soil samples from three permanent plots at each site, generally situated 500 m from the site perimeter along the three dominant landward wind directions. The soil samples include the root mat and are taken to a depth of 7 cm. In 1996 samples continued to be analysed for tritium, carbon-14, sulphur-35, strontium-90, caesium-137, plutonium-238 and plutonium-239+240. Occasional analyses for americium-241 were also performed. The results are given in Table 42.

The mean concentrations of tritium ranged from <25 to 490 Bq kg^{-1} in grass. However, at only one site, Cardiff, did the mean concentration exceed 100 Bq kg^{-1}. The maximum concentration observed, 1100 Bq kg^{-1}, was also observed at this site. The next highest concentration, 81 Bq kg^{-1}, was found at Harwell. Taken together these results are to be expected given the relative disposals of tritium from each site (Table 2) however on this basis higher levels at Sellafield than were observed would have been expected.

Carbon-14 activity concentrations depend on the carbon content of the samples and are highly variable. Interpretation of the data without a knowledge of the carbon content is therefore difficult. Nevertheless, taken with other site-specific data some general conclusions may be drawn. Typical ranges of mean concentrations in grass and soil were approximately 100-200 and 10-20 Bq kg^{-1} respectively. Sites where concentrations were found outside these ranges were:

- Cardiff — 740 Bq kg^{-1} in grass; 130 Bq kg^{-1} in soil
- Dungeness — 54 Bq kg^{-1} in soil
- Oldbury — 27 Bq kg^{-1} in soil and
- Trawsfynydd — 25 Bq kg^{-1} in soil

Of these sites, the carbon-14 signal is clearest at Cardiff and is supported by data on other materials (see Cardiff sub-section). The observation of a significant enhancement of carbon-14 levels near Sellafield in 1994 (MAFF, 1995) was not repeated in 1996. This is probably due to the large reduction in disposals of this nuclide in gaseous wastes from this site (1993: 7.4 TBq; 1994: 1.0 TBq; 1995: 0.71 TBq; 1996: 0.63 TBq). Gaseous wastes have been diverted to a liquid stream.

Mean concentrations of sulphur-35 in grass and soil were typically in the ranges 5-20 and 1-5 Bq kg^{-1} respectively. Significant variations outside these ranges were found at:

- Oldbury — 60 Bq kg^{-1} in grass and
- Sellafield — 86 Bq kg^{-1} in grass

The high levels detected in grass at Oldbury and Sellafield were not reflected in the results of other monitoring carried out in the vicinity of the sites.

Mean concentrations of strontium-90 were generally less than 10 Bq kg^{-1} in grass and soil and similar to values for 1995 (MAFF, 1996). Those in excess of this level were found at:

- Sellafield 20 Bq kg^{-1} in grass and 13 Bq kg^{-1} in soil

Evidence of enhancement of strontium-90 due to site disposals from Sellafield has been found previously (MAFF, 1996) and is reflected in samples of other materials from the site.

Mean caesium-137 concentrations in grass and soil were generally similar to those in 1995, with levels in grass being less than 10 Bq kg^{-1} and in soil being less than 100 Bq kg^{-1}. As previously found, higher levels were observed at Sellafield, Trawsfynydd and Dungeness. The long term effects of fallout from weapon tests and Chernobyl would have played a significant part in determining these differences.

As was found in 1995, mean plutonium-239+240 concentrations detected in grass from Sellafield, ~1 Bq kg^{-1}, were significantly higher than those at other sites which were generally in the range 0.002-0.05 Bq kg^{-1}. In soil, higher concentrations than the norm were found at Dungeness (3.4 Bq kg^{-1}) and Sellafield (16 Bq kg^{-1}). A typical level at other sites was less than 0.5 Bq kg^{-1}. Fallout from weapon testing will have had a major influence on these levels. However, taken with the observations for plutonium-238, there is evidence for a site-related effect at Sellafield. The expected ratio of plutonium-239+240/plutonium-238 in fallout is about 40. That in recent disposals from Sellafield is less than 10. The observed ratios in grass and soil near Sellafield in 1996 were 16 and 18 respectively.

An indication of the potential radiological significance of these measurements can be given by comparing the levels with the appropriate Generalised Derived Limits (GDLs) for these radionuclides. GDLs for grass and soil are activity concentrations which correspond to an exposure of 1 mSv. They are based on simple, conservative models and as such do not provide a realistic assessment of exposures (Attwood *et al.*, 1996). Their main use is in screening monitoring results to establish whether specific studies should be undertaken. Table 43 compares the highest observed concentrations in grass and soil with the relevant GDLs. This comparison is not strictly valid as GDLs are derived for well mixed soil to a depth of 300 mm whereas the soil samples taken as part of this programme are to a depth of 70 mm. Generally, the highest mean concentrations observed were lower than, often very much lower than, the 10% trigger level for site-specific investigations. However at Cardiff and Dungeness, values in excess of 10% were observed. The site-specific assessments for these sites were considered in earlier sub-sections of this report. These assessments evaluate the dose received using the activities found in locally produced foods and show that the doses were significantly less than 0.1 mSv.

13. INDUSTRIAL SITES

13.1 Albright and Wilson Ltd, Whitehaven, Cumbria

In view of the radiological importance of natural radionuclides to fish and shellfish consumers (Pentreath *et al.,* 1989; Rollo *et al*., 1992; Camplin *et al*., 1996), a small programme of monitoring for these radionuclides in the UK marine environment has continued. Previous surveys (Rollo *et al.,* 1992) have established that an important man-made source was the Albright and Wilson chemical plant at Whitehaven in Cumbria which has manufactured phosphoric acid from imported phosphate ore. Phosphogypsum, a waste product of this process, has been discharged as a liquid slurry by pipeline to Saltom Bay. The radioactive waste disposals are authorised by the Environment Agency and contain low levels of natural radioactivity consisting mainly of thorium, uranium and their daughter products. Discharge rates during 1996 continued at the low rates attained since the introduction of changes in waste treatment techniques and the cessation of use of phosphate ore in 1992.

The results of monitoring for natural radioactivity near the site in 1996 are shown in Table 44.

Analytical effort has focused on lead-210 and polonium-210 which concentrate in marine species and are the important radionuclides in terms of potential dose to the public. Concentrations of polonium-210 and other natural radionuclides are slightly enhanced near Whitehaven but quickly reduce to background levels further away. Concentrations of polonium-210 and lead-210 were generally lower than in 1995 due to reductions in disposals and radioactive decay of activity already in the environment. Figure 6 shows how concentrations of polonium-210 in winkles have decreased substantially since 1989. It also demonstrates the seasonal variations in concentrations which have been previously observed (Rollo *et al*., 1992). The level of enhancement of polonium-210 concentrations in winkles is now less than 10 Bq kg^{-1} compared with more than 100 Bq kg^{-1} in the early 1990s. Concentrations of other natural radionuclides are now becoming difficult to distinguish from natural levels.

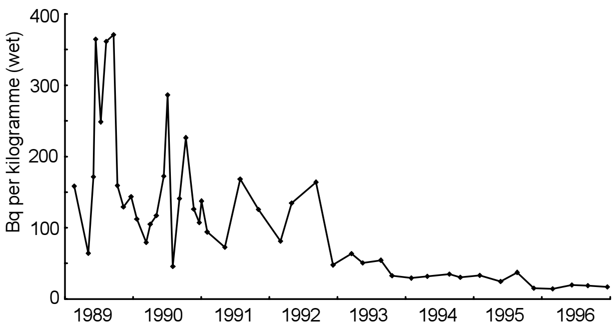

Figure 6. Polonium-210 in Parton winkles

The critical radiation exposure pathway is internal irradiation, due to the ingestion of natural radioactivity in local fish and shellfish. In this assessment, the contribution due to background levels of natural radionuclides has been subtracted. The most exposed group consists of people who consume seafood collected from Saltom Bay and Parton. Consumption rates were reviewed in 1996 and changes to fish and shellfish data were made. The exposure of the most exposed group in 1996 was 0.11 mSv on the basis of the current generic ICRP advice for a gut transfer factor of 0.5 for polonium. This value is to be applied in the absence of specific information.

As discussed in Section 6, a specific research study involving the consumption of crab meat containing natural levels of polonium-210 provides evidence for a gut transfer factor of 0.8 for polonium. Estimates of exposures due to polonium intakes due to consumption of seafood have therefore also been calculated using the conservative assumption that the value of 0.8 applies to the total intake of polonium. These data indicate that the most exposed group dose has reduced from 0.29 mSv in 1995 (MAFF, 1996) to 0.17 mSv in 1996.

The fish and shellfish consumed by the most exposed group also contains artificial radionuclides due to Sellafield disposals. The additional exposure due to artificial radionuclides has been calculated using data from Section 7. In 1996 these exposures added a further 0.082 mSv to the doses above resulting in a total dose to this group of 0.25 mSv. The estimated doses in 1996 are therefore well within the dose limit for members of the public of 1 mSv.

Use of the INTAKE methodology gives a dose to adults of <0.164 mSv

13.2 Other industrial sites

Levels of natural radionuclides in gaseous wastes from some large-scale industrial activities also have the potential to raise the radionuclide concentrations in foodstuffs. Examples of such activities are combustion of fossil fuels and metal or phosphate ore processing. Since 1991, a small rolling programme to examine the effects of these activities has been carried out. In 1996 three sites were chosen for study:

- Buxton, Derbyshire - a lime kiln
- Didcot, Oxfordshire - a coal fired power station and
- Hope, Derbyshire - a cement works.

Bakewell, Derbyshire was chosen as a control site for purposes of comparison.

The results of the sampling of grass, soil and animals in 1996 is given in Table 45. The analyses performed included ones for man-made radionuclides in order to rule out the possibility that there was an unforeseen mechanism whereby the general levels of such nuclides were enhanced.

There is considerable natural variability in the concentrations of natural radionuclides in the terrestrial environment. It is therefore difficult to draw firm conclusions about the effects of man-made sources of natural radionuclides. With this proviso, we conclude that in 1996 the concentrations of natural radionuclides in grass and soil were generally within the ranges expected for natural sources. However, individual results at Buxton and Didcot gave concentration ratios of polonium-210/lead-210 of up to 3.9 and 3.4 respectively. The existence of unsupported polonium-210 has been observed before when monitoring industrial sites (MAFF, 1995) and has been attributed to gaseous disposals of this radionuclide.

The impact of background levels of natural radionuclides can be illustrated by considering the level of natural radionuclides in beef. At Bakewell, where there is no industry likely to lead to enhanced levels of natural radionuclides in the environment an infant consumer of beef would receive a dose of 0.20 mSv. Most of this due to polonium-210. At Buxton where the lime kiln is likely to result in some enhancement of levels of natural radionuclides in the environment the infant consumer of beef would receive a dose of 0.38 mSv. If all this difference was a result of the presence of the lime kiln the infant consumer of beef would receive an additional 0.18 mSv as a result of the presence of enhanced levels. As previously stated, however, natural levels of polonium-210 in the soil vary significantly and the exact dose contribution from discharges from the lime kiln cannot be quantified. Further investigations of possible enhancements of natural radionuclide levels will continue.

The concentrations of man-made radionuclides in all samples were all low and typical of those to be expected due to sources such as weapon test and Chernobyl fallout.

14. LANDFILL SITES

Some organisations are authorised by the Environment Agency or SEPA to dispose solid wastes containing very low levels of radioactivity to landfill waste disposal sites. In addition some items with small radioactive content can be disposed of in general refuse in accordance with RSA 93 in some cases under exemption orders. There is potential for the radioactivity in wastes disposed of in this way to migrate in groundwater and in leachates to surrounding farmland. Monitoring of leachates in England and Wales is carried out by the Environment Agency (Environment Agency, 1997). In Scotland, this function is undertaken by SEPA whose results are presented in

Table 46. These show very low levels of carbon-14 and caesium-137 but, in common with data for sites in England and Wales, there is evidence for migration of tritium from the disposal sites. Inadvertent ingestion of such leachate (2.5 l y^{-1}), even at the highest concentration of tritium observed, would only result in an exposure of 0.0001 mSv.

Once covered over, landfill sites may also be converted back to agricultural use. In recognition of this, the programme in England and Wales includes monitoring of indicator materials (plants) collected near such sites. In 1996 the sites chosen were:

- Beddingham, East Sussex
- Cilgwyn Quarry, Gwynedd, and
- Witton, Cheshire

A control site was chosen at Lyndown in Devon for comparison as this is not licensed to receive radioactive waste.

Grass samples were collected at each site. Mean concentrations of tritium were less than the values detected in 1995 (up to 100 Bq kg^{-1}), being an order of magnitude lower than those which can be detected in grass in the vicinity of some nuclear sites. They are of negligible radiological significance. The evidence for migration of tritium at these landfill sites was limited. However a small enhancement was observed at Beddingham giving support to the observation that this nuclide is present in some landfill sites in England and Wales (Environment Agency, 1997). The results for other nuclides were typical of those expected due to natural background, weapon tests or Chernobyl fallout. These results are summarised in Table 47.

15. CHERNOBYL

The programme of monitoring in relation to the effects of fallout from this accident has continued in 1996. Caesium is still being detected in sheep grazing certain upland areas in the UK which were subjected to heavy rainfall after the Chernobyl accident in 1986. Restrictions are still in place on the movement and slaughter of sheep from these areas in order to prevent animals above the action level of 1000 Bq kg^{-1} of caesium, which was recommended by an EC expert committee in 1986, from entering the food chain.

In the summer of 1996 intensive monitoring surveys of just under 100,000 sheep in parts of the post-Chernobyl restricted areas of Cumbria, north Wales and Scotland were carried out. The results of the surveys enabled some 38 holdings and parts of two others to be removed from restrictions. This leaves fewer than 420 holdings within the restricted areas of England, Scotland and Wales and represents a reduction of 95% since 1986 when approximately 8900 holdings were under restriction.

In addition, the radiocaesium monitoring of sheep carcasses at slaughter-houses has continued in England and north Wales. The mean result of samples analysed in 1996 was 40 Bq kg^{-1} and the highest result was 425 Bq kg^{-1}.

Further information and results have been published by MAFF (MAFF, 1997) and the Scottish and Welsh Offices (Scottish Office, 1997; Welsh Office, 1997).

Sampling locations for freshwater fish were mostly in areas of relatively high deposition of fallout from Chernobyl, namely Cumbria, north Wales and parts of Scotland. Samples from areas of low deposition in England were also obtained for completeness and comparison.

Table 48 presents concentrations of caesium-134 and -137 in fish and water. Artificial radionuclides, other than those of radiocaesium were, in 1996, no longer detectable from the Chernobyl accident.

Concentrations of radiocaesium in freshwater fish varied between locations, reflecting the areas of deposition of radioactivity from Chernobyl and the small sampling programme. Perch had the highest concentrations of any of the freshwater species but, as they are not eaten in large quantities, their radiological significance is low. Concentrations in all species were less than 1000 Bq kg^{-1}. Where there are data for the same species and locations to compare with results for 1995 (MAFF, 1996) there are likely to be large statistical fluctuations because of the small sampling programme, but concentrations of radiocaesium were generally similar in 1996 to those in 1995. Figure 7 shows a plot of mean total radiocaesium concentrations in brown trout from Ennerdale Water against time. In recent years the rate of decline has reduced and it is likely that levels have now become more stable.

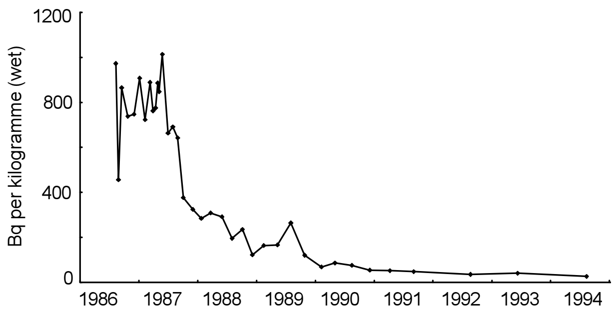

Figure 7. Radiocaesium in Brown Trout - Ennerdale water

Radiation exposures have been estimated using a procedure based on cautious assumptions, as previously (MAFF, 1996). A consumption rate of brown trout of 37 kg $year^{-1}$, sustained for one year, was taken to be an upper estimate for adults subject to the highest exposures. Actual exposures are likely to be much lower, not only because this consumption rate is cautious (Leonard *et al*., 1990) but also because, in practice, hatchery-reared or farmed fish of much lower radiocaesium concentrations may contribute to the diet. In 1996, estimated exposures were less than 0.1 mSv.

The ICRP (ICRP, 1993) provides guidance in the context of emergencies, which includes suggested levels of averted dose above which particular countermeasures would almost certainly be justified. It recommends that intervention should be taken by restricting a single foodstuff if the averted effective dose is in excess of 10 mSv in a year. Given that the dose estimates here are cautious, it is clear that the residual contamination of freshwater fish from fallout from Chernobyl is only of minor radiological importance.

16. REGIONAL MONITORING

This section presents the results of regional monitoring in areas of the British Isles. The component parts of the programme considered in subsequent sub-sections cover:

- The Isle of Man
- The Channel Islands
- General diet
- Milk
- Crops, bread, meat and drinking water
- Seawater surveys in the British Isles

16.1 Isle of Man

MAFF carries out an on-going programme of radioactivity monitoring on behalf of the Department of Local Government and the Environment on the Isle of Man for a wide range of terrestrial foodstuffs. Results are reported in Isle of Man Government press releases in addition to this report. Results of monitoring of aquatic foodstuffs are presented in Tables 8 and 9.

Radioactivity monitoring of terrestrial foods on the Island serves two purposes: firstly to monitor the continuing effects of radiocaesium deposition resulting from the Chernobyl accident in 1986 and secondly to respond to public concern over the effects of the nuclear industry. The potential sources of exposure from the UK nuclear industry are: (i) liquid disposals into the Irish sea and sea-to-land transfer; and (ii) gaseous disposals of tritium, carbon-14 and sulphur-35 and atmospheric transport.

The results of monitoring for 1996 are presented in Table 49. Tritium, cobalt-60, ruthenium-106, iodine-129, promethium-147, cerium-144 and plutonium-241 activity was not detected above the limit of detection in any of the Manx food samples monitored. Carbon-14 was detected in local milk and crops at activity concentrations similar to the natural background values observed in the regional network of sampling locations remote from nuclear sites. Levels of strontium-90, caesium, plutonium isotopes and americium-241 detected in local milk and crops were all similar to the values observed in the regional networks of UK dairies and crop sampling locations remote from nuclear sites, at those locations known to have received similar levels of Chernobyl and weapon test fallout. Sulphur-35 and technetium-99 were detected in a few samples but only at trace levels. These results demonstrate that there was no significant impact on Manx agriculture from operation of mainland nuclear installations in 1996.

These 1996 data were similar to results obtained in previous years. The exposure of the most exposed group from consumption of Manx foodstuffs monitored in 1996 was less than 0.023 mSv or 2% of the dose limit of 1 mSv.

16.2 Channel Islands

Marine environmental samples provided by the Channel Island States have continued to be analysed, mainly in surveillance of the effects of radioactive liquid disposals from the French reprocessing plant at Cap de la Hague. The programme also serves to monitor the potential effects of historic disposals of solid waste in the Hurd Deep. Fish and shellfish are monitored in relation to the internal irradiation pathway; sediment is analysed with relevance to external exposures. Sea water and seaweeds are sampled as indicator materials and, in the latter case, because of their use as fertilisers.

The results for 1996 are given in Table 50. Concentrations of activity in fish and shellfish were low and similar to those in previous years. Apportionment to different sources, including weapon test fallout, is difficult in view of the low levels detected. However no evidence for release of activity from the Hurd Deep site was found. A theoretical assessment based on a pessimistic choice of consumption rates and occupancy gives an estimated exposure of 0.009 mSv in 1996 or 0.9% of the dose limit for members of the public. The concentrations of artificial radionuclides in the marine environment of the Channel Islands therefore continued to be of negligible radiological significance.

16.3 General diet

As part of the government's general responsibility for food safety, radioactivity in whole diet is determined on a regional basis. Measurements are made on samples of mixed diet from regions throughout the United Kingdom. These samples are analysed for a range of food components including radioactivity. The results for the measurements of radioactivity are presented here. The system of sampling mixed diet rather than individual foodstuffs from specific locations, provides more accurate assessments of radionuclide intakes because people rarely obtain all their food from a local source (Mondon and Walters, 1990). Radionuclides of both natural and man-made origins were measured in samples in 1996. The results are provided in Tables 51 and 52.

All of the results for man-made radionuclides were low and of little radiological significance. Concentrations of tritium were less than the limits of detection. Strontium-90, caesium-137 and actinide activity concentrations results were below or close to the limit of detection and were similar to levels in previous years. Concentrations of sulphur-35 varied by a factor of five between regions and, in some samples, were higher than in previous years. The higher activities are not normally expected to be present in samples of diet because the monitoring in the vicinity of nuclear sites demonstrates that the impact of sulphur-35 disposals tends to be localised. Nevertheless, the concentrations even at the higher levels observed, are of negligible radiological significance.

Exposures as a result of consuming diet at average rates at the concentrations given in Tables 51 and 52 have been assessed for adults, infants and ten-year-old children. In all cases the exposures of infants were higher than other age groups. The data are summarised in Table 53. The most important man-made radionuclide was strontium-90, derived from weapon test fallout, and sulphur-35. The nationwide mean exposure for all man-made radionuclides was low at 0.004 mSv. Similar doses were estimated for 1995 (MAFF, 1996).

The mean concentration of carbon-14 in diet in 1996 was 54 Bq kg^{-1} with a range from 41 to 68 Bq kg^{-1}. In previous years, the mean values have been 33, 38 and 43 Bq kg^{-1} for 1993, 1994 and 1995, respectively. Given the variability of results from region to region and the analytical uncertainties, it is difficult to conclude that the trend of a small increase from year to year is significant, though the general expectation is for a small reduction from year to year due to the Suess effect (the diluting of carbon-14 by carbon-12 released by the burning of fossil fuels) and dispersion of weapon test fallout (Collins and Otlet., 1995). This situation will continue to be monitored in 1997.

The mean concentration of lead-210 decreased from 0.049 Bq kg^{-1} in 1995 to 0.018 Bq kg^{-1} in 1996. This is due to a single unusually high result in 1995. Concentrations of polonium-210 and uranium were similar to those in 1995 (MAFF, 1996). There was a single high result for radium-226 in 1996 which raised the mean concentration from 0.045 Bq kg^{-1} in 1995 to 0.067 Bq kg^{-1} in 1996.

The mean exposure due to consumption of natural radionuclides was 0.11 mSv. The most important radionuclide was polonium-210. Significant contributions would also have been made by other members of the uranium-238 and thorium-232 decay series which were not determined in this year's analytical schedule. Further data for these nuclides is provided by MAFF (1995). Nevertheless it remains true that the results continue to demonstrate that natural radionuclides are by far the most important source of exposure in the average diet of consumers.

16.4 Milk

The programme of milk sampling in the United Kingdom continued in 1996. Samples were collected monthly and analysed for natural and man-made radionuclides. The programme, together with that for crops presented in the following sub-section, provides useful information with which to compare data from farms close to nuclear sites and other establishments which may enhance concentrations above background levels. In Scotland limits of detection for certain nuclides differ from those in England and Wales and sulphur-35 is not measured. This leads to apparently higher doses being received in Scotland. It is intended to standardise the measurements in future to facilitate comparison.

Where measurements are comparable, detected activity concentrations of all radionuclides in 1996 were similar to those for previous years. These results are summarised in Table 54. Sulphur-35, iodine-129, uranium and plutonium results were either very close to or below their respective limits of detection. Results for tritium were generally close to or below the limit of detection and similar to the value detected in rain of 4.8 Bq l^{-1} (Playford *et al.*, 1995). A single raised value of 12 Bq l^{-1} was found at Tyneside. Mean and maximum values for carbon-14 from all dairies were similar and at expected background levels. The mean concentrations observed from all dairies in 1994 and 1995 were 19 and 17 Bq l^{-1}. In 1996 the value for the same dairies was 14 Bq l^{-1}. There is therefore no evidence of the kind observed for diet samples of an increasing trend for carbon-14 concentrations.

The concentration of strontium-90 was approximately 0.04 Bq l^{-1} which is in good agreement with results from other surveillance studies (Smith *et al.*, 1994a).

The levels of radiocaesium in dairy milk were highest from regions that received the greatest amounts of Chernobyl fallout. The results were in good agreement with those from the NRPB surveillance programme which showed mean levels in England and Wales of 0.04 and 0.05 Bq l^{-1} respectively, Scotland 0.16 Bq l^{-1} and those in Northern Ireland to be 0.22 Bq l^{-1} (Smith *et al.*, 1994a).

The assessed doses from consumption of dairy milk at average rates were highest to the one-year-old infant age group. In previous years the doses in Scotland have been evaluated for a 3 month old infant. Thus comparison with previous years is difficult. For the full range of radionuclides analysed, the doses ranged from <0.016 to <0.027 mSv and were dominated by the presence of the natural radionuclides lead-210 and polonium-210. Man-made radionuclides contributed no more than 4% to these exposures.

16.5 Crops, bread and meat

The programme of monitoring natural and man-made radionuclides in crops continued in 1996 (Table 55). Tritium activity was close to or below the limit of detection in all samples except one of leafy green vegetables from Renfrewshire where 57 Bq kg^{-1} was detected. The radiological significance of this level of activity is negligible but its detection lends support to the thesis that the widespread use and disposal of tritium activity in, for example, light sources is becoming detectable in the wider environment. Alternatively, it is conceivable that this sample may have been affected by disposals from Hunterston nuclear power station where similar levels in plants have been observed in the past (Scottish Office, 1996). The activities of carbon-14 detected in crop samples were those expected from consideration of background sources. The concentrations of other radionuclides in crops were similar to those observed in 1995 (MAFF, 1996).

Sampling of bread and meat continued in Scotland in 1996. The results, presented in Tables 56 and 57, show the presence of low-levels of man-made and natural radionuclides consistent with natural and weapon test and Chernobyl fallout sources. Similar levels to those in 1995 were observed (Scottish Office, 1996).

16.6 Fresh water and air particulates

Sampling and analysis of fresh water throughout Scotland continued in 1996. Analyses were made for tritium, strontium-90, caesium-137 and total alpha and beta activity. The results, in Table 58, are similar to those found in England and Wales (DOE, 1997). The observed concentrations were all at low levels typical of those in recent years (Scottish Office, 1996). An assessment of the exposure of high-rate consumers on the basis of the highest concentrations observed gives an estimated dose of less than 0.001 mSv in 1996.

Air particulates continued to be sampled at Eskdalemuir, Glasgow and Lerwick. The results for beta activity were 0.23, <2.0 and 0.23 mBq m^{-3} respectively. Alpha activity was detected at Eskdalemuir and Lerwick at concentrations of 0.16 and 0.21 mBq m^{-3} respectively. These results are similar to those for 1995 and are largely determined by fallout from weapons test and natural radioactivity in the air.

16.7 Seawater surveys

Seawater surveys support international studies concerned with the quality status of coastal seas (e.g. OSPAR, 1993b) and provide information which can be used to distinguish different sources of man-made radioactivity (e.g. Kershaw and Baxter, 1995). In addition, the distribution of radioactivity in seawater around the British Isles is a major factor in determining the variation in individual exposures at coastal sites as well as collective doses. Therefore a programme of surveillance into the distribution of key radionuclides is maintained using research vessels and other means of sampling. Detailed historical data on radiocaesium in seawater have been published in a series of reports to aid model development (Camplin and Steele, 1991; Baxter *et al.,* 1992; Baxter and Camplin 1993(a-c)) and have been used to derive dispersion factors for nuclear sites (Baxter and Camplin, 1994). The research vessel programme on radionuclide distribution currently comprises cruises in the Irish Sea, Scottish waters and the North Sea every two or three years. The results of the 1996 cruises are presented in Figures 8 - 11. Data from shoreline sampling in the Irish Sea and Scottish waters in 1996 are given in Table 59.

Concentrations of caesium-137 typical of (i) the north-eastern Irish Sea and (ii) northern Scottish waters and the North Sea were of the order of 50-500 mBq kg^{-1} and 5-50 mBq kg^{-1} respectively. These data show similar levels to those observed from sampling in recent years (MAFF, 1996), the general distribution being one of falling concentrations as the distance from Sellafield increases. This distribution is governed by recent disposals from the Sellafield site and the effects of activity previously discharged which had become associated with seabed sediments but is now being remobilised into the water column. The concentrations now observed are only a small percentage of those prevailing in the late 1970s, typically 30 000 mBq kg^{-1} (Baxter *et al.,* 1992), when disposals were substantially higher.

A similar distribution to that for caesium-137 exists for tritium with Sellafield as the main source for this radionuclide. The general distribution of tritium in coastal waters in 1996 was similar to that in 1993 (Camplin, 1994) though levels could increase in future years as the THORP plant at Sellafield increases its throughput. Although the concentrations of tritium in sea water are higher than those of caesium-137, they are of much less radiological significance because tritium has very low radiotoxicity.

Technetium-99 concentrations in seawater have been increasing in recent years due to increases in disposals of this nuclide from Sellafield. The results of research cruises to study this radionuclide have been published by Leonard *et al* (1997). Further information is also being published by Leonard, *et al.* (in press).

Measurements of beta and potassium-40 activity in water from the Clyde in 1996 gave results of < 0.15 and < 1900 mBq kg^{-1} respectively. These levels are similar to those for 1995.

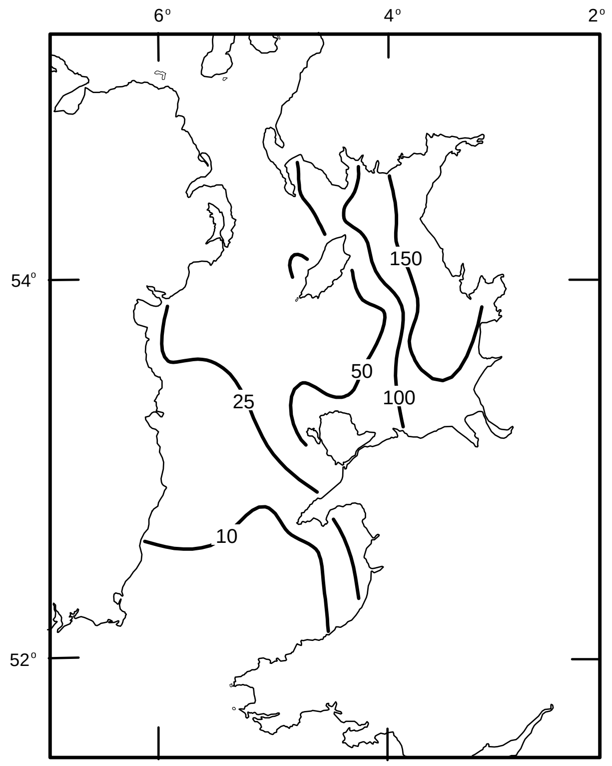

Figure 8. ***Concentrations (mBq kg^{-1}) of caesium-137 in filtered surface water from the Irish Sea, December 1996***

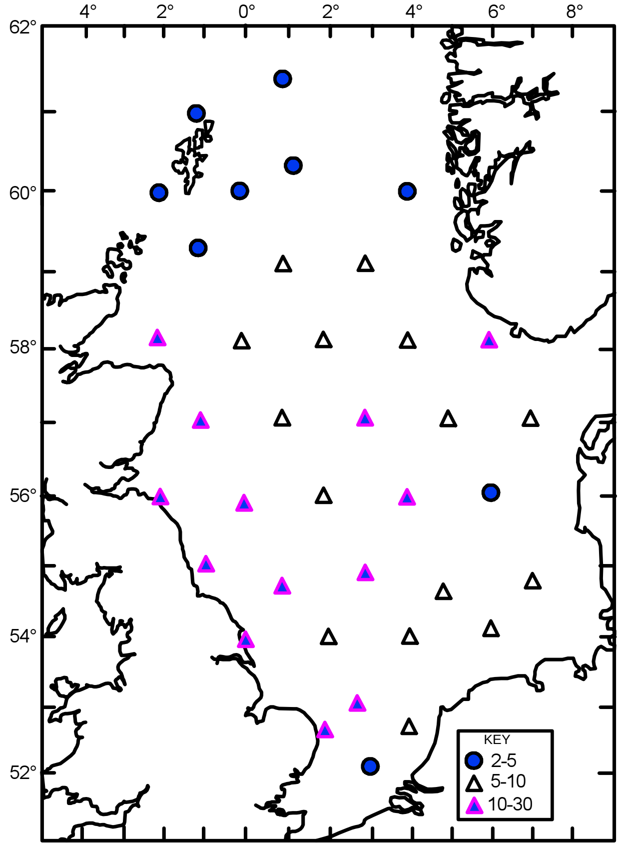

Figure 10. ***Concentrations (mBq kg^{-1}) of caesium-137 in filtered seawater from the North Sea, August-September 1996***

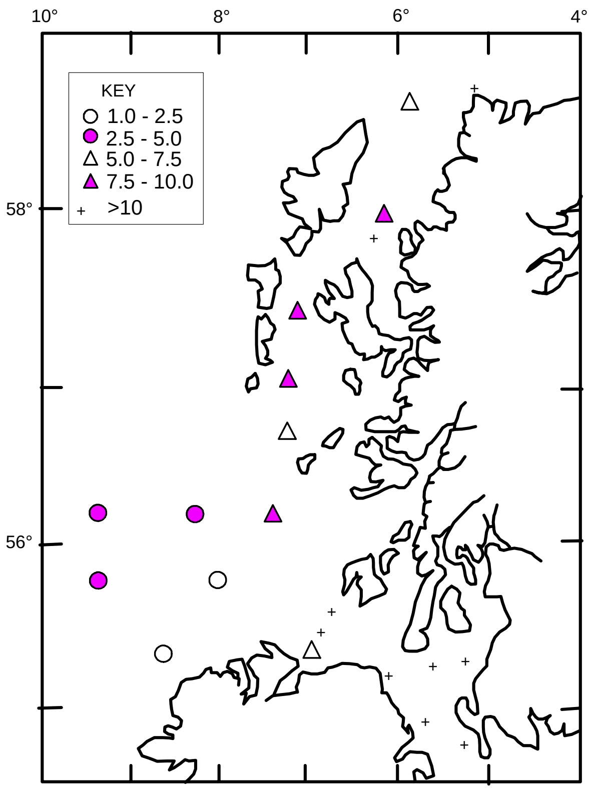

Figure 9. ***Concentrations (mBq kg^{-1}) of caesium-137 in filtered water from the west of Scotland, December 1996***

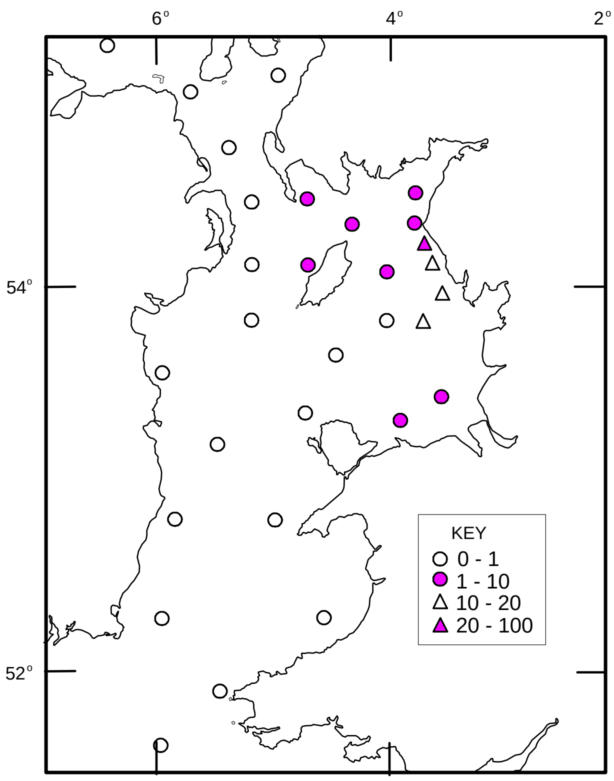

Figure 11. ***Concentrations (Bq kg^{-1}) of tritium in water from the Irish Sea, December 1996***

17. RESEARCH IN SUPPORT OF THE MONITORING PROGRAMME

MAFF and SEPA have extramural programmes of special surveillance investigations and supporting research and development studies to complement the routine surveillance undertaken. This additional work has the following objectives:

- to evaluate the significance of potential sources of radionuclide contamination of the foodchain;
- to identify and investigate specific topics not currently addressed by the routine surveillance programmes and the need for their inclusion in future routine surveillance;
- to develop and maintain site-specific habit and agricultural practice data, in order to improve the realism of dose assessment calculations;
- to develop more sensitive and/or efficient analytical techniques for measurement of radionuclides in natural matrices;
- to evaluate the competence of laboratories radiochemical analytical techniques for specific radionuclides in food;
- to develop improved methods for handling and processing surveillance data.

A list of related R & D projects completed in 1996 is presented in Table 60. Copies of the final reports for each of these projects are available from MAFF. Table 60 also provides information on projects which are currently underway. The results of these projects will be made available in due course.

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Table 1. Principal discharges of liquid radioactive waste from nuclear establishments in the United Kingdom, 1996

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq[a]	% of limit[b]
British Nuclear Fuels plc				
Sellafield	Alpha	1	0.275	27
Sea pipelines	Beta	400	143	36
	Tritium	$1.8\ 10^{4}$	3009	17
	Carbon-14	20.8	10.6	51
	Cobalt-60	13	0.429	3.3
	Strontium-90	48	16.0	33
	Zirconium-95+Niobium-95	9	1.15	13
	Technetium-99	200	155	77
	Ruthenium-106	63	9.01	14
	Iodine-129	1.3	0.412	32
	Caesium-134	6.6	0.271	4.1
	Caesium-137	75	10.3	14
	Cerium-144	8	0.779	9.7
	Plutonium alpha	0.7	0.209	30
	Plutonium-241	27	4.35	16
	Americium-241	0.3	0.0736	25
	Uranium[d]	2040	1158	57
Factory sewer	Alpha	0.0033	$3.2\ 10^{-5}$	<1
	Beta	0.0135	$7.1\ 10^{-4}$	5.3
	Tritium	0.132	0.0125	9.5
Drigg				
Sea pipeline	Alpha	0.1	$2.66\ 10^{-4}$	<1
	Beta[e]	0.3	0.00895	3.0
	Tritium	120	1.95	1.6
Stream[f]	Alpha	$9.0\ 10^{4}$	133	<1
	Beta[e]	$1.2\ 10^{6}$	1423	<1
	Tritium	$6.0\ 10^{8}$	$2.6\ 10^{5}$	<1
Springfields	Alpha	4	0.124	3.1
	Beta	240	153	64
	Technetium-99	0.6	0.0329	5.5
	Thorium-230	2	0.0480	2.4
	Thorium-232	0.2	0.0014	<1
	Neptunium-237	0.04	$2.0\ 10^{-4}$	<1
	Uranium	0.15	0.061	41
Capenhurst				
Rivacre Brook	Uranium	0.02	0.00136	6.8
	Uranium daughters	0.02	0.00309	16
	Non-uranic alpha	0.003	$6.76\ 10^{-5}$	2.3
	Technetium-99	0.1	0.0032	3.2
Chapelcross	Alpha	0.1	$1.22\ 10^{-3}$	1.2
	Beta[e]	25	0.111	<1
	Tritium	5.5	0.368	6.7
United Kingdom Atomic Energy Authority				
Dounreay	Alpha[c]	0.75	0.071	9.4
	Beta[e]	110	6.28	5.7
	Tritium	130	2.03	1.6
	Cobalt-60	1	0.035	3.5
	Strontium-90	12	0.587	4.9
	Zirconium-95+Niobium-95	6	0.127	2.1
	Ruthenium-106	12	1.78	15
	Silver-110m	0.4	0.014	3.4
	Caesium-137	50	4.61	9.2
	Cerium-144	12	0.030	<1
	Plutonium-241	15	0.356	2.4
	Curium-242	1	$6.0\ 10^{-4}$	<1
Harwell (pipeline)	Alpha	0.001	$4.14\ 10^{-5}$	4.1
	Beta[e]	0.02	0.00182	9.1
	Tritium	4	0.0520	1.3
	Cobalt-60	0.007	$8.57\ 10^{-5}$	1.2
	Caesium-137	0.007	$3.11\ 10^{-4}$	4.5
Harwell (Lydebank Brook)	Alpha	$5\ 10^{-4}$	$4.56\ 10^{-5}$	9.1
	Beta[e]	0.002	$3.00\ 10^{-4}$	15
	Tritium	0.1	0.0187	19
Winfrith (inner pipeline)	Alpha	0.3	0.00183	<1
	Tritium	650	1.59	<1
	Cobalt-60	10	0.00199	<1
	Zinc-65	6	$6.77\ 10^{-4}$	<1
	Other radionuclides	80	0.0240	<1

Table 1. continued

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq[a]	% of limit[b]
Winfrith (outer pipeline)	Alpha	0.004	$1.18\ 10^{-4}$	3.0
	Tritium	1	0.0177	1.8
	Other radionuclides	0.01	$1.84\ 10^{-4}$	1.8
Magnox Electric plc[q]				
Berkeley	Tritium	8	0.0372	<1
	Caesium-137	0.2	0.0103	5.2
	Other radionuclides	0.4	0.0387	9.7
Bradwell	Tritium	30	1.36	4.5
	Caesium-137	0.75	0.393	52
	Other radionuclides	1	0.363	36
Dungeness 'A' Station	Tritium	35	1.38	40
	Caesium-137	1.2	0.554	46
	Other radionuclides	1.4	0.282	20
Hinkley Point 'A' Station	Tritium	25	0.670	2.7
	Caesium-137	1.5	0.406	27
	Other radionuclides	1	0.164	16
Hunterston 'A' Station	Total activity[e]	2	0.141	7.1
	Tritium	5	0.0229	<1
Oldbury	Tritium	25	0.186	<1
	Caesium-137	0.7	0.051	7.3
	Other radionuclides	1.3	0.311	24
Sizewell 'A' Station	Tritium	35	1.13	3.2
	Caesium-137	1.0	0.36	36
	Other radionuclides	0.7	0.229	33
Trawsfynydd	Total activity[e,i,j]	0.72	0.0101	1.4
	Tritium	12	0.103	<1
	Strontium-90	0.08	0.00439	5.5
	Caesium-137	0.05	0.00631	13
Wylfa	Tritium	40	9.88	25
	Other radionuclides	0.15	0.0611	41
Nuclear Electric Ltd[q]				
Dungeness 'B' Station	Tritium	650	252	39
	Sulphur-35	2	0.316	16
	Cobalt-60	0.03	0.00166	5.5
	Other radionuclides	0.25	0.0167	7.7
Hartlepool	Tritium	1200	353	29
	Sulphur-35	3	0.899	30
	Cobalt-60	0.03	0.0145	48
	Other radionuclides	0.3	0.00548	1.8
Heysham Station 1	Tritium	1200	341	28
	Sulphur-35	2.8	0.223	8.0
	Cobalt-60	0.03	0.00102	3.4
	Other radionuclides	0.3	0.00782	2.6
Station 2	Tritium	1200	379	32
	Sulphur-35	2.3	0.0358	1.6
	Cobalt-60	0.03	6.89	2.3
	Other radionuclides	0.3	0.0114	3.8
Hinkley Point 'B' Station	Tritium	620	319	52
	Sulphur-35	5	0.795	16
	Cobalt-60	0.033	$4.00\ 10^{-4}$	1.2
	Other radionuclides	0.235	0.00864	3.7

Table 1. continued

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq[a]	% of limit[b]
Sizewell 'B' Station	Tritium	40	37.6	94
	Other radionuclides	0.2	0.0199	10
Scottish Nuclear Ltd[q]				
Hunterston 'B' Station[t]	Alpha	0.001	5.03 10^{-5}	5
	Beta[e,g,p]	0.45	0.00406	<1
	Tritium	800	399	50
	Sulphur-35	10	1.37	14
	Cobalt-60	0.03	0.00186	6.2
Torness[r]	Alpha	0.001	5.79 10^{-6}	<1
	Beta[e,g,p]	0.45	0.0013	<1
	Tritium	800	298	37
	Sulphur-35	10	0.044	<1
	Cobalt-60	0.03	5.02 10^{-4}	1.6
Ministry of Defence				
Aldermaston (pipeline)[k]	Alpha	1.5 10^{-4}	1.28 10^{-5}	8.5
	Tritium	0.05	0.00164	3.3
	Plutonium-241	6.0 10^{-4}	5.10 10^{-5}	8.5
	Other radionuclides	1.5 10^{-4}	1.33 10^{-5}	8.9
Aldermaston (Silchester)[k]	Alpha	1.0 10^{-4}	6.71 10^{-6}	6.7
	Beta	3.0 10^{-4}	4.45 10^{-5}	15
Barrow [l]	Tritium	0.02	2.09 10^{-3}	10
	Manganese-54	2.5 10^{-7}	5.56 10^{-9}	2.2
	Cobalt-58	7.0 10^{-7}	2.70 10^{-9}	<1
	Cobalt-60	7.0 10^{-8}	1.29 10^{-8}	18
	Tin-113	2.5 10^{-7}	5.48 10^{-9}	2.2
	Antimony-124	2.0 10^{-6}	8.84 10^{-9}	<1
	Other radionuclides	3.5 10^{-6}	1.96 10^{-7}	5.6
Burghfield[k]	Alpha	2.0 10^{-6}	3.18 10^{-8}	1.6
	Other radionuclides	1.2 10^{-5}	6.36 10^{-8}	<1
Devonport[m,n] (sewer)	Beta		Nil	
	Tritium		"	
	Cobalt-60		"	
Devonport[m,n] (river)	Beta		"	
	Tritium		"	
	Cobalt		"	
Devonport[n,o] (sewer)	Total activity		4.77 10^{-4}	
	Cobalt-60		4.24 10^{-4}	
Devonport[o] (pipeline)	Total activity[e,p]	0.002	4.03 10^{-5}	2.0
	Tritium	0.12	0.0765	64
	Cobalt-60	0.016	5.16 10^{-5}	<1
Faslane	Alpha activity	2.0 10^{-4}	1.77 10^{-5}	8.9
	Beta activity[e,p]	5.0 10^{-4}	1.78 10^{-4}	36
	Tritium	1	0.198	20
	Cobalt-60	5.0 10^{-4}	8.69 10^{-5}	17
Greenwich	Alpha and beta	4.44 10^{-6}	4.9 10^{-7}	11
Rosyth[h]	Alpha	10^{-6}	1.02 10^{-7}	10
	Beta[e,p]	5 10^{-4}	3.12 10^{-4}	62
	Tritium	0.01	0.00715	72
	Cobalt-60	0.01	6.21 10^{-4}	6.2
Amersham International plc				
Amersham	Alpha	3.0 10^{-4}	6.75 10^{-5}	23
	Beta >0.4 MeV	0.1	0.0159	16
	Tritium	0.2	0.00284	1.4
	Iodine-125	0.2	0.00127	<1
	Caesium-137	0.005	2.67 10^{-5}	<1
	Other radionuclides	0.3	0.128	43
Cardiff	Tritium	900	542	60
	Carbon-14	2	1.60	80
	Phosphorus-32/33	0.01	1.33 10^{-4}	1.3
	Iodine-125	0.05	0.0155	31
	Others	5.0 10^{-4}	1.46 10^{-4}	29

Table 1. continued

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq[a]	% of limit[b]
Imperial College Reactor Centre				
Ascot	Tritium	$1.0\ 10^{-4}$	$6.05\ 10^{-6}$	6.1
	Other radioactivity	$4.0\ 10^{-5}$	$2.63\ 10^{-6}$	6.6
Imperial Chemical Industries plc				
Billingham	Beta/gamma	0.36	$9.79\ 10^{-7}$	<1
Rolls Royce plc				
Derby	Alpha	0.00666	$3.41\ 10^{-4}$	5.1
Scottish Universities Research and Reactor Centre				
East Kilbride	Total activity	$1.56\ 10^{-3}$	$5.97\ 10^{-8}$	<1
Universities Research Reactor Centre				
Risley[s]	Alpha		Nil	
	Beta		Nil	

[a] *Some discharges are upper estimates because they include 'less than' data derived from analyses of effluents at limits of detection. Data quoted to 3 significant figures except where fewer significant figures are provided in source documents*
[b] *Data quoted to 2 significant figures except when values are less than 1%*
[c] *Excluding curium-242*
[d] *The limit and discharge data are expressed in kg*
[e] *Excluding tritium*
[f] *Discharges and limits are expressed in terms of concentrations of activity in Bq m^{-3}*
[g] *Excluding sulphur-35*
[h] *Authorisation was revised with effect from 1 April 1996. Discharges were made by Babcock Rosyth Defence Ltd and Rosyth Royal Dockyard plc in the 1st and 2nd-4th quarters of 1996 respectively. The discharges presented are for 1996. The limits are the annual limits in effect from the date of revision*
[i] *Excluding caesium-137*
[j] *Excluding strontium-90*
[k] *Discharges are made by Hunting-BRAE Ltd*
[l] *Discharges from Barrow are included with those from MoD sites because they are related to submarine activities. Discharges are made by Vickers Shipbuilding and Engineering Ltd*
[m] *Discharges are made by the Ministry of Defence*
[n] *The authorisation includes a limit on concentration of total activity of $4\ 10^{-6}$ TBq m^{-3}. At no time did the concentration exceed the limit*
[o] *Discharges are made by Devonport Management Ltd*
[p] *Excluding cobalt-60*
[q] *Prior to 1 April 1996, of the nuclear power stations listed, those in Scotland were administered by Scottish Nuclear Ltd. The others were administered by Nuclear Electric plc*
[r] *Authorisation was revised with effect from 31 March 1996. The discharges presented are for 1996. The limits are the annual limits in effect from the date of revision*
[s] *The authorisation was revoked with effect from 20 August 1996. No discharges were made during 1996*
[t] *Authorisation was revised with lower limits with effect from 16 January 1996. These data relate to the period 16 January 1996 to 31 December 1996*

Table 2. Principal discharges of gaseous radioactive wastes from nuclear establishments in the United Kingdom, 1996

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq	% of limit
British Nuclear Fuels plc				
Sellafield[a,b]	Alpha	0.0017	$1.20\ 10^{-4}$	7.1
	Beta	0.048	0.00214	4.5
	Tritium	1400	529	38
	Carbon-14	8.4	0.63	7.5
	Sulphur-35	0.21	0.14	67
	Argon-41	3700	2570	69
	Cobalt-60	$9.2\ 10^{-4}$	$4.8\ 10^{-5}$	5.2
	Krypton-85	$3.5\ 10^{5}$	$9.4\ 10^{4}$	27
	Strontium-90	0.0016	$1.2\ 10^{-4}$	7.5
	Ruthenium-106	0.046	$8.80\ 10^{-4}$	1.9
	Antomony-125	0.005	$7.60\ 10^{-4}$	15
	Iodine-129[f]	0.067	0.0052	31
	Iodine-129[g]	0.052	0.0194	28
	Iodine-131	0.055	0.00230	4.2
	Caesium-137	0.0073	$8.4\ 10^{-4}$	12
	Plutonium (alpha)	$8.4\ 10^{-4}$	$6.4\ 10^{-5}$	7.6
	Plutonium-241	0.0051	$5.8\ 10^{-4}$	11
	Americium-241 and curium-242	$3.6\ 10^{-4}$	$4.9\ 10^{-5}$	14
Springfields	Uranium	0.006	$2.11\ 10^{-3}$	35
Capenhurst[d]	Uranium		$5.17\ 10^{-6}$	
Chapelcross	Tritium	5000	1120	22
	Sulphur-35	0.05	0.028	56
	Argon-41	4500	3210	71
United Kingdom Atomic Energy Authority[j]				
Dounreay (Fuel Cycle Area)	Alpha	0.001	$2.87\ 10^{-5}$	2.9
	Beta	0.045	0.00115	2.6
	Tritium	40	0.276	<1
	Krypton-85	1000	218	22
	Strontium-90	0.005	$6.63\ 10^{-4}$	13
	Ruthenium-106	0.007	$3.06\ 10^{-5}$	<1
	Iodine-129	0.004	$2.06\ 10^{-5}$	<1
	Iodine-131	0.003	$1.47\ 10^{-5}$	<1
	Caesium-134	0.001	$5.10\ 10^{-6}$	<1
	Caesium-137	0.007	$1.77\ 10^{-4}$	2.5
	Cerium-144	0.007	$1.63\ 10^{-5}$	<1
	Plutonium-241	0.005	$5.97\ 10^{-4}$	12
	Curium-242	0.001	$7.56\ 10^{-6}$	<1
	Curium-244[k]	10^{-4}	$1.36\ 10^{-5}$	14
Dounreay (Fast Reactor)	Beta	0.0015	$8.15\ 10^{-7}$	<1
	Tritium	130	0.0244	<1
	Krypton-85	$4.0\ 10^{-4}$	$2.12\ 10^{-5}$	5.3
Dounreay (Prototype Fast Reactor)	Tritium	18	0.794	4.4
	Argon-41	1.5	Nil	
	Krypton-85m	10	"	
	Krypton-87	20	"	
	Krypton-88	20	"	
	Xenon-133	3750	"	
	Xenon-133m	75	"	
	Xenon-135	350	"	
Harwell	Alpha	$7.0\ 10^{-6}$	$3.18\ 10^{-7}$	4.5
	Beta	$4.5\ 10^{-4}$	$6.56\ 10^{-6}$	1.5
	Tritium	150	7.16	4.8
Windscale	Alpha	$1.2\ 10^{-5}$	$3.91\ 10^{-7}$	3.3
	Beta	0.005	$2.12\ 10^{-5}$	< 1
	Tritium	2.3	0.00831	<1
	Krypton-85	14	0.0237	<1
	Iodine-131	0.0012	$6.00\ 10^{-6}$	<1
Winfrith	Alpha	$2.0\ 10^{-6}$	$4.08\ 10^{-10}$	<1
	Beta	$2.5\ 10^{-5}$	$9.24\ 10^{-9}$	<1
	Tritium	15	0.960	6.4
	Carbon-14	0.3	$5.8\ 10^{-4}$	<1
	Krypton-85	150	Nil	Nil
Magnox Electric plc[c,e]				
Berkeley Technology Centre	Alpha and beta	$2.0\ 10^{-5}$	$3.14\ 10^{-6}$	1.6
Power Station and Technology Centre	Alpha and beta	$2.0\ 10^{-4}$	$3.76\ 10^{-6}$	1.9
	Tritium	2	0.00959	<1
	Carbon-14	0.2	$2.66\ 10^{-4}$	<1
	Sulphur-35	0.006	Nil	Nil

Table 2. continued

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996 TBq	Discharges during 1996 % of limit
Bradwell	Beta	0.001	2.10 10^{-4}	21
	Tritium	1.5	0.786	52
	Sulphur-35	0.2	0.0765	38
	Carbon-14	0.6	0.357	60
	Argon-41	1000	647	65
Dungeness 'A' Station	Beta	0.001	3.25 10^{-4}	33
	Tritium	2	1.03	52
	Carbon-14	5	2.5	51
	Sulphur-35	0.4	0.0496	12
	Argon-41	2000	1190	60
Hinkley Point 'A' Station	Beta	0.001	7.68 10^{-5}	7.7
	Tritium	25	2.10	8.4
	Carbon-14	4	1.88	47
	Sulphur-35	0.2	0.069	35
	Argon-41	4500	33.2	<1
Hunterston 'A' Station	Beta[l]	10^{-4}	1.61 10^{-7}	<1
	Tritium	1	5.58 10^{-4}	<1
	Carbon-14	0.2	0.00975	4.9
Oldbury	Beta	0.001	9.06 10^{-5}	9.1
	Tritium	5	1.73	35
	Carbon-14	6	3.85	64
	Sulphur-35	0.8	0.25	33
	Argon-41	500	112	22
Sizewell 'A' Station	Beta	0.001	2.22 10^{-5}	2.2
	Tritium	7	0.871	12
	Carbon-14	1.5	0.107	7.1
	Sulphur-35	0.6	9.60 10^{-3}	1.6
	Argon-41	3000	295	9.8
Trawsfynydd	Beta	0.002	1.63 10^{-6}	<1
	Tritium	10	0.0630	<1
	Carbon-14	5	7.02 10^{-4}	<1
	Sulphur-35	0.4	Nil	Nil
	Argon-41	350	“	“
Wylfa	Beta	0.001	8.71 10^{-5}	8.7
	Tritium	20	6.70	34
	Carbon-14	2.4	1.24	52
	Sulphur-35	0.5	0.20	40
	Argon-41	120	43.9	37
Nuclear Electric plc[c,e]				
Dungeness 'B' Station	Beta	0.001	4.86 10^{-5}	4.9
	Tritium	15	1.52	10
	Carbon-14	5	0.490	9.8
	Sulphur-35	0.45	0.0133	3.0
	Argon-41	150	27.9	19
	Iodine-131	0.005	4.14 10^{-6}	<1
Hartlepool	Beta	0.001	3.49 10^{-5}	3.5
	Tritium	6	1.56	26
	Carbon-14	5	1.51	30
	Sulphur-35	0.16	0.0447	28
	Argon-41	60	23.9	40
	Iodine-131	0.005	2.75 10^{-4}	5.5
Heysham Station 1	Beta	0.001	4.74 10^{-5}	4.7
	Tritium	6	0.923	15
	Carbon-14	4	1.02	26
	Sulphur-35	0.12	0.0137	11
	Argon-41	60	10.7	18
	Iodine-131	0.005	0.0012	24
Heysham Station 2	Beta	0.001	2.20 10^{-5}	2.2
	Tritium	15	2.14	14
	Carbon-14	3	0.849	28
	Sulphur-35	0.3	0.0173	5.8
	Argon-41	85	12.9	15
	Iodine-131	0.005	2.32 10^{-4}	4.6
Hinkley Point 'B' Station	Beta	0.001	7.68 10^{-5}	7.7
	Tritium	30	2.10	7.0
	Carbon-14	8	1.88	24
	Sulphur-35	0.4	0.0690	17
	Argon-41	300	33.2	11
	Iodine-131	0.005	2.09 10^{-5}	<1

Table 2. continued

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq	% of limit
Sizewell 'B' Station (outlets 1-3)	Noble gases	295	6.11	2.1
	Halogens	0.0027	4.92 10^{-5}	1.8
	Beta	0.01	8.71 10^{-6}	<1
	Tritium	7.8	0.579	7.4
	Carbon-14	0.59	0.0541	9.2
“ (Approved places)	Noble gases	5	Nil	Nil
	Halogens	3.0 10^{-4}	“	“
	Tritium	0.2	“	“
	Carbon-14	0.01	“	“
Scottish Nuclear Ltd[c,e]				
Hunterston 'B' Station[n]	Beta[l]	0.002	3.56 10^{-5}	1.8
	Tritium	20	2.18	11
	Carbon-14	3	1.35	45
	Sulphur-35	0.8	0.0788	9.9
	Argon-41	220	49.5	23
Torness[n]	Beta[l]	0.002	1.48 10^{-5}	<1
	Tritium	20	1.26	6.3
	Carbon-14	3	0.571	19
	Sulphur-35	0.8	0.0254	3.2
	Argon-41	220	6.99	3.2
Ministry of Defence				
Aldermaston[a]	Alpha	9.0 10^{-7}	1.65 10^{-7}	18
	Beta[h]	4.6 10^{-6}	1.14 10^{-7}	2.5
	Tritium	340	9.48	2.8
	Krypton-85	0.4	3.0 10^{-3}	<1
Barrow[i]	Tritium	3.2 10^{-6}	Nil	Nil
	Argon-41	0.08	“	“
Burghfield[a]	Alpha	2.0 10^{-8}	4.0 10^{-10}	2
	Tritium	0.35	9.4 10^{-5}	< 1
	Krypton-85	1	0.038	3.8
Dounreay (Vulcan)	Noble gases	0.027	0.00295	11
	Iodine	3.70 10^{-4}	2.94 10^{-5}	7.9
Greenwich[d]	Argon-41		0.057	
Rosyth[m]	Beta	10^{-7}	Nil	Nil
	Argon-41	0.4	“	“
Amersham International plc				
Amersham	Alpha	2.0 10^{-6}	3.49 10^{-7}	17
	Other (penetrating)	0.05	1.59 10^{-4}	<1
	Other (non-penetrating)	0.5	0.0236	4.7
	Tritium	40	6.52 10^{-4}	<1
	Selenium-75	0.03	6.72 10^{-4}	2.2
	Iodine-125	0.1	0.0215	22
	Iodine-131	0.05	0.00693	14
	Radon-222	10	1.74	17
Cardiff	Soluble tritium	400	173	43
	Insoluble tritium	1000	522	52
	Carbon-14	6	3.84	64
	Phosphorus-32/33	2.0 10^{-4}	5.53 10^{-6}	2.8
	Iodine-125	5.0 10^{-4}	1.20 10^{-4}	24
	Other activity	0.04	1.22 10^{-3}	3.1
Imperial College Reactor Centre				
Ascot	Tritium	5.0 10^{-4}	1.74 10^{-4}	35
	Argon-41	2.5	0.852	34
Imperial Chemical Industries plc				
Billingham	Tritium	2	8.44 10^{-5}	<1
	Argon-41	2	3.80 10^{-2}	1.9
Johnson and Johnson Clinical Diagnostics Ltd				
Cardiff	Iodine-125	0.015	0.00248	17
	Other activity	5.0 10^{-4}	2.76 10^{-5}	5.5
Rolls Royce plc				
Derby	Alpha	[d]	1.1 10^{-6}	

Table 2. continued

Establishment	Radioactivity	Discharge limit (annual equivalent), TBq	Discharges during 1996	
			TBq	% of limit
Scottish Universities Research and Reactor Centre				
East Kilbride	Tritium	19.2	Nil	
	Argon-41	3.33	“	
URENCO				
Capenhurst	Uranium	2.5 10^{-6}	1.11 10^{-7}	4.4

[a] *Discharge limits and discharges are aggregated from data for individual locations on the site. Percentages are given as a general guide to usage of the limits but should strictly be calculated for individual locations. All discharges were below the appropriate limit for each location.*
[b] *Some limits are related to the operation of the THORP plant and may thus vary from year to year*
[c] *Prior to 1 April 1996, of the nuclear power stations listed, those in Scotland were administered by Scottish Nuclear Ltd. The others were administered by Nuclear Electric plc.*
[d] *There are no numerical limits for this discharge. However, the authorisation stipulates that the Best Practicable Means should be used to control the discharge*
[e] *Discharges may also be authorised from incinerators at these sites*
[f] *Limit was revised with effect from 28 March 1996. These data relate to the period 1 January 1996 to 28 March 1996. '% limit' refers to equivalent limit for this period*
[g] *Limit was revised with effect from 28 March 1996. These data relate to the period 28 March 1996 to 31 December 1996. % limit' refers to equivalent limit for this period*
[h] *Excluding tritium and plutonium-241*
[i] *Discharges from Barrow are included with those from MoD sites because they are related to submarine activities. Discharges are made by Vickers Shipbuilding and Engineering Ltd*
[j] *Data includes contributions from tenants*
[k] *Data includes any curium-243 present*
[l] *Particulate activity*
[m] *Discharges were made by Babcock Rosyth Defence Ltd and Rosyth Royal Dockyard plc in the 1st and 2nd-4th quarters of 1996 respectively*
[n] *Authorisation was revised with effect from 31 March 1996. The discharges presented are annual limits in effect from the date of revision*

Table 3. Disposals of solid radioactive waste at nuclear establishments in the United Kingdom, 1996

Establishment	Radioactivity	Disposal limit, TBq	Disposals during 1996	
			TBq	% of limit
Drigg	Tritium	10	0.493	4.9
	Carbon-14	0.05	0.00872	17
	Cobalt-60	2	0.304	15
	Iodine-129	0.05	1.7×10^{-4}	<1
	Radium-226 plus thorium-232	0.03	0.00691	23
	Uranium	0.3	0.104	35
	Other alpha[a]	0.3	0.104	35
	Others[a,b]	15	3.93	26.2
Dounreay[c]	Alpha		0.0149	
	Beta/gamma		0.367	

[a] *With half-lives greater than three months*
[b] *Other beta emitting radionuclides but including iron-55 and cobalt-60*
[c] *Limits exist for concentrations of activity, activity per unit area and dose rate. All disposals were within the limits in 1996*

Table 4. Scope of the monitoring programmes

Programme	Sub-programme	Main purpose
Nuclear sites[a]	-	Support for RSA 93, assessment of waste disposal
	Grass and soil	Support for EURATOM Treaty
Industrial sites[b]	Chemical works	Support for RSA 93, assessment of waste disposal
	Landfill sites	"
Chernobyl fallout	Sheep monitoring guidance on restrictions	Support for FEPA 85,
	Freshwater fish	Support for FEPA 85, trend analysis
Regional[b]	Milk, crops, bread and meat	General food safety, support for EURATOM Treaty[c]
	Diet	"
	Isle of Man	General food safety
	Northern Ireland	"
	Channel Islands	"
	Freshwater and air particulate[c]	Safety of drinking water and air, support for EURATOM Treaty
	Seawater	Support for OSPAR Convention

[a] *The terrestrial parts of this programme in England and Wales, excluding most grass and soil sampling and all drycloth sampling, are known as TRAMP (Terrestrial Radioactivity Monitoring Programme)*
[b] *The terrestrial parts of these programmes in England and Wales are known as FARM (Food and Agriculture Monitoring Programme)*
[c] *In Scotland*

Table 5. Scope of the nuclear site sampling in 1996*

Measurement	Frequency of measurement	Analyses	Types of material or measurements	Detailed species/materials
Aquatic programme				
Analysis of foods	Annually to monthly	Total beta, gamma spectrometry, ^{3}H, ^{14}C, ^{35}S, ^{90}Sr, ^{99}Tc, ^{147}Pm, $^{134/137}Cs$ Th, U, transuranics	Fish, crustaceans, molluscs, edible aquatic plants	Cod, plaice, grey mullet, bass, dab, ray, herring, flounder, sea trout, dogfish, whiting, whitebait, fish oil, salmon, sole, spurdog, saithe, mackerel, haddock, pollack, eel, crabs, lobsters, winkles, native oysters, mussels, limpets, whelks, cockles, *Nephrops*, pacific oysters, shrimps, squid, scallops, queens, *Porphyra* laverbread, samphire, pike, elvers, brown trout, rainbow trout, perch and spider crabs
Analysis of indicator materials	Annually to weekly	"	Water, sediments, salt marsh, seaweeds, aquatic plants and coarse fish	Fish meal, mud, sand, coal, clay, salt marsh, peat, turf, seawater, freshwater, *Fucus spp., Rhodymenia spp., Fontinalis, Cladophoraceae spp., Laminaria digitata, Elodia canadensis, Nupha lutea,* rudd
Gamma dose rates	Annually to monthly	-	On beaches, harbours, marshes riverbanks, lakesides and boats	-
Beta dose rates	Annually to quarterly	-	On nets, pots, sediments and saltmarsh	
Contamination survey	Annually to monthly	-	On beaches	-
Terrestrial programme				
Analysis of foods	Annually to monthly	Total alpha, beta and gamma gamma spectrometry ^{3}H, organic ^{3}H, ^{14}C, ^{32}P, ^{35}S, ^{45}Ca, ^{90}Sr, ^{99}Tc, Ru, ^{131}I, ^{129}I, ^{147}Pm, Cs, ^{210}Po, U, transuranics	Milk, crops and animals	Cows' and goats' milk, beef meat, kidney and liver, sheep meat and offal, deer meat and offal, pig meat and offal, chicken, eggs, hares, duck, rabbits, honey, mushrooms, hazelnuts, beetroot, wheat, barley, rhubarb, elderberries, apples, grapes, plums, pears, blackberries, strawberries, raspberries, cabbage, sea kale, lettuce, watercress, onions, potatoes, green and runner beans, turnips, leeks, carrots, swede, sprouts, broccoli, parsnips, broad beans, field beans, kale, celery, peas and cauliflower
Analysis of indicator materials	Annually to monthly	"	Grass, soil, faeces, dry cloths and animal food	Grass, soil, silage, animal faeces, rape, fodder beet, lucerne and dry cloths

* *The frequency of measurement, the types of analysis and the materials sampled vary from site to site. Not all analyses are carried out on all materials. Detailed information on the scope of the programme at individual sites is given in the tables of results. The routine programme is supplemented by additional monitoring when necessary, for example in relation to site incidents. The results of such monitoring are included in this report*

Table 6. Analytical methods

Radionuclides	Sample type	Method of measurement
^{3}H ^{3}H (organic) ^{14}C ^{32}P ^{35}S ^{45}Ca ^{147}Pm ^{241}Pu	All	Beta counting by liquid scintillation
^{90}Sr	High-level aquatic samples	Cerenkov counting by liquid scintillation
^{90}Sr	Terrestrial and low-level aquatic samples	Beta counting using gas proportional detectors
^{99}Tc ^{210}Pb beta	All	"
$^{103+106}Ru$ ^{131}I ^{144}Ce $^{134+137}Cs$	Terrestrial samples	"
^{125}I ^{129}I	Terrestrial samples	Gamma counting by solid scintillation
^{134}Cs ^{137}Cs	Seawater	"
Gamma	Dry cloths	"
^{51}Cr ^{54}Mn ^{57}Co ^{58}Co ^{60}Co ^{59}Fe ^{65}Zn ^{95}Nb ^{95}Zr ^{103}Ru ^{106}Ru ^{110m}Ag ^{125}Sb ^{134}Cs ^{137}Cs ^{144}Ce ^{154}Eu ^{155}Eu ^{241}Am ^{233}Pa ^{234}Th	All	Gamma spectrometry using germanium detectors
^{129}I ^{131}I	Aquatic samples	"
U	Terrestrial samples	Activation and delayed neutron counting
^{210}Po ^{226}Ra* ^{234}U $^{235+236}U$ ^{238}U ^{237}Np ^{228}Th ^{230}Th ^{238}Pu $^{239+240}Pu$ ^{241}Am ^{242}Cm $^{243+244}Cm$	All	Alpha spectrometry
^{226}Ra	Terrestrial samples	Alpha counting using thin window proportional detectors
Alpha	Dry cloths	"

* *Determined by gamma spectrometry in sediment samples near Springfields*

Table 7. Beta/gamma radioactivity in fish from the Irish Sea vicinity and further afield, 1996

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}							
			^{14}C	^{60}Co	^{90}Sr	^{99}Tc	^{134}Cs	^{137}Cs	^{147}Pm	Total beta
Sellafield coastal area	Cod	8	-	0.05 *±0.06*	-	-	0.06 *±0.08*	17 *±0.5*	-	200
“	Plaice	4	-	*	-	-	*	13 *±0.5*	-	220
“	Grey mullet	1	-	*	-	-	*	19 *±0.5*	-	-
“	Bass	1	-	*	-	-	*	20 *±0.4*	-	-
Sellafield offshore area	Cod	2	94 *±7.6*	*	0.052 *±0.006*	1.5 *±0.1*	*	10 *±0.3*	-	-
“	Plaice	2	160 *±9.1*	*	0.078 *±0.009*	33 *±2.6*	0.07 *±0.06*	8.2 *±0.1*	*	-
“	Dab	2	-	*	-	-	*	12 *±0.3*	-	-
“	Whiting	2	-	*	-	-	0.05 *±0.07*	17 *±0.4*	-	-
Ravenglass	Cod	8	-	0.04 *±0.06*	-	-	0.02 *±0.04*	12 *±0.4*	-	-
“	Plaice	8	-	*	-	-	*	7.7 *±0.4*	-	-
“	Salmon	1	-	*	-	-	*	0.64 *±0.15*	-	-
Whitehaven	Cod	4	80 *±7.1*	*	0.034 *±0.003*	-	0.03 *±0.03*	6.5 *±0.2*	-	-
“	Plaice	4	-	*	0.040 *±0.004*	-	*	7.4 *±0.3*	-	-
“	Ray	4	-	*	-	-	*	6.1 *±0.3*	-	-
“	Herring	2	-	*	-	-	*	2.2 *±0.2*	-	-
Parton	Cod	4	-	*	-	-	0.04 *±0.04*	16 *±0.3*	-	-
Morecambe Bay (Flookburgh)	Flounder	4	110 *±8.0*	*	-	-	*	26 *±0.7*	-	-
“ (Morecambe)	Plaice	4	-	*	0.034 *±0.006*	13 *±1.0*	*	11 *±0.3*	-	-
“ “	Bass	2	-	*	-	-	*	25 *±0.4*	-	-
“ (Sunderland Point)	Whitebait	1	-	0.21 *±0.11*	0.20 *±0.01*	-	*	10 *±0.3*	-	-
River Derwent	Sea trout	1	-	*	-	-	*	6.1 *±0.26*	-	-
River Ehen	“	1	-	*	-	-	*	2.9 *±0.3*	-	-
River Calder	Eel	1	-	*	-	-	*	2.8 *±0.2*	-	-
Calder Farm	Rainbow trout	1	29 *±8.4*	0.43 *±0.12*	0.72 *±0.02*	-	*	110 *±0.6*	-	-
River Duddon	Sea trout	1	-	*	-	-	*	15 *±0.6*	-	-
River Kent	“	1	-	*	-	-	*	11 *±0.3*	-	-
Fleetwood	Cod	4	68 *±6.8*	*	0.041 *±0.007*	2.8 *±0.2*	*	6.4 *±0.2*	-	-
“	Plaice	4	-	*	-	-	*	8.3 *±0.3*	-	-
“	Fish meal[c]	3	-	*	0.28 *±0.02*	-	*	2.6 *±0.3*	-	-
“	Fish oil[c]	4	-	*	-	-	*	*	-	-
Isle of Man	Cod	4	-	*	-	-	*	3.0 *±0.2*	-	-
“	Plaice	4	43 *±7.4*	*	-	-	*	1.4 *±0.1*	-	-
“	Herring	4	-	*	-	-	*	2.2 ±0.1	-	-
Inner Solway	Flounder	4	61 *±7.7*	*	0.046 *±0.003*	3.5 *±0.3*	*	29 *±0.6*	-	-
“	Sea trout	2	-	*	-	-	*	7.7 *±0.5*	-	-
“	Salmon	1	-	*	-	-	*	1.2 *±0.2*	-	-
Kirkcudbright	Plaice	2	51 *±7.8*	*	0.020 *±0.002*	3.6 *±0.3*	*	4.2 *±0.2*	-	-
North Anglesey	Ray	4	-	*	-	-	*	3.1 *±0.1*	-	-
“	Plaice	2	48 *±7.2*	*	-	-	*	2.0 *±0.1*	-	-
Ribble Estuary	Flounder	1	-	*	-	-	*	14 *±0.3*	-	-
“	Salmon	1	-	*	-	-	*	0.27 *±0.13*	-	-
“	Sea trout	1	-	*	-	-	*	6.1 *±0.2*	-	-

Table 7. continued

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}							
			^{14}C	^{60}Co	^{90}Sr	^{99}Tc	^{134}Cs	^{137}Cs	^{147}Pm	Total beta
Northern Ireland	Cod	5	44 *±6.8*	*	-	-	*	3.3 *±0.1*	-	-
“	Whiting	8	-	*	-	-	*	4.1 *±0.1*	-	-
“	Herring	1	-	*	-	-	*	1.6 *±0.2*	-	-
“	Spurdog	7	-	*	-	-	*	3.9 *±0.2*	-	-
“	Saithe	2	-	*	-	-	*	6.8 *±0.2*	-	-
“	Pollack	1	-	*	-	-	*	4.5 *±0.3*	-	-
Sound of Mull	Salmon	1	-	*	-	-	*	0.70 *±0.08*	-	-
Minch	Cod	4	-	*	-	-	*	0.78 *±0.08*	-	-
“	Plaice	4	-	*	-	-	*	0.66 *±0.07*	-	-
“	Mackerel	2	47 *±10*	*	*	-	*	0.28 *±0.10*	-	-
“	Haddock	4	-	*	-	-	*	0.85 *±0.06*	-	-
“	Herring	4	-	*	-	-	*	0.61 *±0.07*	-	-
Shetland	Fish meal[c]	4	-	*	0.086 *±0.007*	-	*	1.1 *±0.3*	-	-
“	Fish oil[c]	4	-	*	-	-	*	*	-	-
Northern North Sea	Cod	4	-	*	0.0068 *±0.0015*	-	*	1.2 *±0.1*	-	-
“	Plaice	4	-	*	-	-	*	0.56 *±0.09*	-	-
“	Herring	3	-	*	-	-	*	0.49 *±0.09*	-	-
“	Haddock	3	30 *±7.1*	*	-	-	*	0.49 *±0.07*	-	-
Mid-North Sea	Cod	4	28 *±6.7*	*	0.0024 *±0.0007*	-	*	1.1 *±0.1*	-	-
“	Plaice	4	25 *±7.5*	*	0.0031 *±0.0009*	-	*	0.46 *±0.08*	-	-
Southern North Sea	Cod	2	-	*	0.0065 *±0.0011*	-	*	0.67 *±0.09*	-	-
“	Plaice	2	-	*	0.0045 *±0.0010*	-	*	0.38 *±0.09*	-	-
“	Herring	2	-	*	-	-	*	0.78 *±0.14*	-	-
English Channel	Cod	4	-	*	0.0065 *±0.0012*	-	*	0.51 *±0.07*	-	-
“	Plaice	4	-	*	0.0054 *±0.0014*	-	*	0.16 *±0.06*	-	-
“	Mackerel	4	-	*	-	-	*	0.28 *±0.08*	-	-
Gt Yarmouth (retail shop)	Cod	4	-	*	-	-	0.15 *±0.05*	6.2 *±0.1*	-	-
“	Plaice	4	-	*	-	-	*	0.43 *±0.07*	-	-
Skagerrak	Cod	2	-	*	-	-	*	0.51 *±0.05*	-	-
“	Herring	2	-	*	-	-	*	0.66 *±0.11*	-	-
Iceland area	Cod	2	-	*	-	-	*	0.21 *±0.04*	-	-
Icelandic processed	“	2	22 *±6.5*	*	-	-	*	0.31 *±0.07*	-	-
Barents Sea	“	4	-	*	-	-	*	0.43 *±0.07*	-	-
Baltic Sea	“	3	-	*	-	-	0.36 *±0.12*	14 *±0.3*	-	-
“	Herring	3	-	*	-	-	0.22 *±0.12*	9.1 *±0.3*	-	-

\- *not analysed*
* *not detected by the method used*
[a] *Sampling area or landing point*
[b] *See section 5 for definition*
[c] *Concentrations refer to weight of sample as supplied*

Table 8. Beta/gamma radioactivity in shellfish from the Irish Sea vicinity and further afield, 1996

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}									
			^{14}C	^{54}Mn	^{60}Co	^{65}Zn	^{90}Sr	^{95}Zr	^{95}Nb	^{99}Tc	^{103}Ru	^{106}Ru
Sellafield coastal area	Crabs	8	150 ±9.8	*	1.7 ±0.2	*	1.2 ±0.04	*	*	110 ±8.9	*	2.3 ±1.1
"	Lobsters	9	260 ±11	*	1.3 ±0.2	*	0.47 ±0.02	*	*	13000 ±1100	*	1.5 ±1.2
"	Winkles[c]	4	210 ±9.6	*	8.1 ±0.4	*	4.4 ±0.1	1.1 ±0.3	1.7 ±0.6	2200 ±170	0.15 ±0.19	52 ±3.2
"	Mussels[c]	4	-	*	4.3 ±0.3	*	4.7 ±0.1	0.23 ±0.29	0.22 ±0.34	-	*	45 ±2.9
"	Limpets[c]	4	150 ±11	*	3.2 ±0.3	*	3.9 ±0.1	*	*	2000 ±160	0.06 ±0.09	30 ±2.7
"	Whelks	2	230 ±11	*	6.1 ±0.4	*	0.17 ±0.02	*	*	180 ±14	*	18 ±3.9
St Bees	Winkles	4	170 ±9.6	0.03 ±0.05	9.1 ±0.2	*	6.3 ±0.2	0.15 ±0.13	0.43 ±0.10	1000 ±78	0.32 ±0.13	60 ±1.6
"	Mussels	4	-	*	3.9 ±0.2	0.05 ±0.08	-	0.06 ±0.08	0.08 ±0.13	-	0.09 ±0.09	38 ±2.0
"	Limpets	4	-	*	2.7 ±0.3	*	-	0.10 ±0.13	0.15 ±0.19	-	0.08 ±0.15	23 ±2.8
Nethertown	Winkles	12	170 ±9.7	*	8.9 ±0.4	*	6.0 ±0.2	0.15 ±0.24	0.36 ±0.33	1600 ±150	0.30 ±0.21	71 ±3.3
"	Mussels	4	280 ±9.9	*	4.4 ±0.3	*	-	0.29 ±0.17	0.51 ±0.21	830 ±65	0.37 ±0.16	51 ±2.3
Whitriggs	Shrimps	1	-	*	0.54 ±0.25	*	-	*	*	-	*	*
Drigg	Winkles	4	230 ±9.8	*	11 ±0.4	*	-	0.28 ±0.23	0.62 ±0.34	3900 ±330	0.43 ±0.26	100 ±3.4
Ravenglass	Mussels	4	-	*	4.5 ±0.3	*	-	*	*	660 ±52	*	36 ±2.0
"	Cockles	4	300 ±9.9	*	16 ±0.5	*	2.6 ±0.1	0.55 ±0.29	1.0 ±0.4	270 ±21	0.38 ±0.20	41 ±2.6
"	Crabs	4	-	*	0.73 ±0.18	*	0.64 ±0.02	*	*	33 ±2.7	*	0.63 ±0.84
"	Lobsters	4	-	*	0.85 ±0.25	*	0.24 ±0.02	*	*	5300 ±430	*	*
Tarn Bay	Winkles	4	-	*	5.6 ±0.3	*	-	*	*	-	0.21 ±0.16	51 ±3.0
Saltom Bay	"	4	-	*	3.5 ±0.4	*	-	0.07 ±0.10	0.07 ±0.06	-	0.04 ±0.07	15 ±2.7
Whitehaven	*Nephrops*	4	67 ±6.2	*	*	*	0.13 ±0.01	*	*	920 ±77	*	*
Silloth	Mussels	3	-	*	0.52 ±0.13	*	-	*	*	-	*	2.5 ±1.0
Parton	Winkles	4	-	*	3.6 ±0.2	*	-	*	*	-	*	12 ±1.6
"	Crabs	4	-	*	0.88 ±0.30	*	-	*	*	-	*	1.1 ±0.8
"	Lobsters	4	-	*	0.17 ±0.14	*	-	*	*	-	*	*
Haverigg	Cockles	2	-	*	3.6 ±0.2	*	-	*	*	-	*	7.0 ±1.1
Millom	Mussels	2	-	*	1.5 ±0.1	*	-	*	*	-	0.06 ±0.10	16 ±1.0
Roosebeck	Pacific oysters	4	-	*	0.52 ±0.10	0.03 ±0.05	-	*	*	-	*	2.4 ±0.7
Morecambe Bay (Flookburgh)	Shrimps	4	130 ±8.9	*	0.04 ±0.06	*	0.13 ±0.02	*	*	22 ±1.8	*	*
" (Morecambe)	Mussels	4	150 ±9.0	*	0.68 ±0.12	*	-	*	*	400 ±31	*	3.6 ±0.9

Table 8. continued

Location[a]	Material	No. of sampling observ- ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}								
			^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{147}Pm	^{154}Eu	^{155}Eu	Total beta
Sellafield coastal area	Crabs	8	4.3 ±*0.5*	0.11 ±*0.14*	*	3.0 ±*0.2*	*	0.25 ±*0.02*	*	*	200
“	Lobsters	9	7.1 ±*0.5*	0.02 ±*0.04*	*	5.0 ±*0.2*	*	0.88 ±*0.03*	0.03 ±*0.07*	*	8300
“	Winkles[c]	4	16 ±*0.7*	1.4 ±*0.5*	*	10 ±*0.3*	1.0 ±*0.7*	2.5 ±*0.1*	0.20 ±*0.26*	*	-
“	Mussels[c]	4	2.9 ±*0.4*	2.0 ±*0.6*	*	10 ±*0.3*	0.89 ±*0.78*	-	0.49 ±*0.36*	0.08 ±*0.14*	-
“	Limpets[c]	4	8.0 ±*0.6*	2.1 ±*0.5*	*	7.8 ±*0.3*	0.40 ±*0.43*	-	0.16 ±*0.12*	*	-
“	Whelks	2	24 ±*1.0*	0.56 ±*0.69*	*	2.1 ±*0.3*	*	-	*	*	-
St Bees	Winkles	4	17 ±*0.4*	1.8 ±*0.3*	*	16 ±*0.2*	1.4 ±*0.4*	2.3 ±*0.1*	0.49 ±*0.23*	0.24 ±*0.15*	-
“	Mussels	4	0.95 ±*0.27*	1.4 ±*0.4*	*	5.5 ±*0.2*	0.64 ±*0.59*	-	0.43 ±*0.30*	*	-
“	Limpets	4	8.1 ±*0.6*	2.8 ±*0.7*	*	10 ±*0.4*	0.25 ±*0.46*	-	0.17 ±*0.20*	*	-
Nethertown	Winkles	12	22 ±*0.8*	1.7 ±*0.6*	*	17 ±*0.4*	1.1 ±*0.7*	2.9 ±*0.1*	0.52 ±*0.35*	0.07 ±*0.14*	1700
“	Mussels	4	0.77 ±*0.30*	1.3 ±*0.4*	*	5.1 ±*0.2*	0.91 ±*0.66*	-	0.25 ±*0.20*	*	660
Whitriggs	Shrimps	1	2.7 ±*0.5*	*	*	11 ±*0.4*	*	-	*	0.34 ±*0.30*	-
Drigg	Winkles	4	26 ±*0.76*	2.4 ±*0.7*	*	16 ±*0.4*	1.5 ±*0.7*	3.2 ±*0.2*	0.68 ±*0.37*	0.25 ±*0.26*	3600
Ravenglass	Mussels	4	0.58 ±*0.27*	1.3 ±*0.4*	*	3.8 ±*0.2*	*	-	0.31 ±*0.18*	0.13 ±*0.12*	-
“	Cockles	4	2.3 ±*0.5*	1.1 ±*0.6*	*	10 ±*0.3*	1.1 ±*0.7*	-	1.0 ±*0.5*	0.34 ±*0.31*	500
“	Crabs	4	3.1 ±*0.4*	*	*	2.5 ±*0.2*	*	-	*	*	120
“	Lobsters	4	6.5 ±*0.6*	*	*	4.5 ±*0.3*	*	-	0.11 ±*0.14*	*	3400
Tarn Bay	Winkles	4	14 ±*0.6*	1.3 ±*0.5*	*	11 ±*0.3*	0.44 ±*0.55*	-	0.27 ±*0.24*	*	-
Saltom Bay	“	4	3.6 ±*0.5*	2.2 ±*0.6*	*	11 ±*0.3*	0.48 ±*0.44*	-	0.21 ±*0.20*	*	-
Whitehaven	*Nephrops*	4	0.14 ±*0.12*	*	*	6.1 ±*0.2*	*	-	*	*	710
Silloth	Mussels	3	*	0.13 ±*0.15*	0.03 ±*0.05*	6.9 ±*0.2*	*	-	*	*	-
Parton	Winkles	4	3.6 ±*0.3*	0.66 ±*0.34*	*	14 ±*0.3*	*	-	0.17 ±*0.14*	*	-
“	Crabs	4	1.4 ±*0.6*	*	*	3.2 ±*0.3*	*	-	*	*	-
“	Lobsters	4	1.6 ±*0.4*	*	*	4.8 ±*0.2*	*	-	*	*	-
Haverigg	Cockles	2	*	0.19 ±*0.18*	*	6.2 ±*0.2*	0.44 ±*0.32*	-	0.39 ±*0.25*	*	-
Millom	Mussels	2	0.24 ±*0.11*	0.32 ±*0.17*	*	3.1 ±*0.1*	*	-	*	*	-
Roosebeck	Pacific oysters	4	4.8 ±*0.2*	0.05 ±*0.06*	*	3.3 ±*0.1*	*	-	*	*	-
Morecambe Bay (Flookburgh)	Shrimps	4	*	*	*	8.2 ±*0.3*	*	-	*	*	-
“ (Morecambe)	Mussels	4	*	0.24 ±*0.14*	*	3.5 ±*0.2*	*	-	*	*	-

Table 8. continued

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}									
			^{14}C	^{54}Mn	^{60}Co	^{65}Zn	^{90}Sr	^{95}Zr	^{95}Nb	^{99}Tc	^{103}Ru	^{106}Ru
Morecambe Bay “ (Flookburgh)	Cockles	4	130 *±7.8*	*	1.3 *±0.2*	*	0.55 *±0.03*	*	*	73 *±5.8*	*	1.0 *±0.5*
“ (Middleton Sands)	“	2	-	*	1.6 *±0.1*	*	-	*	*	-	*	2.8 *±0.7*
Fleetwood	Squid	1	-		*	*	-	*	*	-	*	*
“	Whelks	4	98 *±8.8*	*	0.59 *±0.19*	*	0.14 *±0.03*	*	*	63 *±5.0*	*	2.3 *±1.4*
Isle of Man	Scallops	4	-	*	*	*	-	*	*	-	*	*
“	Lobsters	1	-	*	*	-	*	*	*	250 *±20*	*	*
Inner Solway	Shrimps	4	-	*	*	*	0.092 *±0.014*	*	*	3.5 *±0.3*	*	*
Southerness	Winkles	4	-	*	0.91 *±0.16*	*	1.8 *±0.1*	*	*	730 *±57*	*	1.9 *±1.1*
Kirkcudbright	Scallops	3	-	*	0.01 *±0.02*	*	-	*	*	-	*	*
“	Queens	4	-	*	0.16 *±0.04*	*	-	*	*	-	*	*
North Solway coast	Crabs	4	71 *±9.3*	*	0.22 *±0.17*	*	0.38 *±0.01*	*	*	16 *±1.3*	*	*
“	Lobsters	4	74 *±9.1*	*	0.11 *±0.08*	*	0.065 *±0.010*	*	*	1700 *±130*	*	*
“	Winkles	4	-	*	1.2 *±0.2*	*	-	*	*	-	*	2.3 *±1.1*
“	Cockles	4	51 *±5.9*	*	1.1 *±0.1*	*	0.70 *±0.04*	*	*	48 *±3.8*	*	1.4 *±0.7*
“	Mussels	4	67 *±7.5*	*	0.73 *±0.11*	*	0.64 *±0.03*	*	*	140 *±11*	*	1.8 *±0.6*
Wirral	Shrimps	2	-	*	*	*	-	*	*	4.9 *±0.4*	*	*
“	Cockles	4	-	*	0.17 *±0.03*	*	-	*	*	29 *±2.3*	*	*
Conwy	Mussels	2	-	*	*	*	-	*	*	-	*	*
Northern Ireland	*Nephrops*	8	-	*	*	*	-	*	*	51 *±4.2*	*	*
“	Lobsters	2	-	*	*	-	*	*	*	150 *±12*	*	*
“	Winkles	4	-	*	0.02 *±0.02*	*	-	*	*	-	*	*
“	Mussels	2	-	*	*	*	-	*	*	26 *±2.1*	*	*
Minch	*Nephrops*	4	-	*	*	*	-	*	*	58 *±4.6*	*	*
Northern North Sea	“	4	-	*	*	*	-	*	*	14 *±1.1*	*	*
Mid North Sea	Mussels[d]	2	-	*	*	*	-	*	*	-	*	*
Southern North Sea	Cockles	2	-	*	0.61 *±0.10*	*	-	*	*	-	*	*
“	“ [e]	2	-	*	0.17 *±0.04*	*	-	*	*	-	*	*
“	Mussels	4	-	*	*	*	-	*	*	1.6 *±0.1*	*	*

Table 8. continued

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}								
			^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{147}Pm	^{154}Eu	^{155}Eu	Total beta
Morecambe Bay “ (Flookburgh)	Cockles	4	*	0.15 *±0.13*	*	5.7 *±0.2*	*	-	0.03 *±0.04*	0.03 *±0.05*	-
“ (Middleton Sands)	“	2	*	0.09 *±0.10*	*	4.6 *±0.1*	*	-	*	*	-
Fleetwood	Squid	1	*	*	*	2.5 *±0.2*	*	-	*	*	-
“	Whelks	4	1.7 *±0.3*	0.19 *±0.26*	*	2.2 *±0.2*	*	-	*	*	-
Isle of Man	Scallops	4	*	*	*	0.42 *±0.07*	*	-	*	*	-
“	Lobsters	1	*	*	*	0.56 *±0.31*	*	-	*	*	-
Inner Solway	Shrimps	4	*	*	*	12 *±0.3*	*	-	*	*	-
Southerness	Winkles	4	1.1 *±0.2*	0.79 *±0.38*	*	11 *±0.2*	*	-	0.03 *±0.04*	0.06 *±0.07*	-
Kirkcudbright	Scallops	3	0.03 *±0.04*	*	*	0.13 *±0.03*	*	-	*	*	-
“	Queens	4	0.19 *±0.07*	*	*	0.69 *±0.04*	*	-	*	*	-
North Solway coast	Crabs	4	0.92 *±0.45*	*	*	2.2 *±0.3*	*	-	*	*	-
“	Lobsters	4	0.80 *±0.51*	*	*	2.8 *±0.3*	*	-	*	*	-
“	Winkles	4	1.2 *±0.2*	0.07 *±0.12*	*	3.3 *±0.2*	*	-	*	*	-
“	Cockles	4	*	0.17 *±0.13*	*	4.6 *±0.1*	*	-	0.11 *±0.07*	*	-
“	Mussels	4	*	0.20 *±0.15*	*	4.6 *±0.1*	*	-	0.15 *±0.10*	0.05 *±0.07*	-
Wirral	Shrimps	2	*	*	*	4.5 *±0.2*	*	-	*	*	-
“	Cockles	4	*	0.06 *±0.03*	*	2.4 *±0.05*	*	-	*	0.02 *±0.02*	-
Conwy	Mussels	2	*	*	*	0.52 *±0.11*	*	-	*	*	-
Northern Ireland	*Nephrops*	8	*	*	*	1.5 *±0.1*	*	-	*	*	-
“	Lobsters	2	*	*	*	0.39 *±0.16*	*	-	*	*	-
“	Winkles	4	0.05 *±0.04*	*	*	0.51 *±0.13*	*	-	*	*	-
“	Mussels	2	*	*	*	1.4 *±0.1*	*	-	*	*	-
Minch	*Nephrops*	4	*	*	*	0.88 *±0.11*	*	-	*	*	-
Northern North Sea	“	4	*	*	*	0.29 *±0.08*	*	-	*	*	-
Mid North Sea	Mussels[d]	2	*	*	*	0.15 *±0.07*	*	-	*	*	51
Southern North Sea	Cockles	2	*	*	*	0.17 *±0.07*	*	-	*	*	-
“	“ [e]	2	*	*	*	0.12 *±0.03*	*	-	*	*	-
“	Mussels	4	*	*	*	0.27 *±0.12*	*	-	*	*	-

- *not analysed*
* *not detected by the method used*
[a] *Sampling area or landing point*
[b] *See section 5 for definition*
[c] *Samples collected by Consumer 116*
[d] *Landed in Denmark*
[e] *Landed in Holland*

Table 9. *Transuranic radioactivity in fish and shellfish from the Irish Sea vicinity and further afield, 1996*

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}						
			^{237}Np	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm
Sellafield coastal area	Cod	2	-	0.0015 *±0.0001*	0.0073 *±0.0003*	-	0.014 *±0.0004*	*	0.000037 *±0.000013*
"	Plaice	1	-	0.0012 *±0.0001*	0.0059 *±0.0002*	-	0.016 *±0.0004*	*	0.000035 *±0.000014*
"	Crabs	2	0.0097 *±0.0005*	0.077 *±0.004*	0.37 *±0.01*	5.1 *±0.2*	1.4 *±0.05*	*	0.0010 *±0.0008*
"	Lobsters	2	0.041 *±0.004*	0.068 *±0.003*	0.33 *±0.01*	4.7 *±0.3*	4.2 *±0.1*	*	0.010 *±0.005*
"	Winkles[c]	1	0.050 *±0.003*	2.4 *±0.1*	11 *±0.3*	150 *±4.1*	18 *±0.6*	*	*
"	Mussels[c]	1	-	3.2 *±0.2*	16 *±0.5*	200 *±6.1*	28 *±0.8*	*	0.047 *±0.025*
"	Limpets[c]	1	-	2.2 *±0.1*	11 *±0.3*	130 *±4.2*	20 *±0.6*	*	0.034 *±0.016*
"	Whelks	1	-	0.40 *±0.02*	1.8 *±0.05*	24 *±0.9*	3.8 *±0.1*	*	0.011 *±0.005*
Sellafield offshore area	Cod	1	-	0.0059 *±0.0002*	0.029 *±0.001*	-	0.045 *±0.001*	0.00012 *±0.00006*	0.000062 *±0.000027*
"	Plaice	1	0.00081 *±0.00008*	0.0078 *±0.0005*	0.035 *±0.001*	-	0.054 *±0.002*	*	0.00016 *±0.00008*
St Bees	Winkles	1	0.062 *±0.004*	3.3 *±0.2*	15 *±0.5*	200 *±6.3*	27 *±0.7*	*	0.034 *±0.018*
"	Mussels	2	-	2.0 *±0.1*	9.4 *±0.2*	120 *±3.1*	17 *±0.4*	*	0.029 *±0.013*
"	Limpets	1	-	1.8 *±0.1*	8.3 *±0.4*	-	15 *±0.4*	*	0.049 *±0.017*
Nethertown	Winkles	4	0.066 *±0.003*	3.9 *±0.2*	19 *±0.6*	240 *±7.7*	33 *±0.9*	0.0073 *±0.0082*	0.048 *±0.024*
"	Mussels	4	-	1.9 *±0.1*	9.0 *±0.3*	-	16 *±0.5*	*	0.038 *±0.018*
Whitriggs	Shrimps	1	-	-	-	-	0.51 *±0.30*	-	-
Drigg	Winkles	4	0.066 *±0.005*	3.8 *±0.2*	19 *±0.5*	240 *±6.8*	34 *±1.0*	*	0.065 *±0.033*
Ravenglass	Cod	1	-	0.00040 *±0.00004*	0.0018 *±0.0001*	-	0.0033 *±0.0002*	*	*
"	Plaice	1	-	0.00091 *±0.00007*	0.0040 *±0.0002*	-	0.011 *±0.0003*	*	0.000019 *±0.000011*
"	Crabs	1	-	0.055 *±0.003*	0.25 *±0.01*	3.3 *±0.2*	1.2 *±0.04*	*	0.0022 *±0.0011*
"	Lobsters	1	-	0.074 *±0.004*	0.35 *±0.01*	4.5 *±0.2*	7.1 *±0.2*	*	0.018 *±0.006*
"	Mussels	1	-	2.0 *±0.1*	9.5 *±0.3*	120 *±3.8*	19 *±0.5*	*	0.051 *±0.019*
"	Cockles	1	-	3.1 *±0.2*	15 *±0.5*	180 *±6.1*	39 *±1.1*	*	0.063 *±0.031*
Tarn Bay	Winkles	1	-	2.6 *±0.1*	13 *±0.3*	150 *±3.6*	23 *±0.6*	*	0.049 *±0.020*
Whitehaven	Cod	1	-	0.00037 *±0.00002*	0.0018 *±0.0001*	-	0.0030 *±0.0001*	*	*
"	Plaice	1	-	0.00073 *±0.00004*	0.0039 *±0.0001*	-	0.0074 *±0.0003*	*	0.000013 *±0.000007*
"	Ray	1	-	0.0010 *±0.0001*	0.0043 *±0.0003*	-	0.0074 *±0.0005*	*	0.000049 *±0.000027*
"	Herring	1	-	0.0019 *±0.0001*	0.010 *±0.0005*	-	0.015 *±0.001*	*	0.000034 *±0.000016*
"	*Nephrops*	1	-	0.029 *±0.002*	0.15 *±0.01*	-	1.5 *±0.04*	*	0.0030 *±0.0014*
Saltom Bay	Winkles	4	-	-	-	-	15 *±0.8*	-	-

Table 9. continued

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}						
			^{237}Np	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Pu	^{241}Am	^{242}Cm	$^{243}Cm+^{244}Cm$
Parton	Winkles	1	-	1.9 *±0.1*	9.2 *±0.3*	120 *±3.4*	16 *±0.4*	*	0.032 *±0.012*
"	Crabs	4	-	-	-	-	1.1 *±0.7*	-	-
"	Lobsters	4	-	-	-	-	1.3 *±0.5*	-	-
Haverigg	Cockles	1	-	1.5 *±0.1*	7.3 *±0.2*	-	19 *±0.4*	*	0.030 *±0.012*
Millom	Mussels	1	-	0.57 *±0.03*	3.0 *±0.1*	-	5.7 *±0.2*	*	0.0099 *±0.0056*
Roosebeck	Pacific oysters	1	-	0.20 *±0.01*	1.0 *±0.04*	-	0.76 *±0.03*	*	*
Morecambe Bay (Flookburgh)	Flounder	1	-	0.00023 *±0.00003*	0.0013 *±0.0001*	-	0.0027 *±0.0002*	*	*
" (Morecambe)	Whitebait	1	-	0.066 *±0.004*	0.35 *±0.02*	3.6 *±0.3*	0.47 *±0.04*	0.00037 *±0.00012*	0.00078 *±0.00011*
" (Flookburgh)	Shrimps	1	-	0.0042 *±0.0002*	0.023 *±0.001*	*	0.033 *±0.001*	*	*
" (Morecambe)	Mussels	1	-	0.35 *±0.02*	1.8 *±0.1*	-	3.2 *±0.1*	*	0.0052 *±0.0029*
" (Flookburgh)	Cockles	1	-	0.46 *±0.03*	2.5 *±0.1*	28 *±1.1*	6.0 *±0.2*	*	0.015 *±0.006*
" (Middleton Sands)	"	1	-	0.40 *±0.02*	2.2 *±0.1*	-	5.2 *±0.1*	*	0.0096 *±0.0047*
Calder Farm	Rainbow trout	1	-	*	0.00010 *±0.00002*	-	0.000099 *±0.000022*	*	*
Fleetwood	Cod	1	-	0.00016 *±0.00002*	0.00088 *±0.00006*	-	0.0016 *±0.0001*	*	*
"	Plaice	1	-	0.00059 *±0.00005*	0.0028 *±0.0001*	-	0.0055 *±0.0002*	*	*
"	Fish meal[d]	1	-	0.0040 *±0.0002*	0.022 *±0.007*	-	0.035 *±0.001*	*	*
"	Whelks	1	-	0.15 *±0.01*	0.82 *±0.03*	10 *±0.6*	1.6 *±0.05*	*	0.0029 *±0.0014*
Isle of Man	Cod	1	-	0.000053 *±0.000015*	0.00026 *±0.00004*	-	0.00059 *±0.00005*	*	*
"	Plaice	1	-	0.00017 *±0.00003*	0.00098 *±0.00008*	-	0.0017 *±0.0001*	*	*
"	Herring	1	-	0.00013 *±0.00002*	0.00062 *±0.00006*	-	0.00089 *±0.00007*	*	*
"	Scallops	1	-	0.019 *±0.001*	0.099 *±0.005*	-	0.031 *±0.001*	*	0.000076 *±0.000041*
Silloth	Mussels	1	-	0.59 *±0.03*	3.0 *±0.1*	-	5.4 *±0.1*	*	0.010 *±0.004*
Inner Solway	Flounder	1	-	0.0021 *±0.0002*	0.010 *±0.0004*	-	0.018 *±0.001*	*	*
"	Sea trout	1	-	0.00045 *±0.00005*	0.0026 *±0.0001*	-	0.0037 *±0.0002*	*	*
"	Shrimps	1	-	0.0030 *±0.0002*	0.016 *±0.001*	-	0.028 *±0.001*	*	0.000052 *±0.000028*
Southerness	Winkles	1	-	0.69 *±0.03*	3.7 *±0.1*	44 *±1.1*	6.2 *±0.2*	*	0.010 *±0.005*
Kirkcudbright	Plaice	1	-	0.00041 *±0.00004*	0.0021 *±0.0001*	-	0.0043 *±0.0002*	*	*
"	Scallops	1	-	0.0055 *±0.0004*	0.028 *±0.001*	-	0.010 *±0.0005*	*	*
"	Queens	1	-	0.020 *±0.001*	0.11 *±0.004*	-	0.15 *±0.005*	*	0.00044 *±0.00019*

Table 9. continued

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}						
			^{237}Np	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm
North Solway coast	Crabs	1	-	0.031 *±0.002*	0.16 *±0.01*	1.9 *±0.2*	0.78 *±0.03*	*	*
"	Lobsters	1	-	0.023 *±0.001*	0.12 *±0.004*	1.5 *±0.1*	1.1 *±0.04*	*	0.0034 *±0.0016*
"	Winkles	1	-	0.44 *±0.03*	2.3 *±0.1*	29 *±1.1*	4.1 *±0.1*	*	0.010 *±0.005*
"	Cockles	4	-	0.62 *±0.04*	3.1 *±0.1*	37 *±1.3*	7.5 *±0.2*	*	0.010 *±0.005*
"	Mussels	1	-	0.60 *±0.03*	3.1 *±0.1*	36 *±1.0*	6.6 *±0.2*	*	0.0084 *±0.0050*
Wirral	Cockles	1	-	0.14 *±0.01*	0.74 *±0.02*	-	2.0 *±0.04*	*	0.0039 *±0.0013*
Conwy	Mussels	1	-	0.036 *±0.002*	0.18 *±0.01*	-	0.31 *±0.01*	*	0.00084 *±0.00031*
North Anglesey	Rays	1	-	0.000076 *±0.000017*	0.00026 *±0.00003*	-	0.00055 *±0.00006*	*	*
Northern Ireland	Whiting	1	-	0.00034 *±0.00004*	0.0020 *±0.0001*	-	0.0035 *±0.0002*	*	*
"	*Nephrops*	1	-	0.0060 *±0.0003*	0.034 *±0.001*	-	0.12 *±0.004*	*	0.00030 *±0.00013*
"	Winkles	1	-	0.027 *±0.001*	0.15 *±0.004*	-	0.14 *±0.004*	*	*
Minch	Cod	1	-	0.000060 *±0.000021*	0.00030 *±0.00004*	-	0.00057 *±0.00006*	*	*
"	Haddock	1	-	0.000051 *±0.000012*	0.00024 *±0.00003*	-	0.00037 *±0.00004*	*	*
"	Mackerel	1	-	0.000025 *±0.000014*	0.00016 *±0.00002*	-	0.00014 *±0.00004*	*	*
"	*Nephrops*	1	-	0.0013 *±0.0001*	0.0070 *±0.0004*	-	0.011 *±0.001*	*	*
Shetland	Fish meal[d]	1	-	0.00025 *±0.00003*	0.0023 *±0.0001*	-	0.00074 *±0.00008*	*	*
Northern North Sea	Cod	1	-	0.000047 *±0.000011*	0.00022 *±0.00003*	-	0.00055 *±0.00005*	*	*
"	Haddock	1	-	0.00060 *±0.00005*	0.0034 *±0.0002*	-	0.0048 *±0.0003*	*	*
"	*Nephrops*	1	-	0.00014 *±0.00004*	0.0012 *±0.0001*	-	0.0018 *±0.0001*	*	*
Mid North Sea	Mussels[e]	1	-	0.00025 *±0.00003*	0.0031 *±0.0002*	-	0.0012 *±0.0001*	*	*
Southern North Sea	Cockles	1	-	0.0018 *±0.0001*	0.0085 *±0.0004*	-	0.010 *±0.0004*	*	0.00063 *±0.00009*
"	" [f]	1	-	0.0031 *±0.0002*	0.0099 *±0.0005*	-	0.013 *±0.001*	*	0.0014 *±0.0001*
"	Mussels	1	-	0.0021 *±0.0002*	0.013 *±0.001*	-	0.0046 *±0.0004*	*	*
Icelandic processed	Cod	1	-	0.000058 *±0.000009*	0.00023 *±0.00002*	-	0.00026 *±0.00003*	*	*

- not analysed
** not detected by the method used*
[a] *Sampling area or landing point*
[b] *See section 5 for definition*
[c] *Samples collected by Consumer 116*
[d] *Concentrations refer to weight as supplied*
[e] *Landed in Denmark*
[f] *Landed in Holland*

Table 10. Individual radiation exposures due to consumption of Irish Sea fish and shellfish, 1996

Exposed population[d]	Critical foodstuffs	Nuclide	Exposure mSv[a]
Consumers in local fishing community	Plaice and cod	^{14}C	0.004
	Crabs and lobsters	^{90}Sr	0.002
	Winkles and other molluscs	^{99}Tc	0.042
		^{106}Ru	0.005
		^{137}Cs	0.005
		^{238}Pu	0.005
		$^{239+240}Pu$	0.026
		^{241}Pu	0.006
		^{241}Am	0.044
		Others	<0.001
		Total	0.14
Consumers associated with commercial fisheries: Whitehaven	Plaice and cod	^{14}C	0.004
	Nephrops	^{99}Tc	0.014
	Whelks	^{137}Cs	0.007
		$^{239+240}Pu$	0.006
		^{241}Pu	0.002
		^{241}Am	0.015
		Others	<0.002
		Total	0.051
Consumers in Dumfries and Galloway	Plaice, cod and salmon	^{14}C	0.001
	Crabs, lobsters and *Nephrops*	^{99}Tc	0.019
	Winkles and mussels	^{137}Cs	0.005
		^{238}Pu	0.001
		$^{239+240}Pu$	0.007
		^{241}Pu	0.002
		^{241}Am	0.017
		Others	<0.002
		Total[b]	0.065
Consumers in Morecambe Bay area	Flounders and plaice	^{14}C	0.005
	Shrimps	^{99}Tc	0.003
	Cockles and mussels	^{137}Cs	0.017
		^{238}Pu	0.002
		$^{239+240}Pu$	0.012
		^{241}Pu	0.003
		^{241}Am	0.022
		Others	<0.001
		Total[c]	0.082
Consumers associated with commercial fisheries: Fleetwood	Plaice and cod	^{14}C	0.006
	Shrimps	^{99}Tc	0.002
	Whelks	^{137}Cs	0.013
		$^{239+240}Pu$	0.005
		^{241}Am	0.008
		Others	<0.001
		Total	0.035
Typical member of the fish-eating public consuming fish landed at Whitehaven/Fleetwood	Plaice and cod	^{137}Cs	0.001
		Others	<0.001
		Total	0.002

[a] *Due to artificial radionuclides: see text for exposures due to natural radionuclides*
[b] *Including exposure due to 1000 h year^{-1} occupancy over intertidal sediments*
[c] *Including exposure due to 900 h year^{-1} occupancy over intertidal sediments*
[d] *Representative of people most exposed unless stated otherwise*

Table 11. Gamma radiation dose rates over areas of the Cumbrian coast and further afield, 1996

Location	Ground type	No. of sampling observations[a]	Mean gamma dose rate in air at 1 m, µGy h^{-1}
Cumbria			
Rockliffe Marsh	Salt marsh	4	0.080
Burgh Marsh	"	4	0.096
Port Carlisle	Mud and sand	1	0.086
"	Mud, sand & stones	3	0.085
Greenend	Salt marsh	4	0.083
"	Mud and sand	3	0.073
"	Sand	1	0.071
Cardurnock Marsh	Salt marsh	4	0.10
Newton Arlosh	"	4	0.12
Silloth - silt pond	Grass	2	0.073
" - boat area	Mud and sand	2	0.097
Allonby	Sand	2	0.086
Maryport - Christchurch	Mud	4	0.12
" - outer harbour	"	4	0.11
Siddick	Sand	4	0.077
Workington Harbour	Mud	4	0.13
Harrington Harbour	Mud and sand	4	0.12
Whitehaven - outer harbour	"	11	0.10
" "	Coal and sand	12	0.14
" "	Sand	1	0.091
Whitehaven - inner harbour	Mud and sand	11	0.19
" "	Mud, sand and stones	1	0.15
" - yacht basin	Mud	12	0.23
Fishing vessel A	Cabin[b]	4	0.091
" B	"	1	0.086
" R	"	2	0.083
" U	"	10	0.073
" V	"	1	0.086
St Bees	Sand	4	0.072
Nethertown	Winkle bed	4	0.10
Sellafield	Sand	4	0.077
R. Calder (Pos. A)	Mud, sand and stones	1	0.11
" " (Pos. B)	Grass	1	0.24
" " (Pos. C)	"	1	0.29
" " (Pos. D)	"	1	0.11
" " (Pos. E)	"	1	0.087
Seascale	Sand	4	0.077
Drigg pipeline	"	8	0.071
Drigg Barn Scar	Mussel bed	4	0.094
Saltcoats	Salt marsh	4	0.21
Muncaster Bridge	"	4	0.24
Ravenglass - Carleton Marsh	"	4	0.25
Ravenglass - salmon garth	Mud and sand	4	0.13
" "	Sand and stones	4	0.091
" "	Mussel bed	4	0.095
" - boat area	Mud and sand	12	0.096
" "	Sand	4	0.071
" - ford	Mud and sand	4	0.11
" - River Mite	Salt marsh	4	0.23
" - Raven Villa	Mud and sand	12	0.13
" "	Salt marsh	12	0.22
" - Eskmeals Nature Reserve	"	4	0.25
Newbiggin	Mud	1	0.20
"	Mud and sand	3	0.20
"	Salt marsh	4	0.27
" - west of bridge	Mud, sand & stones	4	0.11
" "	Salt marsh	4	0.25
Tarn Bay	Sand	2	0.066
Silecroft	"	2	0.064
Haverigg	Mud and sand	4	0.095
"	Sand and stones	1	0.076
"	Sand	3	0.075
Millom	Mud and sand	4	0.090
Low Shaw	Salt marsh	4	0.13
Askam	"	4	0.14
Tummer Hill Marsh	"	4	0.17
Walney Channel	Mud and sand	4	0.078
" - Vickerstown Church	"	4	0.093
" - Sewer outfall	Mussel bed	2	0.084
Walney Island - west shore	Sand	4	0.060
Roa Island	Mud and sand	4	0.080
Greenodd	Salt marsh	2	0.085
Sand Gate Marsh	"	4	0.10
Flookburgh	Mud and sand	4	0.077
High Foulshaw	Salt marsh	4	0.096
Arnside	Mud and sand	4	0.074
"	Salt marsh	4	0.11

Table 11. continued

Location	Ground type	No. of sampling observations[a]	Mean gamma dose rate in air at 1 m, µGy h^{-1}
Lancashire, Merseyside and North Wales			
Sunderland Point	Mud	2	0.093
"	Mud and sand	2	0.092
Sunderland	Mud, sand & stones	4	0.083
Colloway Marsh	Salt marsh	4	0.18
Lancaster	"	4	0.11
Aldcliffe Marsh	"	4	0.14
Conder Green	Mud	1	0.11
"	Mud and sand	3	0.11
"	Salt marsh	4	0.13
Cockerham Marsh	"	4	0.12
Heads - River Wyre	"	2	0.13
Height o' th' hill - River Wyre	"	4	0.14
Hambleton	Mud	3	0.12
"	Mud and sand	1	0.11
"	Salt marsh	4	0.13
Fleetwood	Sand	4	0.067
" Docks	Salt marsh	4	0.15
Skippool Creek	Mud	3	0.11
"	Mud and sand	1	0.13
" (boat 2)	Cabin[b]	3	0.096
Blackpool	Sand	4	0.055
Crossens Marsh	Mud	4	0.11
"	Salt marsh	4	0.11
Southport	Sand	1	0.070
"	Samphire bed	1	0.11
"	Salt marsh	1	0.11
Ainsdale	Sand	4	0.054
New Brighton	Mussel bed	4	0.072
West Kirby	Mud and sand	2	0.063
Rock Ferry	Mud	3	0.11
"	Mud and sand	1	0.11
Little Neston Marsh	"	2	0.073
"	Salt marsh	2	0.079
Flint	Mud	4	0.090
"	Salt marsh	4	0.12
Prestatyn	Sand	2	0.059
Rhyl	Mud	1	0.087
"	Mud and sand	1	0.071
Llandudno	Gravel	2	0.083
Caerhun	Salt marsh	2	0.092
Llanfairfechan	"	2	0.076
South-west Scotland			
Piltanton Burn	Salt marsh	4	0.071
Garlieston	Mud	4	0.087
"	Mud and sand	1	0.084
"	Salt marsh	1	0.10
Innerwell	Mud	4	0.085
Bladnoch	Mud	4	0.096
Creetown	Salt marsh	4	0.12
Carsluith	Mud	3	0.086
"	Mud and sand	1	0.083
Skyreburn Bay (Water of Fleet)	Salt marsh	4	0.087
Cumstoun	"	4	0.11
Kirkcudbright	"	4	0.10
Cutters Pool	Winkle bed	4	0.090
Rascarrel Bay	"	4	0.12
Palnackie Harbour	Mud	2	0.099
"	Mud and sand	2	0.097
Gardenburn	Salt marsh	4	0.13
Kippford - Slipway	Mud	2	0.092
" "	Mud and sand	2	0.088
" - Merse	Salt marsh	4	0.15
Carsethorn	Mud and sand	4	0.073
Kingholm Quay	Mud	1	0.090
Glencaple Harbour	Mud and sand	4	0.085

[a] *See section 5 for definition*
[b] *In the cabin of a boat or houseboat*

Table 12. Radioactivity in sediment from the Cumbrian coast and further afield, 1996

Location	Material	No. of sampling observa-tions[a]	Mean radioactivity concentration (dry), Bq kg^{-1}									
			^{54}Mn	^{60}Co	^{95}Zr	^{95}Nb	^{103}Ru	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs
Cumbria												
Newton Arlosh	Turf	4	*	2.0 *±1.1*	*	*	*	*	*	*	0.79 *±0.76*	1000 *±8.3*
Maryport - Christchurch	Mud	4	*	32 *±3.1*	*	*	*	170 *±27*	*	8.2 *±6.0*	0.64 *±1.1*	770 *±10*
Harrington Harbour	“	4	*	20 *±1.8*	1.9 *±2.1*	2.4 *±2.1*	*	140 *±16*	0.51 *±0.38*	6.3 *±3.9*	0.20 *±0.26*	450 *±5.3*
Whitehaven - yacht basin	“	4	*	20 *±2.1*	*	*	*	140 *±21*	1.7 *±1.5*	11 *±6.5*	1.0 *±1.3*	920 *±8.5*
St Bees	Sand	4	*	2.5 *±0.5*	*	*	*	2.3 *±2.0*	*	*	*	89 *±1.4*
Sellafield	“	4	*	2.1 *±0.5*	*	*	*	3.9 *±2.1*	*	*	*	100 *±1.4*
River Calder (Pos. A)	“	1	*	*	*	*	*	*	*	*	1.1 *±1.3*	140 *±3.1*
“ (Pos. B)	Mud & sand	1	*	46 *±2.1*	*	*	*	*	*	*	8.3 *±1.5*	1800 *±9.4*
“ (Pos. C)	“	1	*	31 *±1.6*	*	*	*	*	*	*	1.6 *±1.0*	830 *±6.2*
“ (Pos. D)	“	1	12 *±1.9*	200 *±4.2*	*	*	*	*	*	*	5.5 *±2.0*	530 *±5.6*
“ (Pos. E)	“	1	*	11 *±1.3*	*	*	*	*	*	*	9.6 *±1.7*	530 *±6.0*
Seascale	Sand	4	*	1.9 *±0.5*	*	*	*	1.7 *±1.9*	*	*	*	67 *±1.3*
Drigg - N of pipeline	“	4	*	2.1 *±0.5*	*	*	*	4.4 *±3.3*	*	0.48 *±0.57*	*	57 *±1.0*
River Mite estuary	Mud	4	*	22 *±1.5*	0.82 *±0.75*	1.4 *±0.7*	*	180 *±15*	0.39 *±0.66*	9.7 *±3.5*	0.26 *±0.39*	450 *±4.4*
Ravenglass - Carleton Marsh	“	4	*	20 *±1.1*	5.1 *±1.8*	6.5 *±2.8*	*	280 *±14*	1.6 *±0.9*	7.7 *±3.0*	0.78 *±0.79*	640 *±4.4*
“ - Raven Villa	Mud & sand	4	*	20 *±1.5*	1.5 *±0.7*	3.3 *±0.8*	0.46 *±0.48*	160 *±14*	0.86 *±0.86*	9.0 *±3.6*	*	330 *±4.1*
Newbiggin	Mud	3	*	24 *±2.6*	8.9 *±4.5*	15 *±6.1*	*	290 *±27*	0.78 *±0.61*	6.8 *±2.5*	0.43 *±0.66*	450 *±13*
“	Mud & sand	1	*	17 *±1.6*	2.3 *±1.8*	5.4 *±2.2*	*	110 *±12*	*	4.6 *±3.7*	*	300 *±4.0*
Millom	“	4	*	6.2 *±0.8*	0.65 *±0.89*	1.7 *±1.7*	*	90 *±8.5*	*	2.8 *±2.1*	*	210 *±2.4*
Low Shaw	Turf	4	*	3.0 *±0.9*	*	*	*	3.6 *±3.9*	*	*	2.2 *±0.9*	950 *±6.9*
Flookburgh	Mud & sand	4	*	0.47 *±0.45*	*	*	*	1.4 *±1.7*	*	*	*	100 *±1.7*
Sand Gate marsh	Turf	4	*	1.6 *±0.7*	*	*	*	*	*	0.98 *±1.2*	0.29 *±0.52*	260 *±3.9*
Lancashire, Merseyside and north Wales												
Sunderland Point	Mud & sand	4	0.16 *±0.32*	2.7 *±0.7*	*	*	*	11 *±5.3*	*	2.3 *±1.7*	*	240 *±2.5*
Conder Green	Turf	4	*	3.2 *±1.5*	*	*	*	3.2 *±5.4*	*	*	*	620 *±7.5*
Hambleton	“	4	*	3.3 *±1.7*	*	*	*	*	*	*	1.5 *±1.4*	1300 *±13*
Skippool Creek	Mud	4	*	3.6 *±1.4*	*	*	*	17 *±15*	*	1.7 *±3.0*	*	560 *±6.9*
Fleetwood	Sand	4	*	*	*	*	*	*	*	*	*	23 *±0.7*
Blackpool	“	4	*	*	*	*	*	*	*	0.14 *±0.25*	*	8.2 *±0.4*

Table 12. continued

Location	Material	No. of sampling observa-tions[a]	Mean radioactivity concentration (dry), Bq kg^{-1}									
			^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total beta
Cumbria												
Newton Arlosh	Turf	4	*	5.5 ±*2.9*	*	-	-	-	280 ±*11*	-	-	-
Maryport - Christchurch	Mud	4	22 ±*14*	15 ±*5.5*	5.0 ±*5.0*	130 ±*6.1*	630 ±*17*	-	1100 ±*30*	*	1.9 ±*0.9*	-
Harrington Harbour	"	4	13 ±*6.5*	11 ±*3.1*	3.3 ±*2.3*	-	-	-	580 ±*13*	-	-	-
Whitehaven - yacht basin	"	4	16 ±*10*	15 ±*4.3*	6.3 ±*4.2*	120 ±*5.7*	620 ±*16*	-	1000 ±*28*	*	1.3 ±*0.7*	3000
St Bees	Sand	4	*	2.5 ±*1.2*	0.67 ±*0.87*	-	-	-	170 ±*4.9*	-	-	-
Sellafield	"	4	*	2.8 ±*1.3*	0.32 ±*0.41*	-	-	-	180 ±*3.8*	-	-	
River Calder (Pos. A)	"	1	*	*	*	-	-	-	*	-	-	-
" (Pos. B)	Mud & sand	1	*	4.3 ±*2.0*	*	-	-	-	41 ±*9.1*	-	-	-
" (Pos. C)	"	1	*	*	*	-	-	-	21 ±*8.0*	-	-	-
" (Pos. D)	"	1	*	*	*	-	-	-	25 ±*6.3*	-	-	-
" (Pos. E)	"	1	*	*	*	-	-	-	25 ±*1.4*	-	-	-
Seascale	Sand	4	*	2.2 ±*1.2*	0.62 ±*0.85*	-	-	-	140 ±*3.6*	-	-	-
Drigg - N of pipeline	"	4	*	3.1 ±*1.3*	1.0 ±*0.8*	-	-	-	200 ±*3.9*	-	-	-
River Mite estuary	Mud	4	13 ±*4.8*	14 ±*3.6*	7.5 ±*3.5*	140 ±*7.3*	690 ±*21*	8400 ±*240*	1100 ±*29*	*	2.3 ±*0.9*	-
Ravenglass - Carleton Marsh	"	4	23 ±*5.8*	19 ±*2.5*	7.8 ±*2.9*	-	-	-	1100 ±*9.9*	-	-	-
" - Raven Villa	Mud & sand	4	16 ±*7.2*	7.0 ±*2.9*	4.5 ±*2.7*	-	-	-	610 ±*12*	-	-	-
Newbiggin	Mud	3	25 ±*12*	14 ±*6.1*	4.1 ±*2.3*	110 ±*5.7*	510 ±*16*	6300 ±*190*	800 ±*24*	*	2.3 ±*0.9*	1800
"	Mud & sand	1	11 ±*6.4*	9.2 ±*2.3*	*	-	-	-	460 ±*12*	-	-	1400
Millom	"	4	9.2 ±*3.2*	4.5 ±*1.6*	2.2 ±*1.6*	-	-	-	270 ±*3.8*	-	-	-
Low Shaw	Turf	4	*	11 ±*2.8*	4.8 ±*3.1*	-	-	-	640 ±*11*	-	-	-
Flookburgh	Mud & sand	4	*	*	0.42 ±*0.64*	-	-	-	43 ±*3.1*	-	-	-
Sand Gate marsh	Turf	4	*	1.1 ±*1.7*	*	-	-	-	96 ±*5.9*	-	-	-
Lancashire, Merseyside and north Wales												
Sunderland Point	Mud & sand	4	*	1.0 ±*0.9*	2.8 ±*1.9*	-	-	-	110 ±*4.8*	-	-	-
Conder Green	Turf	4	*	3.4 ±*2.4*	3.0 ±*3.0*	-	-	-	250 ±*13*	-	-	-
Hambleton	"	4	*	5.3 ±*3.1*	*	-	-	-	410 ±*18*	-	-	-
Skippool Creek	Mud	4	*	3.1 ±*2.2*	2.6 ±*2.4*	-	-	-	250 ±*7.7*	-	-	-
Fleetwood	Sand	4	*	*	0.48 ±*0.48*	-	-	-	14 ±*2.1*	-	-	-
Blackpool	"	4	*	*	*	-	-	-	3.9 ±*1.5*	-	-	-

Table 12. continued

Location	Material	No. of sampling observations[a]	Mean radioactivity concentration (dry), Bq kg^{-1}									
			^{54}Mn	^{60}Co	^{95}Zr	^{95}Nb	^{103}Ru	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs
Lancashire, Merseyside and north Wales *continued*												
New Brighton	Sand	2	*	*	*	*	*	*	*	*	*	9.3 *±0.6*
Rock Ferry	Mud	3	*	0.33 *±0.41*	*	*	*	*	*	*	*	240 *±4.0*
"	Mud & sand	1	*	*	*	*	*	*	*	*	*	210 *±4.1*
Rhyl	Mud	2	*	0.68 *±0.53*	*	*	*	*	*	5.1 *±2.9*	*	250 *±3.1*
Caerhun	Turf	2	*	*	*	*	*	*	*	*	*	230 *±4.2*
Cemlyn Bay	Mud	2	*	0.37 *±0.35*	*	*	*	*	*	*	*	150 *±2.5*
Llanfairfechan	Turf	2	*	*	*	*	*	*	*	*	*	55 *±1.8*
South-west Scotland												
Garlieston	Mud	4	*	5.2 *±1.4*	*	*	*	14 *±7.8*	*	0.79 *±0.97*	0.21 *±0.35*	290 *±4.2*
Innerwell	"	2	*	4.9 *±1.2*	*	*	*	16 *±9.3*	*	*	*	260 *±3.8*
Bladnoch	"	4	*	3.7 *±0.8*	*	*	*	18 *±7.9*	*	1.1 *±1.5*	1.1 *±0.9*	390 *±3.4*
Carsluith	"	4	*	3.3 *±0.9*	*	*	0.37 *±0.86*	17 *±9.5*	*	1.0 *±1.6*	0.27 *±0.63*	310 *±3.6*
Kippford Merse	Salt marsh	4	*	11 *±1.6*	*	*	*	42 *±14*	*	3.8 *±4.0*	0.36 *±0.58*	640 *±7.0*
" Slipway	Mud	4	*	5.1 *±0.8*	*	*	*	20 *±7.6*	*	2.4 *±1.7*	0.36 *±0.50*	310 *±2.9*
Palnackie Harbour	"	4	*	4.7 *±1.0*	*	*	*	21 *±10*	*	0.59 *±1.2*	*	340 *±4.2*
Carsethorn	"	2	*	1.9 *±0.6*	*	*	*	7.0 *±5.6*	*	*	*	220 *±2.9*
Isle of Man												
Douglas	"	1	*	*	*	*	*	*	*	0.88 *±1.0*	0.47 *±0.48*	72 *±1.0*
Northern Ireland												
Lough Foyle	"	2	*	*	*	*	*	*	*	*	*	14 *±0.7*
Portrush	Sand	2	*	*	*	*	*	*	*	*	*	0.85 *±0.35*
Ballymacormick	Mud	2	*	*	*	*	*	*	*	*	*	64 *±1.5*
Strangford Lough - Nickey's Pt	"	2	*	*	*	*	*	*	*	*	*	45 *±0.6*
Dundrum Bay	"	1	*	*	*	*	*	*	*	*	*	9.9 *±0.8*
"	Mud & sand	1	*	*	*	*	*	*	*	*	*	6.9 *±0.7*
Carlingford Lough	Mud	2	*	*	*	*	*	*	*	*	*	110 *±1.4*
Oldmill Bay	"	2	*	*	*	*	*	*	*	*	*	57 *±1.0*

Table 12. continued

Location	Material	No. of sampling observa-tions[a]	Mean radioactivity concentration (dry), Bq kg^{-1}									
			^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total beta
Lancashire, Merseyside and north Wales *continued*												
New Brighton	Sand	2	*	*	*	-	-	-	3.1 *±1.8*	-	-	-
Rock Ferry	Mud	3	*	*	0.96 *±1.2*	-	-	-	65 *±5.8*	-	-	-
"	Mud & sand	1	*	*	3.6 *±2.8*	-	-	-	56 *±4.6*	-	-	-
Rhyl	Mud	2	*	0.72 *±0.88*	1.7 *±1.9*	-	-	-	82 *±6.4*	-	-	-
Caerhun	Turf	2	*	*	*	-	-	-	55 *±4.6*	-	-	-
Cemlyn Bay	Mud	2	*	*	1.2 *±1.2*	4.0 *±0.3*	22 *±0.9*	-	31 *±0.7*	*	0.067 *±0.024*	-
Llanfairfechan	Turf	2	*	*	*	-	-	-	13 *±2.0*	-	-	-
South-west Scotland												
Garlieston	Mud	4	*	4.8 *±2.4*	3.1 *±1.9*	34 *±2.1*	160 *±5.7*	-	280 *±9.0*	*	*	-
Innerwell	"	2	*	4.6 *±2.3*	1.4 *±1.6*	-	-	-	210 *±7.7*	-	-	-
Bladnoch	"	4	*	4.6 *±2.0*	2.4 *±1.6*	-	-	-	250 *±4.8*	-	-	-
Carsluith	"	4	*	4.5 *±2.1*	1.6 *±1.7*	34 *±1.9*	180 *±5.7*	-	280 *±7.2*	*	0.30 *±0.17*	1300
Kippford Merse	Salt marsh	4	*	8.0 *±4.0*	4.2 *±2.8*	67 *±3.6*	340 *±10*	-	540 *±16*	*	1.2 *±0.5*	-
" Slipway	Mud	4	0.97 *±1.4*	3.9 *±1.5*	1.7 *±1.4*	33 *±1.8*	170 *±5.4*	-	280 *±6.5*	*	0.47 *±0.18*	-
Palnackie Harbour	"	4	*	4.7 *±2.6*	0.70 *±1.2*	36 *±1.8*	190 *±5.3*	-	290 *±7.6*	*	0.55 *±0.23*	-
Carsethorn	"	2	*	*	*	-	-	-	63 *±5.4*	-	-	-
Isle of Man												
Douglas	"	1	*	*	2.0 *±1.2*	-	-	-	6.2 *±1.2*	-	-	-
Northern Ireland												
Lough Foyle	"	2	*	*	0.95 *±0.91*	0.52 *±0.03*	3.1 *±0.1*	-	4.6 *±0.2*	*	*	-
Portrush	Sand	2	*	*	*	-	-	-	*	-	-	-
Ballymacormick	Mud	2	*	*	1.4 *±1.0*	3.4 *±0.2*	19 *±0.7*	-	28 *±0.8*	*	0.068 *±0.027*	-
Strangford Lough - Nickey's Pt	"	2	*	*	1.4 *±0.7*	1.7 *±0.1*	8.8 *±0.3*	-	8.4 *±0.3*	*	*	-
Dundrum Bay	"	1	*	*	*	-	-	-	*	-	-	-
"	Mud & sand	1	*	*	*	-	-	-	*	-	-	-
Carlingford Lough	Mud	2	*	*	1.7 *±1.2*	2.4 *±0.1*	14 *±0.4*	-	8.3 *±0.3*	*	0.021 *±0.008*	-
Oldmill Bay	"	2	*	*	0.81 *±0.40*	2.2 *±0.1*	11 *±0.4*	-	15 *±0.4*	*	0.030 *±0.013*	-

\- *not analysed*
* *not detected by the method used*
[a] *See section 5 for definition*

Table 13. Beta radiation dose rates on contact with fishing gear on vessels operating off Sellafield, 1996

Vessel	Type of gear	No. of sampling observations[a]	Mean beta dose rate in tissue, $\mu Sv\ h^{-1}$
A	Nets	4	0.20
	Ropes	4	0.13
R	Nets	4	0.13
S	Gill nets	2	0.20
	Nets	1	*
T	Gill nets	3	0.070
	Pots	1	0.29
U	Nets	6	*
	Ropes	6	0.024
V	Nets	2	0.21
	Ropes	2	*
W	Gill nets	4	0.21
	Nets	2	0.27
X	Gill nets	3	0.066
	Pots	1	0.15

[a] *See section 5 for definition*
* *Not detected by the method used*

Table 14. Radioactivity in terrestrial food and the environment near Sellafield, 1996

Material		Selection[d]	Farms/ samples[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}									
				^{3}H	^{14}C	^{35}S	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}Sb	^{129}I	^{131}I
Milk[f]	Near farms[c]		12	<9.3 ±3.5	17 ±3.9	<1.1 ±0.4	<0.43	0.13 ±0.01	<0.0095	<2.8	<0.84	<0.012 ±0.007	<0.032 ±0.011
“	“	max		15 ±3.7	26 ±3.9	3.7 ±0.6	<0.47	0.33 ±0.02		<3.0	<0.93	0.024 ±0.013	<0.037 ±0.016
“	“	sub-sets	4	-	-	-	<0.26	-	-	<1.7	<0.52	-	-
“	“	max					<0.30			<1.9	<0.57		
“	Far farms[c]		5	<3.3 ±2.1	15 ±3.5	<0.82 ±0.41	<0.43	0.068 ±0.010	<0.014	<2.9	<0.82	<0.0097 ±0.0044	-
“	“	max		<3.7 ±2.9	16 ±3.4	0.93 ±0.58	<0.50	0.082 ±0.011	<0.014	<3.1	<0.94	<0.011 ±0.008	
Apples[c]			1	8.0 ±4.0	15 ±3.0	1.4 ±0.4	<0.40	0.17 ±0.03	-	<2.5	<1.0	<0.0090	-
Barley			1	7.0 ±5.0	89 ±13	15 ±0.6	<0.50	0.35 ±0.03	-	<3.1	<0.80	<0.048	-
Blackberries[c]			1	28 ±4.0	31 ±4.0	7.7 ±0.5	<0.60	10 ±0.5	-	<3.6	<1.0	<0.037	-
Bovine kidney[c]			1	9.0 ±7.0	46 ±14	4.0 ±1.9	<0.40	1.4 ±0.1	<0.040	<2.1	<0.80	0.065 ±0.065	-
“	liver[c]		1	5.0 ±5.0	48 ±14	<2.0	<0.50	1.6 ±0.1	<0.029	<2.9	<0.90	0.10 ±0.08	-
“	muscle[i]		1	11 ±5.0	35 ±9.0	<2.0	<0.60	<0.021	<0.028	<2.2	<0.70	<0.061	-
Cabbage[c]			1	10 ±3.0	9.0 ±4.0	1.3 ±0.5	<0.40	1.5 ±0.1	-	<3.3	<0.90	<0.044	-
Carrots[c]			1	4.0 ±4.0	7.0 ±5.0	<0.40	<0.40	0.64 ±0.04	<0.027	<2.9	<0.80	<0.036	-
Cauliflower			1	-	-	-	-	-	-	-	-	-	-
Deer muscle[e]			1	<10	38 ±6.0	<3.0	-	0.056 ±0.056	<0.042	-	-	<0.049	-
Deer offal			1	6.0 ±5.0	31 ±6.0	<1.4	-	0.13 ±0.02	-	-	-	-	-
Eggs[c]			1	21 ±5.0	45 ±10	7.6 ±0.9	<0.30	0.40 ±0.05	<0.029	<2.5	<0.70	0.044 ±0.044	-
Elderberries[c]			1	17 ±4.0	46 ±4.0	5.5 ±0.7	<0.20	2.4 ±0.1	-	<1.0	<0.50	<0.025	-
Hare[i]			1	12 ±5.0	33 ±5.0	4.2 ±1.7	<0.50	0.085 ±0.054	0.14 ±0.14	<2.2	<0.90	<0.041	-
Honey			1	9.0 ±6.0	100 ±14	<1.0	<0.30	0.091 ±0.048	-	<1.8	<0.80	<0.032	-
Mushrooms[c]			1	8.0 ±5.0	<6.0	0.40 ±0.40	<0.40	0.18 ±0.03	-	<1.9	<0.70	<0.042	-
Ovine offal[i]			2	16 ±7.0	33 ±13	<5.4 ±1.3	<0.35	0.27 ±0.06	<0.032	<2.9	<0.75	<0.036	-
“	“	max		21 ±7.0	45 ±12	8.7 ±1.9	<0.40	0.47 ±0.07		<3.7	<1.0		
“	muscle[i]		2	14 ±5.0	50 ±12	<5.5 ±1.3	<0.50	0.12 ±0.04	<0.036 ±0.028	<3.2	<0.75	<0.058	-
“	“	max		18 ±5.0	68 ±11	9.0 ±1.8		0.15 ±0.04	0.039 ±0.039	<3.5	<1.0	<0.070	
Potatoes[c]			2	22 ±4.5	21 ±6.1	1.5 ±0.4	<0.50	0.25 ±0.04	-	<2.5	<0.85	<0.046 ±0.036	-
“		max		30 ±5.0	28 ±7.0	1.7 ±0.4		0.34 ±0.04			<1.0	<0.051 ±0.051	-
Turnips			1	-	-	-	-	-	-	-	-	-	-
Wheat			1	<3.0	100 ±15	3.8 ±0.4	-	0.46 ±0.04	-	-	-	0.0080 ±0.0080	-
“		sub-sets	1	-	-	-	<0.30	-	-	<1.5	<0.40	-	-
Grass[g,h]			2	-	-	-	-	-	<0.050	-	-	<0.010	-
“		max							<0.072				
Soil			2	-	-	-	-	-	-	-	-	-	-
“		max											
Dry cloths			346	-	-	-	-	-	-	-	-	-	-

Table 14. continued

Material		Selection	Farms/ samples[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}						
				^{134}Cs	^{137}Cs	Total Cs	^{144}Ce	^{210}Po	Total U	^{238}Pu
Milk	Near farms[c]		12	<0.31	<0.50 *±0.04*	0.28 *±0.003*	<1.8	-	-	<0.00019 *±0.00007*
"	"	max		<0.33	<0.58 *±0.09*	0.55 *±0.04*	<1.9	-		<0.00020 *±0.00010*
"	"	sub-sets	4	<0.21	<0.36 *±0.07*	-	<1.2	-	-	-
"	"	max		<0.23	0.47 *±0.10*		<1.6			
"	Far farms[c]		5	<0.29	<0.46	0.15 *±0.03*	<1.7	-	-	<0.00020
"	"	max		<0.34	<0.50 *±0.03*	0.17 *±0.03*	<1.8			<0.00020 *±0.00010*
Apples[c]			1	-	-	0.32 *±0.07*	<0.80	-	-	<0.00050 *±0.00040*
Barley			1	-	-	0.64 *±0.08*	<1.7	-	-	0.0011 *±0.0003*
Blackberries[c]			1	-	-	7.4 *±0.4*	<3.1	-	-	0.0021 *±0.0009*
Bovine kidney[c]			1	-	-	0.93 *±0.13*	<1.9	-	-	<0.00050
"	liver[c]		1	-	-	0.45 *±0.11*	<1.3	-	-	0.0016 *±0.0008*
"	muscle[i]		1	-	-	0.96 *±0.13*	<2.3	-	-	<0.00030
Cabbage[c]			1	-	-	0.088 *±0.072*	<1.6	-	-	0.00030 *±0.00030*
Carrots[c]			1	-	-	0.11 *±0.06*	<2.0	-	-	0.00040 *±0.00040*
Cauliflower			1	-	-	-	-	-	<0.018	-
Deer muscle[e]			1	-	-	38 *±1.9*	-	0.22 *±0.07*	-	<0.00020
Deer offal			1	-	-	11 *±0.6*	-	-	-	-
Eggs[c]			1	-	-	1.5 *±0.2*	<1.7	-	-	<0.00030
Elderberries[c]			1	-	-	12 *±0.6*	<1.2	-	-	0.041 *±0.009*
Hare[i]			1	-	-	0.97 *±0.14*	<1.6	-	-	<0.00020
Honey			1	-	-	11 *±0.6*	<1.4	-	-	<0.00030
Mushrooms[c]			1	-	-	0.29 *±0.08*	<1.3	-	-	0.00040 *±0.00040*
Ovine offal[i]			2	-	-	1.1 *±0.1*	<1.5	-	-	<0.00040 *±0.00035*
"	"	max				1.7 *±0.2*	<1.8			0.00050 *±0.00050*
"	muscle[i]		2	-	-	1.7 *±0.2*	<1.3	-	-	<0.00030
"	"	max				2.2 *±0.2*	<1.5			
Potatoes			2	-	-	0.47 *±0.08*	<1.5	-	-	0.0011 *±0.0006*
"		max		-	-	0.76 *±0.09*	<1.6			0.0015 *±0.0008*
Turnips			1	-	-	-	-	-	0.026 *±0.008*	-
Wheat			1	-	-	0.20 *±0.07*	-	-	-	<0.00020
"		sub-sets	1	-	-	-	<1.3	-	-	-
Grass[g,h]			2	-	-	-	-	-	-	-
"		max								
Soil			2	-	-	-	-	-	70 *±6.2*	-
"		max							81 *±6.6*	
Dry cloths			346	-	-	-	-	-	-	-

Table 14. continued

Material	Selection[d]	Farms/ samples[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}					
			^{239}Pu + ^{240}Pu	^{241}Pu	^{241}Am	Total alpha	Total beta	Total gamma
Milk Near farms		12	<0.00019 ±*0.00008*	<0.074 ±*0.024*	<0.00018 ±*0.00013*	-	-	-
" "	max		<0.00020 ±*0.00005*	<0.087 ±*0.039*	<0.00020 ±*0.00014*			
" "	sub-sets	4	-	-	-	-	-	-
" "	max							
" Far farms[c]		5	<0.00018 ±*0.00010*	<0.094 ±*0.039*	<0.00023	-	-	-
" "	max		<0.00018 ±*0.00014*					
Apples[c]		2	0.0011 ±*0.0006*	<0.084	0.0030 ±*0.0012*	-	-	-
Barley		1	0.0057 ±*0.0016*	0.22 ±*0.14*	0.0054 ±*0.0016*	-	-	-
Blackberries[c]		1	0.015 ±*0.004*	<0.31	0.0085 ±*0.0024*	-	-	-
Bovine kidney[c]		1	<0.00050	<0.11	<0.0055 ±*0.0022*	-	-	-
" liver[c]		1	0.011 ±*0.003*	<0.083	0.011 ±*0.004*	-	-	-
" muscle[i]		1	<0.00030	<0.071	<0.00030 ±*0.00030*	-	-	-
Cabbage[c]		1	<0.00030	<0.20	0.0012 ±*0.0006*	-	-	-
Carrots[c]		1	0.0023 ±*0.0009*	<0.10	0.00070 ±*0.00040*	-	-	-
Cauliflower		1	-	-	-	-	-	-
Deer muscle[e]		1	<0.00020	<0.10	0.00060 ±*0.00050*	-	-	-
Deer offal		1	-	-	-	-	-	-
Eggs[c]		1	<0.00030	0.12 ±*0.12*	0.00070 ±*0.00050*	-	-	-
Elderberries[c]		1	0.64 ±*0.13*	1.8 ±*0.2*	0.099 ±*0.016*	-	-	-
Hare[i]		1	0.00030 ±*0.00030*	0.10 ±*0.10*	0.00030 ±*0.00030*	-	-	-
Honey		1	0.00090 ±*0.00050*	<0.061	0.00090 ±*0.00040*	-	-	-
Mushrooms[c]		1	0.0033 ±*0.0010*	<0.12	0.0018 ±*0.0007*	-	-	-
Ovine offal[i]		2	0.0022 ±*0.0010*	<0.18 ±*0.14*	0.0022 ±*0.0009*	-	-	-
" "	max		0.0030 ±*0.0012*	0.24 ±*0.20*	0.0026 ±*0.0010*			
" muscle[i]		2	<0.00030	<0.075	<0.00045 ±*0.00042*	-	-	-
" "	max			<0.084	0.00060 ±*0.00060*			
Potatoes		2	0.018 ±*0.004*	0.23 ±*0.13*	0.0077 ±*0.0023*	-	-	-
"	max		0.030 ±*0.006*	0.33 ±*0.14*	0.011 ±*0.003*			
Turnips		1	-	-	-	-	-	-
Wheat		1	0.00060 ±*0.00050*	0.21 ±*0.12*	0.0011 ±*0.0005*	-	-	-
"	sub-sets	1	-	-	-	-	-	-
Grass[g,h]		2	-	-	-	-	-	-
"	max							
Soil[j]		2	-	-	-	-	-	-
"	max							
Dry cloths		346	-	-	-	0.53 ±*1.2*	2.8 ±*3.6*	1.4 ±*2.1*

- not analysed
[a] *except for milk where units are Bq l^{-1}, dry cloths where units are Bq per cloth and soil where dry concentrations apply*
[b] *see section 5 for definition*
[c] *the concentration of ^{3}H (organic) was <10 Bq l^{-1} for milk and <3.0 Bq kg^{-1} for other samples*
[d] *data are arithmetic means unless stated as 'max'. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition*
[e] *the concentration of ^{210}Pb was 0.037 ±0.026 Bq kg^{-1}*
[f] *Two samples of milk were analysed to investigate enhanced levels of discharge: the results were ^{129}I (Bq l^{-1}) 0.061 ±0.032 and 0.041 ±0.028*
[g] *the mean concentration of ^{55}Fe was 0.90 ±0.50 Bq kg^{-1}, the maximum was 1.2 ±0.5 Bq kg^{-1}*
[h] *the mean concentration of ^{63}Ni was 0.60 ±0.20 Bq kg^{-1}, the maximum was 1.0 ±0.2 Bq kg^{-1}*
[i] *the concentration of ^{3}H (organic) was <14 Bq kg^{-1}*
[j] *the concentrations of ^{234}U, ^{235}U and ^{238}U were 22 ±1.9, 0.89 ±0.16 and 21 ±1.9 Bq kg^{-1} respectively*

Table 15. Individual radiation exposures due to consumption of terrestrial foodstuffs near Sellafield and Drigg, 1996

Exposed population[b]	Critical foodstuffs	Nuclide	Exposure, mSv[a]
Consumers near Sellafield aged 1 y	Milk Root vegetables	^{14}C	<0.005
		^{35}S	<0.007
		^{60}Co	<0.003
		^{90}Sr	<0.013
		^{106}Ru	<0.008
		^{125}Sb	<0.001
		^{129}I	<0.005
		^{131}I	<0.002
		^{134}Cs	<0.001
		^{137}Cs	<0.003
		^{144}Ce	<0.004
		Others	<0.003
		Total	<0.055
Consumers near Drigg aged 1 y	Milk Potatoes	^{35}S	<0.001
		^{60}Co	<0.003
		^{90}Sr	<0.003
		^{95}Zr	<0.002
		^{106}Ru	<0.004
		^{125}Sb	<0.001
		^{129}I	<0.001
		^{137}Cs	<0.001
		^{144}Ce	<0.002
		Others	<0.002
		Total	<0.020
Consumers near Ravenglass aged 1 y	Milk Fruit	^{35}S	<0.002
		^{60}Co	<0.004
		^{90}Sr	<0.004
		^{95}Zr	<0.002
		^{106}Ru	<0.007
		^{125}Sb	<0.002
		^{129}I	<0.001
		^{134}Cs	<0.001
		^{137}Cs	<0.002
		^{144}Ce	<0.005
		Others	<0.004
		Total	<0.034
Typical adult member of the public eating food grown near Sellafield	Milk Wildfruit	^{90}Sr	<0.005
		^{106}Ru	<0.002
		^{129}I	<0.001
		^{137}Cs	<0.006
		^{144}Ce	<0.001
		^{239}Pu	<0.002
		Others	<0.004
		Total	<0.021

[a] *Excluding natural radionuclides*
[b] *Representative of people most exposed unless stated otherwise*

Table 16. Radioactivity in terrestrial food and the environment near Drigg, 1996

Material and selection[c]	Farms/ samples[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}											
		^{3}H	^{14}C	^{35}S	^{60}Co	^{90}Sr	^{95}Zr	^{95}Nb	^{99}Tc	^{103}Ru	^{106}Ru	^{125}Sb	^{129}I
Milk	1	<5.5 ±*3.5*	14 ±*3.3*	<0.65 ±*0.38*	<0.40	0.096 ±*0.011*	<0.79	<0.75	<0.0050	<0.56	<3.0	<0.83	<0.0095
" sub-sets		-	-	-	<0.30	-	<0.60	<0.50	-	<0.40	<2.0	<0.60	-
Cabbage	1	<3.0	7.0 ±*4.0*	0.90 ±*0.60*	<0.50	0.59 ±*0.05*	<1.0	<0.90	<0.023	<0.60	<2.9	<0.70	<0.040
Mushrooms	1	25 ±*5.0*	4.0 ±*4.0*	1.2 ±*0.5*	<0.40	0.23 ±*0.04*	<0.50	<0.60	-	<0.40	<3.4	<1.0	<0.036
Ovine muscle	1	<3.0	37 ±*10*	<2.0	<0.50	0.031 ±*0.031*	<0.90	<0.70	<0.023	<0.60	<2.6	<0.90	<0.028
Potatoes	1	6.0 ±*4.0*	17 ±*3.0*	<0.30	-	0.074 ±*0.025*	-	-	<0.024	-	-	-	<0.044
" sub-sets					<0.30		<0.60	<0.50		<0.40	<1.8	<0.40	
Rabbit	1	22 ±*5.0*	23 ±*6.0*	<2.0	<0.40	0.045 ±*0.022*	<0.60	<0.40	<0.029	<0.30	<2.7	<0.60	<0.036
Grass	2	-	-	-	-	-	-	-	<0.056 ±*0.061*	-	-	-	-
" max									0.086 ±*0.086*				
Soil	2	-	-	-	-	-	-	-	-	-	-	-	-
" max													

Material and selection[c]	Farms/ samples[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}												
		^{134}Cs	^{137}Cs	Total Cs	^{144}Ce	^{147}Pm	^{234}U	^{235}U	^{238}U	Total U	^{238}Pu	$^{239}Pu + ^{240}Pu$	^{241}Pu	^{241}Am
Milk	1	<0.32	<0.46	0.28 ±*0.03*	<1.8	<0.40 ±*0.35*	-	-	-	-	<0.00023 ±*0.00021*	<0.00025 ±*0.00010*	<0.074	<0.00033 ±*0.00029*
" sub-sets		<0.10	0.30 ±*0.10*	-	<1.2	-	-	-	-	-	-	-	-	-
Cabbage	1	-	-	1.2 ±*0.1*	<1.7	<0.30	-	-	-	-	<0.00030	0.00070 ±*0.00070*	<0.10	0.0010 ±*0.0005*
Mushrooms	1	-	-	0.70 ±*0.10*	<2.2	-	-	-	-	-	0.0018 ±*0.0008*	0.013 ±*0.003*	<0.22 ±*0.14*	0.017 ±*0.004*
Ovine muscle	1	-	-	0.53 ±*0.12*	<2.4	-	-	-	-	-	<0.00030	<0.00040	<0.077	<0.00030
Potatoes	1	-	-	0.12 ±*0.08*	-	<0.30	-	-	-	-	<0.00030 ±*0.00030*	0.00050 ±*0.00050*	<0.0073	0.00080 ±*0.00040*
" sub-sets		-	-	-	<1.0		-	-	-	-	-	-	-	-
Rabbit	1	-	-	0.59 ±*0.12*	<1.8	-	-	-	-	-	<0.00030	<0.00040	<0.086	<0.00030
Grass	2	-	-	-	-	16 ±*0.8*	0.20 ±*0.03*	0.0090 ±*0.0050*	0.19 ±*0.03*	0.31 ±*0.04*	-	-	-	-
" max						18 ±*0.9*				0.46 ±*0.05*				
Soil	2	-	-	-	-	-	8.3 ±*0.8*	0.28 ±*0.09*	7.4 ±*0.7*	33 ±*4.3*	-	-	-	-
" max										34 ±*4.3*				

- not analysed
[a] except for milk where units are Bq l^{-1} and for soil where dry concentrations apply
[b] see section 5 for definition
[c] data are arithmetic means unless stated as 'max'. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition.

Table 17. Beta radiation dose rates over intertidal areas of the Cumbrian coast, 1996

Location		Ground type	No. of sampling observations[a]	µSv h^{-1}
Whitehaven	outer harbour	Mud and sand	2	0.30
"	inner harbour	"	1	0.43
"	"	Mud, sand and stones	1	0.63
"	yacht basin	Mud	2	1.0
St Bees		Sand	2	0.19
Nethertown		Winkle bed	2	0.28
Braystones		Sand	2	0.14
Sellafield pipeline		"	2	0.20
River Ehen		Saltmarsh	2	1.5
Seascale		Sand	2	0.11
Drigg		"	2	0.18
Drigg Barn Scar		Mussel bed	2	0.29
Ravenglass	- Raven Villa	Saltmarsh	2	0.97
"	- salmon garth	Mussel bed	2	0.45
Tarn Bay		Sand	2	0.15

[a] *See section 5 for definition*

Table 18. Radioactivity in terrestrial food and the environment near Ravenglass, 1996

Material and selection[c]	Farms/ samples[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}													
		^{3}H	^{14}C	^{35}S	^{55}Fe	^{60}Co	^{63}Ni	^{90}Sr	^{95}Zr	^{95}Nb	^{99}Tc	^{106}Ru	^{125}Sb	^{129}I	^{134}Cs
Milk	3	<3.4 *±2.3*	15 *±3.9*	<0.66 *±0.30*	-	<0.42	-	0.075 *±0.011*	<0.82	<0.70	<0.0076 *±0.0012*	<2.8	<0.84	<0.0093	<0.33
" max		3.8 *±0.3*	16 *±3.8*	<0.70 *±0.32*		<0.43		0.083 *±0.011*	<0.85	<0.75	<0.0085 *±0.0020*	<2.9	<0.90	<0.0095	<0.36
" sub-sets	3	-	-	-	-	<0.33	-	-	<0.55	<0.52	-	<2.1	<0.60	-	<0.18
" max						<0.40			<0.70	<0.60		<2.6	<0.90		<0.20
Barley	1	<3.0	100 *±22*	1.7 *±0.3*	-	<0.50	-	0.47 *±0.04*	<1.0	<0.80	-	<3.2	<1.0	0.041 *±0.041*	-
Blackberries	1	<3.0	16 *±5.0*	<0.30	-	<0.50	-	0.39 *±0.04*	<0.70	<0.70	-	<3.0	<1.0	<0.044	-
Bovine kidney	1	9.0 *±6.0*	24 *±9.0*	<2.0	-	<0.60	-	0.29 *±0.04*	<1.2	<0.90	<0.024	<3.6	<0.90	<0.042	-
" liver	1	<5.0	58 *±21*	<2.0	-	<0.60	-	0.27 *±0.05*	<0.90	<1.1	<0.021	<3.0	<0.80	<0.024	-
" muscle	1	4.0 *±4.0*	28 *±9.0*	<2.0	-	<0.50	-	<0.025	<1.2	<0.30	0.043 *±0.043*	<3.4	<0.90	<0.025	-
Broad beans	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabbage	1	3.0 *±3.0*	11 *±6.0*	0.80 *±0.30*	-	<0.40	-	1.4 *±0.1*	<1.1	<0.90	<0.024	<3.5	<0.90	<0.046	-
Carrots	1	<3.0	10 *±5.0*	3.2 *±0.5*	-	<0.50	-	0.21 *±0.03*	<0.80	<0.60	<0.031	<1.8	<0.90	<0.050	-
Duck	1	8.0 *±5.0*	24 *±5.0*	<2.0	-	<0.30	-	0.19 *±0.06*	<0.60	<0.50	0.42 *±0.07*	<2.6	<0.70	-	-
Honey	1	<4.0	80 *±14*	<1.0	-	<0.20	-	0.16 *±0.04*	<0.50	<0.30	-	<2.1	<0.50	<0.033	-
Ovine kidney/liver	2	7.0 *±5.5*	35 *±13*	<2.0	-	<0.30	-	0.16 *±0.06*	<0.65	<0.55	<0.19 *±0.07*	<2.5	<0.95	-	-
" max		9.0 *±6.0*	37 *±13*					0.20 *±0.07*	<0.70	<0.60	0.33 *±0.09*		<1.2		
" muscle	2	<3.5 *±2.8*	26 *±8.6*	<2.0	-	<0.55	-	<0.034 *±0.035*	<0.80	<0.80	<0.022	<1.9	<0.95	<0.032	-
" max		4.0 *±4.0*	30 *±10*			<0.60		0.050 *±0.050*	<0.90		<0.024	<2.1	<1.1	<0.036	
Pears	1	7.0 *±4.0*	18 *±5.0*	<0.50	-	<0.40	-	0.33 *±0.04*	<0.90	<0.60	-	<2.4	<0.60	<0.063	-
Lettuce	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potatoes	1	<3.0	17 *±6.0*	<0.20	-	-	-	0.16 *±0.03*	-	-	-	-	-	0.040 *±0.040*	-
" sub-sets	1	-	-	-	-	<0.50	-	-	<1.0	<0.60	-	<1.7	<1.0	-	-
Runner beans	1	5.0 *±4.0*	8.0 *±3.0*	<0.50	-	<0.50	-	0.21 *±0.04*	<0.70	<0.70	-	<2.6	<1.0	<0.071	-
Grass	2	-	-	-	1.7 *±0.5*	-	0.65 *±0.20*	-	-	-	0.055 *±0.021*	-	-	-	-
" max					2.3 *±0.5*		1.0 *±0.2*				0.069 *±0.018*				
Soil	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
" max															

Table 18. continued

Material and selection[c]	Farms/ samples[b]	^{137}Cs	Total Cs	^{144}Ce	^{155}Eu	^{147}Pm	^{234}U	^{235}U	^{238}U	Total U	^{238}Pu	$^{239}Pu + ^{240}Pu$	^{241}Pu	^{241}Am
		Mean radioactivity concentration (wet)[a], Bq kg^{-1}												
Milk	3	<0.47	0.22	<1.8	<0.64 *±0.03*	<0.33 *±0.20*	-	-	-	-	<0.00018 *±0.00003*	<0.00019 *±0.00007*	<0.069	<0.00020 *±0.00014*
" max		<0.48	0.25	<1.9	<0.67 *±0.03*						<0.00020	<0.00023 *±0.00010*	<0.072	<0.00020 *±0.00015*
" sub-sets	3	<0.35	-	<0.88	<0.43	-	-	-	-	-	-	-	-	-
" max		<0.50		<1.1	<0.60									
Barley	1	-	0.32 *±0.08*	<2.0	<0.70	-	-	-	-	-	0.00050 *±0.00050*	0.0026 *±0.0011*	0.32 *±0.18*	0.0076 *±0.0026*
Blackberries	1	-	0.094 *±0.076*	<1.8	<0.60	-	-	-	-	-	0.00050 *±0.00040*	0.00090 *±0.00060*	<0.093	0.0017 *±0.0007*
Bovine kidney	1	-	0.46 *±0.12*	<2.3	<0.70	-	-	-	-	-	<0.00030	<0.00040	<0.097	0.00060 *±0.00060*
" liver	1	-	0.84 *±0.12*	<1.9	<0.70	-	-	-	-	-	0.00040 *±0.00040*	0.0015 *±0.0006*	<0.056	0.0019 *±0.0008*
" muscle	1	-	0.60 *±0.13*	<1.3	<0.70	-	-	-	-	-	<0.00030	<0.00030	<0.073	0.00030 *±0.00030*
Broad beans	1	-	-	-	-	-	-	-	-	0.029 *±0.010*	-	-	-	-
Cabbage	1	-	0.11 *±0.08*	<1.7	<0.70	1.9 *±1.4*	-	-	-	-	<0.00030	0.00040 *±0.00040*	0.20 *±0.20*	0.0010 *±0.0006*
Carrots	1	-	0.15 *±0.08*	<2.3	<0.70	-	-	-	-	-	0.00030 *±0.00030*	0.00060 *±0.00060*	<0.20 *±0.17*	0.0012 *±0.0006*
Duck	1	-	5.5 *±0.3*	<1.9	<1.4	-	-	-	-	-	0.0091 *±0.0017*	0.040 *±0.006*	0.65 *±0.14*	0.065 *±0.013*
Honey	1	-	12 *±0.6*	<1.3	<1.1	-	-	-	-	-	<0.00040	0.00070 *±0.00060*	<0.16	0.0013 *±0.0006*
Ovine kidney/ liver	2	-	0.75 *±0.12*	<1.9	<1.5	-	-	-	-	-	-	-	-	-
" max			0.87 *±0.11*		<1.6									
Ovine muscle	2	-	0.67 *±0.12*	<2.3	<0.65	-	-	-	-	-	<0.00025	<0.00030	<0.072	<0.00045 *±0.00021*
" max			0.89 *±0.13*	<2.4	<0.70						<0.00030		<0.074	0.00060 *±0.00030*
Pears	1	-	0.14 *±0.08*	<1.6	<0.50	-	-	-	-	-	0.0010 *±0.0006*	0.0052 *±0.0015*	<0.074	0.0088 *±0.0026*
Lettuce	1	-	-		-	-	-	-	-	0.12 *±0.02*	-	-	-	-
Potatoes	1	-	<0.044	-	-	0.40 *±0.40*	-	-	-	-	0.00010 *±0.00010*	<0.00030	0.13 *±0.12*	0.00040 *±0.00030*
" sub-sets	1	-	-	<2.4	<0.70	-	-	-	-	-	-	-	-	-
Runner beans	1	-	0.12 *±0.07*	<2.0	<0.70		-	-	-	-	<0.00020	0.00020 *±0.00020*	0.18 *±0.13*	0.00040 *±0.00040*
Grass	2	-	-	-	-	13 *±0.6*	-	-	-	-	-	-	-	-
" max						21 *±0.8*								
Soil	2	-	-	-	-	-	16 *±1.5*	0.56 *±0.12*	15 *±1.4*	60 *±5.7*	-	-	-	-
" max										67 *±6.1*				

- not analysed
[a] except for milk where units are Bq l^{-1} and for soil where dry concentrations apply
[b] see section 5 for definition
[c] data are arithmetic means unless stated as 'max'. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition

Table 19. Radioactivity in aquatic plants from the Cumbrian coast and further afield, 1996

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}											
			^{14}C	^{60}Co	^{90}Sr	^{95}Zr	^{95}Nb	^{99}Tc	^{103}Ru	^{106}Ru	^{110m}Ag	^{125}Sb	^{129}I	^{131}I
England														
St Bees	*Fucus vesiculosus*	4	62 ±*5.5*	3.5 ±*0.1*	1.1 ±*0.1*	0.07 ±*0.08*	*	26000 ±*2200*	*	2.8 ±*0.7*	2.5 ±*0.2*	0.82 ±*0.23*	3.0 ±*0.9*	*
"	*Porphyra*	4	62 ±*4.5*	0.59 ±*0.10*	1.0 ±*0.05*	*	*	19 ±*1.5*	0.04 ±*0.03*	19 ±*1.1*	0.23 ±*0.11*	1.2 ±*0.2*	-	*
"	*Rhodymenia spp.*	2	-	0.56 ±*0.21*	-	0.16 ±*0.23*	0.24 ±*0.30*	-	*	16 ±*2.4*	2.0 ±*0.4*	0.42 ±*0.31*	-	*
Braystones south	*Porphyra*	4	-	1.0 ±*0.2*	-	*	*	-	0.16 ±*0.10*	63 ±*1.9*	0.58 ±*0.19*	1.3 ±*0.3*	-	*
Sellafield	*Fucus vesiculosus*	4	-	7.2 ±*0.3*	6.2 ±*0.2*	0.35 ±*0.21*	0.19 ±*0.29*	62000 ±*5000*	*	12 ±*2.2*	9.1 ±*0.5*	1.5 ±*0.6*	-	*
Seascale	*Porphyra*	53[c]	-	1.0 ±*0.6*	-	*	*	-	0.08 ±*0.18*	47 ±*6.7*	0.64 ±*0.58*	1.4 ±*1.0*	-	*
River Calder (Pos. A)	*Fontinalis*	1	-	*	-	*	*	-	*	*	*	*	-	*
River Calder (Pos. E)	"	1	-	1.3 ±*0.5*	-	*	*	-	*	*	*	*	-	*
Rabbit Cat How, Ravenglass	Samphire	1	-	0.09 ±*0.05*	-	*	*	1.3 ±*0.1*	*	*	*	*	-	*
Cockerham Marsh	"	1	-	*	-	*	*	-	*	*	*	*	-	*
Wales														
Portmadoc	*Fucus vesiculosus*	1	-	*	-	*	*	-	*	*	*	*	-	*
Fishguard	"	1	-	*	-	*	*	12 ±*0.9*	*	*	*	*	-	*
Lavernock Point	*Fucus serratus*	2	-	*	-	*	*	-	*	*	*	*	-	0.51 ±*0.16*
South Wales, Manufacturer A	Laverbread	4	-	*	-	*	*	-	*	*	*	0.06 ±*0.08*	-	*
Manufacturer C	"	4	-	*	-	*	*	-	*	*	*	*	-	*
Manufacturer D	"	4	-	*	-	*	*	-	*	*	*	*	-	*
Scotland														
Port William	*Fucus vesiculosus*	4	-	0.25 ±*0.10*	-	*	*	2600 ±*220*	*	*	*	0.06 ±*0.06*	-	*
Garlieston	"	4	-	0.79 ±*0.15*	-	*	*	5600 ±*450*	*	*	0.03 ±*0.07*	0.21 ±*0.18*	-	*
Auchencairn	"	4	-	0.82 ±*0.16*	-	*	*	7000 ±*600*	*	*	0.09 ±*0.07*	0.23 ±*0.17*	-	*
Knock Bay	*Porphyra*	4	-	*	-	*	*	-	*	0.10 ±*0.19*	*	*	-	*
Cape Wrath	*Fucus vesiculosus*	1	-	*	-	*	*	290 ±*23*	*	*	*	*	-	*
Wick	"	1	-	*	-	*	*	-	*	*	*	*	-	*
Northern Ireland														
Ardglass	"	4	-	*	-	*	*	410 ±*32*	*	*	*	*	-	*
Portrush	*Fucus serratus*	4	-	0.03 ±*0.02*	-	*	*	-	*	*	*	0.03 ±*0.05*	-	*
Strangford Lough	*Rhodymenia spp.*	4	-	*	-	*	*	36 ±*2.9*	*	*	*	*	-	*
Isles of Scilly	*Fucus vesiculosus*	1	-	*	-	*	*	0.72 ±*0.09*	*	*	*	*	-	*

Table 19. continued

Location[a]	Material	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet), Bq kg^{-1}									
			^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Pu	^{241}Am	^{243}Cm+ ^{244}Cm	Total beta
England												
St Bees	*Fucus vesiculosus*	4	7.8 ±0.1	*	0.02 ±0.03	0.13 ±0.11	1.5 ±0.04	6.8 ±0.1	-	3.3 ±0.1	0.0084 ±0.0031	-
"	*Porphyra*	4	2.8 ±0.1	0.18 ±0.31	0.09 ±0.10	*	0.80 ±0.05	4.0 ±0.1	49 ±1.5	6.8 ±0.2	0.014 ±0.006	190
"	*Rhodymenia spp.*	2	9.3 ±0.3	*	*	*	0.75 ±0.04	3.5 ±0.1	-	8.9 ±0.2	0.019 ±0.008	-
Braystones south	*Porphyra*	4	3.2 ±0.1	0.18 ±0.25	*	*	0.54 ±0.03	2.6 ±0.1	32 ±1.2	4.9 ±0.2	0.0084 ±0.0050	-
Sellafield	*Fucus vesiculosus*	4	13 ±0.3	*	*	*	2.5 ±0.1	11 ±0.3	-	6.3 ±0.2	0.018 ±0.006	43000
Seascale	*Porphyra*	53[c]	2.5 ±0.6	*	*	*	-	-	-	5.5 ±1.0	-	-
River Calder (Pos. A)	*Fontinalis*	1	8.2 ±0.7	*	*	1.1 ±0.7	-	-	-	*	-	-
River Calder (Pos. E)	"	1	7.8 ±0.5	*	*	1.6 ±0.7	-	-	-	0.34 ±0.26	-	-
Rabbit Cat How, Ravenglass	Samphire	1	1.4 ±0.1	*	*	*	-	-	-	1.3 ±0.2	-	-
Cockerham Marsh	"	1	4.1 ±0.1	*	*	*	-	-	-	1.3 ±0.1	-	47
Wales												
Portmadoc	*Fucus vesiculosus*	1	0.52 ±0.05	*	*	0.07 ±0.06	-	-	-	*	-	-
Fishguard	"	1	0.23 ±0.17	*	*	*	-	-	-	*	-	220
Lavernock Point	*Fucus serratus*	2	0.22 ±0.04	*	*	*	-	-	-	*	-	150
South Wales, Manufacturer A	Laverbread	4	0.09 ±0.08	*	*	*	-	-	-	*	-	-
Manufacturer C	"	4	0.25 ±0.08	*	*	*	-	-	-	0.14 ±0.09	-	-
Manufacturer D	"	4	0.05 ±0.05	*	*	*	-	-	-	*	-	64
Scotland												
Port William	*Fucus vesiculosus*	4	2.4 ±0.1	*	*	0.06 ±0.07	-	-	-	0.56 ±0.23	-	-
Garlieston	"	4	4.9 ±0.2	*	*	*	-	-	-	2.7 ±0.5	-	-
Auchencairn	"	4	8.0 ±0.2	*	*	0.12 ±0.15	-	-	-	2.7 ±0.6	-	-
Knock Bay	*Porphyra*	4	0.29 ±0.06	*	*	*	-	-	-	0.21 ±0.11	-	-
Cape Wrath	*Fucus vesiculosus*	1	0.22 ±0.07	*	*	*	-	-	-	*	-	270
Wick	"	1	0.42 ±0.08	*	*	*	-	-	-	*	-	300
Northern Ireland												
Ardglass	"	4	0.91 ±0.12	*	*	*	-	-	-	*	-	-
Portrush	*Fucus serratus*	4	0.26 ±0.05	*	*	*	-	-	-	0.10 ±0.07	-	-
Strangford Lough	*Rhodymenia spp.*	4	1.5 ±0.2	*	*	*	0.055 ±0.003	0.30 ±0.01	-	0.50 ±0.01	*	-
Isles of Scilly	*Fucus vesiculosus*	1	*	*	*	*	-	-	-	*	-	180

\- *not analysed*
* *not detected by the method used*
[a] *Sampling area*
[b] *See section 5 for definition*
[c] *counted wet*

Table 20(a). Radioactivity in food and the environment near Springfields, 1996

Material	Location[b] or selection[c]	No. of sampling observ-ations[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}										
			^{3}H	^{14}C	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	Total Cs	^{154}Eu
Aquatic samples													
Flounder	Ribble Estuary	1	-	-	*	-	-	*	*	*	14 *±0.3*	-	*
Salmon	"	1	-	-	*	-	-	*	*	*	0.27 *±0.13*	-	*
Sea trout	"	1	-	-	*	-	-	*	*	*	6.1 *±0.2*	-	*
Shrimps	"	1	-	-	*	-	6.1 *±0.5*	*	*	*	5.4 *±0.1*	-	*
Cockles	"	1	-	-	0.33 *±0.22*	-	-	*	*	*	4.3 *±0.2*	-	*
Mallard	"	1	-	-	*	-	-	*	*	*	1.2 *±0.1*	-	*
Samphire	"	1	-	-	*	-	-	*	*	*	2.7 *±0.1*	-	*
Turf	Hesketh Bank	4	-	-	1.2 *±0.8*	-	-	*	1.2 *±1.2*	*	500 *±5.6*	-	2.2 *±1.6*
Mud	Becconsall	4	-	-	1.7 *±0.8*	-	-	4.8 *±4.7*	*	*	350 *±4.9*	-	*
"	Pipeline	3	-	-	3.4 *±1.3*	-	-	6.2 *±6.9*	2.5 *±2.1*	*	450 *±6.2*	-	1.4 *±1.8*
"	Savick Brook	4	-	-	3.5 *±1.0*	-	-	*	*	4.2 *±4.0*	550 *±10*	-	*
"	Penwortham	4	-	-	1.8 *±1.2*	-	-	*	*	*	360 *±6.1*	-	*
Mud & sand	Pipeline	1	-	-	1.3 *±1.0*	-	-	*	*	*	280 *±4.1*	-	*
"	30m S of pipeline	3	-	-	*	-	-	*	*	*	170 *±10*	-	*
"	Deepdale Brook	3	-	-	*	-	-	*	4.2 *±1.5*	*	10 *±0.6*	-	0.74 *±0.51*
"	Ribble Estuary	1	-	-	0.42 *±0.34*	-	-	*	1.1 *±1.3*	*	99 *±1.4*	-	*
Terrestrial samples													
Milk	Near farms	5	-	-	-	-	-	-	-	-	-	-	-
"	Far farms	1	-	-	-	-	-	-	-	-	-	-	-
Blackberries		1	<3.0	17 *±4.0*	<0.30	0.26 *±0.05*	-	<2.8	-	-	-	<0.074	-
Cabbage[e]		1	<3.0	6.0 *±2.0*	<0.40	3.4 *±0.2*	-	<3.8	-	-	-	0.092 *±0.068*	-
Duck		2	7.0 *±4.0*	29 *±5.0*	<0.35	<0.025	-	<3.8	-	-	-	3.9 *±0.2*	-
"	max				<0.40			<3.9					
Potatoes[e]		2	<3.0	18 *±4.5*	<0.40	0.052 *±0.048*	-	<3.1	-	-	-	0.092 *±0.061*	-
"	max					0.055 *±0.055*						0.11 *±0.06*	
"	sub-sets	1	-		<0.30	-	-	<1.9	-	-	-	-	-
Sprouts[e]		1	<3.0	10 *±3.0*	<0.50	0.75 *±0.05*	-	<2.9	-	-	-	<0.072	-
Bovine Faeces		6	-	-	-	-	-	-	-	-	-	-	-
"	max												
Ovine Faeces		4	-	-	-	-	-	-	-	-	-	-	-
"	max												
Grass		8	-	-	-	-	-	-	-	-	-	-	-
"	max												
Sileage		4	-	-	-	-	-	-	-	-	-	-	-
"	max												
Soil		4	-	-	-	-	-	-	-	-	-	-	-
"	max												
Dry cloths		142	-	-	-	-	-	-	-	-	-	-	-

Table 20(a). continued

Material	Location[b] or selection[c]	No. of sampling observations[d]	^{155}Eu	^{226}Ra	^{228}Th	^{230}Th	^{232}Th	^{234}Th	^{233}Pa	^{234}U	^{235}U+^{236}U	^{238}U	Total U
			Mean radioactivity concentration (wet)[a], Bq kg^{-1}										
Aquatic samples													
Flounder	Ribble Estuary	1	*	-	-	-	-	*	*	-	-	-	-
Salmon	"	1	*	-	-	-	-	*	*	-	-	-	-
Sea trout	"	1	*	-	-	-	-	*	*	-	-	-	-
Shrimps	"	1	*	0.15 *±0.16*	0.004 *±0.002*	0.025 *±0.002*	0.005 *±0.001*	13 *±1.3*	*	-	-	-	-
Cockles	"	1	*	-	-	-	-	19 *±3.0*	*	-	-	-	-
Mallard	"	1	*	-	-	-	-	-	*	-	-	-	-
Samphire	"	1	*	-	-	-	-	-	*	-	-	-	-
Turf	Hesketh Bank	4	3.0 *±2.9*	24 *±3.9*	-	-	-	480 *±130*	*	-	-	-	-
Mud	Becconsall	4	*	31 *±12*	22 *±1.8*	78 *±3.1*	20 *±1.1*	27000 *±290*	*	18 *±0.9*	0.75 *±0.19*	15 *±0.8*	-
"	Pipeline	3	*	22 *±4.6*	27 *±1.8*	95 *±3.4*	24 *±1.2*	30000 *±290*	*	20 *±1.0*	0.80 *±0.19*	16 *±0.9*	-
"	Savick Brook	4	*	130 *±55*	-	-	-	530000 *±860*	*	-	-	-	-
"	Penwortham	4	*	33 *±8.4*	21 *±1.8*	140 *±6.3*	19 *±1.0*	130000 *±420*	*	41 *±2.5*	1.7 *±0.4*	32 *±2.1*	-
Mud & sand	Pipeline	1	*	69 *±30*	24 *±1.7*	55 *±2.6*	20 *±1.3*	12000 *±130*	*	13 *±0.8*	0.32 *±0.18*	12 *±0.8*	-
"	30m S of pipeline	3	*	30 *±13*	12 *±1.3*	480 *±27*	13 *±0.8*	690000 *±930*	*	200 *±12*	8.9 *±1.0*	200 *±12*	-
"	Deepdale Brook	3	3.3 *±1.9*	84 *±2.1*	21 *±1.7*	900 *±27*	20 *±1.1*	990	10 *±2.5*	980 *±64*	43 *±3.9*	900 *±60*	-
"	Ribble Estuary	1	2.7 *±1.6*	41 *±1.7*	24 *±1.8*	22 *±0.9*	24 *±0.9*	920 *±38*	*	-	-	-	-
Terrestrial samples													
Milk	Near farms	5	-	-	-	-	-	-	-	-	-	-	<0.0065
"	Far farms	1	-	-	-	-	-	-	-	-	-	-	<0.0065
Blackberries[c]		1	-	-	-	-	-	-	-	-	-	-	-
Cabbage[e]		1	-	-	-	0.31 *±0.08*	0.31 *±0.08*	-	-	-	-	-	-
Duck		2	-	-	-	0.015 *±0.007*	<0.0030	-	-	-	-	-	-
"	max												
Potatoes[e]		2	-	-	-	0.012 *±0.004*	0.0075 *±0.0030*	-	-	-	-	-	-
"	max						0.0080 *±0.0030*						
"	sub-sets	1	-	-	-	-	-	-	-	-	-	-	-
Sprouts[e]		1	-	-	-	0.015 *±0.011*	0.015 *±0.011*	-	-	-	-	-	-
Bovine faeces		6	-	-	-	-	-	-	-	-	-	-	1.6 *±0.1*
"	max												2.9 *±0.1*
Ovine faeces		4	-	-	-	-	-	-	-	6.7 *±0.6*	0.30 *±0.03*	6.3 *±0.5*	7.5 *±0.4*
"	max												*14* *±0.6*
Grass		8	-	-	-	-	-	-	-	-	-	-	0.88 *±0.07*
"	max												2.5 *±0.1*
Sileage		4	-	-	-	-	-	-	-	-	-	-	1.6 *±0.1*
"	max												2.5 *±0.2*
Soil		4	-	-	-	-	-	-	-	49 *±4.1*	2.3 *±0.3*	45 *±3.9*	90 *±6.9*
"	max												130 *±8.6*
Dry cloths		142	-	-	-	-	-	-	-	-	-	-	-

Table 20(a). continued

Material	Location[b] or selection[c]	No. of sampling observa-tions[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}								
			^{237}Np	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Pu	^{241}Am	^{243}Cm+ ^{244}Cm	Total alpha	Total beta	Total gamma
Aquatic samples											
Flounder	Ribble Estuary	1	-	-	-	-	*	-	-	-	-
Salmon	“	1	-	-	-	-	*	-	-	-	-
Sea trout	“	1	-	-	-	-	*	-	-	-	-
Shrimps	“	1	0.00092 *±0.00025*	0.0046 *±0.0008*	0.025 *±0.002*	-	0.039 *±0.002*	*	-	-	-
Cockles	“	1	-	-	-	-	4.0 *±0.3*	-	-	-	-
Mallard	“`	1	-	-	-	-	*	-	-	-	-
Samphire	“`	1	-	-	-	-	0.66 *±0.30*	-	-	57	-
Turf	Hesketh Bank	4	-	-	-	-	180 *±11*	-	-	-	-
Mud	Becconsall	4	-	-	-	-	50 *±3.5*	-	-	-	-
“	Pipeline	3	-	14 *±1.0*	76 *±2.7*	-	120 *±2.8*	0.16 *±0.08*	-	8200	-
“	Savick Brook	4	-	30 *±1.6*	170 *±4.9*	1900 *±62*	260 *±5.3*	0.43 *±0.15*	-	-	-
“	Penwortham	4	0.35 *±0.02*	-	-	-	*	-	-	-	-
Mud & sand	Pipeline	1	-	-	-	-	*	-	-	3700	-
“	30m S of pipeline	3	-	-	-	-	*	-	-	-	-
“	Deepdale Brook	3	2.4 *±0.11*	-	-	-	*	-	-	-	-
“	Ribble Estuary	1	-	-	-	-	52 *±3.0*	-	-	-	-
Terrestrial samples											
Milk	Near farms	5	-	-	-	-	-	-	-	-	-
“	Far farms	1	-	-	-	-	-	-	-	-	-
Blackberries[c]		1	-	<0.00050	0.0058 *±0.0017*	<0.14	0.0041 *±0.0019*	-	-	-	-
Cabbage[e]		1	-	<0.00060	0.0044 *±0.0017*	<0.21	0.0074 *±0.0031*	-	-	-	-
Duck		2	-	0.00090 *±0.00080*	0.0043 *±0.0014*	<0.11	0.0045 *±0.0013*	-	-	-	-
“	max					<0.12					
Potatoes[e]		2	-	<0.00025	<0.00030	<0.12 *±0.08*	<0.00035 *±0.00021*	-	-	-	-
“	max			<0.00030		0.18 *±0.12*	0.00040 *±0.00030*				
“	sub-sets	1	-	-	-	-	-	-	-	-	-
Sprouts[e]		1	-	<0.00020	0.00090 *±0.00050*	0.18 *±0.12*	0.00080 *±0.00070*	-	-	-	-
Bovine Faeces		6	-	-	-	-	-	-	-	-	-
“	max										
Ovine Faeces		4	-	-	-	-	-	-	-	-	-
“	max										
Grass		8	-	-	-	-	-	-	-	-	-
“	max										
Sileage		4	-	-	-	-	-	-	-	-	-
“	max										
Soil		4	-	-	-	-	-	-	-	-	-
“	max										
Dry cloths		142	-	-	-	-	-	-	1.2 *±3.1*	5.6 *±13*	1.1 *±2.0*

- *not analysed*
* *not detected by the method used*
[a] *Except for milk where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment and uranium in soil where dry concentrations apply*
[b] *Landing point or sampling area*
[c] *Data are arithmetic means unless stated as ‘max’. ‘Max’ data are selected to be maxima. If no ‘max’ value is given, the mean is also the maximum. See section 5 for definition*
[d] *See section 5 for definition*
[e] *The concentration of ^{129}I was <0.062 Bq kg^{-1}*

Table 20(b). Monitoring of radiation dose rates near Springfields, 1996

Location	Material or ground type	No. of sampling observations[a]	µGy h⁻¹
Gamma dose rates at 1 m over intertidal areas			
Lytham - Boatyard	Mud	4	0.12
" - Windmill Marsh	Salt marsh	1	0.12
Warton Marsh	Mud	4	0.15
"	" [c]	4	0.17
"	Salt marsh	4	0.14
The Naze	"	1	0.13
Banks marsh	Mud	4	0.16
"	" [c]	4	0.17
"	Salt marsh	4	0.18
Hesketh Bank	Mud	4	0.14
"	" [c]	4	0.15
"	Salt marsh	4	0.14
Freckleton	Mud	4	0.14
River Douglas	Grass	1	0.21
Becconsall	Mud	4	0.11
" (boat 2)	"	5	0.12
" "	Cabin[b]	15	0.083
" (boat 5)	" [b]	2	0.077
Hutton Marsh	Mud	4	0.18
"	Salt marsh	4	0.18
Pipeline	Mud	2	0.11
"	Mud and sand	2	0.12
Pipeline (south bank)	Mud	1	0.11
"	Mud and sand	3	0.11
"	Salt marsh	4	0.17
Savick Brook - tidal limit	Mud	3	0.33
" "	Mud and sand	1	0.17
" - A583 bridge	Mud	4	0.37
" - confluence with Ribble	"	2	0.12
" "	Mud and sand	2	0.16
Penwortham	Mud	4	0.15
Lower Penwortham	Mud	4	0.18
"	Grass	4	0.095
Penwortham Railway Bridge	Mud	4	0.14
"	Grass	4	0.086
River Darwen	Mud	2	0.12
"	Mud and sand	1	0.089
"	Grass	4	0.098
Southport	Salt marsh	1	0.11
"	Sand	1	0.070
"	Samphire Bed	1	0.11
Beta dose rates			µSv h⁻¹
Lytham - Windmill Marsh	Salt marsh	1	0.88
" - Boatyard	Mud	4	8.9
Warton Marsh	"	4	7.7
"	Salt marsh	4	1.1
The Naze	"	1	1.3
Banks Marsh	Mud	4	4.4
"	Salt marsh	4	1.7
Hesketh Bank	Mud	4	4.7
"	Salt marsh	4	1.9
Freckleton	Mud	4	12
River Douglas	Grass	1	1.1
Deepdale Brook	Mud	1	0.83
"	Mud and sand	3	0.91
Becconsall	Mud	4	6.3
" - boat 2	"	1	5.8
" "	Cabin[b]	1	0.52
Hutton Marsh	Mud	4	1.5
"	Salt marsh	4	2.2
Pipeline	Mud	2	4.0
"	Mud and sand	2	10
Pipeline (south bank)	Mud	1	6.4
"	Mud and sand	3	5.0
"	Salt marsh	4	2.1
Savick Brook - tidal limit	Mud	3	110
" "	Mud and sand	1	16
" - A583 bridge	Mud	4	71
" - confluence with Ribble	"	2	9.7
" "	Mud and sand	2	21
Penwortham	Mud	4	23
Lower Penwortham	Mud	4	28
"	Grass	4	5.5
Penwortham Railway Bridge	"	4	1.1
"	Mud	4	31
River Darwen	Mud	2	14
"	Mud and sand	1	18
"	Grass	4	1.9
Ribble estuary	Gill net	2	1.4
"	Shrimp net	2	1.3

[a] *See section 5 for definition*
[b] *In the cabin of a houseboat*
[c] *15 cm above substrate*

Table 21. Radioactivity in food and the environment near Capenhurst, 1996

Material	Location	No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																
			^{3}H	^{60}Co	^{99}Tc	^{125}Sb	^{137}Cs	^{155}Eu	^{233}Pa	^{234}Th	^{234}U	$^{235+236}$U	^{238}U	^{237}Np	^{238}Pu	$^{239+240}$Pu	^{241}Am	$^{243+244}$Cm	Total beta
Aquatic samples																			
Shrimps	Hoylake	2	-	*	4.9 ±0.4	*	4.5 ±0.2	*	*	*	-	-	-	-	-	-	*	-	-
Cockles	Dee estuary	4	-	0.17 ±0.06	29 ±2.3	0.06 ±0.05	2.4 ±0.1	0.02 ±0.04	0.25 ±0.18	3.6 ±2.4	-	-	-	-	0.14 ±0.01	0.74 ±0.02	2.0 ±0.04	0.0039 ±0.0013	-
Cladophoraceae sp.	Rivacre Brook	1	-	*	660 ±51	*	0.81 ±0.18	*	88	180	32 ±1.0	1.9 ±0.2	21 ±0.7	11 ±0.4	-	-	*	-	970
Elodea canadensis	“	2	-	*	340 ±29	*	1.1 ±0.1	0.28 ±0.16	9.4	93	30 ±0.8	1.8 ±0.1	22 ±0.6	8.2 ±0.4	-	-	0.19 ±0.10	-	470
Mud	“	1	-	*	1900 ±150	*	17 ±1.0	2.4 ±1.5	110	360	350 ±8.2	23 ±1.4	300 ±7.2	99 ±3.2	-	-	*	-	-
Mud & sand	“	1	-	*	1000 ±79	*	7.8 ±0.5	*	35	150	190 ±9.0	11 ±1.3	130 ±6.6	22 ±1.0	-	-	*	-	-
Freshwater	“	2	31 ±2.0	*	0.72 ±0.07	*	*	*	*	*	0.13 ±0.004	0.0079 ±0.0011	0.078 ±0.003	0.0087 ±0.0003	-	-	*	-	-

Material	Location or selection[c]	No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}								
			^{3}H	^{99}Tc	^{234}U	^{235}U	^{238}U	Total U	Total alpha	Total beta	Total gamma
Terrestrial samples											
Milk	Near farms	6	9.8 ±3.4	<0.0075	-	-	-	<0.0065	-	-	-
“	max		18 ±4.3								
“	Far farms	1	-	-	-	-	-	<0.0065	-	-	-
Celery		1	-	<0.074	-	-	-	<0.019	-	-	-
Potatoes		1	-	<0.039	-	-	-	<0.020	-	-	-
Strawberries		1	-	<0.063	-	-	-	0.013 ±0.004	-	-	-
Bovine faeces		8	-	<0.041	2.0 ±0.2	0.077 ±0.012	2.0 ±0.2	1.5 ±0.1	-	-	-
“	max			<0.052				4.0 ±0.2			
Grass		8	-	-	0.40 ±0.04	0.017 ±0.006	0.35 ±0.04	<0.53 ±0.07	-	-	-
“	max							1.5 ±0.1			
Silage		4	-	<0.057	-	-	-	0.21 ±0.03	-	-	-
“	max			<0.058				0.32 ±0.04			
Soil		4	-	-	9.8 ±0.9	0.36 ±0.09	10 ±1.0	48 ±5.0	-	-	-
“	max							52 ±5.2			
Rain water		7	74 ±5.7	-	-	-	-	-	-	-	-
“	max		240 ±9.8								
Dry cloths		119	-	-	-	-	-	-	0.14 ±0.16	1.4 ±1.2	0.73 ±0.45

- *not analysed*
* *not detected by the method used*
[a] *Except for milk and water where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for soil and sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as ‘Max’ in this column. ‘Max’ data are selected to be maxima. If no ‘max’ value is given, the mean is also the maximum. See section 5*

Table 22(a). Radioactivity in food and the environment near Chapelcross nuclear power station, 1996

Material	Location[b]	No. of sampling observa-tions[c]	Mean radioactivity concentration (wet)[a], Bq kg⁻¹ ^{3}H	^{14}C	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{154}Eu	^{155}Eu	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Pu	^{241}Am	$^{243}Cm+^{244}Cm$	Total beta
Flounder	Inner Solway	4	-	61 *±7.7*	*	0.046 *±0.003*	3.5 *±0.3*	*	*	*	*	29 *±0.6*	*	*	0.0021 *±0.0002*	0.010 *±0.0004*	-	0.018 *±0.001*	*	-
Seatrout	"	2	-	-	*	-	-	*	*	*	*	7.7 *±0.5*	*	*	0.00045 *±0.00005*	0.0026 *±0.0001*	-	0.0037 *±0.0002*	*	-
Salmon	"	1	-	-	*	-	-	*	*	*	*	1.2 *±0.2*	*	*	-	-	-	*	-	-
Shrimps	"	4	-	-	*	0.092 *±0.014*	3.5 *±0.3*	*	*	*	*	12 *±0.3*	*	*	0.0030 *±0.0002*	0.016 *±0.001*	-	0.028 *±0.001*	0.000052 *±0.000028*	-
Winkles	Southerness	4	-	-	0.91 *±0.16*	1.8 *±0.1*	730 *±57*	1.9 *±1.1*	1.1 *±0.2*	0.79 *±0.38*	*	11 *±0.2*	0.03 *±0.04*	0.06 *±0.07*	0.69 *±0.03*	3.7 *±0.1*	44 *±1.1*	6.2 *±0.2*	0.010 *±0.005*	-
Fucus vesiculosus	Pipeline	4	-	-	0.38 *±0.13*	-	3200 *±270*	*	*	0.19 *±0.20*	*	17 *±0.3*	*	0.24 *±0.26*	0.38 *±0.02*	2.0 *±0.1*	-	2.0 *±0.1*	0.0034 *±0.0020*	2500
Mud	Bladnoch	4	-	-	3.7 *±0.8*	-	-	18 *±7.9*	*	1.1 *±1.5*	1.1 *±0.9*	390 *±3.4*	4.6 *±2.0*	2.4 *±1.6*	-	-	-	250 *±4.8*	-	-
Mud and sand	Pipeline	4	-	-	1.3 *±0.6*	-	-	3.0 *±2.2*	*	*	*	220 *±3.0*	0.76 *±0.59*	0.39 *±0.51*	9.3 *±0.5*	51 *±1.6*	-	81 *±2.1*	0.12 *±0.05*	-
Sea water	"	4	6.7 *±1.8*	-	-	-	-	-	-	-	0.0019 *±0.0014*	0.30 *±0.002*	-	-	-	-	-	-	-	-
"	Southerness	4	5.2 *±1.8*	-	-	-	-	-	-	-	0.0021 *±0.0014*	0.33 *±0.002*	-	-	0.00033 *±0.00002*	0.0017 *±0.0001*	-	0.00096 *±0.00006*	0.0000019 *±0.0000013*	-

Material	Location[b] or selection[d]	No. of sampling observa-tions[c]	Mean radioactivity concentration (wet)[a], Bq kg⁻¹ ^{3}H	^{14}C	^{35}S	^{90}Sr	^{137}Cs
Terrestrial samples							
Milk	Near farms	4	94 *±9.6*	14 *±2.0*	<5.0	<0.10	<0.055
"	" max		180 *±14*				<0.070
"	Far farms	4	83 *±8.6*	12 *±1.9*	<5.0	<0.10	<0.055 *±0.019*
"	" max		160 *±12*				0.060 *±0.037*
Grass		6	<520 *±46*	22 *±4.3*	6.0 *±0.4*	0.50 *±0.08*	<0.25 *±0.11*
"	" max		1900 *±100*	45 *±6.7*	9.6 *±0.8*	0.83 *±0.12*	0.92 *±0.11*

\- *not analysed*
* *not detected by the method used*
[a] *Except for sea water and milk where units are Bq l⁻¹ and for sediment where dry concentrations apply*
[b] *Landing point or sampling area*
[c] *See section 5 for definition*
[d] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition.*

Table 22(b). Monitoring of radiation dose rates near Chapelcross, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h⁻¹
Gamma dose rates at 1 m over intertidal areas			
Seafield	Mud and sand	4	0.088
"	Salt marsh	4	0.087
Battle Hill	Mud and sand	4	0.090
Browhouses	"	2	0.11
"	Mud, sand and stones	2	0.11
Dornoch Brow	Mud and sand	2	0.087
"	Salt marsh	4	0.10
Powfoot	Mud and sand	3	0.083
"	Sand	1	0.081
Priestside Bank	Salt marsh	4	0.084
" [b]	"	4	0.087
Southerness	Winkle bed	4	0.074
Beta dose rates			µSv h⁻¹
Seafield	Stake nets	2	0.15
Priestside Bank	Salt marsh	4	0.091

[a] *See section 5 for definition*
[b] *15 cm above substrate*

Table 23(a). Radioactivity in food and the environment near Dounreay, 1996

Material	Location[b]	No. of sampling observa-tions[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																					
			^{14}C	^{54}Mn	^{58}Co	^{60}Co	^{90}Sr	^{95}Zr	^{95}Nb	^{99}Tc	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total beta
Aquatic samples																								
Cod	Pipeline	4	-	*	*	*	-	*	*	-	*	*	*	0.02 *±0.03*	0.73 *±0.07*	*	*	*	0.000098 *±0.000013*	0.00047 *±0.00003*	0.0019 *±0.0001*	*	*	-
Crabs	"	4	33 *±8.4*	*	*	*	-	*	*	18 *±1.4*	*	0.84 *±0.33*	*	*	0.31 *±0.13*	*	*	*	0.0023 *±0.0001*	0.010 *±0.0003*	0.016 *±0.0004*	0.00039 *±0.00009*	0.00020 *±0.00004*	-
Lobsters	"	4	-	*	*	*	-	*	*	30 *±2.4*	*	1.0 *±0.3*	*	*	0.31 *±0.15*	*	*	*	0.0027 *±0.0001*	0.012 *±0.0003*	0.021 *±0.001*	0.00046 *±0.00021*	0.00030 *±0.00010*	-
Winkles	Brims Ness	4	-	*	*	0.89 *±0.27*	-	*	*	-	6.4 *±2.6*	29 *±0.7*	*	*	0.29 *±0.18*	0.12 *±0.23*	*	*	0.13 *±0.01*	0.45 *±0.02*	0.25 *±0.01*	0.013 *±0.002*	0.0048 *±0.0009*	-
"	Sandside Bay	4	-	*	*	0.76 *±0.25*	-	*	*	30 *±2.4*	6.8 *±2.3*	26 *±0.7*	*	*	0.21 *±0.17*	0.64 *±0.59*	*	*	0.13 *±0.01*	0.48 *±0.02*	0.23 *±0.01*	0.0091 *±0.0019*	0.0025 *±0.0006*	-
Sludge	Oigins Geo	4	-	18 *±5.5*	*	70 *±7.5*	-	54 *±23*	260 *±80*	-	8200 *±250*	360 *±25*	330 *±35*	200 *±11*	2700 *±21*	220 *±54*	10 *±8.9*	48 *±20*	240 *±7.5*	850 *±21*	280 *±7.1*	11 *±1.7*	2.8 *±0.5*	-
Sand	Sandside Bay	4	-	*	*	0.13 *±0.12*	-	*	*	-	*	*	*	0.25 *±0.22*	5.3 *±0.3*	*	0.48 *±0.32*	1.2 *±0.6*	2.4 *±0.1*	9.3 *±0.4*	8.8 *±0.3*	0.072 *±0.033*	0.10 *±0.02*	-
"	Foreshore	4	-	*	*	*	32 *±7.0*	*	*	-	*	*	*	*	2000 *±150*	*	*	*	700 *±55*	1100 *±80*	640 *±65*	<0.17 *±0.01*	<0.26 *±0.04*	-
Fucus vesiculosus	"	4	-	0.21 *±0.06*	*	0.88 *±0.08*	-	*	*	350 *±27*	2.2 *±0.6*	2.6 *±0.2*	*	0.15 *±0.06*	1.2 *±0.1*	0.27 *±0.21*	*	*	-	-	0.04 *±0.08*	-	-	440
"	Brims Ness	4	-	0.76 *±0.09*	0.12 *±0.07*	1.9 *±0.1*	-	*	*	-	2.5 *±0.8*	3.3 *±0.2*	0.06 *±0.07*	0.18 *±0.07*	1.2 *±0.1*	0.09 *±0.12*	*	*	-	-	0.10 *±0.14*	-	-	-
Sea water	Sandside Bay	4	-	-	-	-	-	-	-	-	-	-	-	0.006 *±0.002*	0.02 *±0.001*	-	-	-	-	-	-	-	-	-

Material	Location or selection[d]	No. of sampling observa-tions[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}										
			^{3}H	^{90}Sr	^{129}I	^{131}I	^{137}Cs	^{238}Pu	$^{239+240}$Pu	^{241}Am	Total alpha	Total beta	Total gamma
Terrestrial samples													
Ovine liver		3	-	-	-	-	23 *±2.2*	<0.0045	<0.0045	<0.0090	-	-	-
"	max						68 *±3.8*	<0.0080	<0.0080	<0.020	-	-	-
Ovine thyroid		3	-	-	<0.020	<0.030	-	-	-	-			
Grass		6	<25	<0.69 *±0.12*	<0.11	<0.48	0.64 *±0.22*	<0.0050	<0.0050	<0.0050	-	-	-
"	max			1.5 *±0.2*	<0.20	<0.50	1.4 *±0.3*						
Soil		6	<25	1.9 *±0.5*	<0.11	<0.36	22 *±1.8*	0.046 *±0.010*	0.31 *±0.03*	0.29 *±0.04*	-	-	-
"	max			2.3 *±0.5*	<0.20	<0.50	38 *±2.5*	0.16 *±0.02*	0.51 *±0.05*	1.1 *±0.1*	-	-	-
Landfill leachate		2	-	-	-	-	<0.46	-	-	-	0.17 *±0.08*	1.2 *±0.6*	-
Dry cloths		69	-	-	-	-	-	-	-	-	0.09 *±0.11*	1.2 *±1.4*	0.46 *±0.52*

\- *not analysed*
* *not detected by the method used*
[a] *Except for sea water and leachate where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *Landing point or sampling area*
[c] *See section 5 for definition*
[d] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*

Table 23(b). Monitoring of radiation dose rates near Dounreay, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over substrate			
Oigins Geo	Intertidal sediment	4	0.15
Sandside Bay	Sand	1	0.062
"	Winkle bed	4	0.12
"	Net store	1	0.079
Brims Ness	Winkle bed	2	0.12
Castletown Harbour	Mud	3	0.075
Beta dose rates			µSv h^{-1}
Sandside Bay	Gill nets	1	*
"	Winkle bed	1	0.24
Pipeline offshore	Pots	1	*
Brims Ness	Winkle bed	1	0.44

[a] *See section 5 for definition*
* *Not detected by the method used*

Table 24(a). *Radioactivity in food and the environment near Harwell, 1996*

Material	Location	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1} ^{57}Co	^{51}Cr	^{60}Co	^{90}Sr	^{131}I	^{134}Cs	^{137}Cs	^{155}Eu	^{238}Pu	$^{239+240}$Pu	^{241}Am	Total beta
Aquatic samples														
Pike	Outfall (Sutton Courtenay)	1	*	*	*	0.0093 *±0.0024*	*	0.05 *±0.04*	5.0 *±0.1*	*	0.000039 *±0.000018*	0.00020 *±0.00003*	0.00033 *±0.00005*	-
“	Newbridge	1	*	*	*	0.0050 *±0.0020*	*	*	0.06 *±0.05*	*	*	0.000031 *±0.000010*	*	-
“	Staines	1	*	*	*	-	*	*	0.30 *±0.08*	*	-	-	*	-
Nuphar lutea	Outfall (Sutton Courtenay)	1	*	2.6 *±1.0*	0.13 *±0.06*	-	*	*	0.99 *±0.07*	*	-	-	*	-
“	Newbridge	1	*	*	*	-	*	*	0.07 ±0.04	*	-	-	*	-
“	Staines	1	0.09 *±0.03*	*	*	-	0.83 *±0.65*	*	0.05 *±0.06*	*	-	-	*	-
Mud & Sand	Staines	1	1.0 *±0.3*	*	1.8 *±0.5*	-	*	*	24 *±0.7*	1.7 *±1.2*	-	-	*	330
“	Outfall (Sutton Courtenay)	1	*	*	12 *±1.3*	-	*	*	470 *±4.4*	*	-	-	*	690
Soil	“	1	*	*	2.4 *±0.6*	-	*	*	350 *±3.9*	*	-	-	*	820
Mud	Newbridge	1	*	*	*	-	*	*	6.4 *±0.6*	2.5 *±1.0*	-	-	-	-
“	Lydebank/Ginge Brook confluence	1	*	*	0.89 *±0.22*	-	*	*	16 *±0.4*	1.2 *±0.7*	0.10 *±0.01*	0.75 *±0.04*	0.35 *±0.03*	-
“	Position ‘E’[e]	1	*	*	9.9 *±0.9*	-	*	*	850 *±4.1*	3.1 *±1.9*	-	-	1.4 *±1.3*	-

Material	Location or selection[c]	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1} ^{3}H	^{60}Co	^{134}Cs	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples									
Milk[d]	Near farms	4	<3.1 *±1.0*	<0.46	<0.31	<0.43	-	-	-
“	“ max		<3.3 *±2.0*	<0.48	<0.35	<0.45			
“	Far farms	1	<3.0	<0.50	<0.30	<0.40	-	-	-
Apples[d]		1	49 *±5.0*	<0.50	<0.40	<0.40	-	-	-
Blackberries[d]		1	64 *±5.0*	<0.30	<0.40	<0.30	-	-	-
Honey		1	<5.0	<0.30	<0.20	<0.30	-	-	-
Lettuce[d]		1	<3.0	<0.30	<0.30	<0.30	-	-	-
Potatoes[d]		1	<3.0	<0.50	<0.30	<0.40	-	-	-
Runner beans[d]		1	<3.0	<0.30	<0.20	<0.30	-	-	-
Dry cloths		95	-	-	-	-	0.12 *±0.11*	1.1 *±1.0*	0.55 *±0.37*

- not analysed
** not detected by the method used*
[a] *Except for milk and dry cloths where units are Bq l^{-1} and Bq per cloth respectively, and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as ‘max’ in this column. ‘Max’ data are selected maxima. If no ‘max’ value is given, the mean is also the maximum. See section 5 for definition.*
[d] *The concentration of ^{3}H (organic) was <3 Bq l^{-1}*
[e] *Near the outfall*

Table 24(b). *Monitoring of radiation dose rates near Harwell, 1996*

Location	Ground type	No. of sampling observations[a]	µGy h^{-1}
Gamma dose rates at 1 m over river bank			
Outfall (Sutton Courtenay)	Soil	2	0.075
Position ‘E’[b]	“	2	0.078
Lydebank/Ginge Brook confluence	Mud	2	0.058
Newbridge	Grass	1	0.064

[a] *See section 5 for definition*
[b] *Near the outfall*

Table 25(a). Radioactivity in food and the environment near Winfrith, 1996

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}							
			^{60}Co	^{131}I	^{137}Cs	^{238}Pu	^{239}Pu + ^{240}Pu	^{241}Am	^{243}Cm + ^{244}Cm	Total beta
Aquatic samples										
Plaice	Weymouth Bay	2	*	*	0.15 *±0.08*	-	-	*	-	-
Cod	"	1	*	*	0.67 *±0.10*	-	-	*	-	-
Crabs	Chapman's Pool	1	1.0 *±0.2*	*	*	0.00022 *±0.00004*	0.0010 *±0.0001*	0.0024 *±0.0002*	*	-
"	Lulworth Banks	1	2.0 *±0.3*	*	*	0.00096 *±0.00010*	0.0036 *±0.0002*	0.0045 *±0.0004*	0.00075 *±0.00012*	-
Pacific Oysters	Poole	1	0.15 *±0.05*	*	0.05 *±0.04*	-	-	*	-	-
Cockles	"	1	2.3 *±0.1*	*	0.05 *±0.04*	-	-	*	-	-
Whelks	Weymouth Bay	1	3.2 *±0.3*	*	*	-	-	*	-	-
"	Poole	1	0.77 *±0.15*	*	*	0.0011 *±0.0001*	0.0043 *±0.0003*	0.0062 *±0.0004*	0.000080 *±0.000035*	-
Fucus serratus	Kimmeridge	2	1.8 *±0.1*	*	0.09 *±0.04*	-	-	*	-	110
"	Bognor Rock	2	1.2 *±0.1*	0.05 *±0.06*	0.06 *±0.04*	-	-	*	-	-
Mud	Parkstone Bay	1	3.2 *±0.6*	*	1.6 *±0.5*	0.075 *±0.006*	0.37 *±0.02*	0.31 *±0.02*	0.0036 *±0.0018*	-
"	Hardway	2	4.2 *±0.5*	*	2.9 *±0.3*	-	-	*	-	-
Mud & sand	Kimmeridge	2	0.76 *±0.41*	*	0.61 *±0.27*	-	-	*	-	-
Sand	Parkstone Bay	1	0.68 *±0.23*	*	*	-	-	*	-	-

Material	Location or selection[d]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}						
			^{3}H	^{14}C	^{60}Co	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples									
Milk	Near farms[e]	4	<2.9 *±0.5*	16 *±3.6*	<0.42	<0.41	-	-	-
"	" max		<3.0	18 *±3.3*	<0.45	<0.43			
"	Far farms[e]	1	<3.0	18 *±4.0*	<0.50	<0.40	-	-	-
Apples[e]		1	<3.0	11 *±4.0*	<0.40	<0.40	-	-	-
Cabbage[e]		1	<3.0	<6.0 *±3.0*	<0.40	<0.30	-	-	-
Carrots[e]		1	<3.0	11 *±5.0*	<0.50	<0.40	-	-	-
Potatoes[e]		1	<3.0	26 *±6.0*	<0.40	<0.50	-	-	-
Raspberries[e]		1	<3.0	9.0 *±3.0*	<0.40	<0.30	-	-	-
Watercress[e]		1	<3.0	6.0 *±4.0*	<0.20	<0.30	-	-	-
Grass[e]		4	<3.0	-	-	-	-	-	-
Dry cloths		60	-	-	-	-	0.09 *±0.10*	0.75 *±0.75*	0.33 *±0.23*

\- *not analysed*
* *not detected by the method used*
[a] *Except for milk where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *Landing point or sampling area.*
[c] *See section 5 for definition*
[d] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*
[e] *The concentration of ^{3}H (organic) was <3.0 Bq l^{-1}*

Table 25(b). Monitoring of radiation dose rates near Winfrith, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Kimmeridge	Mud and sand	2	0.064
Parkstone Bay	Mud	1	0.045
"	Sand and stones	1	0.048
Hardway	Mud	2	0.058

[a] *See section 5 for definition*

Table 26(a). Radioactivity in food and the environment near Berkeley and Oldbury nuclear power stations, 1996

Material	Location	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}										
			^{14}C	^{60}Co	^{131}I	^{134}Cs	^{137}Cs	^{155}Eu	^{238}Pu	^{239}Pu+^{240}Pu	^{241}Am	^{243}Cm+^{244}Cm	Total beta
Aquatic samples													
Dover sole	Lydney	2	270 *±9.5*	*	*	*	0.42 *±0.05*	*	-	-	*	-	-
Elvers	Littleton Warth	1	-	*	*	*	0.11 *±0.04*	*	-	-	*	-	-
Shrimps	Lydney	2	140 *±7.0*	*	*	*	0.37 *±0.06*	*	0.00054 *±0.00004*	0.0027 *±0.0001*	0.0044 *±0.0003*	0.000030 *±0.000012*	-
Fucus vesiculosus	Pipeline[d]	2	-	*	0.15 *±0.11*	0.04 *±0.05*	0.61 *±0.07*	0.14 *±0.10*	-	-	*	-	140
Mud	"	2	-	*	*	0.98 *±0.61*	33 *±0.8*	2.2 *±0.9*	-	-	0.45 *±0.61*	-	-
"	Lydney	2	-	*	*	0.52 *±0.51*	27 *±0.8*	1.7 *±0.8*	-	-	*	-	-
"	Hills Flats	2	-	*	*	0.96 *±0.63*	28 *±0.8*	2.1 *±1.0*	-	-	0.33 *±0.49*	-	-
"	1km south of Oldbury	2	-	0.18 *±0.17*	*	0.71 *±0.43*	36 *±0.6*	1.9 *±0.8*	-	-	*	-	-

Material	Location or selection[c]		No. of sampling observ-ations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}								
				^{3}H	^{14}C	^{35}S	^{60}Co	^{134}Cs	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples												
Milk	Near farms		8	<3.0 *±0.5*	15 *±3.6*	<0.48 *±0.23*	<0.38	<0.28	<0.38	-	-	-
"	"	max		<3.0 *±1.5*	18 *±3.3*	<0.60 *±0.25*	<0.45	<0.35	<0.43			
"	"	sub-sets	2	-	-	-	<0.30	<0.22	<0.29	-	-	-
"	"	max						<0.23	<0.33			
Apples			1	<3.0	13 *±3.0*	0.30 *±0.30*	<0.30	<0.20	<0.30	-	-	-
Beetroot			1	<3.0	12 *±3.0*	<0.80	<0.50	<0.40	<0.40	-	-	-
Blackberries			1	5.0 *±4.0*	10 *±4.0*	3.1 *±0.8*	<0.30	<0.20	<0.20	-	-	-
Cabbage			1	<3.0	8.0 *±3.0*	0.60 *±0.40*	<0.50	<0.20	<0.40	-	-	-
Carrots			1	<3.0	14 *±3.0*	<0.30	<0.50	<0.30	<0.50	-	-	-
Potatoes			1	<3.0	16 *±5.0*	<0.50	<0.40	<0.20	<0.30	-	-	-
Runner Beans			1	3.0 *±3.0*	10 *±3.0*	5.0 *±0.5*	<0.50	<0.40	<0.50	-	-	-
Wheat			1	<3.0	110 *±22*	1.8 *±0.2*	-	-	-	-	-	-
"		sub-sets	1	-	-	-	<0.30	<0.20	<0.20			
Dry cloths			162	-	-	-	-	-	-	0.11 *±0.16*	1.1 *±1.3*	0.43 *±0.32*

- not analysed
** not detected by the method used*
[a] *Except for milk where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'Max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*
[d] *Berkeley*

Table 26(b). Monitoring of radiation dose rates near Berkeley and Oldbury nuclear power stations, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
1 km south of Oldbury	Mud	2	0.075
2 km south west of Berkeley	"	2	0.070
Guscar Rocks	"	2	0.084
Lydney Locks	"	2	0.074
Berkeley pipeline (new)	"	2	0.075
Sharpness	"	2	0.076
Hills Flats	"	2	0.076

[a] *See section 5 for definition*

Table 27(a). Radioactivity in food and the environment near Bradwell nuclear power station, 1996

Material	Location	No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}											
			^{14}C	^{60}Co	^{65}Zn	^{99}Tc	^{134}Cs	^{137}Cs	^{155}Eu	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Am	$^{243}Cm+^{244}Cm$	Total beta
Aquatic Samples														
Sole	Bradwell	1	-	*	*	-	0.25 ±*0.10*	1.2 ±*0.1*	*	-	-	*	-	-
Flatfish	“	1	-	*	0.39 ±*0.18*	-	0.15 ±*0.08*	1.8 ±*0.1*	*	-	-	*	-	-
Bass	Pipeline	1	-	*	*	-	0.26 ±*0.07*	2.1 ±*0.1*	*	-	-	*	-	-
Mullet	“	1	-	*	*	-	*	0.64 ±*0.07*	*	-	-	*	-	-
Native oysters	Tollesbury N Channel	2	16 ±*4.4*	*	1.0 ±*0.1*	-	0.07 ±*0.03*	0.35 ±*0.04*	*	0.00035 ±*0.00004*	0.0015 ±*0.0001*	0.0051 ±*0.0002*	0.00027 ±*0.00004*	-
Pacific oysters	Goldhanger Creek	1	-	*	1.5 ±*0.2*	-	*	0.44 ±*0.08*	*	-	-	*	-	-
Winkles	Pipeline	2	-	0.32 ±*0.13*	0.83 ±*0.54*	-	0.46 ±*0.28*	1.8 ±*0.3*	*	-	-	*	-	-
Fucus vesiculosus	Waterside	2	-	0.43 ±*0.09*	0.12 ±*0.10*	4.9 ±*0.4*	1.3 ±*0.1*	4.7 ±*0.1*	0.08 ±*0.08*	-	-	*	-	190
Mud	Pipeline	1	-	3.1 ±*0.4*	*	-	7.2 ±*0.5*	34 ±*0.6*	2.0 ±*0.8*	-	-	*	-	-
“	West Mersea	1	-	0.91 ±*0.25*	*	-	2.3 ±*0.4*	16 ±*0.4*	2.2 ±*1.0*	-	-	*	-	-
“	Maldon	1	-	1.7 ±*0.3*	*	-	7.3 ±*0.6*	66 ±*0.9*	*	-	-	*	-	-

Material	Location or selection[c]		No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}								
				^{3}H	^{14}C	^{35}S	^{60}Co	^{134}Cs	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples												
Milk	Near farms		3	<3.0 ±*1.2*	15 ±*3.6*	<0.41 ±*0.25*	<0.43	<0.30	<0.38	-	-	-
“	“	max		<3.0 ±*1.5*	17 ±*4.1*	<0.48 ±*0.20*	<0.45	<0.35	<0.40			
“	Far farms		3	<3.0	15 ±*3.5*	<0.42 ±*0.30*	<0.42	<0.27	<0.39	-	-	-
“	“	max		<3.0 ±*1.5*	16 ±*3.3*	<0.43 ±*0.34*	<0.45	<0.30	<0.40			
“	“	sub-sets	2	-	-	-	<0.25	<0.20	<0.30	-	-	-
Apples			1	<3.0	15 ±*5.0*	<0.50	<0.30	<0.30	<0.30	-	-	-
Blackberries			1	<3.0	20 ±*4.0*	<0.30	<0.40	<0.30	<0.40	-	-	-
Kale			1	6.0 ±*6.0*	11 ±*3.0*	1.1 ±*0.3*	<0.60	<0.40	<0.50	-	-	-
Onions			1	<3.0	13 ±*3.0*	<0.50	<0.40	<0.30	<0.40	-	-	-
Potatoes			2	<3.0	21 ±*5.5*	<0.40	<0.50	<0.30	<0.40	-	-	-
“		max	1			<0.50				-	-	-
“		sub-sets	1	-	-	-	<0.30	<0.20	<0.30			
Wheat			1	<3.0	100 ±*20*	1.2 ±*0.4*	<0.50	<0.30	<0.40	-	-	-
Lucerne			1	5.0 ±*4.0*	27 ±*6.0*	8.5 ±*1.1*	<0.50	<0.20	<0.40	-	-	-
Grass[d]			4	<10	40 ±*9.3*	18 ±*0.7*	-	-	-	-	-	-
“		max			70 ±*10*	57 ±*1.0*						
Dry cloths			120	-	-	-	-	-	-	0.18 ±*0.18*	1.7 ±*1.3*	0.96 ±*0.72*

- not analysed
** not detected by the method used*
[a] *Except for milk where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*
[d] *The concentration of ^{55}Fe was 0.80 ±0.40 Bq kg^{-1}*

Table 27(b). Monitoring of radiation dose rates near Bradwell, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Pipeline	Mud	2	0.26
1.5 km east of pipeline	Sand	1	0.043
“	Shell and sand	1	0.048
Waterside	Mud	2	0.064
West Mersea	“	2	0.066
Maldon	“	2	0.060

[a] *See section 5 for definition*

Table 28(a). Radioactivity in food and the environment near Dungeness nuclear power stations, 1996

Material	Location	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}											
			^{3}H	^{14}C	^{90}Sr	^{60}Co	^{134}Cs	^{137}Cs	^{155}Eu	^{238}Pu	^{239}Pu+^{240}Pu	^{241}Am	^{243}Cm+^{244}Cm	Total beta
Aquatic samples														
Plaice	Pipeline	2	-	-	-	*	*	0.27 *±0.08*	*	-	-	*	-	-
Cod	“	2	-	-	-	*	*	0.36 *±0.06*	*	-	-	*	-	-
Bass	“	1	-	-	-	*	*	1.0 *±0.2*	*	-	-	*	-	-
Spiny spider crabs	Hastings	1	-	-	-	0.72 *±0.12*	*	*	*	-	-	*	-	-
Shrimps	Pipeline	2	-	29 *±9.1*	-	0.05 *±0.04*	*	0.32 *±0.08*	*	-	-	*	-	-
Whelks	“	2	-	-	0.012 *±0.003*	0.13 *±0.05*	*	0.13 *±0.11*	*	0.00073 *±0.00007*	0.0031 *±0.0002*	0.0025 *±0.0002*	0.00024 *±0.00005*	-
Fucus vesiculosus	Copt Point	2	-	-	-	0.56 *±0.09*	*	0.17 *±0.07*	*	-	-	*	-	170
Mud & sand	Rye Harbour	2	-	-	-	3.6 *±0.3*	*	3.1 *±0.2*	1.3 *±0.7*	0.11 *±0.01*	0.46 *±0.02*	0.42 *±0.02*	0.029 *±0.004*	-
Sand	Camber Sands	2	-	-	-	0.70 *±0.15*	*	0.51 *±0.14*	*	-	-	*	-	-
“	Pilot Inn	2	-	-	-	0.79 *±0.28*	0.21 *±0.21*	0.94 *±0.25*	0.57 *±0.43*	-	-	*	-	-
Sea water	Pipeline	2	2.6 *±1.7*	-	-	-	-	-	-	-	-	-	-	-

Material	Location or selection[c]	No. of sampling observ-ations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}														
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{60}Co	^{131}I	^{134}Cs	^{137}Cs	Total Cs	^{238}Pu	^{239}Pu+^{240}Pu	^{241}Am	Total alpha	Total beta	Total gamma
Terrestrial samples																	
Milk[d]	Far farms	2	<3.0	15 *±3.5*	<0.48 *±0.20*	-	<0.44	<0.022 *±0.010*	<0.34	<0.46	-	-	-	-	-	-	-
“	“ “ max			16 *±3.8*			<0.45	<0.024	<0.35	<0.48							
“	“ “ sub-sets	1	-	-	-	-	<0.30	-	<0.20	<0.25	-	-	-	-	-	-	-
Beans		1	<3.0	95 *±14*	1.8 *±0.2*	-	<0.80	-	<0.50	<0.50	-	-	-	-	-	-	-
Blackberries		1	<3.0	17 *±4.0*	1.2 *±0.4*	-	<0.30	-	<0.30	<0.30	-	-	-	-	-	-	-
Honey		1	<5.0	60 *±17*	<1.3	-	<0.50	-	<0.20	<0.40	-	-	-	-	-	-	-
Ovine muscle		2	<3.0	22 *±9.1*	<2.0	0.049 *±0.049*	<0.35	-	<0.20	<0.30	0.12 *±0.11*	<0.00020	<0.00020	0.00050 *±0.00050*	-	-	-
“	max			26 *±10*			<0.40	-									
Ovine offal		2	<5.0	25 *±14*	<2.5	1.3 *±0.1*	<0.40	-	<0.30	<0.40	0.53 *±0.12*	<0.00010	0.00020 *±0.00020*	<0.00040	-	-	-
“	max				<3.0												
Peas		1	<3.0	82 *±32*	3.9 *±0.6*	-	<0.60	-	<0.40	<0.50		-	-	-	-	-	-
Porcine Muscle		1	<3.0	31 *±7.0*	<2.0	<0.025	<0.50	-	<0.30	<0.40	0.19 *±0.11*	<0.00050	<0.00020	<0.00030	-	-	-
Porcine Offal		1	<4.0	28 *±13*	<2.0	<0.022	<0.50	-	<0.40	<0.40	0.23 *±0.11*	<0.00010	0.00020 *±0.00020*	<0.00030	-	-	-
Potatoes		1	<3.0	18 *±5.0*	<0.30	-	-	-	-	-	-	-	-	-	-	-	-
“	sub-sets	1	-	-	-	-	<0.30	-	<0.20	<0.30	-	-	-	-	-	-	-
Sea kale		1	6.0 *±6.0*	10 *±3.0*	2.0 *±0.4*	-	<0.40	-	<0.40	0.50 *±0.10*	-	-	-	-	-	-	-
Dry cloths		95	-	-	-	-	-	-	-	-		-	-	-	0.18 *±0.16*	1.6 *±1.1*	0.83 *±0.49*

\- *not analysed*
* *not detected by the method used*
[a] *Except for milk and seawater where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as ‘max’ in this column. ‘Max’ data are selected to be maxima. If no ‘max’ value is given, the mean is also the maximum. See section 5*
[d] *There are no farms producing milk near this site*

Table 28(b). Monitoring of radiation dose rates near Dungeness nuclear power stations, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Camber Sands	Sand	2	0.050
Old Lifeboat Station	Stones	2	0.046
Pilot Inn	Sand	2	0.053
Rye Harbour	Mud and sand	2	0.063
Beta dose rates			µSv h^{-1}
Rye Harbour	Mud and sand	1	0.22

[a] *See section 5 for definition*

Table 29(a). Radioactivity in food and the environment near Hartlepool nuclear power station, 1996

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}										
			^{3}H	^{14}C	^{99}Tc	^{131}I	^{137}Cs	^{155}Eu	^{238}Pu	^{239}Pu + ^{240}Pu	^{241}Am	^{243}Cm + ^{244}Cm	Total beta
Aquatic samples													
Plaice	Pipeline	2	-	39 *±7.4*	-	*	0.38 *±0.06*	*	-	-	*	-	-
Cod	"	2	-	-	-	*	1.0 *±0.1*	*	-	-	*	-	-
Crabs	"	2	-	38 *±10*	-	*	0.22 *±0.09*	*	0.00047 *±0.00004*	0.0026 *±0.0001*	0.0031 *±0.0002*	*	-
Winkles	South Gare	2	-	-	-	*	0.39 *±0.07*	*	0.0080 *±0.0004*	0.047 *±0.001*	0.026 *±0.001*	0.000047 *±0.000027*	-
Fucus vesiculosus	Pilot Station	2	-	-	56 *±4.4*	7.9 *±1.0*	0.41 *±0.05*	*	-	-	*	-	260
Mud	Greatham Creek	2	-	-	-	*	7.7 *±0.5*	1.8 *±0.9*	-	-	*	-	-
"	Paddy's Hole	2	-	-	-	*	23 *±0.6*	2.3 *±1.1*	-	-	*	-	-
Coal & sand	Little Scar	1	-	-	-	*	2.3 *±0.2*	0.54 *±0.43*	-	-	*	-	-
Sand	"	1	-	-	-	*	0.62 *±0.12*	*	-	-	*	-	-
Sea water	Pipeline	2	1.5 *±1.3*	-	-	-	-	-	-	-	-	-	-

Material	Location[b] or selection[d]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}							
			^{3}H	^{14}C	^{35}S	^{131}I	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples										
Milk	Near farms	1	<3.0	18 *±4.5*	<0.73 *±0.38*	<0.019	<0.30	-	-	-
"	" sub-sets	1	-	-	-	-	<0.30	-	-	-
"	Far farms	4	<3.0	<17 *±4.2*	<0.68 *±0.30*	<0.018	<0.41	-	-	-
"	" max			19 *±4.5*	<0.78 *±0.32*	<0.022	<0.43			
Apples		1	<3.0	16 *±5.0*	<0.50	-	<0.40	-	-	-
Blackberries		1	<3.0	29 *±5.0*	0.30 *±0.30*	-	<0.50	-	-	-
Cabbage		1	<3.0	12 *±4.0*	0.50 *±0.30*	-	<0.60	-	-	-
Carrots		1	<3.0	14 *±5.0*	<0.30		<0.40	-	-	-
Green beans		1	<3.0	17 *±6.0*	<0.50	-	-	-	-	-
"	sub-sets	1	-	-	-	-	<0.20	-	-	-
Honey		1	<4.0	80 *±13*	<1.0	-	0.20 *±0.10*	-	-	-
Potatoes		1	<3.0	18 *±4.0*	0.50 *±0.40*	-	<0.40	-	-	-
Wheat		1	<3.0	59 *±16*	0.80 *±0.40*	-	<0.40	-	-	-
Dry cloths		108	-	-	-	-	-	0.18 *±0.18*	1.3 *±1.1*	0.96 *±0.74*

\- *not analysed*
* *not detected by the method used*
[a] *Except for milk and seawater where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *Landing point or sampling area*
[c] *See section 5 for definition*
[d] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*

Table 29(b). Monitoring of radiation dose rates near Hartlepool nuclear power station, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Greatham Creek	Mud	1	0.074
"	Mud and sand	1	0.071
Little Scar	Coal and sand	1	0.059
"	Sand	1	0.053
North Gare	"	2	0.064
Paddy's Hole	Mud	2	0.097
Beta dose rates			µSv h^{-1}
Little Scar	Coal and sand	1	*
"	Sand	1	*

[a] *See section 5 for definition*
* *Not detected by the method used*

Table 30(a). Radioactivity in food and the environment near Heysham nuclear power stations, 1996

Material	Location[b] or selection[c]	No. of sampling observ-ations[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																
			^{3}H	^{14}C	^{35}S	^{54}Mn	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{110m}Ag	^{125}Sb	^{131}I	^{134}Cs	^{137}Cs	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+^{240}Pu
Aquatic samples																			
Flounder	Flookburgh	4	-	110 *±8.0*	-	*	*	-	-	*	*	*	-	*	26 *±0.7*	*	*	0.00023 *±0.00003*	0.0013 *±0.0001*
Plaice	Morecambe	4	-	-	-	*	*	0.034 *±0.006*	13 *±1.0*	*	*	*	-	*	11 *±0.3*	*	*	-	-
Bass	“	2	-	-	-	*	*	-	-	*	*	*	-	*	25 *±0.4*	*	*	-	-
Whitebait	Sunderland Point	1	-	-	-	*	0.21 *±0.11*	0.20 *±0.01*	-	*	*	*	-	*	10 *±0.3*	*	*	0.066 *±0.004*	0.35 *±0.02*
Cockles	Middleton Sands	2	-	-	-	*	1.6 *±0.1*	-	-	2.8 *±0.7*	*	0.09 *±0.10*	-	*	4.6 *±0.1*	*	*	0.40 *±0.02*	2.2 *±0.1*
“	Flookburgh	4	-	130 *±7.8*	-	*	1.3 *±0.2*	0.55 *±0.03*	73 *±5.8*	1.0 *±0.5*	*	0.15 *±0.13*	-	*	5.7 *±0.2*	0.03 *±0.04*	0.03 *±0.05*	0.46 *±0.03*	2.5 *±0.1*
Winkles	Red Nab Point	4	-	-	-	0.05 *±0.05*	1.1 *±0.2*	-	-	9.1 *±1.1*	1.2 *±0.2*	0.77 *±0.24*	-	*	13 *±0.2*	0.03 *±0.04*	0.04 *±0.08*	0.73 *±0.04*	3.8 *±0.1*
Shrimps	Flookburgh	4	-	130 *±8.9*	-	*	0.04 *±0.06*	0.13 *±0.02*	22 *±1.8*	*	*	*	-	*	8.2 *±0.3*	*	*	0.0042 *±0.0002*	0.023 *±0.001*
Mussels	Morecambe	4	-	150 *±9.0*	-	*	0.68 *±0.12*	-	400 *±31*	3.6 *±0.9*	*	0.24 *±0.14*	-	*	3.5 *±0.2*	*	*	0.35 *±0.02*	1.8 *±0.1*
Fucus vesiculosus	Half Moon Bay	4	-	-	-	*	0.54 *±0.11*	-	11000 *±940*	0.24 *±0.35*	*	0.54 *±0.21*	-	*	8.1 *±0.2*	*	*	-	-
Samphire	Cockerham Marsh	1	-	-	-	*	*	-	-	*	*	*	-	*	4.1 *±0.1*	*	*	-	-
Mud & sand	Flookburgh	4	-	-	-	*	0.47 *±0.45*	-	-	1.4 *±1.7*	*	*	-	*	100 *±1.7*	*	0.42 *±0.64*	-	-
“	Half Moon Bay	4	-	-	-	*	5.4 *±0.7*	-	-	30 *±7.8*	*	3.4 *±2.2*	-	0.26 *±0.47*	320 *±3.1*	3.0 *±1.8*	0.74 *±0.94*	28 *±1.3*	160 *±4.7*
“	Sunderland Point	4	-	-	-	0.16 *±0.32*	2.7 *±0.7*	-	-	11 *±5.3*	*	2.3 *±1.7*	-	*	240 *±2.5*	1.0 *±0.9*	2.8 *±1.9*	-	-
“	Morecambe Central Pier	4	-	-	-	*	2.0 *±0.4*	-	-	12 *±3.8*	*	1.6 *±1.2*	-	*	180 *±1.6*	1.0 *±0.7*	2.0 *±1.2*	-	-
Turf	Conder Green	4	-	-	-	*	3.2 *±1.5*	-	-	3.2 *±5.4*	*	*	-	*	620 *±7.5*	3.4 *±2.4*	3.0 *±3.0*	-	-
“	Sand Gate Marsh	4	-	-	-	*	1.6 *±0.7*	-	-	*	*	0.98 *±1.2*	-	0.29 *±0.52*	260 *±3.9*	1.1 *±1.7*	*	-	-
Sea water	Pipeline	2	27 *±2.2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
“	Half Moon Bay	1	-	-	-	-	-	-	-	-	-	-	-	0.0063 *±0.0016*	0.31 *±0.002*	-	-	-	-
Terrestrial samples																			
Milk	Near farms	10	<3.2 *±1.4*	15 *±3.7*	<0.69 *±0.42*	-	<0.44	-	-	<2.9	<0.51	-	<0.020	<0.31	<0.42	-	-	-	-
“	“ max		4.0 *±3.0*	18 *±4.1*	1.7 *±1.0*		<0.60			<3.4	<0.55		<0.026	<0.40	<0.45				
“	“ sub-sets	2	-	-	-	-	<0.28	-	-	<1.9	<0.33	-	-	<0.20	<0.25	-	-	-	-
“	“ max						<0.30			<2.0	<0.35				<0.30				
“	Far farms	2	<3.0 *±2.1*	14 *±4.0*	<0.55 *±0.35*	-	<0.50	-	-	<2.9	<0.60	-	-	<0.40	<0.45	-	-	-	-
“	“ max		3.0 *±3.0*	16 *±4.0*	0.70 *±0.50*					<3.0					<0.50				
Apples		1	<3.0	13 *±4.0*	0.60 *±0.60*	-	<0.40	-	-	<2.0	<0.40	-	-	<0.20	<0.40	-	-	-	-
Barley		1	<3.0	90 *±16*	1.9 *±0.6*	-	<0.30	-	-	<1.5	<0.30	-	-	<0.10	<0.20	-	-	-	-
Blackberries		1	4.0 *±3.0*	43 *±4.0*	0.40 *±0.40*	-	<0.40	-	-	<2.7	<0.40	-	-	<0.20	<0.30	-	-	-	-
Broccoli		1	<3.0	10 *±5.0*	0.60 *±0.30*	-	<0.50	-	-	<2.8	<0.50	-	-	<0.30	<0.40	-	-	-	-
Honey		1	9.0 *±6.0*	79 *±21*	<1.3	-	<0.20	-	-	<0.60	<0.30	-	-	<0.20	0.20 *±0.10*				
Parsnips		1	<3.0	23 *±6.0*	<0.50	-	<0.50	-	-	<3.7	<0.50	-	-	<0.40	<0.50	-	-	-	-
Potatoes		1	<3.0	30 *±7.0*	1.2 *±1.2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
“	sub-sets	1	-	-	-	-	<0.30	-	-	<1.5	<0.30	-	-	<0.20	<0.20				
Sprouts		1	<3.0 *±3.0*	8.0 *±4.0*	1.9 *±0.7*	-	<0.40	-	-	<1.9	<0.50	-	-	<0.20	<0.40	-	-	-	-
Dry cloths		93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 30(a). continued

Material	Location[b] or selection[c]	No. of sampling observa-tions[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}						
			^{241}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total alpha	Total beta	Total gamma
Aquatic samples									
Flounder	Flookburgh	1	-	0.0027 *±0.0002*	*	*	-	-	-
Plaice	Morecambe	4	-	*	-	-	-	-	-
Bass	"	2	-	*	-	-	-	-	-
Whitebait	Sunderland Point	1	3.6 *±0.3*	0.47 *±0.04*	0.00037 *±0.00012*	0.00078 *±0.00011*	-	-	-
Cockles	Middleton Sands	2	-	5.2 *±0.1*	*	0.0096 *±0.0047*	-	-	-
"	Flookburgh	4	28 *±1.1*	6.0 *±0.2*	*	0.015 *±0.006*	-	-	-
Winkles	Red Nab Point	4	-	6.5 *±0.2*	*	*	-	-	-
Shrimps	Flookburgh	4	*	0.033 *±0.001*	*	*	-	-	-
Mussels	Morecambe	4	-	3.2 *±0.1*	*	0.0052 *±0.0029*	-	-	-
Fucus vesiculosus	Half Moon Bay	4	-	0.93 *±0.38*	-	-	-	8500	-
Samphire	Cockerham Marsh	1	-	1.3 *±0.1*	-	-	-	47	-
Mud & sand	Flookburgh	4	-	43 *±3.1*	-	-	-	-	-
"	Half Moon Bay	4	-	240 *±7.5*	*	0.55 *±0.24*	-	-	-
"	Sunderland Point	4	-	110 *±4.8*	-	-	-	-	-
"	Morecambe Central Pier	4	-	90 *±3.1*	-	-	-	-	-
Turf	Conder Green	4	-	250 *±13*	-	-	-	-	-
"	Sand Gate Marsh	4	-	96 *±5.9*	-	-	-	-	-
Sea water	Pipeline	2	-	-	-	-	-	-	-
"	Half Moon Bay	1	-	-	-	-	-	-	-
Terrestrial samples									
Milk	Near farms	10	-	-	-	-	-	-	-
"	" max								
"	" sub-sets	2	-	-	-	-	-	-	-
"	" max								
"	Far farms	2	-	-	-	-	-	-	-
"	" max								
Apples		1	-	-	-	-	-	-	-
Barley		1	-	-	-	-	-	-	-
Blackberries		1	-	-	-	-	-	-	-
Broccoli		1	-	-	-	-	-	-	-
Honey		1	-	-	-	-	-	-	-
Parsnips		1	-	-	-	-	-	-	-
Potatoes		1	-	-	-	-	-	-	-
"	sub-sets	1	-	-	-	-	-	-	-
Sprouts		1	-	-	-	-	-	-	-
Dry cloths		93	-	-	-	-	0.17 *±0.23*	1.5 *±2.0*	0.60 *±0.57*

Table 30(b). Monitoring of radiation dose rates near Heysham nuclear power stations, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Greenodd	Salt marsh	2	0.085
Sand Gate marsh	"	4	0.10
Flookburgh	Mud and sand	4	0.077
High Foulshaw	Salt marsh	4	0.096
Arnside	Mud and sand	4	0.074
"	Salt marsh	4	0.11
Morecambe Central Pier	Mussel bed	4	0.080
"	Mud and sand	4	0.081
Half Moon Bay	"	4	0.086
Pipeline	"	4	0.079
Red Nab Point	"	4	0.082
Sunderland Point	Mud	2	0.093
"	Mud and sand	2	0.092
Sunderland	Mud, sand and stones	4	0.083
Colloway Marsh	Salt marsh	4	0.18
Lancaster	"	4	0.11
Aldcliffe Marsh	"	4	0.14
Conder Green	Mud	1	0.11
"	Mud and sand	3	0.11
"	Salt marsh	4	0.13
Cockerham Marsh	"	4	0.12

[a] *See section 5 for definition*

\- *not analysed*
* *not detected by the method used*
[a] *Except for milk and seawater where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *Landing point or sampling area*
[c] *Data are arithmetic means unless stated as 'max'. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*
[d] *See section 5 for definition*

Table 31(a). Radioactivity in food and the environment near Hinkley Point nuclear power stations, 1996

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																
			^{3}H	^{14}C	^{54}Mn	^{60}Co	^{106}Ru	^{110m}Ag	^{134}Cs	^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total beta
Aquatic samples																			
Flounder	Stolford	2	-	99 *±8.6*	*	*	*	*	0.13 *±0.07*	0.55 *±0.07*	*	*	*	-	-	*	-	-	-
Shrimps	"	2	-	88 *±7.8*	*	*	*	*	0.18 *±0.09*	0.69 *±0.09*	*	*	*	0.00050 *±0.00005*	0.0018 *±0.0001*	0.0021 *±0.0001*	0.00023 *±0.00005*	0.000085 *±0.000019*	-
Fucus vesiculosus	Pipeline	2	-	-	1.5 *±0.1*	0.62 *±0.10*	0.87 *±0.56*	0.10 *±0.05*	1.2 *±0.1*	4.2 *±0.1*	1.1 *±0.3*	0.08 *±0.10*	0.09 *±0.11*	-	-	*	-	-	190
Mud	River Parrett	1	-	-	*	*	*	*	2.7 *±1.2*	35 *±1.4*	*	*	*	-	-	*	-	-	-
"	1.6km east of pipeline	2	-	-	*	0.48 *±0.25*	2.2 *±2.3*	*	5.3 *±0.7*	31 *±0.9*	*	*	0.79 *±0.79*	-	-	*	-	-	-
Mud & sand	Pipeline	2	-	-	0.29 *±0.26*	0.54 *±0.30*	2.8 *±2.7*	*	4.7 *±0.6*	21 *±0.7*	2.3 *±1.8*	*	0.35 *±0.38*	-	-	*	-	-	-
"	River Parrett	1	-	-	*	1.4 *±0.8*	*	*	3.0 *±1.0*	37 *±1.0*	*	*	1.8 *±1.2*	-	-	*	-	-	-
Sea water	Pipeline	2	18 *±2.0*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Material	Location[b] or selection[d]		No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}												
				^{3}H	^{14}C	^{35}S	^{60}Co	^{106}Ru	^{110m}Ag	^{131}I	^{134}Cs	^{137}Cs	^{144}Ce	Total alpha	Total beta	Total gamma
Terrestrial samples																
Milk	Near farms		7	<3.0 *±0.8*	16 *±3.8*	<0.69 *±0.41*	<0.43	<3.0	<0.50	<0.025	<0.31	<0.41	<1.7	-	-	-
"	"	max		<3.3 *±2.0*	21 *±4.6*	<1.3 *±0.6*	<0.47	<3.5	<0.55	<0.031	<0.33	<0.45	<1.9	-	-	-
"	"	sub-sets	2	-	-	-	<0.28	<1.9	<0.25	-	<0.13	<0.23	<1.0	-	-	-
"	"	max					<0.30		<0.30		<0.17	<0.27	<1.1			
"	Far farms		2	<3.0	18 *±4.1*	<0.40	<0.45	<3.8	<0.60	-	<0.35	<0.45	<2.1	-	-	-
"	"	max			20 *±3.0*		<0.50		<0.70		<0.40	<0.50				
Apples			1	<3.0	9.0 *±3.0*	<0.30	-	-	-	-	-	-	-	-	-	-
"		sub-sets	1	-	-	-	<0.20	<1.0	<0.20	-	<0.20	<0.20	<0.90	-	-	-
Beans			1	<3.0	30 *±7.0*	13 *±2.0*	<0.60	<2.6	<0.60	-	<0.40	<0.50	<1.3	-	-	-
Blackberries			1	<3.0	15 *±3.0*	1.1 *±0.3*	<0.40	<3.6	<0.40	-	<0.30	<0.40	<1.6	-	-	-
Honey			1	<4.0	90 *±13*	2.1 *±1.2*	<0.20	<1.6	<0.30	-	<0.10	0.20 *±0.10*	<1.0	-	-	-
Kale			1	<3.0	14 *±4.0*	0.40 *±0.30*	<0.40	<3.4	<0.50	-	<0.40	<0.50	<1.2	-	-	-
Potatoes			1	<3.0	34 *±16*	2.1 *±0.4*	<0.30	<3.1	<0.60	-	<0.40	<0.50	<1.9	-	-	-
Wheat			1	<3.0	110 *±16*	6.9 *±0.5*	<0.60	<3.7	<0.50	-	<0.30	<0.40	<1.3	-	-	-
Fodder Beet			1	<3.0	11 *±4.0*	<0.30	<0.40	<2.6	<0.50	-	<0.30	<0.50	<1.3	-	-	-
Dry cloths			95	-	-	-	-	-	-	-	-	-	-	0.16 *±0.17*	1.7 *±1.5*	1.1 *±0.8*

- not analysed
** not detected by the method used*
[a] Except for milk and seawater where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply
[b] Landing point or sampling area.
[c] See section 5 for definition
[d] Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5

Table 31(b). Monitoring of radiation dose rates near Hinkley Point nuclear power stations, 1996

Location	Ground type	No. of sampling observa-tions[a]	μGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
0.8 km east of pipeline	Mud	2	0.056
0.8 km west of pipeline	"	1	0.086
"	Sand	1	0.22
1.6 km east of pipeline	Mud	1	0.079
"	Mud and sand	1	0.085
Pipeline	"	2	0.088
River Parrett	Mud	2	0.077

[a] See section 5 for definition

Table 32(a). Radioactivity in food and the environment near Hunterston nuclear power station, 1996

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																	
			^{3}H	^{14}C	^{51}Cr	^{54}Mn	^{58}Co	^{60}Co	^{65}Zn	^{106}Ru	^{110m}Ag	^{134}Cs	^{137}Cs	^{155}Eu	^{238}Pu	$^{239+240}$Pu	^{241}Am	^{242}Cm	$^{243+244}$Cm	Total Beta
Aquatic samples																				
Saithe	Millport	1	-	-	*	*	*	*	*	*	*	*	5.3 ±0.1	*	-	-	*	-	-	-
Crabs	"	2	-	35 *±7.1*	*	*	*	*	*	*	*	*	0.51 ±0.13	*	0.0030 *±0.0002*	0.016 *±0.0005*	0.0099 *±0.0005*	*	*	-
Nephrops	"	2	-	-	*	*	*	*	*	*	*	*	2.6 ±0.1	*	-	-	*	-	-	-
Velvet swimming crabs	Largs	1	-	-	*	*	*	*	*	*	*	*	0.50 *±0.23*	*	-	-	*	-	-	-
Lobsters	"	1	-	-	*	*	*	*	*	*	*	*	0.42 *±0.25*	*	-	-	*	-	-	-
Oysters	Fairlie	1	-	-	*	0.19 *±0.04*	*	0.15 *±0.04*	0.35 *±0.08*	*	0.72 *±0.07*	*	0.44 *±0.03*	*	-	-	*	-	-	-
Winkles	Pipeline	2	-	-	8.4 *±1.2*	4.5 *±0.2*	0.23 *±0.08*	2.6 *±0.1*	0.22 *±0.16*	0.57 *±0.75*	4.2 *±0.2*	*	1.8 *±0.1*	*	0.043 *±0.002*	0.18 *±0.01*	0.081 *±0.002*	0.0030 *±0.0006*	0.0030 *±0.0004*	-
Fucus vesiculosus	"	2	-	-	18 *±2.6*	19 *±0.2*	0.43 *±0.11*	4.1 *±0.1*	0.29 *±0.19*	*	0.82 *±0.15*	0.071 *±0.082*	5.1 *±0.1*	0.11 *±0.08*	-	-	0.052 *±0.050*	-	-	870
Sand	"	2	-	-	4.7 *±2.5*	2.3 *±0.3*	*	0.67 *±0.18*	*	*	*	*	13 *±0.4*	*	-	-	0.53 *±0.52*	-	-	-
Sea water	"	12	2.5 *±1.6*		-	-	-	-	-	-	-	0.0014 *±0.0013*	0.055 *±0.001*	-	-	-	-	-	-	-

Material	Location[b] or selection[d]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}					
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{131}I	^{137}Cs
Terrestrial samples								
Milk		4	<25 *±2.9*	13 *±2.0*	<8.0 *±1.0*	<0.10 *±0.01*	<0.050	0.53 *±0.08*
"	max		26 *±5.8*	15 *±2.3*	16 *±1.6*	0.11 *±0.03*		1.1 *±0.1*
Grass		4	<25	20 *±3.2*	<5.0	1.2 *±0.2*	-	<0.23 *±0.12*
"	max					1.6 *±0.2*		0.38 *±0.18*

- not analysed
** not detected by the method used*
[a] Except for milk and sea water where units are Bq l^{-1}and for sediment where dry concentrations apply
[b] Landing point or sampling area
[c] See section 5 for definition
[d] Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition

Table 32(b). Monitoring of radiation dose rates near Hunterston nuclear power station, 1996

Location	Ground type	No. of sampling observa-tions[a]	μGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
0.5 km north of pipeline	Sand	2	0.059
0.5 km south of pipeline	Sand and stones	2	0.075

[a] See section 5 for definition

Table 33(a). Radioactivity in food and the environment near Sizewell nuclear power stations, 1996

Material	Location[b]	No. of sampling observ-ations[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}												
			^{3}H	^{14}C	^{58}Co	^{60}Co	^{65}Zn	^{134}Cs	^{137}Cs	^{155}Eu	^{238}Pu	^{239}Pu+^{240}Pu	^{241}Am	^{243}Cm+^{244}Cm	Total beta
Aquatic samples															
Cod	Sizewell	1	-	-	*	*	*	*	1.0 *±0.1*	*	-	-	*	-	-
Dover sole	"	1	-	-	*	*	*	*	0.65 *±0.21*	*	-	-	*	-	-
Shrimps	"	1	-	-	0.15 *±0.06*	*	*	0.38 *±0.08*	1.4 *±0.1*	0.19 *±0.13*	0.00017 *±0.00005*	0.00083 *±0.00009*	0.0012 *±0.0002*	*	-
Crabs	"	2	-	39 *±8.6*	*	*	*	*	0.20 *±0.09*	*	0.000075 *±0.000019*	0.00048 *±0.00005*	0.00081 *±0.00009*	0.000072 *±0.000023*	-
Pacific oysters	Blyth estuary	1	-	-	*	*	0.08 *±0.05*	0.02 *±0.02*	0.12 *±0.03*	*	-	-	*	-	-
Whelks	Dunwich	1	-	-	*	0.12 *±0.07*	*	*	0.25 *±0.06*	*	-	-	*	-	-
Mud	Southwold	2	-	-	*	1.4 *±0.5*	*	*	15 *±0.7*	1.9 *±1.2*	-	-	*	-	730
Sand	Rifle Range	2	-	-	*	*	*	*	0.45 *±0.17*	*	-	-	*	-	-
"	Aldeburgh	2	-	-	*	*	*	0.39 *±0.29*	0.67 *±0.16*	*	-	-	*	-	-
Sea water	"	2	1.2 *±1.2*	-	-	-	-	-	-	-	-	-	-	-	-

Material	Location[b] or selection[c]	No. of sampling observ-ations[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}								
			^{3}H	^{14}C	^{35}S	^{60}Co	^{134}Cs	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples											
Milk	Near farms	3	<3.0	14 *±3.6*	<0.38 *±0.10*	<0.46	<0.28	<0.40	-	-	-
"	" max			15 *±3.5*	<0.40 *±0.10*	<0.50	<0.35		-	-	-
"	" sub-sets	1	-	-	-	<0.27	<0.23	<0.27	-	-	-
"	Far farms	4	<3.3 *±1.4*	16 *±3.9*	<0.43 *±0.12*	<0.44	<0.33	<0.41	-	-	-
"	" max		<3.8 *±2.0*	17 *±4.1*	<0.45 *±0.15*	<0.50	<0.35	<0.45	-	-	-
Apples		1	<3.0	16 *±5.0*	<0.20	<0.40	<0.30	<0.40	-	-	-
Blackberries		1	<3.0	19 *±5.0*	<0.30	<0.20	<0.10	0.20 *±0.10*	-	-	-
Cabbage		1	<3.0	13 *±5.0*	1.1 *±0.4*	<0.40	<0.40	<0.40	-	-	-
Carrots		1	<3.0	12 *±4.0*	<0.30	<0.40	<0.20	<0.30	-	-	-
Honey		1	<3.0	77 *±13*	0.70 *±0.70*	<0.10	<0.10	<0.20	-	-	-
Potatoes		1	<3.0	20 *±4.0*	<0.30	<0.50	<0.30	<0.40	-	-	-
Runner Beans		1	<3.0	9.0 *±4.0*	<0.30	<0.40	<0.30	<0.40	-	-	-
Wheat		1	<4.0	86 *±15*	<0.30	-	-	-	-	-	-
"	sub-sets	1	-	-	-	<0.30	<0.20	<0.20	-	-	-
Dry cloths		116	-	-	-	-	-	-	0.31 *±0.58*	2.0 *±2.4*	1.1 *±0.8*

\- *not analysed*
* *not detected by the method used*
[a] *Except for milk and seawater where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *Landing point or sampling area.*
[c] *Data are arithmetic means unless stated as 'max'. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition.*
[d] *See section 5 for definition*

Table 33(b). Monitoring of radiation dose rates near Sizewell nuclear power station, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Pipeline	Sand	2	0.045
Dunwich	"	2	0.045
Rifle range	"	2	0.045
Sizewell Hall	"	2	0.045
Aldeburgh	"	1	0.043
"	Sand and gravel	1	0.045
Southwold Harbour	Mud	2	0.063
Beta dose rates			µSv h^{-1}
Southwold Harbour	Mud	1	0.22

[a] *See section 5 for definition*

Table 34(a). Radioactivity in food and the environment near Torness nuclear power station, 1996

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}											
			^{3}H	^{14}C	^{54}Mn	^{60}Co	^{110m}Ag	^{137}Cs	^{155}Eu	^{238}Pu	$^{239+240}Pu$	^{241}Am	$^{243+244}Cm$	Total beta
Aquatic samples														
Cod	Pipeline	2	-	-	*	*	*	1.3 *±0.1*	*	-	-	*	-	-
Crabs	Cove	2	-	34 *±9.5*	*	*	*	0.24 *±0.08*	*	0.00071 *±0.00007*	0.0038 *±0.0002*	0.0027 *±0.0002*	*	-
Lobsters	"	1	-	-	*	*	*	*	*	0.0024 *±0.0002*	0.011 *±0.001*	0.020 *±0.001*	0.000051 *±0.000028*	-
Nephrops	Dunbar	4	-	-	*	*	*	0.52 *±0.12*	*	0.00063 *±0.00005*	0.0036 *±0.0002*	0.0058 *±0.0003*	0.000032 *±0.000015*	-
Winkles	Pipeline	2	-	-	*	0.13 *±0.11*	0.54 *±0.27*	0.24 *±0.14*	*	0.0046 *±0.0003*	0.026 *±0.001*	0.011 *±0.001*	0.000041 *±0.000023*	58
Fucus vesiculosus	"	2	-	-	0.29 *±0.06*	0.36 *±0.07*	0.07 *±0.05*	0.39 *±0.05*	*	-	-	*	-	290
Mud	Eyemouth Harbour	1	-	-	*	*	*	30 *±0.9*	2.9 *±1.5*	-	-	*	-	-
Mud and sand	Dunbar inner harbour	2	-	-	*	*	*	16 *±0.6*	1.3 *±0.8*	-	-	0.59 *±0.26*	-	-
"	Barns Ness	1	-	-	*	*	*	4.5 *±0.6*	*	-	-	*	-	-
Sand	Thornton Loch Beach	2	-	-	*	*	*	1.9 *±0.2*	*	-	-	*	-	-
Seawater	Pipeline	12	13 *±2.0*	-	-	-	-	0.014 *±0.001*	-	-	-	-	-	-

Material	Location or selection[d]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}					
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{131}I	^{137}Cs
Terrestrial samples								
Milk		4	<25	13 *±2.1*	<5.0	<0.10	<0.050	<0.073 *±0.24*
"	max			15 *±2.1*				0.10 *±0.06*
Grass		6	<25	26 *±4.0*	<5.2 *±0.3*	0.36 *±0.06*	-	<0.21 *±0.14*
"	max			36 *±5.1*	6.2 *±0.6*	0.47 *±0.09*		0.42 *±0.15*

- not analysed
** not detected by the method used*
[a] Except for milk and sea water where units are Bq l^{-1} and for sediment where dry concentrations apply
[b] Landing point or sampling area
[c] See section 5 for definition
[d] Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition

Table34(b). Monitoring of radiation dose rates near Torness, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Barns Ness	Mud, sand and stones	2	0.066
Skateraw Harbour	Sand	2	0.060
Thornton Loch Beach	"	2	0.055
Eyemouth Harbour	Mud and sand	1	0.075
Dunbar Inner Harbour	"	2	0.068
St Abbs	"	2	0.085
Beta dose rates on fishing gear			µSv h^{-1}
Cove	Pots	2	0.072
Dunbar Harbour	Nets	2	*

[a] See section 5 for definition
** Not detected by the method used*

Table 35(a). Radioactivity in food and the environment near Trawsfynydd nuclear power station, 1996

Material	Location or selection[c]	No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																
			^{3}H	^{14}C	^{35}S	^{60}Co	^{90}Sr	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	Total Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	$^{239+240}$Pu	^{241}Pu	^{241}Am
Freshwater samples																			
Brown trout	Lake	6	-	47 ±*8.4*	-	*	6.1 ±*0.2*	*	*	9.2 ±*0.5*	180 ±*1.8*	-	*	*	*	0.00038 ±*0.00004*	0.0016 ±*0.0001*	-	0.0029 ±*0.0002*
Rainbow trout	"	7	-	-	-	*	1.3 ±*0.03*	*	*	1.3 ±*0.2*	30 ±*0.6*	-	*	*	*	0.00012 ±*0.00003*	0.00049 ±*0.00005*	-	0.00091 ±*0.00009*
"	Hatchery	1	-	-	-	*	-	*	*	0.09 ±*0.09*	2.8 ±*0.1*	-	*	*	*	-	-	-	*
Perch	Lake	4	-	-	-	*	2.4 ±*0.1*	*	*	15 ±*0.8*	330 ±*2.9*	-	*	*	*	0.00016 ±*0.00004*	0.00045 ±*0.00007*	-	0.00090 ±*0.00006*
Rudd	"	1	-	-	-	*	-	*	*	21 ±*1.1*	420 ±*3.8*	-	*	*	*	-	-	-	*
Fontinalis	Afon Prysor	2	-	-	-	*	-	*	*	*	6.9 ±*0.6*	-	*	*	0.96 ±*0.49*	-	-	-	*
"	Gwylan Stream	2	-	-	-	26 ±*1.2*	-	3.9 ±*2.9*	23 ±*1.9*	1.5 ±*0.9*	47 ±*1.2*	-	1.0 ±*1.2*	3.0 ±*1.2*	4.2 ±*1.1*	-	-	-	3.7 ±*1.5*
Mud	Pipeline (bankside)	1	-	-	-	97 ±*4.2*	-	170 ±*40*	130 ±*15*	130 ±*4.5*	3400 ±*18*	-	36 ±*20*	44 ±*6.2*	23 ±*9.5*	-	-	-	100 ±*19*
"	Hot lagoon	2	-	-	-	58 ±*5.0*	-	32 ±*22*	300 ±*25*	100 ±*6.3*	5000 ±*31*	-	7.9 ±*9.8*	37 ±*11*	19 ±*11*	29 ±*1.1*	86 ±*2.4*	2000 ±*74*	140 ±*4.1*
"	Barrier wall	2	-	-	-	110 ±*4.3*	-	170 ±*39*	390 ±*18*	160 ±*4.7*	5800 ±*21*	-	26 ±*15*	45 ±*7.4*	27 ±*8.2*	-	-	-	150 ±*14*
Mud, sand and stones	Gwylan Stream	2	-	-	-	11 ±*1.7*	-	*	30 ±*8.8*	38 ±*2.7*	1500 ±*11*	-	*	*	*	-	-	-	4.5 ±*3.9*
Peat	Below Maentwrog power station	1	-	-	-	940 ±*26*	-	470 ±*110*	1000 ±*53*	190 ±*17*	5200 ±*47*	-	79 ±*65*	120 ±*27*	82 ±*30*	-	-	-	230 ±*34*
Water	Bailey bridge	4	1.5 ±*1.5*	-	-	-	-	-	-	0.0042 ±*0.0026*	0.068 ±*0.002*	-	-	-	-	-	-	-	-
"	Cold lagoon	4	-	-	-	-	-	-	-	0.0022 ±*0.0020*	0.049 ±*0.002*	-	-	-	-	-	-	-	-
"	Afon Prysor	2	-	-	-	-	-	-	-	*	0.0063 ±*0.0014*	-	-	-	-	-	-	-	-
Terrestrial samples																			
Milk	Near farms	1	<3.0	17 ±*3.8*	<0.53 ±*0.43*	<0.35	0.086 ±*0.012*	<3.6	<0.85	<0.30	<0.50	0.13 ±*0.02*	<2.3	<0.60	<0.60	<0.00018	<0.00023 ±*0.00015*	<0.077	<0.00020 ±*0.00010*
"	sub-sets	1	-	-	-	<0.20	-	<1.7	<0.50	<0.10	<0.20	-	<1.1	<0.30	<0.35	-	-	-	-
"	Far farms	1	<3.0	15 ±*3.8*	<0.80 ±*0.56*	<0.35	0.084 ±*0.011*	<3.0	<0.78	<0.35	<0.45	0.18 ±*0.03*	<1.8	<0.48	<0.65	<0.00013	<0.00018 ±*0.00005*	<0.068	<0.00020
Beetroot		1	<3.0	8.0 ±*4.0*	<0.30	<0.50	-	<3.5	<0.90	<0.30	<0.40	-	<1.6	<0.50	<0.50	<0.00010	<0.00020	-	0.00020 ±*0.00020*
Blackberries		1	<3.0	15 ±*3.0*	<0.40 ±*0.40*	-	-	-	-	-	-	-	-	-	-	0.00020 ±*0.00020*	<0.00020	-	0.00030 ±*0.00030*
"	sub-sets	1	-	-	-	<0.20	-	<1.9	<0.40	<0.10	0.50 ±*0.10*	-	<0.80	<0.30	<0.30	-	-	-	-
Cabbage		1	<3.0	12 ±*4.0*	2.3 ±*0.4*	<0.60	-	<3.3	<0.80	<0.30	<0.50	-	<2.4	<0.60	<0.70	<0.00010	<0.00020	-	<0.00080
Chicken		1	<3.0	29 ±*5.0*	1.5 ±*0.5*	<0.30	-	<1.6	<0.50	<0.20	<0.30	-	<0.90	<0.30	<0.40	<0.00020	<0.00030	-	<0.00020
Hazelnuts		1	<3.0	41 ±*10*	1.3 ±*1.0*	<0.20	-	<1.8	<0.80	<0.30	13 ±*0.2*	-	<2.0	<0.50	<1.1	<0.00030	<0.00030	-	<0.00060
Ovine muscle		2	<3.5 ±*2.8*	28 ±*11*	<2.0	<0.30	0.056 ±*0.057*	<2.6	<0.90	-	-	4.2 ±*0.2*	<1.5	<0.55	<0.55	<0.00015	<0.00015	-	<0.00030
"	Max		4.0 ±*4.0*	36 ±*10*			0.068 ±*0.068*	<3.2	<1.1			5.6 ±*0.3*	<1.9	<0.60	<0.60	<0.00020	<0.00020		
Ovine offal		2	<4.0	29 ±*13*	<2.0	<0.50	0.26 ±*0.05*	<3.6	<1.1	-	-	2.1 ±*0.2*	<2.4	<0.65	<0.70	<0.00010	<0.00015	-	0.00030 ±*0.00030*
"	Max			32 ±*16*		<0.70	0.46 ±*0.05*	<3.8	<1.6			2.3 ±*0.2*	<3.2	<0.90	<0.90		<0.00020		
Potatoes		1	<3.0	25 ±*3.0*	0.70 ±*0.50*	<0.50	-	<4.0	<1.0	<0.30	<0.50	-	<2.5	<0.60	<0.70	<0.00020	0.0011 ±*0.0004*	-	0.00040 ±*0.00040*
Dry cloths		129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 35(a). continued

Material	Location or selection[c]	No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}				
			^{242}Cm	$^{243+244}$Cm	Total alpha	Total beta	Total gamma
Freshwater samples							
Brown trout	Lake	6	*	0.000036 *±0.000013*	-	-	-
Rainbow trout	"	7	*	*	-	-	-
"	Hatchery	1	-	-	-	-	-
Perch	Lake	4	*	0.000019 *±0.000008*	-	-	-
Rudd	"	1	-	-	-	-	-
Fontinalis	Afon Prysor	2	-	-	-	-	-
"	Gwylan Stream	2	-	-	-	-	-
Mud	Pipeline (bankside)	1	-	-	-	-	-
"	Hot lagoon	2	0.65 *±0.27*	4.5 *±0.5*	-	5900	-
"	Barrier wall	2	-	-	-	-	-
Mud, sand and stones	Gwylan Stream	2	-	-	-	-	-
Peat	Below Maentwrog power station	1	-	-	-	-	-
Water	Bailey bridge	4	-	-	-	-	-
"	Cold lagoon	4	-	-	-	-	-
"	Afon Prysor	2	-	-	-	-	-
Terrestrial samples							
Milk	Near farms	1	-	-	-	-	-
"	sub-sets	1	-	-	-	-	-
"	Far farms	1	-	-	-	-	-
Beetroot		-	-	-	-	-	-
Blackberries		1	-	-	-	-	-
"	sub-sets	-	-	-	-	-	-
Cabbage		1	-	-	-	-	-
Chicken		1	-	-	-	-	-
Hazelnuts		1	-	-	-	-	-
Ovine muscle		2	-	-	-	-	-
"	max						
Ovine offal		2	-	-	-	-	-
"	max						
Potatoes		1	-	-	-	-	-
Dry cloths		129	-	-	0.08 *±0.06*	0.95 *±0.81*	0.53 *±0.62*

- not analysed
** not detected by the method used*
[a] *Except for milk and water where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition*

Table 35(b). Monitoring of radiation dose rates near Trawsfynydd nuclear power station, 1996

Location	Ground type	No. of sampling observa-tions[a]	μGy h^{-1}
Gamma dose rates at 1 m over areas near lake shoreline			
Bailey Bridge	Peat	2	0.088
"	Rock	1	0.083
South end of lake	Peat	2	0.086
Cae Adda boat mooring	"	2	0.071
"	Stones	1	0.074
Footbridge	Rock	2	0.10
Nant Islyn Bay	Mud and stones	1	0.097
"	Rock	1	0.086
West of footbridge	Stones	2	0.10

[a] *See section 5 for definition*

Table 36(a). Radioactivity in food and the environment near Wylfa nuclear power station, 1996

Material	Location	No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}										
			^{14}C	^{60}Co	^{99}Tc	^{137}Cs	^{155}Eu	^{238}Pu	$^{239+240}Pu$	^{241}Pu	^{241}Am	$^{243+244}Cm$	Total beta
Aquatic samples													
Plaice	Pipeline	2	48 *±7.2*	*	-	2.0 *±0.1*	*	-	-	-	*	-	-
Crabs	"	2	-	*	6.1 *±0.5*	0.50 *±0.08*	*	0.0027 *±0.0002*	0.014 *±0.001*	-	0.043 *±0.002*	*	-
Winkles	Cemaes Bay	2	-	0.19 *±0.09*	-	0.86 *±0.10*	*	0.035 *±0.002*	0.19 *±0.01*	2.0 *±0.2*	0.26 *±0.01*	0.00049 *±0.00025*	-
Fucus vesiculosus	"	2	-	0.15 *±0.07*	-	1.3 *±0.1*	*	-	-	-	0.08 *±0.10*	-	1200
Mud	Cemlyn Bay	2	-	0.37 *±0.35*	-	150 *±2.5*	1.2 *±1.2*	4.0 *±0.3*	22 *±0.9*	-	31 *±0.7*	0.067 *±0.024*	-
Seawater	Cemaes Bay	1	-	-	-	0.04 *±0.001*	-	-	-	-	-	-	-

Material	Location or selection[c]		No. of sampling observa-tions[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}							
				^{3}H	^{14}C	^{35}S	^{60}Co	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples											
Milk	Near farms		5	<3.1 *±1.2*	14 *±3.8*	<0.71 *±0.50*	<0.43	<0.42	-	-	-
"	"	max		<3.5 *±2.0*	15 *±3.8*	<0.98 *±0.43*	<0.50	<0.50			
"	"	sub-sets	2	-	-	-	<0.73	<0.30	-	-	-
"	"	max					<1.2				
"	Far farms		1	<3.0	16 *±3.0*	0.40 *±0.40*	<0.40	<0.40	-	-	-
"	"	max		<3.0 *±1.5*							
Apples			1	<3.0	14 *±4.0*	0.30 *±0.30*	<0.40	<0.50	-	-	-
Barley			1	4.0 *±4.0*	120 *±13*	2.9 *±0.2*	<0.40	<0.30	-	-	-
Blackberries			1	3.0 *±3.0*	23 *±4.0*	4.5 *±0.5*	<0.30	<0.40	-	-	-
Carrots			1	<3.0	11 *±5.0*	<0.30	<0.40	<0.40	-	-	-
Goats milk			2	<6.0 *±5.7*	13 *±4.0*	<0.55 *±0.42*	<0.35	<0.35	-	-	-
"		max		9.0 *±8.0*	17 *±4.0*	0.80 *±0.60*		<0.50			
Honey			1	<5.0	77 *±18*	<1.3	<0.30	<0.30	-	-	-
Potatoes			1	<3.0	18 *±6.0*	0.80 *±0.30*	<0.20	<0.30	-	-	-
Rhubarb			1	<3.0	6.0 *±3.0*	<0.30	<0.50	<0.40	-	-	-
Runner beans			1	<3.0	11 *±4.0*	0.70 *±0.50*	<0.30	<0.40	-	-	-
Dry cloths			95	-	-	-	-	-	0.20 *±0.23*	2.3 *±1.9*	0.84 *±0.72*

\- *not analysed*
* *not detected by the method used*
[a] *Except for milk and sea water where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5*

Table 36(b). Monitoring of radiation dose rates near Wylfa nuclear power station, 1996

Location	Ground type	No. of sampling observa-tions[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
Cemaes Bay	Sand	4	0.053
Cemlyn Bay	Mud	4	0.082

[a] *See section 5 for definition*

Table 37(a). Radioactivity in food and the environment near Aldermaston, 1996

Material	Location	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}									
			^{57}Co	^{60}Co	^{90}Sr	^{131}I	^{137}Cs	^{155}Eu	^{238}Pu	$^{239+240}$Pu	^{241}Am	Total beta
Aquatic samples												
Pike	Newbridge	1	*	*	0.0050 *±0.0020*	*	0.06 *±0.05*	*	*	0.000031 *±0.000010*	*	-
"	Outfall (Pangbourne)	1	*	*	-	*	0.54 *±0.09*	*	0.000039 *±0.000014*	0.00017 *±0.00002*	0.00027 *±0.00003*	-
"	Staines	1	*	*	-	*	0.30 *±0.08*	*	-	-	*	-
Nuphar lutea	Newbridge	1	*	*	-	*	0.07 *±0.04*	*	-	-	*	-
"	Outfall (Pangbourne)	1	*	*	-	*	0.09 *±0.07*	*	-	-	*	-
"	Staines	1	0.09 *±0.03*	*	-	0.83 *±0.65*	0.05 *±0.06*	*	-	-	*	-
Clay	Outfall (Pangbourne)	1	*	*	-	*	3.6 *±0.3*	1.8 *±0.8*	-	-	*	360
Mud	Foudry Brook	1	*	*	-	7.0 *±3.2*	5.2 *±0.3*	2.5 *±0.8*	-	-	*	-
"	Newbridge	1	*	*	-	*	6.4 *±0.6*	2.5 *±1.0*	-	-	*	-
Mud & sand	Staines	1	1.0 *±0.3*	1.8 *±0.5*	-	*	24 *±0.7*	1.7 *±1.2*	-	-	*	330

Material	Location or selection[c]	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}									
			^{3}H	^{60}Co	^{137}Cs	Total U	^{238}Pu	$^{239+240}$Pu	^{241}Am	Total alpha	Total beta	Total gamma
Terrestrial samples												
Milk	Near farms	4	<3.0	<0.43	<0.43	<0.0065	<0.00010 *±0.00005*	<0.00012 *±0.00003*	<0.00019	-	-	-
"	max			<0.45	<0.45		<0.00010 *±0.00007*	<0.00013 *±0.00005*	<0.00020			
Apples		1	<3.0	<0.40	<0.40	<0.010	<0.00030	<0.00030	0.00050 *±0.00050*	-	-	-
Blackberries		1	5.0 *±3.0*	<0.40	<0.30	0.025 *±0.007*	<0.00010	<0.00010	<0.00030	-	-	-
Carrots		1	<3.0	<0.50	<0.40	0.040 *±0.009*	<0.00020	<0.00020	<0.00020	-	-	-
Honey		1	<4.0	<0.40	<0.40	<0.028	<0.00020	<0.00020	0.00040 *±0.00040*	-	-	-
Lettuce		1	<3.0	<0.40	<0.50	0.47 *±0.04*	<0.00020	0.0018 *±0.0007*	0.0012 *±0.0006*	-	-	-
Potatoes		1	<3.0	<0.40	<0.50	<0.028	0.00010 *±0.00010*	<0.00020	<0.00020	-	-	-
Swede		1	<3.0	<0.30	<0.40	0.020 *±0.007*	<0.00020	<0.00010	<0.00030	-	-	-
Wheat		1	<3.0	<0.50	<0.40	<0.032	<0.00010	<0.00010	0.00050 *±0.00050*			
Grass		8	-	-	-	-	<0.00053 *±0.00014*	<0.0042 *±0.0021*	-	-	-	-
"	max						<0.00090	0.019 *±0.005*				
Soil[d]		4	-	-	-	35 *±4.1*	-	-	-	-	-	-
"	max					48 *±5.1*						
Dry cloths		84	-	-	-	-	-	-	-	0.08 *±0.10*	0.72 *±0.94*	0.39 *±0.34*

- not analysed
** not detected by the method used*
[a] *Except for milk where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment and soil where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'max' in this column.'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition.*
[d] *The concentrations of ^{234}U, ^{235}U and ^{238}U were 10 ±1.0, 0.39 ±0.11 and 9.8 ±1.0 Bq kg^{-1} respectively*

Table 37(b). Monitoring of radiation dose rates near Aldermaston, 1996

Location	Ground type	No. of sampling observa-tions[a]	μGy h^{-1}
Gamma dose rates at 1 m over river bank			
Pangbourne	Grass	1	0.064
Newbridge	"	1	0.064

[a] *see section 5 for definition*

Table 38(a). Radioactivity in food and the environment near naval establishments, 1996

Material	Location[b] or selection[c]	No. of sampling observa- tions[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}															
			^{3}H	^{14}C	^{60}Co	^{95}Nb	^{95}Zr	^{106}Ru	^{125}Sb	^{131}I	^{134}Cs	^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Am
Barrow																		
Mud and sand	Walney channel (outfall)	2	-	-	4.3 ±0.8	3.3 ±1.0	1.6 ±0.9	58 ±9.9	2.9 ±1.8	*	*	200 ±2.9	6.5 ±3.3	3.4 ±1.9	2.0 ±1.7	-	-	240 ±7.3
"	" (Vickerstown church)	4	-	-	5.0 ±0.6	0.79 ±0.52	0.70 ±0.51	35 ±5.6	2.7 ±1.5	*	*	190 ±1.9	1.5 ±1.2	3.5 ±1.3	1.7 ±1.1	-	-	220 ±4.4
Chatham																		
Mud	Commodores Hard	1	-	-	1.4 ±0.4	*	*	*	*	*	*	13 ±0.7	*	*	1.4 ±0.8	-	-	*
"	Hoo Marina	1	-	-	1.3 ±0.4	*	*	*	*	*	0.79 ±0.45	16 ±0.5	*	*	2.2 ±1.0	-	-	*
Devonport																		
Dogfish	Plymouth Sound	1	-	-	*	*	*	*	*	*	*	0.38 ±0.30	*	*	*	-	-	*
Crabs	"	2	-	28 ±8.3	*	*	*	*	*	*	*	0.10 ±0.10	*	*	*	-	-	*
Fucus vesiculosus	Kinterbury	2	-	-	0.03 ±0.02	*	*	*	*	1.2 ±0.2	*	0.10 ±0.03	*	*	0.04 ±0.06	-	-	*
Mud	"	2	-	-	*	*	*	*	*	*	*	5.4 ±0.6	*	*	2.1 ±1.1	0.030 ±0.003	0.63 ±0.03	0.22 ±0.02
"	Torpoint Ferry East	2	-	-	0.29 ±0.21	*	*	*	*	*	*	7.6 ±0.6	*	*	2.3 ±0.9	-	-	*
"	Torpoint South	2	-	-	*	*	*	*	*	*	*	4.0 ±0.8	*	*	*	-	-	*
"	Calstock	2	-	-	*	*	*	*	*	*	*	9.7 ±0.8	*	*	1.3 ±1.0	-	-	*
"	Lopwell	2	-	-	*	*	*	*	*	*	*	10 ±0.6	*	*	2.3 ±1.4	-	-	*
"	Wilcove	2	-	-	*	*	*	*	*	*	*	3.9 ±0.4	*	*	1.1 ±0.7	0.023 ±0.003	0.49 ±0.03	0.17 ±0.01
Grass	Devonport	3	<3.0	-	<0.47	<1.2	<1.0	<2.6	*	*	<0.33	<0.43	<1.8	*	*	-	-	*
"	max				<0.50	<1.5	<1.1	<3.1			<0.40	<0.50	<2.2					
Faslane																		
Mud	Carnban boatyard	1	-	-	6.5 ±0.7	*	*	*	2.0 ±1.3	*	*	44 ±1.1	*	*	*	-	-	*
Mud, sand and stones	"	1	-	-	2.3 ±0.4	*	*	*	1.0 ±0.8	*	*	28 ±0.7	*	*	1.1 ±0.9	-	-	*
Sea water	"	1	1.5 ±1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Holyloch																		
Sand	Mid-Loch	1	-	-	0.62 ±0.33	*	*	*	*	*	*	7.1 ±0.6	*	*	*	-	-	*

Table 38(a). continued

Material	Location[b] or selection[c]	No. of sampling observa-tions[d]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}															
			^{3}H	^{14}C	^{60}Co	^{95}Nb	^{95}Zr	^{106}Ru	^{125}Sb	^{131}I	^{134}Cs	^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Am
Rosyth																		
Crabs	East of dockyard	2	-	-	*	*	*	*	*	*	*	0.22 *±0.06*	*	*	*	-	-	*
Fucus vesiculosus	“	2	-	-	*	*	*	*	*	0.59 *±0.16*	*	0.42 *±0.08*	*	*	*	-	-	*
Mud	East of dockyard	2	-	-	0.16 *±0.20*	*	*	*	*	*	*	23 *±0.7*	*	*	0.56 *±0.67*	-	-	*
“	Port Edgar	2	-	-	*	*	*	*	*	*	*	27 *±1.1*	*	*	1.9 *±1.2*	-	-	*
Mud and sand	Blackness Castle	2	-	-	*	*	*	*	*	*	*	29 *±0.6*	*	*	1.8 *±0.9*	-	-	*
“	West of dockyard	2	-	-	*	*	*	*	*	*	*	14 *±0.8*	*	*	0.98 *±0.73*	-	-	*
Sand	Pettycur	2	-	-	*	*	*	*	*	*	*	2.2 *±0.4*	*	*	*	-	-	*

\- *not analysed*
* *not detected by the method used*
[a] *Except for sediment where dry concentrations apply, and for seawater where units are Bq l^{-1}*
[b] *Landing point or sampling area*
[c] *Data are arithmetic means unless stated as ‘max’. ‘Max’ data are selected to be maxima. If no ‘max’ value is given, the mean is also the maximum. See section 5 for definition*
[d] *See section 5 for definition*

Table 38(b). Monitoring of radiation dose rates near naval establishments, 1996

Establishment	Location	Ground type	No. of sampling observations[a]	µGy h^{-1}
Gamma dose rates at 1 m over intertidal areas				
Barrow	Walney Channel (1 km south of outfall)	Mud and sand	4	0.078
“	“ (Vickerstown church)	“	4	0.093
“	“ (Sewer outfall)	Mussel bed	2	0.084
Chatham	Commodores Hard	Mud	1	0.060
“	Hoo Marina	“	1	0.066
“	Medway Yacht Club	“	1	0.058
Devonport	Kinterbury	“	1	0.074
“	“	Mud and sand	1	0.070
“	Brunel Bridge East	Mud	1	0.066
“	“	Mud and sand	1	0.084
“	Torpoint Ferry East	Mud	2	0.067
“	Stonehouse	“	2	0.071
“	Torpoint South	“	2	0.075
“	Calstock	“	2	0.095
“	Lopwell	“	2	0.084
“	Wilcove	“	2	0.082
Faslane	Gareloch Head	Mud, sand and stones	1	0.062
“	“	Mud and sand	1	0.066
“	Gulley Bridge Pier	Sand and stones	2	0.069
“	Rhu Narrows	Mussel bed	1	0.060
“	“	Gravel	1	0.056
“	Rosneath	Sand and gravel	2	0.064
“	Carnban boatyard	Mud	1	0.078
“	“	Mud, sand and stones	1	0.073
Holy Loch	North Sandbank	Mud and sand	1	0.072
“	Kilmun Pier	Sand and stones	1	0.069
“	Mid-Loch	Mussel bed	1	0.055
Rosyth	Blackness Castle	Mud	2	0.072
“	Pettycur	Sand	2	0.059
“	East of Dockyard	“	1	0.063
“	“	Sand and stones	1	0.067
“	Port Edgar	Mud	2	0.072
“	West of Dockyard	Mud and sand	2	0.080

[a] *See section 5 for definition*

Table 39(a). Radioactivity in food and the environment near Amersham, 1996

Material	Location	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}												
			^{14}C	^{54}Mn	^{57}Co	^{58}Co	^{60}Co	^{65}Zn	^{90}Sr	^{131}I	^{134}Cs	^{137}Cs	^{155}Eu	$^{239+240}Pu$	Total beta
Aquatic samples															
Pike	Newbridge	1	-	*	*	*	*	*	0.0050 ±*0.0020*	*	*	0.06 ±*0.05*	*	0.000031 ±*0.000010*	-
"	Outfall (Grand Union Canal)	1	30 ±*7.3*	*	0.07 ±*0.03*	*	*	*	-	*	0.08 ±*0.05*	0.24 ±*0.06*	*	-	-
"	Staines	1	-	*	*	*	*	*	-	*	*	0.30 ±*0.08*	*	-	-
Nuphar lutea	Newbridge	1	-	*	*	*	*	*	-	*	*	0.07 ±*0.04*	*	-	-
"	Outfall (Grand Union Canal)	1	-	0.09 ±*0.03*	0.73 ±*0.02*	0.12 ±*0.03*	*	0.32 ±*0.07*	-	1.5 ±*0.2*	*	0.03 ±*0.02*	*	-	-
"	Staines	1	-	*	0.09 ±*0.03*	*	*	*	-	0.83 ±*0.65*	*	0.05 ±*0.06*	*	-	-
Mud	Outfall (Grand Union Canal)	1	-	*	9.3 ±*0.4*	1.9 ±*0.4*	*	4.0 ±*0.7*	-	14 ±*3.4*	0.47 ±*0.49*	2.1 ±*0.3*	1.4 ±*0.9*	-	390
"	Newbridge	1	-	*	*	*	*	*	-	*	*	6.4 ±*0.6*	2.5 ±*1.0*	-	-
Mud & sand	Staines	1	-	*	1.0 ±*0.3*	*	1.8 ±*0.5*	*	-	*	*	24 ±*0.7*	1.7 ±*1.2*	-	330

Material	Location or selection[c]		No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}									
				^{3}H	^{35}S	^{60}Co	^{75}Se	^{125}I	^{131}I	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples													
Milk	Near farms		2	<3.0 ±*1.5*	<0.40 ±*0.28*	<0.43	<0.55	<0.031 ±*0.021*	<0.036 ±*0.006*	<0.43	-	-	-
"	"	max		<3.0 ±*2.1*	<0.45 ±*0.36*	<0.45	<0.65	<0.033 ±*0.029*	<0.037	<0.45			
"	"	sub-sets	2	-	-	<0.30	<0.35	-	-	<0.28	-	-	-
"	"	max				<0.35	<0.40			<0.30			
"	Far farms		1	<3.0	<0.40	<0.70	<0.70	<0.045	<0.022	<0.50	-	-	-
"	"	max	1	<3.0 ±*2.1*									
Apples			1	<3.0	0.90 ±*0.40*	<0.30	<0.50	<0.096	-	<0.40	-	-	-
Cabbage			1	<3.0	0.70 ±*0.40*	<0.40	<0.50	<0.15	-	<0.30	-	-	-
Elderberries			1	<3.0	0.80 ±*0.30*	<0.50	<0.50	<0.12	-	<0.50	-	-	-
Honey			1	<3.0	<1.3	<0.90	<0.50	<0.043	-	<0.60	-	-	-
Leeks			1	<3.0	2.3 ±*0.4*	<0.60	<0.60	<0.18	-	<0.50	-	-	-
Potatoes			1	<3.0	0.40 ±*0.30*	-	-	<0.097	-	-	-	-	-
"		sub-sets	1	-	-	<0.30	<0.20	-	-	<0.20	-	-	-
Runner beans			1	<3.0	<0.30	<0.50	<0.60	<0.085	-	<0.40	-	-	-
Wheat			1	<3.0	1.5 ±*0.4*	<0.30	<0.30	<0.075	-	<0.30	-	-	-
Dry cloths			70	-	-	-	-	-	-	-	0.08 ±*0.06*	0.79 ±*0.52*	0.43 ±*0.26*

\- *not analysed*
* *not detected by the method used*
[a] *except for milk where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima. If no 'max' value is given, the mean is also the maximum. See section 5 for definition*

Table 39(b). Monitoring of radiation dose rates near Amersham, 1996

Location	Ground type	No. of sampling observations[a]	µGy h^{-1}
Gamma dose rates at 1 m over river bank			
Grand Union Canal	Grass and concrete	1	0.050
Newbridge	Grass	1	0.064

[a] *See section 5 for definition*

Table 40(a). Radioactivity in food and the environment near Cardiff, 1996

Material	Location[b]	No. of sampling observations	Mean radioactivity concentration (wet)[a], Bq kg^{-1} ^{3}H	^{14}C	^{131}I	^{134}Cs	^{137}Cs	^{155}Eu	Total beta
Aquatic samples									
Flounder	East of new pipeline	3	-	610 ±*12*	*	*	0.39 ±*0.06*	*	-
Mussels	Orchard Ledges	1	-	730 ±*12*	*	*	0.27 ±*0.14*	*	-
Fucus vesiculosus	"	2	-	29 ±*4.2*	2.2 ±*1.0*	*	0.41 ±*0.06*	0.20 ±*0.12*	-
Fucus spiralis	East of new pipeline	2	-	27 ±*4.6*	0.29 ±*0.14*	0.05 ±*0.06*	0.41 ±*0.09*	0.27 ±*0.16*	160
Mud	"	2	-	45 ±*3.5*	*	0.67 ±*0.59*	31 ±*1.3*	1.4 ±*1.2*	-
"	West of new pipeline	1	-	21 ±*2.5*	*	*	3.0 ±*0.5*	*	-
Mud and sand	"	1	-	-	*	*	5.2 ±*0.4*	*	-
Sea water	Orchard Ledges East	2	26 ±*2.1*	-	-	-	-	-	-

Material	Location[b] or selection[c]	No. of sampling observations	Mean radioactivity concentration (wet)[a], Bq kg^{-1} ^{3}H (organic)	^{3}H	^{14}C	^{32}P	^{35}S	^{45}Ca	^{57}Co	^{125}I	^{134}Cs	^{137}Cs	Total alpha	Total beta	Total gamma
Terrestrial samples															
Milk	Near farms	4	<24 ±*4.4*	<44 ±*4.8*	22 ±*4.6*	<0.45 ±*0.21*	<0.52 ±*0.32*	<0.39 ±*0.30*	<0.27	<0.030 ±*0.013*	<0.30	<0.39	-	-	-
"	" max		44 ±*5.3*	79 ±*5.7*	26 ±*4.5*	<0.48 ±*0.22*	<0.73 ±*0.35*	<0.45 ±*0.36*	<0.28	<0.035 ±*0.016*		<0.40	-	-	-
"	" sub-sets	1	-	-	-	-	-	-	<0.18	-	<0.23	<0.30	-	-	-
"	Far farms	2	<4.8 ±*3.0*	<8.0 ±*3.4*	15 ±*4.3*	-	<0.65 ±*0.39*	<0.43 ±*0.33*	<0.29	<0.033	<0.35	<0.41	-	-	-
"	" max		<6.0 ±*3.8*	11 ±*3.9*	15 ±*4.7*		<0.83 ±*0.49*	<0.43 ±*0.40*	<0.30		<0.38	<0.43			
Barley		1	-	40 ±*6.0*	100 ±*20*	-	2.0 ±*0.4*	2.5 ±*0.5*	<0.30	<0.072	<0.40	<0.50	-	-	-
Blackberries		1	<3.0	79 ±*5.0*	28 ±*4.0*	-	<0.50	1.0 ±*0.4*	<0.30	<0.14	<0.20	<0.20	-	-	-
Cabbage		2	<5.0 ±*2.1*	9.5 ±*3.5*	8.0 ±*4.0*	-	0.50 ±*0.30*	<1.7 ±*0.4*	<0.20	<0.084	<0.40	<0.40	-	-	-
"	max		7.0 ±*3.0*	16 ±*4.0*				3.0 ±*0.6*		<0.089			-	-	-
"	sub-sets	1	-	-	-	-	-	-	<0.20	-	<0.20	<0.30	-	-	-
Honey		1	-	55 ±*7.0*	96 ±*14*	-	<1.3	<0.80	<0.20	<0.042	<0.30	<0.50	-	-	-
Potatoes		1	<3.0	12 ±*4.0*	24 ±*7.0*	-	0.40 ±*0.30*	<0.20	<0.20	<0.095	<0.20	<0.30	-	-	-
Swede		1	4.0 ±*2.0*	22 ±*4.0*	11 ±*6.0*	-	0.90 ±*0.60*	3.6 ±*0.6*	<0.20	<0.10	<0.20	<0.40	-	-	-
Rape		1	-	50 ±*8.0*	120 ±*30*	-	5.7 ±*0.7*	<0.90	<0.30	<0.076	<0.30	<0.40	-	-	-
Silage		5	<37 ±*6.9*	69 ±*8.0*	50 ±*7.2*	-	-	-	-	-	-	-	-	-	-
"	max		81 ±*7.0*	160 ±*8.0*	63 ±*7.0*										
Dry cloths		89	-	-	-	-	-	-	-	-	-	-	0.08 ±*0.10*	0.63 ±*0.87*	0.47 ±*1.1*

- not analysed
** not detected by the method used*
[a] *except for milk and sea water where units are Bq l^{-1}, for dry cloths where units are Bq per cloth and for sediment where dry concentrations apply*
[b] *landing point or sampling area.*
[c] *Data are arithmetic means unless stated as 'max' in this column. 'Max' data are selected to be maxima.*
If no 'max' value is given, the mean is also the maximum. See section 5 for definition.

Table 40(b). Monitoring of radiation dose rates near Cardiff, 1996

Location	Ground type	No. of sampling observations[a]	μGy h^{-1}
Gamma dose rates at 1 m over intertidal areas			
East of pipeline	Mud	2	0.079
West of pipeline	Mud and sand	2	0.063
Beta dose rates			μSv h^{-1}
West of pipeline	"	1	*

[a] *See section 5 for definition*
** Not detected by the method used*

Table 41. Radioactivity in the environment near Derby, 1996

Material	No. of samples	Mean radioactivity concentration, Bq kg^{-1}			
		Total U	^{234}U	^{235}U	^{238}U
Grass[a]	4	0.51 *±0.07*	-	-	-
" max		1.5 *±0.1*			
Soil[b]	4	91 *±6.8*	44 *±3.9*	1.7 *±0.3*	43 *±3.8*
" max		150 ±8.5			

[a] *fresh weight*
[b] *dry weight*
\- *not analysed*

Table 42. Radioactivity in grass and soil near nuclear sites - EURATOM[c] sampling, 1996

Site/material	No. of samples	Selection[b]	Mean radioactivity concentration (dry)[a], Bq kg^{-1}							
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}$Pu	^{241}Am
Grass										
Aldermaston	3		<28 ±6.4	95 ±15	<2.9 ±1.5	3.5 ±0.3	<3.5 ±1.7	<0.0040 ±0.0014	0.034 ±0.005	-
		max	35 ±11	100 ±16	3.0 ±1.7	5.5 ±0.4	4.6 ±2.9	0.0051 ±0.0021	0.061 ±0.008	
Amersham	3		<25	91 ±15	26 ±2.5	2.0 ±0.2	<1.5 ±0.8	<0.0037	0.016 ±0.003	-
		max		98 ±15	37 ±2.5	3.7 ±0.3	1.4 ±1.3			
Cardiff	3		490 ±32	740 ±63	6.9 ±1.4	3.8 ±0.7	<3.1 ±1.2	<0.0037 ±0.0012	<0.0059 ±0.0016	-
		max	1100 ±51	1200 ±89	8.5 ±1.8	6.1 ±0.9	3.2 ±2.0	0.0070 ±0.0020	0.013 ±0.002	
Berkeley	3		<34 ±6.9	110 ±16	5.9 ±1.1	<0.82 ±0.15	<2.7	<0.0020	<0.0022 ±0.0009	-
		max	51 ±12	120 ±16	8.8 ±1.1	1.3 ±0.2	<3.0		0.0027 ±0.0012	
Bradwell	3		<25	85 ±15	19 ±1.6	<0.75 ±0.14	<2.7	<0.0037	<0.0045 ±0.0011	-
		max		92 ±16	25 ±1.7	1.1 ±0.2	<3.0	<0.0060	<0.0060	
Capenhurst	3		57 ±13	92 ±13	6.0 ±1.5	3.3 ±0.5	<2.0	<0.0027	<0.0057 ±0.0018	-
		max	67 ±13	100 ±14	7.4 ±1.4	4.0 ±0.6		<0.0040	0.0080 ±0.0020	
Dungeness	2		<25	140 ±17	24 ±1.6	2.7 ±0.7	<3.0	<0.0020	<0.010 ±0.002	-
		max		150 ±17	30 ±1.7	3.0 ±0.9			0.013 ±0.002	
Hartlepool	3		<25	100 ±14	17 ±1.7	<0.63 ±0.17	<3.0	<0.0033	<0.0035 ±0.0006	-
		max		130 ±15	22 ±1.7	1.3 ±0.3		<0.0060	<0.0060	
Harwell	3		<52 ±12	86 ±14	<3.0 ±1.4	0.76 ±0.14	<2.7	<0.0037	0.011 ±0.003	<0.0073 ±0.0019
		max	81 ±15	91 ±14	3.8 ±1.7	1.1 ±0.2	<3.0	<0.0040	0.014 ±0.003	0.011 ±0.003
Heysham	3		<25	110 ±15	7.3 ±1.4	<0.78 ±0.16	<2.7	<0.0029 ±0.0011	<0.012 ±0.002	-
		max		140 ±17	7.8 ±1.5	1.6 ±0.3	<3.0	0.0038 ±0.0014	0.018 ±0.003	
Hinkley Point	3		<26 ±6.4	140 ±16	16 ±1.3	<0.92 ±0.18	<2.7	<0.0020	<0.0022 ±0.0005	-
		max	29 ±11	180 ±19	35 ±1.8	1.9 ±0.3	<3.0		0.0026 ±0.0009	
Oldbury	3		<25	140 ±17	60 ±2.2	<1.6 ±0.3	<3.1 ±1.1	<0.0022 ±0.0008	<0.0036 ±0.0013	-
		max		210 ±20	74 ±2.3	2.7 ±0.5	3.3 ±1.9	0.0026 ±0.0013	0.0060 ±0.0014	
Sellafield	3		<25	150 ±18	86 ±4.1	20 ±3.6	14 ±4.6	0.048 ±0.010	0.77 ±0.07	0.30 ±0.03
		max		160 ±19	180 ±6.1	32 ±4.8	19 ±5.1	0.084 ±0.014	1.4 ±0.1	0.54 ±0.04
Sizewell	3		<25	100 ±15	8.5 ±1.4	<2.5 ±0.9	<3.0	<0.0020	<0.0022 ±0.0005	<0.0050
		max		120 ±18	18 ±1.8	5.2 ±1.5			0.0027 ±0.0009	<0.0070
Springfields	3		<27 ±6.9	100 ±16	2.9 ±1.4	2.5 ±0.3	<2.0	<0.0037	0.012 ±0.003	-
		max	31 ±12		5.6 ±2.0	3.7 ±0.3		<0.0050	0.021 ±0.004	
Trawsfynydd	3		<25	100 ±15	7.2 ±2.1	4.3 ±0.8	31 ±4.7	<0.0023	<0.0070 ±0.0020	-
		max		110 ±15	13 ±2.4	6.6 ±1.1	51 ±6.4	<0.0030	0.017 ±0.004	
Winfrith	3		<31 ±7.5	104 ±15	5.1 ±1.3	5.6 ±0.4	<5.9 ±2.2	<0.0047 ±0.0012	<0.0066 ±0.0017	-
		max	43 ±13	120 ±16	8.8 ±1.5	7.3 ±0.5	13 ±3.5	0.0051 ±0.0020	0.011 ±0.003	
Wylfa	3		<25	110 ±16	14 ±2.2	9.8 ±2.4	<2.8 ±1.6	<0.0052 ±0.0020	0.019 ±0.005	-
		max			16 ±2.2	22 ±4.0	4.4 ±2.7	0.0065 ±0.0034	0.042 ±0.007	

Table 42. continued

Site/material	No. of samples	Selection[b]	Mean radioactivity concentration (dry)[a], Bq kg-1							
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}Pu$	^{241}Am
Soil										
Aldermaston	3		-	11 *±3.6*	<1.7 *±0.4*	2.3 *±0.7*	9.3 *±2.5*	0.032 *±0.011*	0.34 *±0.03*	-
		max		14 *±4.2*	1.2 *±0.8*	4.9 *±1.2*	16 *±2.0*	0.058 *±0.014*	0.42 *±0.04*	
Amersham	3		-	<13 *±3.6*	<1.9 *±0.6*	0.77 *±0.15*	6.8 *±1.9*	<0.022 *±0.010*	0.20 *±0.03*	-
		max		20 *±3.8*	1.6 *±1.1*	0.95 *±0.16*	7.3 *±1.9*	0.024 *±0.013*	0.25 *±0.03*	
Cardiff	3		-	130 *±13*	<1.5 *±0.5*	<1.1 *±0.2*	19 *±2.5*	<0.013 *±0.003*	0.36 *±0.03*	-
		max		240 *±20*	2.4 *±0.6*	1.4 *±0.3*	25 *±3.0*	0.014 *±0.004*	0.49 *±0.04*	
Berkeley	3		-	14 *±3.5*	7.6 *±1.5*	2.6 *±0.5*	19 *±2.3*	0.039 *±0.010*	0.56 *±0.05*	-
		max		16 *±3.6*	13 *±1.7*	5.4 *±0.7*	33 *±3.1*	0.076 *±0.016*	1.2 *±0.1*	
Bradwell	3		-	12 *±3.6*	<4.0 *±2.0*	1.8 *±0.3*	21 *±2.5*	0.025 *±0.007*	0.26 *±0.03*	-
		max		15 *±3.7*	7.7 *±3.1*	2.5 *±0.4*	28 *±2.8*	0.028 *±0.007*	0.47 *±0.05*	
Capenhurst	3		-	12 *±3.6*	<2.0	4.4 *±0.7*	15 *±3.0*	<0.023 *±0.008*	0.40 *±0.04*	-
		max		12 *±3.9*		8.9 *±1.1*	20 *±2.8*	0.025 *±0.009*	0.50 *±0.04*	
Dungeness	2		-	54 *±7.5*	4.1 *±2.4*	8.2 *±1.1*	170 *±12*	0.17 *±0.02*	3.4 *±0.2*	-
		max		83 *±9.8*	4.8 *±2.1*	9.1 *±1.2*	220 *±15*	0.19 *±0.03*	4.3 *±0.3*	
Hartlepool	3		-	13 *±3.5*	<2.3	1.5 *±0.2*	11 *±2.0*	0.017 *±0.005*	0.22 *±0.02*	-
		max		15 *±3.9*	<3.0	2.1 *±0.3*	16 *±2.3*	0.024 *±0.007*	0.37 *±0.03*	
Harwell	3		-	11 *±3.2*	<3.0 *±0.9*	<3.1 *±0.7*	20 *±3.3*	0.096 *±0.017*	0.77 *±0.06*	0.24 *±0.03*
		max		15 *±3.6*	5.4 *±1.3*	4.6 *±0.9*	24 *±3.9*	0.15 *±0.02*	1.2 *±0.1*	0.39 *±0.05*
Heysham	3		-	17 *±3.4*	<1.8 *±0.8*	<1.7 *±0.4*	26 *±3.2*	<0.027 *±0.009*	0.35 *±0.04*	-
		max		23 *±3.6*	1.5 *±1.3*	2.9 *±0.5*	37 *±4.3*	0.033 *±0.013*	0.57 *±0.06*	
Hinkley Point	3		-	7.9 *±3.0*	<6.4 *±1.4*	<3.7 *±0.7*	8.5 *±1.7*	0.021 *±0.005*	0.27 *±0.03*	-
		max		14 *±3.3*	12 *±2.0*	6.0 *±0.9*	17 *±2.0*	0.025 *±0.007*	0.51 *±0.04*	
Oldbury	3		-	27 *±4.5*	<5.2 *±1.0*	<3.3 *±0.6*	24 *±2.8*	0.026 *±0.007*	0.42 *±0.04*	-
		max		38 *±4.9*	10 *±1.7*	5.4 *±0.9*	40 *±3.8*	0.040 *±0.007*	0.69 *±0.05*	
Sellafield	3		-	20 *±4.1*	<4.1 *±1.0*	13 *±2.1*	110 *±8.4*	0.90 *±0.18*	16 *±1.3*	4.1 *±0.3*
		max		30 *±4.4*	8.3 *±1.5*	19 *±2.9*	180 *±12*	1.4 *±0.2*	25 *±1.8*	7.3 *±0.4*
Sizewell	3		-	7.1 *±3.3*	2.0 *±1.2*	0.83 *±0.20*	4.3 *±1.1*	<0.014 *±0.006*	0.11 *±0.02*	0.048 *±0.012*
		max		7.4 *±3.2*	3.1 *±1.5*	1.4 *±0.3*	7.0 *±1.1*	0.024 *±0.010*	0.17 *±0.02*	0.078 *±0.017*
Springfields	3		-	18 *±4.3*	<3.3 *±1.2*	1.9 *±0.4*	33 *±5.3*	<0.026 *±0.008*	0.46 *±0.05*	-
		max		20 *±4.9*	5.1 *±1.8*	2.5 *±0.6*	42 *±5.7*	0.037 *±0.014*	0.61 *±0.06*	
Trawsfynydd	3		-	25 *±4.9*	<2.5 *±0.9*	1.7 *±0.3*	130 *±11*	0.052 *±0.013*	0.97 *±0.08*	-
		max		34 *±4.8*	3.6 *±1.5*	2.4 *±0.4*	240 *±15*	0.078 *±0.020*	1.5 *±0.1*	
Winfrith	3		-	19 *±5.5*	<1.7 *±0.5*	3.1 *±0.6*	26 *±3.6*	<0.035 *±0.014*	0.88 *±0.08*	-
		max		29 *±6.3*	3.5 *±0.8*	5.6 *±0.9*	45 *±4.7*	0.050 *±0.014*	1.5 *±0.1*	
Wylfa	3		-	16 *±4.0*	<7.6 *±1.2*	3.2 *±0.5*	27 *±3.8*	0.026 *±0.010*	0.33 *±0.04*	-
		max		21 *±4.8*	19 *±1.8*	4.8 *±0.7*	43 *±4.9*	0.033 *±0.011*	0.42 *±0.05*	

- *not analysed*
[a] *Except for ^{3}H where wet concentrations apply*
[b] *Data are arithmetic means unless stated as 'max' in this column*
'Max ' data are selected to be maxima. If no 'max' value is given,the mean is also the maximum. See section 5
[c] *Other data for grass and soil samples near nuclear sites can be found in the site-specific tables*

Table 43. Comparison of highest observed grass and soil concentrations with Generalised Derived Limits[b], 1996

	Mean activity concentration Bq kg^{-1} (dry)[c]							
	Grass				Soil			
	Observed	GDL	%	Site	Observed	GDL[a]	%	Site
^{3}H	490	30000	2	Cardiff	-			
^{14}C	740	4000	19	Cardiff	-			
^{35}S	86	20000	<1	Sellafield	7.6	30000	<1	Hinkley
^{90}Sr	20	2000	1	Sellafield	13	400	3	Sellafield
^{137}Cs	31	3000	1	Trawsfynydd	170	1000	17	Dungeness
^{238}Pu		-			0.90	5000	<1	Sellafield
$^{239+240}Pu$		-			16	5000	<1	Sellafield
^{241}Am		-			4.1	5000	<1	Sellafield

- not available
[a] Assumed to be well mixed soil, 0-30 cm
[b] Based on Attwood et al, 1996 and MAFF assessments
[c] except for ^{3}H where wet concentrations apply

Table 44. Natural radioactivity in fish and shellfish, 1996

Material	Location[a]	No. of sampling observ-ations	Mean radioactivity concentration (wet), Bq kg^{-1}								
			^{210}Po	^{210}Pb	^{226}Ra	^{228}Th	^{230}Th	^{232}Th	^{234}U	^{235}U	^{238}U
Winkles	Saltom Bay	4	13 *±0.7*	1.5 *±0.2*	-	-	-	-	-	-	-
“	Parton	4	17 *±1.0*	3.1 *±0.3*	1.1 *±0.2*	0.64 *±0.04*	2.1 *±0.1*	0.50 *±0.03*	1.8 *±0.1*	0.066 *±0.008*	1.7 *±0.1*
“	North Harrington	1	17 *±0.4*	-	-	-	-	-	-	-	-
“	Fleswick Bay	4	15 *±0.7*	-	-	-	-	-	-	-	-
“	Nethertown	4	13 *±0.6*	2.5 *±0.3*	-	-	-	-	-	-	-
“	Drigg	4	-	-	-	0.61 *±0.03*	0.98 *±0.04*	0.49 *±0.02*	-	-	-
“	Tarn Bay	1	13 *±0.7*	-	-	-	-	-	-	-	-
Mussels	Parton	2	37 *±0.9*	*1.5* *±0.2*	-	-	-	-	-	-	-
“	Nethertown	4	31 *±1.3*	1.6 *±0.3*	-	-	-	-	-	-	-
Cockles	Southern North Sea	2	-	-	-	0.31 *±0.02*	0.19 *±0.01*	0.25 *±0.01*	-	-	-
Crabs	Parton	4	17 *±0.7*	0.12 *±0.02*	-	0.068 *±0.003*	0.026 *±0.001*	0.011 *±0.001*	0.10 *±0.005*	0.0039 *±0.0006*	0.091 *±0.004*
“	St Bees	4	9.9 *±0.5*	0.15 *±0.04*	-	-	-	-	-	-	-
“	Sellafield coastal area	4	10 *±0.6*	0.091 *±0.030*	-	-	-	-	-	-	-
Lobsters	Parton	3	12 *±0.5*	0.026 *±0.016*	-	0.019 *±0.001*	0.010 *±0.001*	0.0039 *±0.0006*	0.021 *±0.002*	0.00090 *±0.00039*	0.020 *±0.002*
“	St Bees	4	7.6 *±0.4*	0.017 *±0.022*	-	-	-	-	-	-	-
Shrimps	Ribble Estuary	1	-	-	0.15 *±0.16*	0.0040 *±0.0020*	0.025 *±0.002*	0.0050 *±0.0010*	-	-	-
Cod	Parton	1	0.68 *±0.06*	0.017 *±0.006*	-	0.016 *±0.001*	0.0020 *±0.0003*	0.00070 *±0.00020*	0.0050 *±0.0004*	0.00021 *±0.00009*	0.0043 *±0.0004*
Flounder	Whitehaven	1	1.0 *±0.1*	-	-	-	-	-	-	-	-

\- *not analysed*
[a] *landing point or sampling area*

Table 45. Radioactivity in food and the environment near industrial sites, 1996

Site	Material	No. of samples	Mean radioactivity concentration (dry)[a], Bq kg^{-1}							
			^{134}Cs	^{137}Cs	^{210}Pb	^{210}Po	^{226}Ra	^{232}Th	^{238}Pu	$^{239+240}Pu$
Bakewell, Derbyshire	Grass	2	<0.41	<0.60 *±0.23*	13 *±3.8*	3.3 *±0.1*	1.3 *±0.2*	0.88 *±0.20*	<0.0020	0.010 *±0.002*
	Soil	2	<0.62	<13 *±1.4*	37 *±3.8*	51 *±2.2*	73 *±14*	21 *±2.6*	0.0083 *±0.0028*	0.29 *±0.02*
	Bovine muscle	2	<0.19	<0.18	0.75 *±0.41*	2.0 *±0.1*	0.017 *±0.004*	<0.0037 *±0.0008*	-	0.00025 *±0.00014*
Buxton, Derbyshire	Grass	3	<0.83	<1.2 *±0.5*	8.8 *±0.9*	9.8 *±0.6*	2.4 *±0.2*	0.71 *±0.14*	<0.0037	0.0078 *±0.0024*
	Soil	3	<0.91	22 *±2.5*	67 *±7.6*	98 *±4.4*	110 *±12*	19 *±1.7*	0.011 *±0.006*	0.39 *±0.03*
	Bovine muscle	1	<0.19	<0.19	0.54 *±0.18*	4.1 *±0.2*	0.012 *±0.002*	<0.0050	-	0.00050 *±0.00020*
Didcot, Oxfordshire	Grass	4	<0.55	<0.60 *±0.35*	14 *±1.5*	13 *±1.2*	1.0 *±0.1*	0.65 *±0.11*	<0.0031	<0.0068 *±0.0036*
	Soil	4	<0.36	9.0 *±1.0*	18 *±2.3*	26 *±0.8*	26 *±3.5*	18 *±1.2*	0.0045 *±0.0031*	0.18 *±0.02*
	Rabbit	2	<0.12	0.13 *±0.05*	<0.011 *±0.003*	0.017 *±0.002*	0.023 *±0.001*	0.0053 *±0.0021*	-	<0.00035 *±0.00012*
Hope, Derbyshire	Grass	3	<0.60	0.83 *±0.40*	13 *±1.7*	9.2 *±0.6*	2.0 *±0.1*	0.71 *±0.13*	<0.0024	0.0070 *±0.0023*
	Soil	3	<0.56	14 *±1.5*	32 *±3.1*	47 *±1.4*	14 *±3.3*	17 *±1.8*	0.0052 *±0.0024*	0.23 *±0.02*
	Ovine muscle	1	<0.14	0.14 *±0.09*	1.4 *±0.3*	2.2 *±0.1*	0.020 *±0.003*	0.0042 *±0.0020*	-	0.0040 *±0.0020*

\- *not analysed*
[a] *except for animal samples where wet concentrations apply*

Table 46. Radioactivity in surface water leachate from landfill sites in Scotland, 1996

Area	Location	No. of sampling observations	Mean radioactivity concentration, Bq l^{-1}			
			^{3}H	^{14}C	^{40}K	^{137}Cs
Aberdeen City	Ness Tip	1	290 *±22*	0.22 *±0.08*	1.8 *±0.2*	<0.050
City of Edinburgh	Braehead	1	69 *±14*	0.74 *±0.10*	8.0 *±0.6*	<0.050
City of Glasgow	Summerston Tip	1	890 *±50*	3.0 *±0.2*	18 *±1.2*	0.14 *±0.05*
Clackmannanshire	Black Devon	1	<25	0.27 *±0.07*	4.7 *±0.4*	<0.050
Dundee City	Riverside	1	<25	1.1 *±0.2*	5.5 *±0.4*	<0.050
East Dunbartonshire	Birdston Tip	1	<25	1.8 *±0.2*	<0.74	0.10 *±0.03*
Fife	Balbarton	1	40 *±13*	0.71 *±0.14*	1.6 *±0.1*	<0.050
"	Melville Wood	1	<25	1.1 *±0.1*	4.5 *±0.4*	<0.050
Highland	Longman Tip	1	<25	0.19 *±0.08*	4.1 *±0.4*	0.053 *±0.025*
North Lanarkshire	Dalmacoulter	1	630 *±37*	0.40 *±0.09*	11 *±0.8*	0.07 *±0.04*
"	Kilgarth	1	<25	2.2 *±0.2*	0.49 *±0.07*	<0.050
Stirling	Lower Polmaise	1	<25	0.38 *±0.08*	5.2 *±0.4*	<0.050

Table 47. Radioactivity in plants near landfill sites, 1996

Sampling location	Material	No. of samples	Mean radioactivity concentration (dry)[a], Bq kg^{-1}							
			^{3}H	^{14}C	^{90}Sr	^{125}I	^{134}Cs	^{137}Cs	^{238}Pu	$^{239+240}Pu$
Beddingham Lewes, East Sussex	Grass	4	<40 *±18*	130 *±28*	1.8 *±0.1*	<0.19	<0.61	<0.54 *±0.30*	<0.00099 *±0.00037*	0.0067 *±0.0012*
Cilgwyn Quarry, Gwynedd	"	4	<30	360 *±55*	3.0 *±0.2*	<0.63	<0.69	<5.2 *±0.9*	<0.0095	0.018 *±0.005*
Lyndown, Devon	"	4	<28	150 *±30*	2.4 *±0.2*	<1.3 *±0.2*	<0.60	<0.62 *±0.17*	<0.0010	<0.0024 *±0.0009*
Witton, Cheshire	"	4	<38	130 *±33*	0.76 *±0.12*	<1.1 *±0.3*	<0.59	<0.63	<0.0013	0.0021 *±0.0016*

[a] *Results are available for other artificial nuclides detectable by gamma spectrometry All such results are less than the limit of detection*

Table 48. Caesium radioactivity in the freshwater environment, 1996

Location	Material	No. of sampling observa-tions	Mean radioactivity concentration (wet)[a], Bq kg^{-1}	
			^{134}Cs	^{137}Cs
England				
Branthwaite	Rainbow trout	1	*	0.25 *±0.06*
Narborough[b]	"	1	*	0.22 *±0.10*
Ennerdale Water	Water	1	*	0.0019 *±0.0007*
Devoke Water	Perch	1	7.3 *±0.3*	450 *±1.6*
"	Brown trout	1	1.4 *±0.2*	79 *±0.8*
"	Water	1	*	0.014 *±0.001*
Wales				
Llyn Hiraethlyn	Perch	1	2.3 *±0.3*	130 *±0.9*
"	Water	1	*	0.016 *±0.001*
Scotland				
Loch Dee	Brown trout	1	2.5 *±0.2*	160 *±1.0*
"	Water	3	*	0.023 *±0.001*

* *not detected by the method used*
[a] *except for water where units are Bq l^{-1}*
[b] *Concentrations of 41 ±9.7, 0.00011 ±0.00002, 0.00048 ±0.00005 and 0.00072 ±0.00006 Bq kg^{-1} (wet) of carbon-14, plutonium-238, plutonium-239+240 and americium-241 were also detected in this sample*

Table 49. Radioactivity in terrestrial food from the Isle of Man, 1996

Material or selection[c]	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}														
		^{3}H	^{14}C	^{35}S	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{129}I	Total Cs	^{147}Pm	^{144}Ce	^{238}Pu	$^{239+240}$Pu	^{241}Pu	^{241}Am
Milk[d]	4	<3.0	16 *±3.3*	<0.87 *±0.34*	<0.45	<0.12 *±0.01*	<0.023	<2.9	<0.015	<0.20 *±0.02*	<0.30	<1.8	<0.00020	<0.00015 *±0.00007*	<0.089	<0.00025 *±0.00014*
" max			18 *±3.9*	<1.0	<0.50	<0.20	<0.040	<3.5	<0.020	<0.22 *±0.02*		<2.2		<0.00020	<0.10	<0.00030
" sub-sets	2	-	-	-	<0.25	-	-	<1.8	-	-	-	<1.3	-	-	-	-
" max					<0.30			<2.0				<1.4				
Apples	1	<3.0	13 *±5.0*	0.80	<0.30	<0.061 *±0.049*	-	<2.6	-	0.12 *±0.05*	-	<1.5	-	-	-	-
Cabbage	1	<3.0	3.0 *±3.0*	1.6 *±0.3*	-	0.95 *±0.06*	0.060 *±0.060*	-	<0.039	0.90 *±0.10*	<1.0	-	0.00020 *±0.00020*	<0.00030	<0.11	0.00090 *±0.00060*
" sub-sets	1	-	-	-	<0.50	-	-	<1.7	-	-	-	<1.7	-	-	-	-
Potatoes	1	<3.0	15 *±5.0*	<0.80	<0.40	<0.012	<0.029	<1.2	<0.032	0.21 *±0.06*	<0.30	<0.90	<0.00030	0.00040 *±0.00040*	<0.076	<0.00030

- *not analysed*
* *not detected by the method used*
[a] *except for milk where units are Bq l^{-1}*
[b] *See section 5 for definition*
[c] *Data are arithmetic means unless stated as 'max in this column. 'Max' data are selected to be maxima If no 'max' value is given, the mean is also the maximum. See section 5 for definition*
[d] *The concentration of ^{3}H (organic) was <10 Bq l^{-1}*

Table 50. Radioactivity in seafood and the environment near the Channel Islands, 1996

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																
			^{3}H	^{14}C	^{54}Mn	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{110m}Ag	^{129}I	^{137}Cs	^{155}Eu	^{238}Pu	^{239}Pu + ^{240}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total beta
Rays	Guernsey	1	-	-	*	*	-	-	*	*	-	0.59 *±0.08*	*	0.00030 *±0.00007*	0.0016 *±0.0002*	0.0036 *±0.0002*	*	*	96
Crabs	"	1	-	-	*	0.57 *±0.08*	-	-	*	*	-	*	*	0.0013 *±0.0001*	0.0044 *±0.0003*	0.0044 *±0.0003*	*	0.0010 *±0.0001*	47
"	Jersey	1	-	-	*	0.30 *±0.07*	-	-	*	*	-	0.08 *±0.05*	*	0.00045 *±0.00005*	0.00088 *±0.00008*	0.0026 *±0.0002*	*	0.00059 *±0.00008*	110
"	Alderney	2	-	24 *±6.2*	*	0.27 *±0.08*	-	0.19 *±0.06*	*	*	-	0.03 *±0.04*	*	0.00060 *±0.00006*	0.0014 *±0.0001*	0.0037 *±0.0002*	*	0.00074 *±0.00009*	50
Lobsters	Guernsey	1	-	-	*	*	-	-	*	*	-	*	*	0.00025 *±0.00004*	0.00081 *±0.00008*	0.012 *±0.001*	*	0.0028 *±0.0003*	57
"	Jersey	1	-	-	*	*	-	-	*	*	-	*	*	0.00048 *±0.00006*	0.00095 *±0.00009*	0.0022 *±0.0002*	*	0.00052 *±0.00008*	75
"	Alderney	1	-	-	*	*	-	-	*	*	-	*	*	0.0019 *±0.0001*	0.0086 *±0.0004*	0.027 *±0.001*	0.00099 *±0.00019*	0.0032 *±0.0002*	55
Winkles	Alderney	1	-	26 *±7.2*	*	1.2 *±0.1*	0.045 *±0.005*	-	1.4 *±0.7*	0.14 *±0.11*	-	*	*	0.014 *±0.001*	0.026 *±0.001*	0.044 *±0.002*	*	0.011 *±0.001*	46
Oysters	Jersey	1	-	-	*	0.23 *±0.05*	-	-	*	0.08 *±0.06*	-	0.05 *±0.03*	*	0.0051 *±0.0003*	0.011 *±0.0004*	0.014 *±0.001*	*	0.0029 *±0.0002*	78
Limpets	Guernsey	1	-	-	*	0.10 *±0.07*	-	-	*	*	-	0.09 *±0.05*	*	-	-	*	-	-	59
"	Jersey La Rozel	1	-	-	*	0.27 *±0.06*	-	-	*	*	-	0.05 *±0.04*	*	0.0052 *±0.0003*	0.012 *±0.0005*	0.017 *±0.001*	*	0.0030 *±0.0002*	68
"	Alderney	1	-	-	*	0.20 *±0.04*	-	-	0.83 *±0.36*	*	-	0.03 *±0.02*	*	0.0057 *±0.0003*	0.012 *±0.0005*	0.023 *±0.001*	*	0.0048 *±0.0003*	65
Ormers	Guernsey	1	-	-	*	*	-	-	*	*	-	0.09 *±0.05*	*	-	-	*	-	-	77
Porphyra	Guernsey Fermain Bay	4	-	-	*	0.33 *±0.09*	-	-	*	*	-	0.05 *±0.06*	*	0.0040 *±0.0003*	0.011 *±0.001*	0.015 *±0.001*	0.000052 *±0.00033*	0.0028 *±0.0003*	110
"	Jersey Plemont Bay	4	-	-	*	0.05 *±0.03*	-	-	0.13 *±0.18*	*	-	0.10 *±0.06*	*	-	-	*	-	-	230
"	Alderney Quenard Point	4	-	-	*	0.15 *±0.04*	-	-	1.2 *±0.4*	*	-	0.02 *±0.02*	*	-	-	*	-	-	96

Table 50. continued

Material	Location[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}																
			^{3}H	^{14}C	^{54}Mn	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{110m}Ag	^{129}I	^{137}Cs	^{155}Eu	^{238}Pu	^{239}Pu + ^{240}Pu	^{241}Am	^{242}Cm	^{243}Cm+ ^{244}Cm	Total beta
Fucus vesiculosus	Alderney Quenard Point	2	-	-	-	-	-	-	-	-	1.5 *±0.4*	-	-	-	-	-	-	-	-
Fucus serratus	Guernsey Fermain Bay	4	-	-	*	0.31 *±0.06*	0.069 *±0.004*	-	*	*	-	0.06 *±0.03*	*	0.0064 *±0.0003*	0.019 *±0.001*	0.0082 *±0.0003*	*	0.0015 *±0.0001*	140
"	Jersey La Rozel	4	-	-	*	0.72 *±0.09*	0.091 *±0.010*	-	*	*	-	0.14 *±0.06*	*	0.018 *±0.001*	0.038 *±0.001*	0.018 *±0.001*	0.00013 *±0.00007*	0.0034 *±0.0002*	210
"	Alderney Quenard Point	4	-	-	*	0.60 *±0.10*	0.093 *±0.020*	-	*	*	-	0.08 *±0.05*	0.14 *±0.12*	0.0094 *±0.0005*	0.021 *±0.001*	0.011 *±0.001*	*	0.0025 *±0.0004*	170
Laminaria digitata	Jersey Verclut	4	-	-	*	0.04 *±0.03*	-	-	*	*	-	0.11 *±0.05*	*	-	-	*	-	-	300
Mud	Jersey St Helier	1	-	-	0.41 *±0.30*	27 *±0.6*	-	-	6.5 *±2.7*	*	-	5.7 *±0.3*	*	1.2 *±0.05*	2.7 *±0.1*	4.4 *±0.2*	0.018 *±0.009*	0.81 *±0.05*	700
Sand	Guernsey Bordeaux Harbour	1	-	-	*	0.47 *±0.24*	-	-	*	*	-	1.3 *±0.3*	*	0.067 *±0.009*	0.27 *±0.02*	0.23 *±0.02*	*	0.026 *±0.006*	490
"	Alderney Lt. Crabbe Harbour	1	-	-	*	0.60 *±0.25*	-	-	*	*	-	2.0 *±0.2*	*	-	-	*	-	-	300
Sea water	Guernsey	4	-	-	-	-	-	-	-	-	-	0.005 *±0.001*	-	-	-	-	-	-	-
"	Jersey	1	-	-	-	-	-	-	-	-	-	0.003 *±0.001*	-	-	-	-	-	-	-
"	Alderney	4	3.6 *±1.7*	-	-	-	-	-	-	-	-	0.005 *±0.001*	-	-	-	-	-	-	-

- not analysed
** not detected by the method used*
[a] *Except for seawater where units are Bq l^{-1} and for sediment where dry concentrations apply*
[b] *Landing point or sampling area*
[c] *See section 5 for definition*

Table 51. Radioactivity in regional diet in England and Wales, 1996

Region	No. of sampling observations[b]	Mean radioactivity concentration (wet)[a], Bq kg^{-1}												
		^{3}H	^{14}C	^{35}S	^{40}K	^{90}Sr	^{137}Cs	^{210}Pb	^{210}Po	^{226}Ra	U	^{238}Pu	$^{239+240}$Pu	^{241}Am
Wales	1	<12	68 *±7.8*	2.8 *±0.6*	68 *±7.7*	<0.090	<0.14	0.0048 *±0.0031*	0.027 *±0.004*	0.037 *±0.009*	0.020 *±0.004*	0.000088 *±0.000077*	0.00033 *±0.00014*	<0.00030
East Midlands	1	<12	45 *±4.3*	0.71 *±0.54*	69 *±7.9*	<0.10	<0.15	0.025 *±0.005*	0.037 *±0.003*	0.042 *±0.005*	0.027 *±0.005*	<0.00020	0.00011 *±0.00007*	<0.00040
South West	1	<13	57 *±7.6*	1.9 *±0.3*	78 *±8.6*	0.060 *±0.040*	0.06 *±0.05*	0.0070 *±0.0031*	0.031 *±0.002*	0.034 *±0.006*	0.019 *±0.004*	<0.00030	0.00020 *±0.00013*	<0.00060
North East	1	<12	60 *±20*	1.3 *±0.4*	74 *±8.4*	<0.10	<0.16	0.018 *±0.012*	0.030 *±0.007*	0.033 *±0.001*	0.019 *±0.004*	<0.00020	0.00016 *±0.00009*	<0.00010
South East	1	<13	50 *±6.7*	0.79 *±0.41*	69 *±8.0*	<0.20	<0.17	0.0097 *±0.0048*	0.036 *±0.003*	0.031 *±0.004*	0.024 *±0.005*	<0.00020	0.00011 *±0.00009*	<0.00030
West Midlands	1	<13	55 *±6.4*	1.6 *±0.5*	66 *±7.4*	0.080 *±0.040*	<0.10	0.036 *±0.022*	0.044 *±0.005*	0.035 *±0.005*	0.021 *±0.004*	<0.00020	0.00019 *±0.00014*	<0.00040
East	1	<12	47 *±4.7*	0.68 *±0.53*	71 *±8.0*	0.080 *±0.040*	<0.10	0.015 *±0.004*	0.040 *±0.005*	0.32 *±0.03*	0.015 *±0.004*	<0.00020	0.00030 *±0.00020*	<0.00040
South	1	<13	50 *±10*	3.7 *±0.9*	66 *±7.4*	0.10 *±0.09*	<0.12	0.033 *±0.013*	0.056 *±0.005*	0.042 *±0.006*	0.028 *±0.005*	<0.00020	0.00024 *±0.00012*	<0.00040
North West	1	<12	41 *±3.8*	<0.60	71 *±8.2*	0.12 *±0.07*	<0.16	0.011 *±0.004*	0.036 *±0.004*	0.032 *±0.005*	0.020 *±0.004*	<0.00010	0.00040 *±0.00013*	<0.00040

[a] *Results are available for other artificial nuclides detectable by gamma spectrometry*
All such results are less than the limit of detection

[b] *See section 5 for definition*

Table 52. Radioactivity in regional diet in Scotland, 1996

Area	No. of sampling observa-tions	Mean radioactivity concentration (wet), Bq kg^{-1}			
		^{3}H	^{40}K	^{90}Sr	^{137}Cs
Dumfries and Galloway (Dumfries)	12	<25	79 *±4.9*	<0.10	<0.11 *±0.07*
East Lothian (North Berwick)	12	<25	82 *±5.1*	<0.10	<0.087 *±0.037*
Highland (Dingwall)	12	<25	84 *±5.2*	<0.10	<0.084 *±0.047*
Renfrewshire (Paisley)	12	<25	83 *±5.2*	<0.10	<0.15 *±0.08*

Table 53 . Estimates of radiation exposure from radionuclides in regional diet, 1996

Nuclide[a]	Exposure, mSv[b]	
	Mean	Range
Man-made radionuclides		
Tritium	0.0002	0.0001-0.0002
Sulphur-35	0.002	0.0006-0.004
Strontium-90	0.002	0.001-0.004
Caesium-137	0.0003	0.0001-0.0004
Plutonium-238	0.00001	0.000007-0.00002
Plutonium-239+240	0.00002	0.000009-0.00003
Americium-241	0.00003	0.000007-0.00004
Sub-total	0.004	
Natural radionuclides		
Carbon-14	0.016	0.013-0.021
Lead-210	0.012	0.007-0.025
Polonium-210	0.064	0.046-0.096
Radium-226	0.013	0.006-0.060
Uranium	0.0005	0.0004-0.0007
Sub-total	0.11	
Total	0.11	

[a] *Tritium is also produced by natural means and carbon-14 by man. Levels of natural radionuclides may be enhanced by man's activities*

[b] *To a 1 year old child consuming at average rates. Exposures due to the potassium-40 content of food are not included here because they do not vary according to the potassium-40 content of food. Levels of potassium in the body are homeostatically controlled*

Table 54. Radioactivity in milk remote from nuclear sites, 1996

Location	Selection[a]	No. of sampling observa-tions[b]	Mean radioactivity concentration, Bq l^{-1}											
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{129}I	Total Cs	^{210}Pb	^{210}Po	Total U	^{238}Pu	$^{239}Pu+^{240}Pu$	Total alpha
Co. Antrim		11	<2.9 *±1.1*	16 *±4.0*	-	0.037 *±0.010*	-	0.31 *±0.03*	<0.019	0.0050 *±0.0040*	<0.0065	0.00010 *±0.00010*	<0.00010	-
	max		3.0 *±3.0*	22 *±3.0*		0.047 *±0.008*		0.44 *±0.04*						
Co. Armagh		12	<3.0	16 *±3.5*	-	0.042 *±0.010*	-	0.097 *±0.026*	0.022 *±0.022*	0.0060 *±0.0040*	<0.0065	<0.00010	<0.00010	-
	max			19 *±4.0*		0.070 *±0.014*		0.17 *±0.03*						
Cambridgeshire[c]		12	<2.0	14 *±3.6*	-	0.026 *±0.006*	-	0.062 *±0.011*	<0.021	0.0040 *±0.0040*	<0.0065	<0.00010	<0.00010	-
	max			18 *±5.0*		0.038 *±0.005*		0.080 *±0.011*						
Clwyd		11	<3.0	13 *±3.7*	-	0.034 *±0.010*	-	0.056 *±0.024*	0.022 *±0.022*	<0.0030	<0.0065	<0.00010	<0.00010	-
	max			18 *±5.0*		0.038 *±0.010*		0.10 *±0.03*						
Cornwall		24	<3.0	13 *±3.4*	-	0.054 *±0.010*	-	0.074 *±0.023*	<0.017	<0.0065 *±0.0028*	<0.0065	<0.00020	<0.00015	-
	max			21 *±4.0*		0.068 *±0.010*		0.12 *±0.02*		0.0070 *±0.0040*			<0.00020	
Co. Down		12	<3.0	15 *±3.6*	-	0.048 *±0.010*	-	0.12 *±0.03*	<0.019	0.0070 *±0.0040*	<0.0065	0.00010 *±0.00010*	<0.00010	-
	max			18 *±5.0*		0.065 *±0.010*		0.17 *±0.03*						
Dumfries and Galloway		12	<25	13 *±2.2*	<5.0	<0.10	<0.16	<0.12[d] *±0.05*	-	-	-	-	-	<0.35
	max			15 *±2.1*			<0.20	0.43[d] *±0.07*						<0.37
Co. Fermanagh		12	<3.0	15 *±4.1*	-	0.050 *±0.011*	-	0.24 *±0.03*	<0.020	0.0060 *±0.0040*	<0.0065	0.00010 *±0.00010*	0.00010 *±0.00010*	-
	max			23 *±5.0*		0.076 *±0.012*		0.42 *±0.02*						
Gloucestershire		12	<3.0	14 *±3.6*	-	0.032 *±0.010*	-	0.050 *±0.021*	<0.015	0.0040 *±0.0030*	<0.0065	<0.00020	<0.00010	-
	max			17 *±4.0*		0.042 *±0.009*		0.077 *±0.023*						
Gwent[c]		11	<2.4 *±1.6*	13 *±3.5*	-	0.042 *±0.005*	-	0.060 *±0.009*	<0.019	<0.0040	0.0067 *±0.0026*	<0.00020	<0.00020	-
	max		4.0 *±3.0*	16 *±3.0*		0.055 *±0.004*		0.096 *±0.010*						
Gwynedd		10	<3.0	14 *±4.0*	-	0.052 *±0.012*	-	0.068 *±0.023*	0.031 *±0.027*	<0.0030	<0.0065	<0.00010	<0.00020	-
	max			20 *±4.0*		0.062 *±0.026*		0.14 *±0.03*						

Table 54. continued

Location	Selection[a]	No. of sampling observa-tions[b]	Mean radioactivity concentration, Bq l^{-1}											
			^{3}H	^{14}C	^{35}S	^{90}Sr	^{129}I	Total Cs	^{210}Pb	^{210}Po	Total U	^{238}Pu	$^{239}Pu+^{240}Pu$	Total alpha
Hampshire		12	<3.0	14 *±3.9*	-	0.035 *±0.009*	-	0.070 *±0.021*	<0.022	0.0070 *±0.0030*	<0.0065	<0.00020	<0.00010	-
	max			25 *±4.0*		0.049 *±0.009*		0.11 *±0.03*						
Highland		12	<25	13 *±2.6*	<5.0	<0.10	<0.16	<0.12[d] *±0.06*	-	-	-	-	-	<0.33
	max			14 *±2.2*			<0.20	0.20[d] *±0.07*						<0.34
Humberside		12	<3.1 *±1.2*	13 *±3.5*	-	0.024 *±0.011*	-	0.088 *±0.023*	<0.025	0.0070 *±0.0030*	<0.0065	<0.00010 *±0.00010*	<0.00010	-
	max		4.0 *±4.0*	18 *±4.0*		0.029 *±0.012*		0.28 *±0.03*						
Kent		9	<3.0	15 *±3.8*	-	0.027 *±0.011*	-	0.053 *±0.022*	<0.017	0.0070 *±0.0040*	<0.0065	<0.00010	<0.00010	-
	max			24 *±4.0*		0.035 *±0.015*		0.095 *±0.022*						
Lancashire		10	<3.1 *±1.3*	12 *±3.6*	-	0.034 *±0.013*	-	0.099 *±0.027*	<0.017	0.0050 *±0.0040*	<0.0065	0.00010 *±0.00010*	<0.00010	-
	max		4.0 *±4.0*	16 *±3.0*		0.068 *±0.010*		0.28 *±0.03*						
Lincolnshire		12	<3.0 *±0.9*	15 *±3.8*	-	0.018 *±0.010*	-	0.066 *±0.022*	<0.020	0.0040 *±0.0040*	<0.0065	<0.00020	<0.00010	-
	max		3.0 *±3.0*	25 *±5.0*		0.023 *±0.007*		0.15 *±0.03*						
Co. Londonderry		12	<3.0	14 *±3.8*	-	0.041 *±0.010*	-	0.15 *±0.03*	0.027 *±0.010*	0.0060 *±0.0040*	<0.0065	0.00010 *±0.00010*	<0.00010	-
	max			19 *±4.0*		0.053 *±0.010*		0.32 *±0.03*						
Midlothian		12	<25	13 *±2.6*	<5.0	<0.10	<0.16	<0.062[d] *±0.017*	-	-	-	-	-	<0.35
	max			16 *±2.3*			<0.20	0.085[d] *±0.044*						<0.38
Norfolk		12	<3.1 *±1.2*	12 *±3.4*	-	0.023 *±0.011*	-	0.097 *±0.023*	<0.020	0.012 *±0.005*	<0.0065	<0.00010	<0.00010	-
	max		4.0 *±4.0*	16 *±3.0*		0.029 *±0.010*		0.31 *±0.03*						
North Yorkshire		12	<3.0	13 *±3.6*	-	0.032 *±0.010*	-	0.065 *±0.023*	<0.021	0.0090 *±0.0030*	<0.0065	0.00010 *±0.00010*	<0.00010	-
	max			17 *±3.0*		0.041 *±0.010*		0.092 *±0.023*						
Oxfordshire		12	<3.1 *±1.2*	14 *±3.6*	-	0.025 *±0.010*	-	0.069 *±0.022*	<0.021	0.0050 *±0.0030*	<0.0065	<0.00020	<0.00010	-
	max		4.0 *±4.0*	20 *±3.0*		0.058 *±0.011*		0.13 *±0.03*						

Table 54. continued

Location	Selection[a]	No. of sampling observa-tions[b]	Mean radioactivity concentration, Bq l^{-1} ^{3}H	^{14}C	^{35}S	^{90}Sr	^{129}I	Total Cs	^{210}Pb	^{210}Po	Total U	^{238}Pu	^{239}Pu+ ^{240}Pu	Total alpha
Renfrewshire		12	<25	13 *±2.0*	<5.0	<0.10	<0.16	<0.22[d] *±0.06*	-	-	-	-	-	<0.33
	max			14 *±2.0*			<0.20	0.62[d] *±0.08*						
Shropshire		12	<3.2 *±1.2*	15 *±3.2*	-	0.035 *±0.009*	-	0.053 *±0.021*	<0.021	0.0090 *±0.0050*	<0.0065	<0.00010	<0.00010	-
	max		5.0 *±4.0*	22 *±3.0*		0.058 *±0.010*		0.087 *±0.023*						
Somerset		12	<3.0	14 *±3.5*	-	0.047 *±0.010*	-	<0.077 *±0.021*	<0.023	0.0050 *±0.0040*	<0.0065	0.00010 *±0.00010*	<0.00010	-
	max			18 *±3.0*		0.067 *±0.011*		0.16 *±0.03*						
Suffolk		12	<3.0	14 *±3.9*	-	0.013 *±0.010*	-	0.064 *±0.022*	<0.022	0.010 *±0.005*	<0.0065	<0.00010	<0.00010	-
	max			18 *±5.0*		0.021 *±0.006*		0.12 *±0.03*						
Tyneside		12	<4.8 *±2.3*	12 *±3.3*	-	0.038 *±0.009*	-	0.079 *±0.023*	<0.021	0.012 *±0.005*	<0.0065	<0.00010	<0.00020	-
	max		12 *±4.0*	14 *±4.0*		0.057 *±0.010*		0.13 *±0.03*						
Co. Tyrone[c]		12	<2.0	15 *±3.8*	-	0.037 *±0.004*	-	0.19 *±0.01*	<0.023	0.0060 *±0.0040*	<0.0065	<0.00010	<0.00010	-
	max			20 *±4.0*		0.049 *±0.005*		0.24 *±0.01*						
West Midlands		12	<3.0	14 *±3.6*	-	0.032 *±0.011*	-	0.067 *±0.023*	<0.015	0.012 *±0.004*	<0.0065	<0.00010	<0.00010	-
	max			19 *±4.0*		0.074 *±0.010*		0.18 *±0.03*						
Mean values														
England			<3.1 *±0.9*	14 *±3.6*	-	0.031 *±0.010*	-	0.071 *±0.022*	<0.020	0.0074 *±0.0039*	<0.0065	<0.00013 *±0.00005*	<0.00011	-
Northern Ireland			<2.8 *±0.4*	15 *±3.8*	-	0.043 *±0.009*	-	0.18 *±0.03*	<0.022 *±0.010*	0.0060 *±0.0040*	<0.0065	<0.00010 *±0.00008*	<0.00010 *±0.00004*	-
Wales			<2.8 *±0.9*	13 *±3.7*	-	0.043 *±0.009*	-	0.061 *±0.020*	<0.024 *±0.020*	<0.0033	<0.0066 *±0.0015*	<0.00013	<0.00017	-
Scotland			<25	13 *±2.4*	<5.0	<0.010	<0.16	<0.13[d] *±0.05*	-	-	-	-	-	<0.34
United Kingdom			<8.4 *±0.6*	14 *±3.4*	-	<0.032 *±0.008*	-	<0.11 *±0.03*	<0.022 *±0.013*	<0.0056 *±0.0032*	<0.0065 *±0.0001*	<0.00012 *±0.00005*	<0.00013 *±0.00002*	-

[a] *Data are arithmetic means unless stated as 'max'. 'Max' data are selected to be maxima*
If no 'max' value is given, the mean is also the maximum. See section 5 for definition
[b] *See section 5 for definition*
\- *Not analysed*
[c] *Sub-sets for ^{3}H, ^{90}Sr and Total Cs*
[d] *^{137}Cs only*

Table 55. Radioactivity in crops remote from nuclear sites, 1996[b]

Location		Material	No of samples[a]	Mean radioactivity concentration (wet), Bq kg^{-1}													
				^{3}H	^{14}C	^{35}S	^{90}Sr	Total Cs	^{210}Pb	^{210}Po	^{226}Ra	^{232}Th	Total U	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Am	Total Alpha
Cambridgeshire	Ely	Calabrese	1	<3.0	11 ±3.0	-	0.061 ±0.061	<0.071	0.13 ±0.03	0.054 ±0.007	0.035 ±0.016	<0.0030	<0.028	<0.00020	0.00030 ±0.00030	<0.00030	-
		Potatoes	1	<3.0	19 ±3.0	-	0.050 ±0.050	<0.046	0.055 ±0.028	0.0090 ±0.0040	0.013 ±0.004	0.0040 ±0.0030	0.032 ±0.010	<0.00010	0.00020 ±0.00020	<0.00030	-
		Strawberries	1	<3.0	4.0 ±3.0	-	0.041 ±0.021	<0.043	-	-	-	-	-	<0.00020	<0.00020	0.00040 ±0.00040	-
Cornwall	Launceston	Apples	1	<3.0	14 ±4.0	-	0.11 ±0.03	0.085 ±0.060	-	-	-	-	-	<0.00020	0.00010 ±0.00010	<0.00040	-
		Fodder Beet	1	<3.0	10 ±4.0	-	0.69 ±0.04	0.12 ±0.07	-	-	-	-	-	0.00020 ±0.00020	0.00040 ±0.00020	<0.00020	-
		Leafy Green Veg.	1	<3.0	8.0 ±4.0	-	0.24 ±0.03	0.14 ±0.06	-	-	-	-	-	0.00030 ±0.00030	0.00020 ±0.00020	<0.00040	-
Devon	South Molton	Kale	1	4.0 ±4.0	8.0 ±3.0	-	1.2 ±0.6	0.080 ±0.070	0.25 ±0.06	0.084 ±0.009	0.11 ±0.01	0.0060 ±0.0060	<0.047	<0.00020	<0.00020	0.00040 ±0.00040	-
		Turnips	1	<3.0	<3.0	-	0.29 ±0.04	<0.049	0.057 ±0.040	0.032 ±0.010	0.018 ±0.005	0.0020 ±0.0020	0.027 ±0.009	<0.00010	0.00010 ±0.00010	0.00030 ±0.00030	-
		Strawberries	1	<3.0	7.0 ±4.0	-	0.18 ±0.03	<0.048	-	-	-	-	-	<0.00010	<0.00020	0.00030 ±0.00030	-
Dumfries and Galloway	Dumfries	Leafy Green Veg.	4	<25	4.1 ±0.9	<5.0	<0.10	<0.089[c]	-	-	-	-	-	-	-	-	<0.27
Dyfed	Camarthen	Cabbage	1	<3.0	7.0 ±4.0	-	0.98 ±0.06	0.16 ±0.08	-	-	-	-	-	<0.00020	<0.00020	0.00040 ±0.00040	-
		Potatoes	2	<3.0	19 ±5.5	-	0.089 ±0.031	<0.086 ±0.053	-	-	-	-	-	<0.00015 ±0.00007	0.00030 ±0.00026	<0.00045 ±0.00028	-
East Lothian	North Berwick	Leafy Green Veg.	4	<25	4.3 ±0.9	<5.0	<0.10	<0.075[c] ±0.027	-	-	-	-	-	-	-	-	<0.24
Hampshire	Winchester	Beetroot	1	<3.0	13 ±5.0	-	0.12 ±0.03	0.13 ±0.05	-	-	-	-	-	<0.00010	0.00010 ±0.00010	<0.00030	-
		Cabbage	1	<3.0	6.0 ±4.0	-	0.086 ±0.027	0.051 ±0.051	-	-	-	-	-	<0.00010	<0.00010	<0.00020	-
		Raspberries	1	<3.0	13 ±4.0	-	0.088 ±0.036	0.049 ±0.043	-	-	-	-	-	<0.00010	<0.00020	<0.00040	-
Highlands	Dingwall	Leafy Green Veg.	4	<25	4.3 ±0.9	<5.0	<0.10	<0.085[c] ±0.039	-	-	-	-	-	-	-	-	<0.27
Leicestershire	Beeby	Plums	1	<3.0	9.0 ±4.0	-	<0.017	0.48 ±0.09	-	-	-	-	-	<0.00020	<0.00020	0.00020 ±0.00020	-
	Thurlaston	Leafy Green Veg.	1	<3.0	8.0 ±3.0	-	0.37 ±0.03	<0.044	0.23 ±0.05	0.071 ±0.012	0.064 ±0.014	<0.0050	<0.021	<0.00010	<0.00020	<0.00030	-
		Root Veg.	1	<3.0	13 ±3.0	-	0.26 ±0.04	0.23 ±0.07	0.16 ±0.06	0.050 ±0.009	0.047 ±0.016	0.044 ±0.012	0.10 ±0.02	<0.00020	0.00020 ±0.00020	0.00030 ±0.00030	-
Lincolnshire	Lincoln	Cabbage	1	<3.0	6.0 ±3.0	-	0.11 ±0.02	0.096 ±0.046	-	-	-	-	-	<0.00010	<0.00020	<0.00020	-
		Potatoes	1	<3.0	17 ±4.0	-	0.083 ±0.036	<0.052	-	-	-	-	-	<0.00020	<0.00020	<0.00050	-
		Raspberries	1	<3.0	18 ±5.0	-	0.064 ±0.015	<0.044	-	-	-	-	-	<0.00020	0.00020 ±0.00020	<0.00020	-
Norfolk	Fakenham	Blackcurrants	1	<3.0	23 ±6.0	-	0.10 ±0.02	<0.043	-	-	-	-	-	<0.00010	<0.00020	<0.00030	-
		Cabbage	1	<3.0	9.0 ±3.0	-	0.097 ±0.035	<0.049	-	-	-	-	-	<0.00010	<0.00010	<0.00030	-
		Carrots	1	<3.0	10 ±4.0	-	0.10 ±0.02	<0.044	-	-	-	-	-	0.00010 ±0.00010	<0.00020	0.00050 ±0.00050	-

Table 55. continued

Location	Material	No of samples[a]	^{3}H	^{14}C	^{35}S	^{90}Sr	Total Cs	^{210}Pb	^{210}Po	^{226}Ra	^{232}Th	Total U	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Am	Total Alpha
			Mean radioactivity concentration (wet), Bq kg^{-1}													
Northumberland																
Berwick Upon Tweed	Apples	1	<3.0	13 *±4.0*	-	0.031 *±0.021*	<0.049	-	-	-	-	-	<0.00020	0.00010 *±0.00010*	<0.00040	-
	Cabbage	1	<3.0	7.0 *±3.0*	-	0.73 *±0.05*	0.18 *±0.06*	0.081 *±0.035*	0.047 *±0.010*	0.050 *±0.007*	0.0060 *±0.0040*	0.040 *±0.010*	<0.00010	<0.00020	<0.00040	-
	Carrots	1	<3.0	8.0 *±4.0*	-	0.12 *±0.03*	0.084 *±0.058*	0.48 *±0.06*	0.016 *±0.008*	0.031 *±0.006*	0.0050 *±0.0030*	0.019 *±0.007*	<0.00010	<0.00020	0.00040 *±0.00040*	-
Hexham	Kale	1	5.0 *±4.0*	9.0 *±3.0*	-	2.5 *±0.1*	0.073 *±0.070*	-	-	-	-	-	0.00010 *±0.00010*	0.00020 *±0.00020*	0.00030 *±0.00030*	-
	Strawberries	1	<3.0	7.0 *±4.0*	-	0.15 *±0.03*	<0.044	-	-	-	-	-	<0.00010	<0.00010	<0.00030	-
	Turnips	1	<3.0	8.0 *±3.0*	-	0.41 *±0.04*	0.048 *±0.048*	-	-	-	-	-	<0.00010	0.00020 *±0.00020*	<0.00020	-
Powys																
Brecon	Cabbage	1	<3.0	4.0 *±3.0*	-	-	-	0.23 *±0.03*	0.084 *±0.012*	0.0090 *±0.0090*	0.0030 *±0.0030*	<0.020	<0.00020	<0.00020	<0.00050	-
	Strawberries	1	<3.0	12 *±4.0*	-	0.43 *±0.04*	<0.051	-	-	-	-	-	<0.00020	<0.00020	0.0010 *±0.0006*	-
	Swede	1	5.0 *±4.0*	9.0 *±5.0*	-	0.38 *±0.04*	0.053 *±0.053*	0.17 *±0.03*	0.069 *±0.010*	0.015 *±0.015*	0.0050 *±0.0040*	0.022 *±0.007*	<0.00020	0.00030 *±0.00030*	<0.00020	-
Renfrewshire																
Paisley	Leafy Green Veg.	4	<33 *±6.5*	4.7 *±1.0*	<5.0	<0.11 *±0.01*	<0.11[c] *±0.03*	-	-	-	-	-	-	-	-	<0.31
Shropshire																
Ludlow	Leafy Green Veg.	1	<3.0	12 *±3.0*	-	1.0 *±0.05*	<0.044	0.19 *±0.04*	0.071 *±0.016*	0.16 *±0.03*	<0.0020	<0.030	<0.00020	<0.00020	<0.00030	-
	Potatoes	1	<3.0	20 *±6.0*	-	0.075 *±0.021*	0.060 *±0.060*	0.059 *±0.033*	0.021 *±0.005*	0.024 *±0.004*	0.0080 *±0.0050*	0.038 *±0.012*	<0.00010	<0.00020	0.00060 *±0.00040*	-
	Redcurrants	1	<3.0	15 *±3.0*	-	0.11 *±0.02*	<0.044	-	-	-	-	-	<0.00010	<0.00010	<0.00020	-
Somerset																
Shepton Mallet	Cabbage	1	3.0 *±3.0*	14 *±5.0*	-	0.55 *±0.05*	0.10 *±0.07*	0.55 *±0.05*	0.22 *±0.03*	0.44 *±0.05*	0.025 *±0.008*	0.10 *±0.02*	<0.00020	<0.00020	0.0011 *±0.0009*	-
	Grapes	1	<3.0	8.0 *±3.0*	-	0.051 *±0.034*	1.1 *±0.1*	-	-	-	-	-	<0.00010	<0.00020	<0.00030	-
	Potatoes	1	<3.0	23 *±6.0*	-	<0.012	<0.049	0.13 *±0.03*	0.10 *±0.03*	0.13 *±0.01*	0.032 *±0.006*	0.088 *±0.013*	<0.00010	<0.00020	0.00030 *±0.00030*	-
South Yorkshire																
Barnsley	Blackberries	1	<3.0	16 *±4.0*	-	0.16 *±0.04*	0.26 *±0.09*	-	-	-	-	-	<0.00010	<0.00020	0.00030 *±0.00030*	-
	Cabbage	1	4.0 *±4.0*	10 *±3.0*	-	0.13 *±0.03*	0.19 *±0.18*	-	-	-	-	-	<0.00010	<0.00020	<0.00070	-
	Kohlrabi	1	<3.0	8.0 *±5.0*	-	0.15 *±0.04*	<0.050	-	-	-	-	-	<0.00010	0.00010 *±0.00010*	<0.00040	-
Staffordshire																
Stafford	Leafy Green Veg.	1	<3.0	5.0 *±4.0*	-	0.22 *±0.03*	0.063 *±0.042*	-	-	-	-	-	<0.00020	0.00020 *±0.00020*	<0.00030	-
	Strawberries	1	<3.0	9.0 *±4.0*	-	0.10 *±0.03*	<0.043	-	-	-	-	-	0.00010 *±0.00010*	<0.00020	<0.00030	-
	Turnips	1	<3.0	7.0 *±5.0*	-	0.32 *±0.04*	<0.043	-	-	-	-	-	0.00020 *±0.00020*	<0.00020	<0.00030	-
West Midlands																
Wallsall	Cabbage	2	<3.0	12 *±3.0*	-	0.29 *±0.05*	<0.070 *±0.026*	-	-	-	-	-	<0.00015 *±0.00014*	<0.0014 *±0.0006*	<0.00055 *±0.00028*	-
	Potatoes	1	4.0 *±4.0*	16 *±5.0*	-	0.028 *±0.018*	0.076 *±0.069*	-	-	-	-	-	0.00010 *±0.00010*	0.00020 *±0.00020*	<0.00030	-

Table 55. continued

Location	Material	No of samples[a]	Mean radioactivity concentration (wet), Bq kg^{-1}													
			^{3}H	^{14}C	^{35}S	^{90}Sr	Total Cs	^{210}Pb	^{210}Po	^{226}Ra	^{232}Th	Total U	^{238}Pu	^{239}Pu+ ^{240}Pu	^{241}Am	Total Alpha
West Sussex																
Chichester	Leeks	1	<3.0	12 *±3.0*	-	0.72 *±0.05*	<0.054	0.62 *±0.04*	0.24 *±0.02*	0.047 *±0.005*	0.10 *±0.02*	0.29 *±0.03*	<0.00020	0.0010 *±0.0004*	0.00090 *±0.00060*	-
	Potatoes	1	<3.0	29 *±5.0*	-	0.052 *±0.052*	<0.050	<0.022	0.013 *±0.006*	0.016 *±0.004*	0.024 *±0.005*	0.052 *±0.014*	<0.00020	<0.00020	<0.00060	-
	Wheat	1	<4.0	81 *±20*	-	0.15 *±0.04*	<0.051	-	-	-	-	-	<0.00020	0.00060 *±0.00040*	<0.00050	-
West Yorkshire																
Leeds	Cabbage	1	<3.0	9.0 *±3.0*	-	0.44 *±0.04*	0.048 *±0.048*	0.21 *±0.04*	0.062 *±0.014*	0.11 *±0.02*	0.0030 *±0.0030*	<0.041	<0.00010	0.00010 *±0.00010*	0.00050 *±0.00040*	-
	Elderberries	1	<3.0	24 *±5.0*	-	0.11 *±0.03*	0.13 *±0.06*	-	-	-	-	-	0.00010 *±0.00010*	<0.00020	0.00040 *±0.00040*	-
	Potatoes	1	<3.0	15 *±4.0*	-	<0.016	0.064 *±0.056*	1.6 *±0.1*	0.023 *±0.007*	0.013 *±0.005*	0.0070 *±0.0040*	0.032 *±0.011*	<0.00010	<0.00020	<0.00030	-
Wiltshire																
Devizes	Cabbage	1	<3.0	13 *±4.0*	-	0.18 *±0.03*	<0.047	-	-	-	-	-	<0.00020	0.00020 *±0.00020*	0.00030 *±0.00030*	-
	Parsnips	1	5.0 *±4.0*	18 *±5.0*	-	0.18 *±0.03*	<0.050	-	-	-	-	-	<0.00020	<0.00020	<0.00040	-
	Swede	1	<3.0	9.0 *±5.0*	-	0.26 *±0.04*	<0.050	-	-	-	-	-	<0.00020	0.00040 *±0.00030*	<0.00030	-
Worcestershire																
Bromsgrove	Apples	1	<3.0	11 *±5.0*	-	<0.021	<0.071	-	-	-	-	-	<0.00010	<0.00010	<0.00020	-
	Cabbage	1	<3.0	6.0 *±4.0*	-	0.18 *±0.04*	<0.051	<0.024	0.015 *±0.004*	<0.0040	<0.0020	<0.023	<0.00020	<0.00020	<0.00050	-
	Potatoes	1	<3.0	24 *±6.0*	-	0.059 *±0.038*	<0.051	0.066 *±0.029*	0.044 *±0.006*	0.025 *±0.003*	0.024 *±0.005*	0.084 *±0.014*	0.00020 *±0.00020*	0.00030 *±0.00030*	<0.00050	-
Mean values																
England			<3.2 *±1.3*	13 *±4.9*	-	<0.26 *±0.09*	<0.10 *±0.05*	<0.27 *±0.05*	0.065 *±0.014*	<0.074 *±0.017*	<0.017 *±0.007*	<0.061 *±0.013*	<0.00015 *±0.00007*	<0.00024 *±0.00016*	<0.00038 *±0.00024*	-
Wales			<3.3 *±1.6*	12 *±4.6*	-	0.39 *±0.04*	<0.087 *±0.056*	0.20 *±0.03*	0.077 *±0.011*	0.012 *±0.012*	0.0040 *±0.0035*	<0.021 *±0.005*	<0.00018 *±0.00004*	<0.00025 *±0.00019*	<0.00050 *±0.00034*	-
Scotland			<27 *±3.3*	4.4 *±0.9*	<5.0	<0.10 *±0.01*	<0.090[c] *±0.028*	-	-	-	-	-	-	-	-	<0.27
Great Britain			<11 *±2.2*	9.8 *±3.9*	-	<0.25 *±0.06*	<0.092 *±0.046*	<0.24 *±0.04*	0.071 *±0.013*	<0.043 *±0.015*	<0.011 *±0.006*	<0.041 *±0.010*	<0.00017 *±0.00006*	<0.00025 *±0.00018*	<0.00044 *±0.00029*	-

- not analysed
[a] *see section 5 for definition*
[b] *Results are available for other artificial nuclides detectable by gamma spectrometry. All such results are less than the limit of detection.*
[c] *^{137}Cs only*

Table 56. Radioactivity in bread in Scotland, 1996

Area	No. of sampling observa-tions	Mean radioactivity concentration (wet), Bq kg^{-1}					
		^{3}H	^{14}C	^{35}S	^{90}Sr	^{137}Cs	Total alpha
Dumfries and Galloway (Dumfries)	4	<25	61 *±11*	<5.0	<0.10	<0.14 *±0.05*	<0.93
East Lothian (North Berwick)	4	<25	63 *±11*	<5.0	<0.10 *±0.03*	<0.23 *±0.18*	<0.89
Highland (Dingwall)	4	<25	50 *±9.2*	<5.0	<0.10 *±0.02*	<0.22 *±0.11*	<0.96
Renfrewshire (Paisley)	4	<25	58 *±11*	<5.0	<0.10 *±0.02*	<0.12	<0.86

Table 57. Radioactivity in meat in Scotland, 1996

Area	No. of sampling observa-tions	Mean radioactivity concentration (wet), Bq kg^{-1}					
		^{3}H	^{14}C	^{35}S	^{90}Sr	^{137}Cs	Total alpha
Dumfries and Galloway (Dumfries)	4	<25	41 *±7.2*	<5.0	<0.10	<0.15 *±0.10*	<0.38
East Lothian (North Berwick)	4	<25	45 *±11*	<5.0	<0.10	<0.15 *±0.09*	<0.72
Highland (Dingwall)	4	<25	31 *±6.3*	<5.0	<0.10	0.21 *±0.12*	<0.49
Renfrewshire (Paisley)	4	<25	27 *±5.7*	<5.0	<0.10	<0.17 *±0.11*	<0.45

Table 58. Radioactivity in freshwater in Scotland, 1996

Area	Location	No. of sampling observ-ations[a]	Mean radioactivity concentration, Bq l⁻¹				
			^{3}H	^{90}Sr	^{137}Cs	Total alpha	Total beta
Angus	Loch Lee	12	<1.2	<0.0054 *±0.0018*	<0.0078 *±0.0040*	-	-
Argyll and Bute	Auchengaich	1	<1.1	0.0050 *±0.0010*	-	<0.02	<0.02
"	Helensburgh Reservoir	3	-	-	<0.0053	<0.0080	<0.020 *±0.012*
"	Loch Ascog	3	-	-	<0.0057	<0.0083	0.058 *±0.019*
"	Loch Eck	1	<1.1	0.0081 *±0.0013*	-	<0.01	0.021 *±0.019*
"	Loch Finlas	3	-	-	<0.0067	<0.0097 *±0.0046*	0.064 *±0.021*
"	Lochan Ghlas (Coulport)	3	-	-	<0.0077 *±0.0029*	<0.012	0.040 *±0.019*
Clackmannanshire	Gartmorn	1	<1.3	<0.005	-	<0.02	<0.02
Dumfries and Galloway	Black Esk	1	<1.3	<0.005	-	<0.01	<0.02
"	Purdomstone	3	-	-	<0.0067	<0.0083	0.040 *±0.013*
"	Winterhope	1	<1.1	<0.005	-	<0.01	<0.02
East Lothian	Hopes Reservoir	1	<1.3	<0.005	-	<0.02	0.029 *±0.019*
"	Thorters Reservoir	1	<1.3	<0.005	-	<0.02	<0.02
"	Whiteadder	2	-	-	<0.0055	<0.010	0.045 *±0.018*
Fife	Holl Reservoir	1	<1.3	<0.005	-	<0.02	<0.02
Highland	Loch Baligill	1	<1.3	<0.005	-	<0.02	<0.02
"	Loch Calder	3	-	-	<0.0050	<0.012	0.062 *±0.020*
"	Loch Glass	12	<1.2	<0.0065 *±0.0014*	<0.012 *±0.006*	-	-
"	Loch Shurrerey	1	<1.3	<0.005	-	<0.02	<0.02
North Ayrshire	Camphill	1	<1.1	0.0056 *±0.0012*	-	<0.02	<0.02
"	Knockendon Reservoir	3	-	-	<0.0080 *±0.0012*	<0.010 *±0.005*	0.081 *±0.021*
"	Munnoch Reservoir	1	1.7 *±1.0*	0.0048 *±0.0011*	-	<0.02	<0.02
"	Outerwards	1	1.2 *±1.0*	0.0085 *±0.0012*	-	<0.02	<0.02
Orkney Islands	Heldale Water	1	<1.1	0.0076 *±0.0013*	-	<0.02	0.040 *±0.020*
Perth and Kinross	Castlehill	3	-	-	<0.0070	<0.013 *±0.004*	<0.021 *±0.012*
Scottish Borders	Knowsdean	12	<1.2	<0.0063 *±0.0015*	<0.0047 *±0.0025*	-	-
Stirling	Loch Katrine	6	<1.3	<0.0064 *±0.0033*	<0.0076 *±0.0026*	-	-
West Dunbartonshire	Loch Lomond (Ross Priory)	1	<1.1	<0.005	-	<0.01	<0.02
West Lothian	Morton No. 2	1	<1.3	<0.005	-	<0.02	<0.02

-not analysed or not available

[a] See section 5 for definition

Table 59. Radioactivity in sea water from the Irish Sea and Scottish waters, 1996

Location	No. of sampling observa-tions	Mean radioactivity concentration, Bq l^{-1}			
		^{3}H	^{99}Tc	^{134}Cs	^{137}Cs
Seascale	4	-	-	0.0026 ±*0.0016*	0.23 ±*0.002*
St Bees	4	13 ±*1.9*	1.1 ±*0.1*	0.0023 ±*0.0014*	0.24 ±*0.002*
Whitehaven	1	-	-	*	0.22 ±*0.002*
Maryport	1	-	-	*	0.28 ±*0.002*
Silloth	1	-	-	0.0023 ±*0.0016*	0.53 ±*0.003*
Silecroft	1	-	-	0.0015 ±*0.0015*	0.19 ±*0.002*
Walney-west shore	4	16 ±*1.9*	-	*	0.20 ±*0.002*
Isle of Whithorn	1	-	-	0.0014 ±*0.0016*	0.048 ±*0.001*
Drummore	1	-	-	*	0.046 ±*0.001*
Half Moon Bay	1	-	-	0.0063 ±*0.0016*	0.31 ±*0.002*
Rossal (Fleetwood)	1	-	-	0.0043 ±*0.0016*	0.24 ±*0.002*
Ainsdale	1	-	-	*	0.23 ±*0.002*
New Brighton	1	-	-	0.0026 ±*0.0016*	0.24 ±*0.002*
Ross Bay	1	-	-	*	0.088 ±*0.001*
North of Larne	11	-	0.028 ±*0.002*	0.0010 ±*0.0011*	0.027 ±*0.001*
Seafield	4	6.7 ±*1.8*	-	0.0019 ±*0.0014*	0.30 ±*0.002*
Southerness	4	5.2 ±*1.8*	-	0.0021 ±*0.0014*	0.33 ±*0.002*
Knock Bay	4	0.46 ±*1.7*	-	0.0015 ±*0.0013*	0.043 ±*0.001*
Prestatyn	1	-	-	0.0023 ±*0.0016*	0.14 ±*0.002*
Llandudno	1	-	-	0.0024 ±*0.0016*	0.093 ±*0.001*
Cemaes Bay	1	-	-	*	0.041 ±*0.001*
Holyhead	4	1.0 ±*0.002*	-	*	0.027 ±*0.001*
Cape Wrath	4	-	-	*	0.014 ±*0.001*
Pentland Firth	4	-	-	*	0.011 ±*0.001*
Fair Isle	3	-	-	*	0.0086 ±*0.0008*
Aberdeen	4	-	-	*	0.013 ±*0.001*

\- *not analysed*
* *not detected by the method used*

Table 60. Extramural projects in support of the monitoring programmes

	Target completion date
Interlaboratory comparison of Pb-210 and Po-210 measurements in foodstuffs	Complete
Sensitivity analysis of critical group assessments	"
Communication of surveillance results	"
Collective dose determination based on environmental monitoring	"
The dynamics of radionuclides in sheep	"
Radionuclides in macrofungi	"
Hot particles in the foodchain	"
Radioactivity in UK beverages	"
Free foods in the vicinity of nuclear sites	Jun-98
Potential variability of naturally occurring radionuclides in foodstuffs	Feb-98
Variability of concentrations between individual crabs and lobsters	Mar-98
Quality control for the determination of radionuclides in foodstuffs	Mar-98
Optimisation of MAFF's monitoring programme	Mar-98
Relative contribution of historical and current discharges to Sellafield exposures	Apr-98
Remobilisation from contaminated Irish Sea sediments	Apr-98
Food production and distribution surveys	Jul-98
Variability of radionuclides in terrestrial foodstuffs	May-98
Samplers for radionuclides in freshwaters	Apr-99
Dietary studies near nuclear installations	Mar-00

APPENDIX 1. Modelling of radioactivity in food

1.1 Introduction

There are two cases where the results of terrestrial monitoring in 1996 have been amended or supplemented when carrying out assessments of exposures to consumers. Firstly some data for Sellafield, Drigg, Ravenglass and the Isle of Man have been changed where relatively high limits of detection exist or where no measurements were made. Secondly, data for Chapelcross, Dounreay, Hunterston and Torness have been supplemented to provide a more complete coverage of food groups. The methods and data are outlined below.

1.2 Sellafield, Drigg, Ravenglass and the Isle of Man

Activities in milk, meat and offal were calculated for ^{99}Tc, ^{106}Ru, ^{144}Ce, ^{147}Pm and ^{241}Pu using the equations:

$$C_m = F_m Ca\, Q_f \quad \text{and}$$

$$C_f = F_f Ca\, Q_f \quad \text{where}$$

C_m is the concentration in milk (Bq l^{-1}),

C_f is the concentration in meat or offal (Bq kg^{-1} (wet)),

F_m is the fraction of the animal's daily intake by ingestion transferred to milk (d l^{-1}),

F_f is the fraction of the animal's daily intake by ingestion transferred to meat or offal (d kg^{-1}(wet)),

Ca is the concentration in fodder (Bq kg^{-1}(dry)),

Q_f is the amount of fodder eaten per day (kg(dry) d^{-1}).

No direct account is taken of radionuclide decay or the intake by the animal of soil associated activity. The concentration in fodder is assumed to be the same as the maximum observed concentration in grass, or in the absence of such data, in leafy green vegetables. The foodchain data for the calculations are given in Table 1.1 (Simmonds *et al*., 1995; Brent *et al*., unpublished) and the estimated concentrations in milk, meat and offal are presented in Table 1.2.

1.3 Chapelcross, Dounreay, Hunterston and Torness

Soil to plant concentration ratios for green vegetables and potatoes are similar to or less than those for pasture (Simmonds *et al*., 1995). These food groups make up a substantial part of the plant based intake by humans which is likely to be locally sourced. Therefore, in the absence of site-specific data for vegetables at Chapelcross and Dounreay, Hunterston and Torness, concentrations of activity in green vegetables and potatoes were assumed to be the same as those measured in grass. This approach does not take account of the relative foliar uptake of different crops and therefore may underestimate the activities in foodstuffs.

Table 1.1 Data for foodchain model

Parameter	Nuclide	Food				
		Milk	Beef	Beef offal	Lamb	Sheep offal
Q_f		13	13	13	1.5	1.5
F_m or F_f	^{99}Tc	10^{-2}	10^{-2}	$4\ 10^{-2}$	10^{-1}	$4\ 10^{-1}$
	^{106}Ru	10^{-6}	10^{-3}	10^{-3}	10^{-2}	10^{-2}
	^{144}Ce	$2\ 10^{-5}$	10^{-3}	$2\ 10^{-1}$	10^{-2}	2
	^{147}Pm	$2\ 10^{-5}$	$5\ 10^{-3}$	$4\ 10^{-2}$	$5\ 10^{-2}$	$3\ 10^{-1}$
	^{241}Pu	10^{-6}	10^{-4}	$2\ 10^{-2}$	$4\ 10^{-4}$	$3\ 10^{-2}$

Table 1.2 Predicted concentrations from foodchain model used in assessments of exposures

Foodstuff	Location	Radioactivity concentration (wet weight), Bq kg^{-1}				
		^{99}Tc	^{106}Ru	^{144}Ce	^{147}Pm	^{241}Pu
Milk	Sellafield	[b]	$<4.29\ 10^{-4}$	$<4.16\ 10^{-3}$	[e]	[a]
	Ravenglass	[a]	$<4.55\ 10^{-4}$	$<4.42\ 10^{-3}$	[a]	[b]
	Drigg	[b]	$<3.77\ 10^{-4}$	“	[a]	[b]
	Isle of Man	[b]	$<2.21\ 10^{-4}$	“	$<2.6\ 10^{-3}$	[b]
Beef	Sellafield	[b]	$<4.29\ 10^{-1}$	$<2.08\ 10^{-1}$	[e]	[b]
	Ravenglass	[a]	$<4.55\ 10^{-1}$	$<2.21\ 10^{-1}$	13.65	[b]
Lamb	Sellafield	[a]	$<4.95\ 10^{-1}$	$<2.4\ 10^{-1}$	[e]	[b]
	Ravenglass	[b]	$<5.25\ 10^{-1}$	$<2.55\ 10^{-1}$	15.75	[b]
	Drigg	[b]	$<4.35\ 10^{-1}$	“	13.5	[b]
Beef offal	Sellafield	[b]	$<4.29\ 10^{-1}$	[c]	[e]	[b]
	Ravenglass	[b]	$<4.55\ 10^{-1}$	[c]	109.2	[b]
Lamb offal	Sellafield	[b]	$<4.95\ 10^{-1}$	[c]	[e]	[a]
	Ravenglass	[a]	$<5.25\ 10^{-1}$	[c]	94.5	$<9.0\ 10^{-2}$

[a] *Positive monitoring result used*
[b] *LOD monitoring result used*
[c] *Modelled result greater than LOD, therefore LOD used*
[d] *Based on grass data*
[e] *Grass or leafy green veg. result not available*

APPENDIX 2. Abbreviations

AGR	Advanced Gas-Cooled Reactor
ALARA	As Low as Reasonably Achievable
BPM	Best Practicable Means
BNFL	British Nuclear Fuels plc
CARE	Centre for Analytical Research in the Environment (Imperial College)
CEFAS	Centre for Environment, Fisheries and Aquaculture Science (MAFF)
EARP	Enhanced Actinide Removal Plant
FARM	Food and Agriculture Monitoring Programme
GDL	Generalised Derived Limit
G-M	Geiger-Muller
IAEA	International Atomic Energy Agency
HMIP	Her Majesty's Inspectorate of Pollution
ICRP	International Commission on Radiological Protection
LoD	Limit of Detection
MAFF	Ministry of Agriculture, Fisheries and Food
MRL	Minimum reporting level
ND	Not detected
NEA	Nuclear Energy Agency
NRPB	National Radiological Protection Board
OECD	Organisation for Economic Co-operation and Development
OSPAR	Oslo and Paris Commission
PWR	Pressurised Water Reactor
RSND	Radiological Safety and Nutrition Division (MAFF)
SEPA	Scottish Environment Protection Agency
SGHWR	Steam Generating Heavy Water Reactor
THORP	Thermal Oxide Reprocessing Plant
TRAMP	Terrestrial Radioactivity Monitoring Programme
UKAEA	United Kingdom Atomic Energy Authority
VLA	Veterinary Laboratories Agency
WRI	Westlakes Research Institute

APPENDIX 3. Consumption, handling and occupancy rates

This appendix gives the consumption, handling and occupancy rate data used in the assessment of exposures. Consumption rates for terrestrial foods are given in Table 3.1. These are based on national statistics and are taken to apply at each site. Site-specific data for aquatic pathways based on local surveys are given in Table 3.2.

Table 3.1 Consumption rates for terrestrial foods

Food Group	Consumption rates ($kg\ y^{-1}$)					
	Average			Above average consumption rate*		
	Adult	10 year old	Infant	Adult	10 year old	Infant
Beef	15	15	3	45	30	10
Cereals	50	45	15	100	75	30
Eggs	8.5	6.5	5	25	20	15
Fruit	20	15	9	75	50	35
Game	6	4	0.8	15	7.5	2.1
Green Vegetables	15	6	3.5	45	20	10
Honey	2.5	2	2	9.5	7.5	7.5
Lamb	8	4	0.8	25	10	3
Legumes	20	8	3	50	25	10
Milk	95	110	130	240	240	320
Mushrooms	3	1.5	0.6	10	4.5	1.5
Nuts	3	1.5	1	10	7	2
Offal	5.5	3	1	20	10	5.5
Pork	15	8.5	1.5	40	25	5.5
Potatoes	50	45	10	120	85	35
Poultry	10	5.5	2	30	15	5.5
Root crops	10	6	5	40	20	15
Wild fruit	7	3	1	25	10	2

* *These rates are the 97.5th percentile of the distribution across all consumers*

Table 3.2 Consumption, handling and occupancy rates for aquatic pathways

Site	Group[a]	Rates
Aldermaston		1 $kg\ y^{-1}$ pike 360 $h\ y^{-1}$ over riverbank
Amersham		1 $kg\ y^{-1}$ pike 1600 $h\ y^{-1}$ over riverbank
Barrow		1000 $h\ y^{-1}$ over mud and sand
Berkeley and Oldbury		17 $kg\ y^{-1}$ flounders 4.9 $kg\ y^{-1}$ shrimps 980 $h\ y^{-1}$ over mud
Bradwell	A	75 $kg\ y^{-1}$ fish 5.0 $kg\ y^{-1}$ crustaceans 2000 $h\ y^{-1}$ over mud
	B	4.7 $kg\ y^{-1}$ oysters
Capenhurst		0.0025 $kg\ y^{-1}$ sediment 2.5 $l\ y^{-1}$ water
Cardiff		28 $kg\ y^{-1}$ flounders 2.9 $kg\ y^{-1}$ mussels 650 $h\ y^{-1}$ over mud

Table 3.2 continued

Site	Group[a]	Rates
Channel Islands		110 kg y^{-1} fish
		7 kg y^{-1} crustaceans
		18 kg y^{-1} molluscs
		1000 h y^{-1} over sediment
Chapelcross	A	8.7 kg y^{-1} flounders
		11 kg y^{-1} salmonids
		7.3 kg y^{-1} shrimps
		0.45 kg y^{-1} mussels
		1000 h y^{-1} over mud and sand
	B	1200 h y^{-1} over salt marsh
	C	250 h y^{-1} handling nets
Chatham		3000 h y^{-1} over mud
Devonport		14 kg y^{-1} salmonids
		13 kg y^{-1} fish
		5 kg y^{-1} crustaceans
		2000 h y^{-1} over mud
Dounreay	A	1600 h y^{-1} handling pots
	B	54 kg y^{-1} cod
		20 kg y^{-1} crab and lobster
		0.40 kg y^{-1} winkles
	C	5.5 kg y^{-1} winkles
		380 h y^{-1} over winkle beds
	D	100 h y^{-1} in a Geo
Drinking water	Adults	600 l y^{-1}
	10 y	350 l y^{-1}
	1 y	260 l y^{-1}
Dungeness		98 kg y^{-1} fish
		9.4 kg y^{-1} shrimps
		14 kg y^{-1} whelks
		2000 h y^{-1} over mud
Faslane	A	500 h y^{-1} over mud
	B	38 kg y^{-1} fish
		4.8 kg y^{-1} molluscs
		670 h y^{-1} over mud and sand
Hartlepool	A	42 kg y^{-1} fish
		23 kg y^{-1} crab
		18 kg y^{-1} winkles
	B	3000 h y^{-1} over sand/coal
Harwell		1 kg y^{-1} pike
		650 h y^{-1} over river bank
Heysham		54 kg y^{-1} fish
		21 kg y^{-1} shrimps
		22 kg y^{-1} mussels and cockles
		900 h y^{-1} over mussel beds
Hinkley Point	A	48 kg y^{-1} flounder
		6.5 kg y^{-1} shrimps
		780 h y^{-1} over mud
	B	1000 h y^{-1} over mud
Holy Loch		900 h y^{-1} over mud
Hunterston		82 kg y^{-1} fish
		41 kg y^{-1} Nephrops
		21 kg y^{-1} scallops
		860 h y^{-1} over sand and mud

Table 3.2 continued

Site	Group[a]	Rates
Rosyth	A	2.7 kg y^{-1} crab
	B	1900 h y^{-1} over mud and sand
Sellafield	A	25 kg y^{-1} plaice and cod
		12 kg y^{-1} crab (60%) and lobster (40%)
		12 kg y^{-1} winkles (60%) and other molluscs (40%)
	B	2500 h y^{-1} handling nets and pots
	C (Whitehaven boat dwelling)	280 h y^{-1} over mud
		37 kg y^{-1} cod and plaice
	D (anglers)	510 h y^{-1} over sediment (Whitehaven outer harbour)
		420 h y^{-1} over sand (Sellafield coastal area)
		28 kg y^{-1} cod and plaice
	E (Whitehaven commercial)	57 kg y^{-1} plaice and cod
		21 kg y^{-1} Nephrops
		11 kg y^{-1} whelks
	F (Morecambe Bay)	See Heysham
	G (Fleetwood)	93 kg y^{-1} plaice and cod
		29 kg y^{-1} shrimps
		23 kg y^{-1} whelks
	H (Dumfries and Galloway)	38 kg y^{-1} fish
		15 kg y^{-1} Nephrops (50%), crabs (25%) and lobsters(25%)
		8.2 kg y^{-1} winkles and mussels
		1000 h y^{-1} over winkle beds
	I (Laverbread)	47 kg y^{-1} laverbread
	J (Trout)	6.8 kg y^{-1} rainbow trout
Sizewell		56 kg y^{-1} fish
		6.6 kg y^{-1} crustaceans
		3.8 kg y^{-1} molluscs
		260 h y^{-1} over mud
Springfields	A	3000 h y^{-1} over mud
	B	530 h y^{-1} handling nets
	C	360 h y^{-1} wildfowling
		16 kg y^{-1} wildfowl
	D	360 h y^{-1} angling
	E	730 h y^{-1} over saltmarsh
		550 h y^{-1} handling mud
	F	35 kg y^{-1} fish
		34 kg y^{-1} shrimps
		3.0 kg y^{-1} cockles and mussels
		5.1 kg y^{-1} samphire
		1100 h y^{-1} over sand
Torness	A	58 kg y^{-1} fish
		11 kg y^{-1} crab and lobster
		10 kg y^{-1} Nephrops
		2.2 kg y^{-1} molluscs
	B	430 h y^{-1} over sand
	C	640 h y^{-1} over winkle beds
Trawsfynydd		1.8 kg y^{-1} Brown trout
		22 kg y^{-1} rainbow trout
		0.93 kg y^{-1} perch
		1000 h y^{-1} over lake shore
Upland lake		37 kg y^{-1} fish
Whitehaven		22 kg y^{-1} fish
		15 kg y^{-1} lobsters (60%) and crab (40%)
		1.5 kg y^{-1} winkles
Winfrith	A	77 kg y^{-1} cod
		26 kg y^{-1} crab
		39 kg y^{-1} whelks
	B	390 h y^{-1} over mud
Wylfa		94 kg y^{-1} fish
		23 kg y^{-1} crab
		1.8 kg y^{-1} molluscs
		370 h y^{-1} over sand

[a] *Where more than one group exists at a site the groups are denoted A, B, etc.*

APPENDIX 4. Dosimetric data

Radionuclide	Half Life (years)	Mean β energy (MeV per disintegration)	Mean γ energy (MeV per disintegration)	Dose per unit intake by ingestion using ICRP-60 methodology (Sv Bq^{-1})		
				Adults	10 yr	1 yr
H 3	1.24E+01	5.683E-03	0.000E+00	1.80E-11	2.30E-11	4.80E-11
OT3 (f)	1.24E+01	5.683E-03	0.000E+00	4.20E-11	5.70E-11	1.20E-10
C 14	5.73E+03	4.945E-02	0.000E+00	5.80E-10	8.00E-10	1.60E-09
P 32	3.91E-02	6.950E-01	0.000E+00	2.40E-09	5.30E-09	1.90E-08
S 35	2.39E-01	4.884E-02	0.000E+00	7.70E-10	1.60E-09	5.40E-09
CA45	4.46E-01	7.720E-02	0.000E+00	7.10E-10	1.80E-09	4.90E-09
MN54	8.56E-01	4.220E-03	8.364E-01	7.10E-10	1.30E-09	3.10E-09
FE55	2.70E+00	4.201E-03	1.691E-03	3.30E-10	1.10E-09	2.40E-09
CO57	7.42E-01	1.860E-02	1.250E-01	2.10E-10	5.80E-10	1.60E-09
CO58	1.94E-01	3.413E-02	9.976E-01	7.40E-10	1.70E-09	4.40E-09
CO60	5.27E+00	9.656E-02	2.500E+00	3.40E-09	1.10E-08	2.70E-08
ZN65	6.67E-01	6.870E-03	5.845E-01	3.90E-09	6.40E-09	1.60E-08
SE75	3.28E-01	1.452E-02	3.946E-01	2.60E-09	6.00E-09	1.30E-08
SR90 †	2.91E+01	1.131E+00	3.163E-03	3.07E-08	6.59E-08	9.30E-08
ZR95 †	1.75E-01	1.605E-01	1.505E+00	1.53E-09	2.99E-09	8.78E-09
NB95	9.62E-02	4.444E-02	7.660E-01	5.80E-10	1.10E-09	3.20E-09
TC99	2.13E+05	1.010E-01	0.000E+00	6.40E-10	1.30E-09	4.80E-09
RU103 †	1.07E-01	7.478E-02	4.685E-01	7.30E-10	1.50E-09	4.60E-09
RU106 †	1.01E+00	1.422E+00	2.049E-01	7.00E-09	1.50E-08	4.90E-08
AG110M †	6.84E-01	8.699E-02	2.740E+00	2.80E-09	5.20E-09	1.40E-08
SB125	2.77E+00	1.007E-01	4.312E-01	1.10E-09	2.10E-09	6.10E-09
I 125	1.65E-01	1.940E-02	4.205E-02	1.50E-08	3.10E-08	5.70E-08
I 129	1.57E+07	6.383E-02	2.463E-02	1.10E-07	1.90E-07	2.20E-07
I 131 †	2.20E-02	1.935E-01	3.813E-01	2.20E-08	5.20E-08	1.80E-07
CS134	2.06E+00	1.634E-01	1.550E+00	1.90E-08	1.40E-08	1.60E-08
CS137 †	3.00E+01	2.486E-01	5.651E-01	1.30E-08	1.00E-08	1.20E-08
BA140 †	3.49E-02	8.493E-01	2.502E+00	4.60E-09	1.00E-08	3.10E-08
CE144 †	7.78E-01	1.278E+00	5.282E-02	5.20E-09	1.10E-08	3.90E-08
PM147	2.62E+00	6.200E-02	4.374E-06	2.60E-10	5.70E-10	1.90E-09
EU154	8.80E+00	2.923E-01	1.237E+00	2.00E-09	4.10E-09	1.20E-08
EU155	4.96E+00	6.340E-02	6.062E-02	3.20E-10	6.80E-10	2.20E-09
PB210 †	2.23E+01	4.279E-01	4.810E-03	6.91E-07	1.90E-06	3.61E-06
BI210	1.37E-02	3.890E-01	0.000E+00	1.30E-09	2.90E-09	9.70E-09
PO210 (c)	3.79E-01	0.000E+00	0.000E+00	1.20E-06	2.60E-06	8.80E-06
PO210 (d)	3.79E-01	0.000E+00	0.000E+00	1.92E-06	4.16E-06	1.41E-05
RA226 †	1.60E+03	9.559E-01	1.765E+00	2.80E-07	8.00E-07	9.60E-07
TH228 †	1.91E+00	9.130E-01	1.567E+00	1.43E-07	4.31E-07	1.10E-06
TH230	7.70E+04	1.462E-02	1.553E-03	2.10E-07	2.40E-07	4.10E-07
TH232	1.41E+10	1.251E-02	1.332E-03	2.30E-07	2.90E-07	4.50E-07
TH234 †	6.60E-2	8.815E-01	2.103E-02	3.40E-9	7.40E-09	2.50E-08
U 234	2.44E+05	1.320E-02	1.733E-03	4.90E-08	7.40E-08	1.30E-07
U 235 †	7.04E+08	2.147E-01	1.815E-01	4.70E-08	7.10E-08	1.30E-07
U 238 †	4.47E+09	8.915E-01	2.235E-02	4.84E-08	7.54E-08	1.45E-07
NP237 †	2.14E+06	2.668E-01	2.382E-01	1.10E-07	1.10E-07	2.10E-07
PU238 (a)	8.77E+01	1.061E-02	1.812E-03	2.30E-07	2.40E-07	4.00E-07
PU238 (b)				9.20E-08	9.60E-08	1.60E-07
PU239 (a)	2.41E+04	6.738E-03	8.065E-04	2.50E-07	2.70E-07	4.20E-07
PU239 (b)				1.00E-07	1.08E-07	1.68E-07
PU α (e)	2.41E+04	6.738E-03	8.065E-04	2.50E-07	2.70E-07	4.20E-07
PU240 (a)	6.54E+03	1.061E-02	1.731E-03	2.50E-07	2.70E-07	4.20E-07
PU240 (b)				1.00E-07	1.08E-07	1.68E-07
PU241 (a)	1.44E+01	5.246E-03	2.546E-06	4.80E-09	5.10E-09	5.70E-09
PU241 (b)				1.92E-09	2.04E-09	2.28E-09
AM241 (a)	4.32E+02	5.207E-02	3.253E-02	2.00E-07	2.20E-07	3.70E-07
AM241 (b)				8.00E-08	8.80E-08	1.48E-07
CM242	4.46E-01	9.594E-03	1.832E-03	1.20E-08	2.40E-08	7.60E-08
CM243	2.85E+01	1.384E-01	1.347E-01	1.50E-07	1.60E-07	3.30E-07
CM244	1.81E+01	8.590E-03	1.700E-03	1.20E-07	1.40E-07	2.90E-07

† *Energy and dose per unit intake data include the effects of radiations of short-lived daughter products*
(a) Gut transfer factor 5.00E-4 for consumption of all foodstuffs except Cumbrian winkles
(b) Gut transfer factor 2.00E-4 for consumption of Cumbrian winkles
(c) Gut transfer factor 0.5
(d) Gut transfer factor 0.8
(e) PU239 data used
(f) Organically bound tritium

APPENDIX 5. Estimates of concentrations of natural radionuclides

5.1 Aquatic foodstuffs

Table 5.1 gives estimated values of concentrations of radionuclides due to natural sources in aquatic foodstuffs. The values are based on sampling and analysis carried out by MAFF. Dose assessments for aquatic foodstuffs are based on activity concentrations of these radionuclides net of natural background. Similarly, natural levels of carbon-14 are subtracted when assessing exposures due to man-made sources of this radionuclide. The natural concentrations of carbon-14 are determined by measuring the carbon concentration in each sample and applying a specific activity of 252 Bq ^{14}C natural/kg C (Collins, *et al*., 1995).

5.2 Terrestrial foodstuffs

The values of carbon-14 in terrestrial foodstuffs due to natural sources that are used in dose assessments are given in Table 5.2 (MAFF, 1995).

Table 5.1 Radioactivity in seafood due to natural sources

Radionuclide	Concentration of radioactivity (Bq kg^{-1} (wet))								
	Fish	Crustaceans	Crabs	Lobsters	Molluscs	Winkles	Mussels	Cockles	Whelks
Lead-210	0.025	0.08	0.3	0.08	0.69	0.69	1.1		
Polonium-210	0.28	5.2	15	5.2	9.4	12	33	18	9.4
Radium-226	0.04	0.03	0.03	0.06	0.08	0.08			
Thorium-228	0.0054	0.0096	0.04	0.0096	0.37	0.46		0.37	
Thorium-230	0.00081	0.0026	0.008	0.0026	0.19	0.26		0.19	
Thorium-232	0.00097	0.0014	0.01	0.0014	0.28	0.33		0.28	
Uranium-234	0.0045	0.040	0.055	0.040	0.99	0.99			
Uranium-238	0.0039	0.035	0.046	0.035	0.89	0.89			

Table 5.2 Carbon-14 in terrestrial foodstuffs due to natural sources

Food Category	% Carbon content (wet)	Concentration of carbon-14 (Bq kg^{-1} (wet))
Milk	7	18
Bovine meat	17	44
Ovine meat	21	54
Pork	21	54
Poultry	28	72
Game	15	38
Offal	12	31
Eggs	15	38
Green vegetables	3	8
Root vegetables	3	8
Legumes/other domestic vegetables	8	20
Dry beans	20	51
Potato	9	23
Cereals	41	105
Cultivated fruit	4	10
Wild fruit	4	10
Mushrooms	2	5
Honey	31	79
Nuts	58	148

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