

# Summary of Radioactivity in Food and the Environment 2004-2008





ENVIRONMENT AGENCY  
FOOD STANDARDS AGENCY  
NORTHERN IRELAND ENVIRONMENT AGENCY  
SCOTTISH ENVIRONMENT PROTECTION AGENCY

# **Summary of Radioactivity in Food and the Environment 2004-2008**

April 2010

This report was compiled by the Centre for Environment, Fisheries and Aquaculture Science on behalf of the Environment Agency, Food Standards Agency, Northern Ireland Environment Agency and the Scottish Environment Protection Agency.



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<i>LIST OF FIGURES AND TABLES</i> .....	4
<i>PREFACE</i> .....	5
<i>INTRODUCTION</i> .....	6
<b>1. Overview of total dose and environmental indicators near the UK's nuclear sites</b> .....	8
1.1 Total dose assessment .....	8
1.2 Environmental indicators close to and away from nuclear sites .....	8
1.3 Doses to the public from diet away from nuclear sites .....	11
<b>2. Nuclear fuel production and reprocessing</b> .....	12
2.1 Public's exposure to radiation due to discharges of radioactive waste .....	12
2.2 Sellafield, Cumbria .....	14
2.2.1 Discharges of radioactive waste .....	14
2.2.2 Concentrations of radionuclides in food and the environment .....	15
2.3 Capenhurst – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	16
2.4 Springfields – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	16
2.5 Summary .....	18
<b>3. Research establishments</b> .....	19
3.1 Public's exposure to radiation due to discharges of radioactive waste .....	19
3.2 Dounreay – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	19
3.3 Harwell – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	20
3.4 Winfrith – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	21
3.5 Summary .....	23
<b>4. Nuclear power stations</b> .....	24
4.1 Public's exposure to radiation due to discharges of radioactive waste .....	24
4.2 Discharges of radioactive waste from nuclear power stations .....	26
4.3 Concentrations of radionuclides in food and the environment .....	29
4.4 Trawsfynydd – Discharges of radioactive waste and concentrations of radionuclides in the environment .....	29
4.5 Summary .....	31
<b>5. Defence establishments</b> .....	32
5.1 Public's exposure to radiation due to discharges of radioactive waste .....	32
5.2 Aldermaston, Devonport, Faslane and Coulport, and Rosyth – Discharges of radioactive waste .....	32
5.3 Defence establishments – Concentrations of radionuclides in food and the environment .....	32
5.4 Summary .....	35
<b>6. Radiochemical production</b> .....	36
6.1 Public's exposure to radiation due to discharges of radioactive waste .....	36
6.2 Amersham – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	36
6.3 Cardiff – Discharges of radioactive waste and concentrations of radionuclides in food and the environment .....	37
6.4 Summary .....	38
<b>Summary and Conclusions</b> .....	40

# List of Figures and Tables

Abbreviated Figure Title	Number	Page
<b>Total dose and environmental indicators</b>		
UK doses from all sources	1	9
Indicator monitoring- technetium-99 in seaweed	2	10
<b>Nuclear fuel production and reprocessing</b>		
Doses from discharges – including wider communities	3	13
Sellafield – discharges of radioactive waste	4	14
Sellafield – monitoring from radioactive waste	5	15
Capenhurst – discharges and monitoring the environment	6	17
Springfields – discharges and monitoring the environment	7	18
<b>Research establishments</b>		
Doses from discharges	8	20
Dounreay – discharges and monitoring the environment	9	21
Harwell – discharges and monitoring the environment	10	22
Winfrith – discharges and monitoring the environment	11	23
<b>Nuclear power stations</b>		
Doses from discharges	12	25
Discharges of gaseous radioactive waste	13	27
Discharges of liquid radioactive waste	14	28
Monitoring – caesium-137 in marine sediments	15	30
Trawsfynydd – discharges and monitoring the environment	16	31
<b>Defence</b>		
Doses from discharges	17	33
Discharges of radioactive waste	18	34
Aldermaston – monitoring the environment	19	35
<b>Radiochemical production</b>		
Doses from discharges	20	37
Amersham – discharges and monitoring the environment	21	38
Cardiff – discharges and monitoring the environment	22	39

Abbreviated Table Title	Number	Page
<b>Total dose and environmental indicators</b>		
UK general diet (Total Diet Study)	1	11
<b>Nuclear fuel production and reprocessing</b>		
Summary of trends for sector	2	18
<b>Research establishments</b>		
Summary of trends for sector	3	23
<b>Nuclear power stations</b>		
Summary of trends for sector	4	31
<b>Defence</b>		
Summary of trends for sector	5	35
<b>Radiochemical production</b>		
Summary of trends for sector	6	38
<b>Summary and Conclusions</b>		
Overall summary for nuclear sectors	7	40

# Preface

Each year the Environment Agency, the Food Standards Agency, the Northern Ireland Environment Agency (NIEA) and the Scottish Environment Protection Agency (SEPA) carry out a UK wide monitoring programme of radioactivity in food and the environment around all 39 nuclear licensed sites and assess the public's exposure to radiation.

As partner agencies for environment and food protection, we publish our joint findings in an annual report, 'Radioactivity in Food and the Environment' (RIFE) which brings together the results of our radiological monitoring and provides an overall detailed assessment of radioactivity for the UK. The report is a compilation of the evaluations we make on the public's exposure to ionising radiation from authorised discharges, to show that exposure is within EU and UK limits.

Building on the information derived from the last five RIFE reports (RIFE 10-14), we have prepared this review to give an overview of recent trends in data from 2004-2008. The report primarily focuses on trends associated with:

- radiation exposure (doses) to people living around nuclear sites
- disposals of radioactive waste (discharges) to air and water
- radionuclide activity (concentrations) in samples collected around nuclear sites

This report shows that for all 39 nuclear licensed sites, the overall amount of radiation the public was exposed to was less than the UK and European limit of 1 millisievert (mSv, a measure of dose) per year, in each year over the five-year review period. A key observation is that radionuclide concentrations were very low at many sites, indeed so low they could not be detected with the sensitive methods used. In many cases there is a correlation between lower environmental concentrations and reducing discharges to the environment, showing that the efforts of regulators and the industry to progressively reduce discharges is having a beneficial effect.

At several nuclear sites, trends in *total doses* were dominated by direct radiation (radiation arising from processes or operations on the premises), with the largest *total dose* over the five-year period reported at Dungeness. However, this direct radiation reduced after 2006 when the first generation Magnox reactors at Dungeness A ceased power generation. Radiation exposure around Sellafield and Whitehaven was the

second largest *total dose*, with trends broadly reflecting a combination of changes in shellfish consumption rates, and the concentrations of naturally-occurring radionuclides arising as a result of past discharges from the former phosphate works at Whitehaven, in these shellfish.

The cessation, decommissioning and defueling of the majority of first generation nuclear power stations and reduction in reprocessing over the review period has clearly had a significant impact in reducing discharges and radiation doses to the public.

For nuclear power station sites, the most significant trend over the five-year period was an overall decline in gaseous and liquid discharges. The most pronounced effects were at Chapelcross where discharges reduced significantly after the site stopped generating electricity and at Hartlepool where all radionuclide discharges reduced whilst the site was closed down for repair work.

Discharges of man-made radionuclides over the last two decades have shown large and sustained reductions of the most important radionuclides. This is particularly true of the nuclear fuel reprocessing sector where investment, for example in new treatment plants, has had a significant effect. Concentrations of radionuclides in food and the environment have also declined over a similar time-frame. In addition, reductions in discharges and doses have occurred from older Magnox power stations where the reactors have been shut down and ended electricity production. Therefore, in comparison to earlier decades, some downward trends in environmental concentrations have become less significant in the last five years. Where there have been radionuclide fluctuations in recent years, this has been mostly at low concentrations in the environment, due to normal year to year variation. In some cases no clear trend is apparent and variation or 'noise' is a key feature of the monitoring data.

It is important to note that this is a summary of trend data over the last five years and is not a detailed technical report. Anyone wanting to understand the in-depth background to the methodologies applied in the specific yearly assessments should consult the relevant annual RIFE report.

<http://www.food.gov.uk/science/surveillance/radiosurv/rife>

# Introduction

This report provides a summary of the public's exposure (doses) to radiation to people, between 2004 and 2008, living around nuclear sites. It also gives more detail of time trends on discharges of radioactivity to the environment and concentrations of radionuclides in food and the environment over the same time period for each of the nuclear industry sectors (e.g. nuclear fuel production and processing). The information in this report is taken from more detailed data published in the annual Radioactivity in Food and the Environment (RIFE) reports. The RIFE reports give analytical results from independent monitoring carried out by the Environment Agency, SEPA, NIEA and the Food Standards Agency.

The data are presented to indicate the overall trends in doses, discharges and concentrations. These data allow a broad interpretation of the picture with time to whether the trends are generally increasing, decreasing, largely staying the same or not showing a trend.

The report provides information that can be considered in its own right and in relation to a strategic view of the UK approach to managing the impact of radioactive discharges over recent years. In particular it allows the radioactivity concentrations and public radiation doses to be considered in relation to the 1998 Ministerial OSPAR agreement and the UK's commitments under its national Radioactive Discharge Strategy. Westminster and Devolved Administrations have also recently published guidance to the Environment Agency and SEPA on regulation of discharges so as to deliver the requirements of the Strategy.

These more strategic elements are briefly described below.

## OSPAR

The OSPAR Radioactive Substances Strategy was agreed by Ministers in 1998. Its strategic objective is to prevent pollution of the OSPAR maritime area (marine environment of the North-East Atlantic) from ionising radiation through progressive and substantial reductions in radioactive discharges, emissions and losses. This has the ultimate aim of concentrations in the environment near background values for naturally-occurring radioactive substances and close to zero for artificial radioactive substances. This Strategy will be implemented so that by the year 2020 any releases of radioactive substances are low enough so that any increase in the levels, above historic levels, in the marine environment from these discharges will be close to zero.

## The UK Strategy for Radioactive Discharges

The first UK Strategy for Radioactive Discharges was published in July 2002 and was updated in 2009. The Strategy was prepared in response to commitments entered into by the UK in 1998 as one of the OSPAR Contracting Parties. It gives a framework for implementing the UK's obligations in respect of the OSPAR Radioactive Substances Strategy. It presents a strategic framework for discharge reductions by each nuclear sector to help decision making by the nuclear industry and regulators. There are some specific objectives in the Strategy, including achieving progressive and substantial reductions in radioactive discharges so that human doses should be kept as low as reasonably achievable.

The UK Strategy for Radioactive Discharges presents Key Marine Environmental Indicators (KMEIs) at a number of locations around the coast of the UK. These help evaluate progress against the OSPAR targets and are included in the OSPAR Periodic Report Series. The KMEIs include seaweed at all the site locations. At some locations KMEIs include marine foods and seawater. All of the KMEI data are from monitoring carried out by the Environment Agency, the Food Standards Agency, SEPA and the NIEA. Selected KMEI data have been presented in this report.

## Statutory Guidance to the Environment Agency and SEPA on Regulation of Discharges into the Environment

Statutory Guidance has been issued to the Environment Agency by the Department of Energy and Climate Change (DECC) and the Welsh Assembly Government (WAG), and to SEPA by the Scottish Government. This offers additional strategic high-level guidance on the key responsibilities of the Environment Agency for England and Wales and SEPA for Scotland. It provides guidance about how the environment agencies should implement the UK Strategy for Radioactive Discharges and OSPAR commitments. The implementation and development of detailed guidance is the responsibility of the regulator.

The main focus of the Guidance from DECC and WAG to the Environment Agency is the combination of Best Practicable Means (BPM) and Best Practicable Environmental Option (BPEO) as Best Available Techniques (BAT), as the main regulatory tool for controlling radioactive discharges. The Guidance also highlights the importance of the use of BAT in the optimisation of doses and the setting of discharge limits. In Scotland, Statutory Guidance to SEPA retains both BPM and BPEO approaches for regulation and the authorisation of

discharges which requires the optimisation of doses. SEPA takes account of the requirements of the UK Discharge Strategy and OSPAR during the authorisation process.

The Environment Agency has prepared “Regulatory Environmental Principles” (REPs) which underpin how it will implement the Statutory Guidance.

In Northern Ireland, the Department of the Environment does not provide statutory guidance but instead directs the Chief Inspector to ensure that when granting discharge authorisations they are consistent with the UK Waste Discharge Strategy. NIEA currently retains the BPM approach to regulation and authorisation of radioactive discharges.

# 1. Overview of *total dose* and environmental indicators near the UK's nuclear sites

This section considers the time trends of *total dose*<sup>1</sup> summed over all sources at each site in the UK. It also considers Key Marine Environmental Indicators (KMEIs) around the UK that have been used to evaluate the UK Strategy for Radioactive Discharges.

## 1.1 *Total dose* assessment

By 2008, the environment agencies and the Food Standards Agency had assessed *total doses* to the public at 24 nuclear site locations. Trends of *total dose* over time (2004–2008) around UK's nuclear sites are shown in Figure 1. The *total doses* from radiation at all sites were all less than the annual national (UK) and the European limit for members of the public of 1 mSv per year, in each year over the five year period. An additional comparison can be made with doses from natural radioactivity. The UK average has been reported to be 2.2 mSv per year, with a range across the UK counties from 1.5 to 7.2 mSv per year.

Figure 1 shows the annual *total dose* was highest at Dungeness in Kent, ranging between 0.28 and 0.63 mSv, over the five-year period. *Total doses* at Dungeness were dominated by direct radiation, and following 2006, this dose declined due to the end of power generation from the first generation Magnox reactors.

The second highest annual *total dose* was at Sellafield and Whitehaven in Cumbria, ranging between 0.37 and 0.58 mSv over the five years. This trend broadly reflected a combination of changes in the amount of shellfish eaten and of naturally-occurring radionuclides from the non-nuclear industry in these shellfish. The larger step changes (from 2004 to 2005 and from 2007 to 2008) were due to variations in naturally-occurring radionuclides (mainly polonium-210 and lead-210). These radiologically significant concentrations are enhanced in fish and shellfish near Whitehaven because of past discharges from a former phosphate plant. The changes in *total dose* in the intervening years (from 2005 to 2007) were mainly a result of changes in seafood consumption rates. The third highest exposure was at Amersham in Buckinghamshire, where annual *total doses* ranged from 0.22 and 0.24 mSv over the five-year period. This trend remained broadly similar with time and was dominated by direct radiation.

Other notable observations in *total dose* included increased exposure at Capenhurst in Cheshire. This was attributable in recent years to direct radiation. At Cardiff, the *total doses* were

## Key points

- All *total doses* were less than the UK and European dose limit
- *Total dose* and their trends were dominated by direct radiation at many sites
- *Total dose* trend at Sellafield was influenced by changes in natural radioactivity from non-nuclear industry activity
- *Total dose* declined when electricity generation ended at several older Magnox power stations.
- Trends in Key Marine Environmental Indicators around the UK show decreasing concentrations over the time period

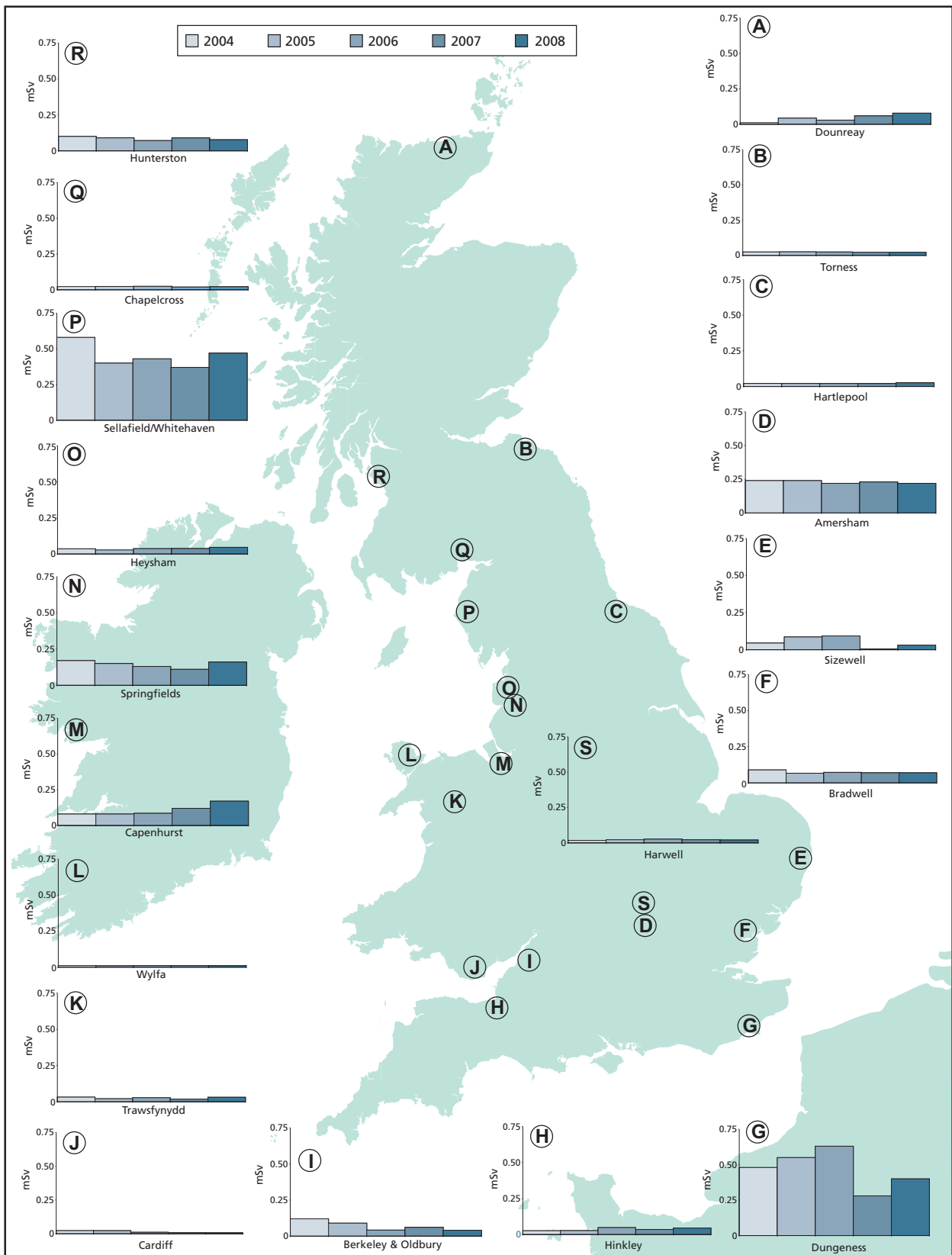
very low and decreased over time. The largest contributor to dose was low levels of external radiation above sediment at Cardiff. This was due to naturally-occurring radionuclides or radioactive sources other than from the GE Healthcare site in Cardiff. The *total dose* at Sizewell in Suffolk declined at the end of 2006, following the closure of the Magnox reactors at Sizewell A. This was attributable in recent years to direct radiation. At Springfields in Lancashire the *total dose* decreased over time, although there was an increase in 2008 compared with 2007. The trend at this site was primarily due to variations in gamma dose rates over sediment and improvements in the methods used for dose assessments.

*Total doses* at all the remaining locations in Figure 1 were low. Any variations in *total doses* with time at these sites were primarily due to changes in direct radiation or variations in gamma dose rates from environmental variability.

## 1.2 Environmental indicators close to and away from nuclear sites

Monitoring carried out by the Environment Agency, SEPA, NIEA and the Food Standards Agency includes data that are used as part of the KMEIs. These are used to show how the UK is meeting its OSPAR obligations. The KMEI include concentrations of radionuclides in fish and shellfish, seaweed and seawater. Seaweed data are available for a wide range of locations around the UK (as indicators for Sellafield-derived technetium-99) and are shown in Figure 2. The data show that concentrations of all radionuclides have either reduced or are unchanged over the five-year period.

<sup>1</sup> *Total dose* is an assessment that uses a defined method that takes account of all exposure pathways in combination e.g. radionuclides in food, the environment and direct radiation.



**Figure 1.** Total radiation exposures around the UK's nuclear sites due to radioactive waste discharges and direct radiation (2004-2008). (Exposures at Sellafeld/Whitehaven receive a significant contribution to the dose from technologically enhanced naturally occurring radionuclides from previous non-nuclear industrial operations)

Footnote: Trends at Aldermaston and Burghfield, Devonport, Faslane and Coulport, Rosyth and Winfrith are excluded from the figure as, throughout the time period, the total doses from all sources were assessed to have been less than 0.005mSv. Total dose assessments have been updated from values reported in previous RIFE publications, to take into account revised direct radiation data.

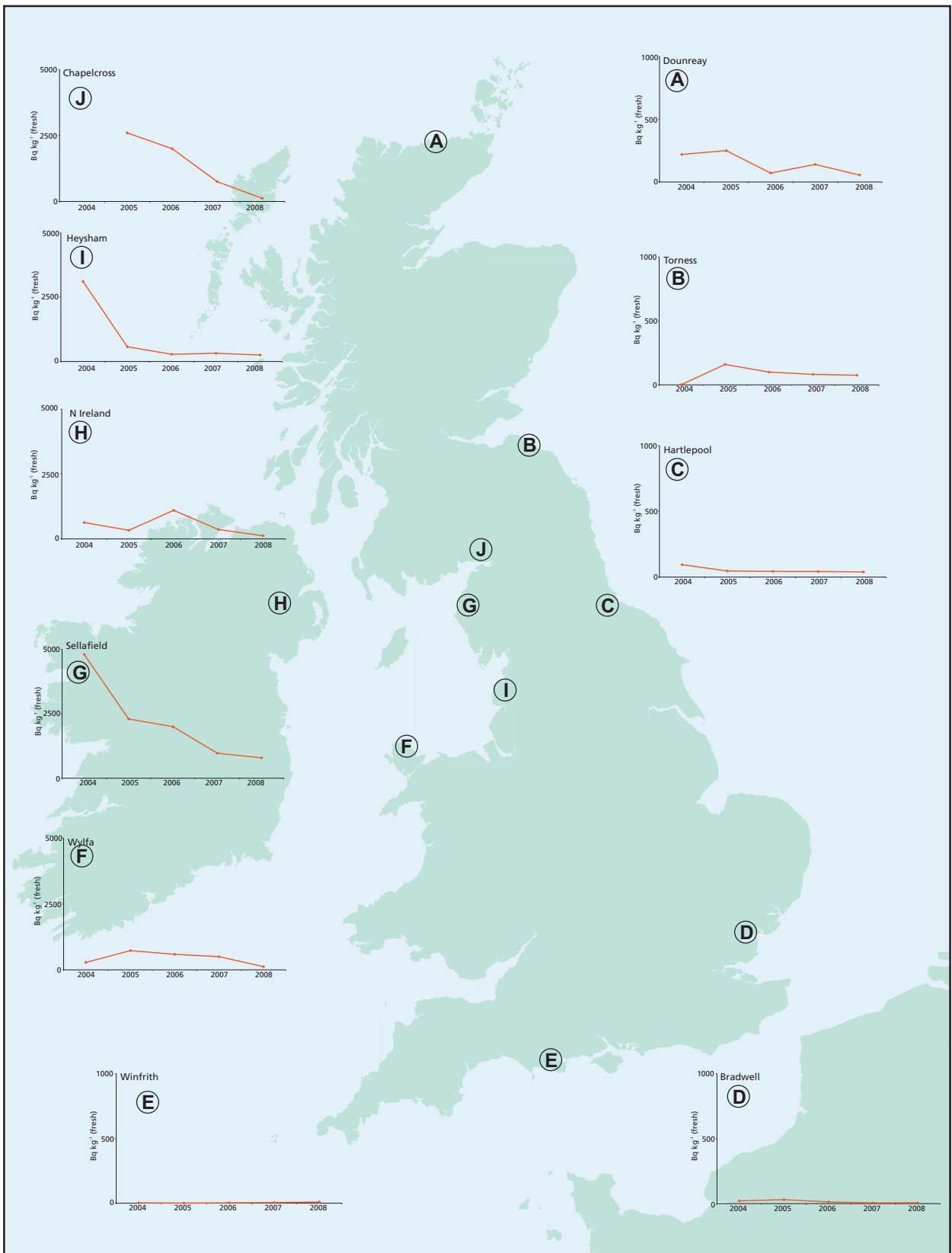


Figure 2. Technetium-99 concentrations in seaweed around the UK (2004-2008)

### 1.3 Doses to the public from diet away from nuclear sites

The Food Standards Agency also has responsibility for food safety, and determines the doses from radionuclides in foods eaten around the UK. These data are presented in Table 1. This gives an indication of the range of doses to the public from foods between 2005 and 2008.

**Table 1. Ranges of estimated dose from radionuclides in diet between 2005-2008#**

Country	Mean exposure mSv/y		
	Man-made radionuclides	Naturally-occurring radionuclides	All radionuclides
England	0.001 - 0.002	0.035 - 0.28	0.036 - 0.28
Wales	0.001	0.029 - 0.098	0.030 - 0.099
Northern Ireland	0.001 - 0.002	0.039 - 0.075	0.04 - 0.077
Scotland	0.002 - 0.003	0.054 - 0.16	0.057 - 0.17
UK	0.001 - 0.002	0.039 - 0.24	0.040 - 0.24

# Note : no equivalent dose data by region was reported in 2004 (RIFE 10)

## 2. Nuclear fuel production and reprocessing

This section looks at the trends over the five years (2004-2008) from the UK's nuclear fuel production and reprocessing sites. The time trends show the public's exposure, discharges of radioactive waste and concentrations of radionuclides in food and the environment. The public's exposure\* (dose) from radioactive waste discharges is assessed using radionuclide concentrations and gamma dose rates in the environment. The public's exposure from naturally-occurring radionuclides is also considered near Sellafield.

There are four sites in the UK involved with production and reprocessing of nuclear fuel. Capenhurst, near Ellesmere Port in Cheshire has two licensed nuclear sites; one produces enriched uranium and the other is currently being decommissioned. The third site is at Springfields, near Preston, where fuel for nuclear power stations is made. The fourth site is Sellafield in West Cumbria where irradiated fuel from nuclear power stations is reprocessed.

### 2.1 Public's exposure to radiation due to discharges of radioactive waste

Trends over time (2004-2008) for the exposure to radiation due to waste discharges from the UK's nuclear fuel production and reprocessing sites are for those groups most exposed to radiation and shown in Figure 3.

At all locations, the doses from radioactive waste discharges were significantly below the UK and European limit for members of the public of 1 mSv per year.

The highest annual dose (from artificial radionuclides) was 0.24 mSv in 2008 near Sellafield. Over the five years these Sellafield annual doses ranged from 0.22 to 0.24 mSv. This was less than a quarter of the dose limit. This was determined in people who ate seafood, and was mostly due to the accumulation of radionuclides including caesium-137, plutonium isotopes and americium-241 in seafood and the environment. These doses were attributable to historic liquid discharges from Sellafield which were at their highest during the 1970s and 80s. Between 2004 and 2007, habit surveys indicated an increase in the amount of fish and shellfish eaten, which led to a slight rise in doses during this time. In 2008 consumption went down again leading to a reduction in doses, together with a reduction in dose from artificial radionuclides.

### Key points

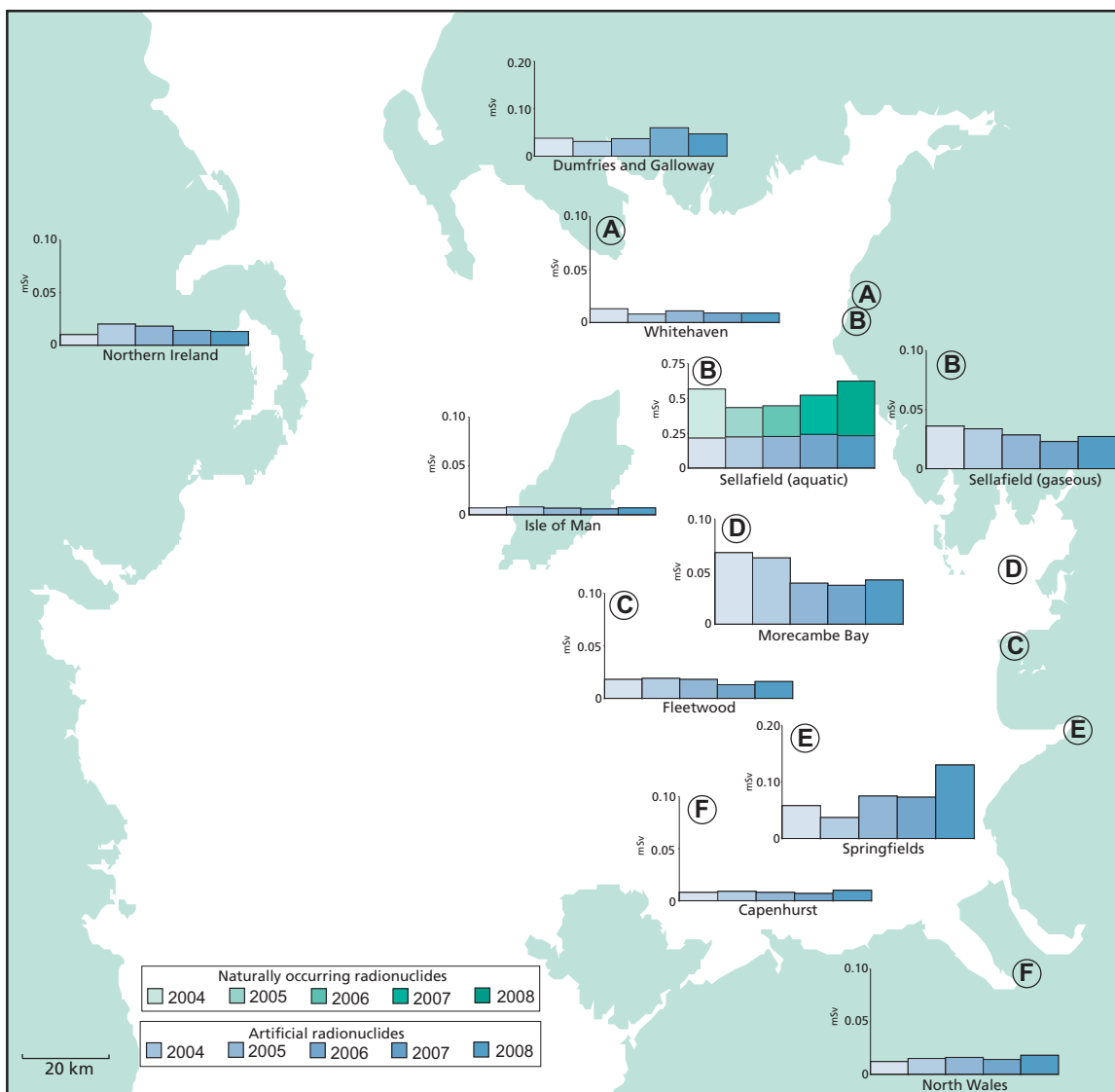
- All doses were significantly less than the dose limit for members of the public of 1 mSv per year
- Highest annual dose (from artificial radionuclides) was 0.24 mSv at Sellafield
- Overall trend was a reduction in gaseous and liquid discharges, with all authorised discharges below authorised limits
- Doses from historic non-nuclear industry activity (naturally-occurring radionuclides) were significant near Sellafield

Figure 3 also shows the trend of doses to people who ate seafood near Sellafield resulting from the historic discharges of naturally-occurring radionuclides from the former phosphate works (non-nuclear industry) at Whitehaven (shown in green). The data show that the doses from naturally-occurring radionuclides were significantly larger than for artificial radionuclides. The increases in dose for naturally-occurring radionuclides in recent years were due to changes to both concentrations (polonium-210) in sea food and consumption rates (of fish and shellfish).

Exposure of communities associated with fisheries in other parts of the Irish Sea was also assessed. These included Whitehaven, Dumfries and Galloway, Morecambe Bay, Fleetwood, Northern Ireland, North Wales and the Isle of Man. The assessments show that exposures in these areas were lower than to people local to Sellafield. This was due to the lower concentrations and dose rates further away from Sellafield. There were small changes in the reported doses in each area over the time period. These were caused by variations in gamma dose rates over sediment, new information on people's eating habits and fluctuations in radionuclide concentrations (mainly americium-241 in some shellfish).

At Dumfries and Galloway, the people who consumed seafood received the highest annual dose in Scotland over the five year-period. This was the group most exposed to the effects of Sellafield discharges. The annual doses ranged between 0.031 and 0.060 mSv over the five-year period. The increase in dose in 2007 around Dumfries and Galloway was attributed to an increase in the amount of shellfish eaten, identified from

\* The monitoring results are interpreted in terms of radiation exposures of the public, commonly termed 'doses'. These people are a group, who generally eat large quantities of locally grown food (high rate consumers) or who spend long periods of time in the locations being assessed. This dose, referred to in Sections 2-6, is an exposure that uses a different assessment method to that of *total dose* in Section 1.



**Figure 3.** Individual radiation exposures to most exposed groups from artificial radionuclides, Irish Sea (2004-2008) (includes exposures from naturally-occurring radionuclides near Whitehaven)

new habits survey information. For all assessments of exposure of the fishing communities, there would also have been fluctuations in concentrations due to normal sampling variability. Whilst there were changes between years in the concentrations of some radionuclides in seafood, their effect was relatively minor.

The annual doses received by people at Sellafield, who were exposed to gaseous discharges from the site ranged between 0.023 and 0.036 mSv over the five-year period. The dose was from inhaling gases, from radiation emitted from the gas and from eating food grown on land around the site. Before 2008, this trend was generally declining because of the permanent shut down of Calder Hall power station on the Sellafield site which ended gaseous discharges of argon-41 and sulphur-35. In 2008, the assessment method changed slightly to include cobalt-60 results (which were at the limits of analytical detection) which increased the dose over previous years.

The next group most affected by artificial radionuclide discharges was in the Ribble Estuary near the Springfields site. For those people living on houseboats in the Ribble Estuary, there was an apparent increase in annual dose, which ranged between 0.037 and 0.130 mSv over the five-year period. However, the trend over time included improvements in the methods used for dose assessments. The increase in doses from 2006 was due to updated information and additional measurements concerning the exact location of houseboats. The further increase in 2008 was due to a combination of increased gamma dose rates and the time spent on the houseboats.

At Capenhurst, children playing in and around Rivacre Brook received the highest annual dose. This ranged between 0.007 and 0.010 mSv over the five-year period. The doses were estimated using gamma dose rates, assuming children spent time on the banks of the brook and swallowed some water and sediment. The changes in dose over time were due to variations in gamma dose rates over sediment.

## 2.2 Sellafield, Cumbria

### 2.2.1 Discharges of radioactive waste

Authorised discharges of gaseous and liquid waste are released into the atmosphere and into the Irish Sea, from a wide variety of facilities and sources. Figure 4 shows the trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

The Sellafield site included a Magnox power station, at Calder Hall. In 2003 the power station stopped generating electricity.

Gaseous discharges from Calder Hall dropped significantly from then on. Since 2004, the overall trend was a reduction of gaseous and liquid discharges with time. In 2008, a revised gaseous authorisation limit was introduced for antimony-125 to reflect increased discharges of this radionuclide as a result of reprocessing Magnox spent fuel. All liquid discharges followed a pattern of overall reduction, technetium-99 for example continued to significantly decline over the five-year period. Other reductions in liquid discharges in recent years were due to a decrease in the rate of spent fuel reprocessing operations.

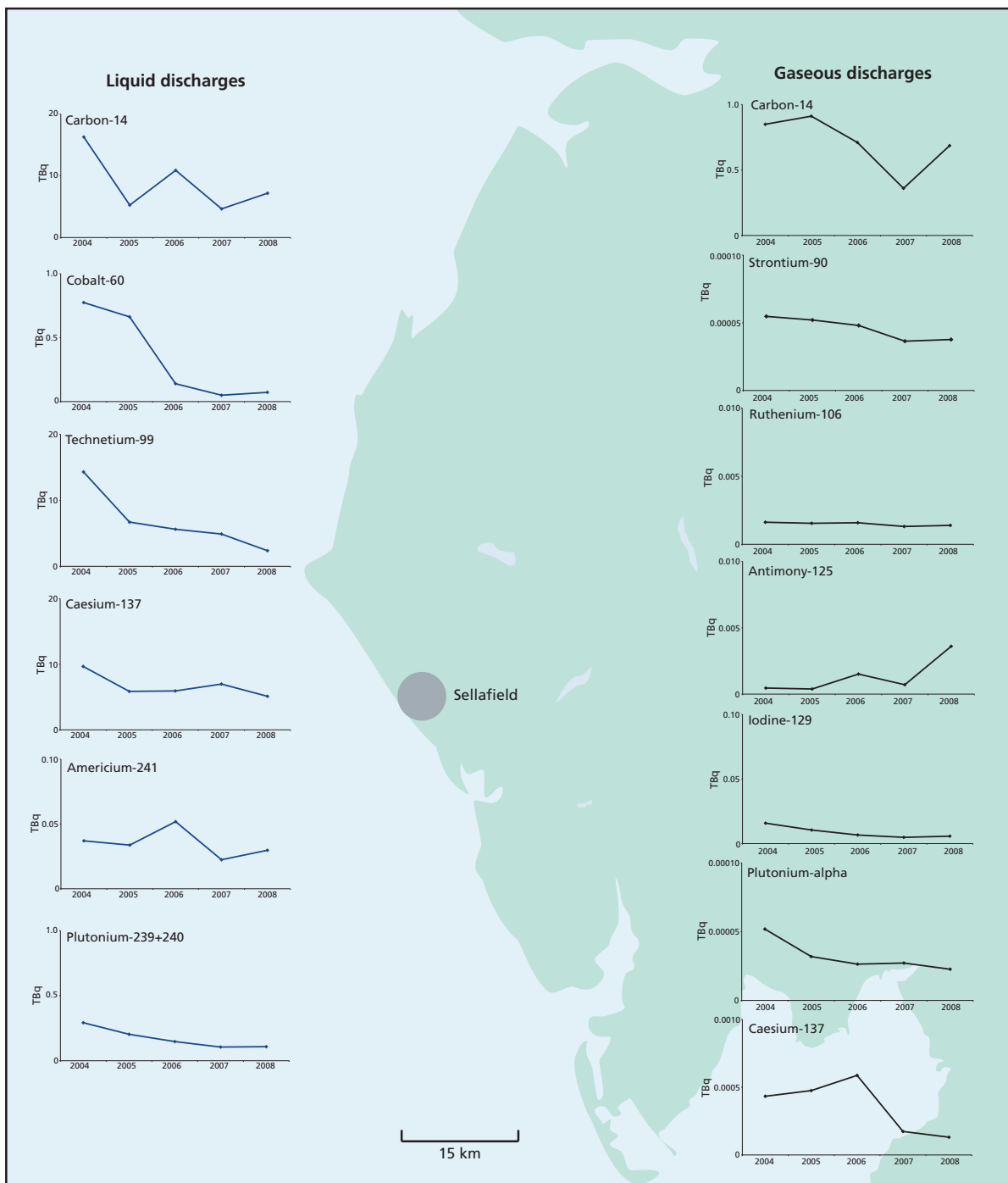


Figure 4. Authorised discharges of gaseous and liquid wastes, Sellafield (2004-2008)

## 2.2.2 Concentrations of radionuclides in food and the environment

The food and environment monitoring programmes around Sellafield are the most extensive in the UK; this includes monitoring for the effects from Sellafield in other parts of the Irish Sea. The monitoring reflects the range and concentrations of radionuclides that have been discharged from Sellafield over a considerable number of years.

Figure 5 shows the trends of radionuclide concentrations in food (winkles, lobsters, plaice and milk) and the environment (seawater and sediment) near Sellafield between 2004 and

2008. All radionuclide concentrations in the environment from gaseous discharges were very low. Over the five-year period, concentrations of caesium-137, carbon-14 and strontium-90 in milk were relatively constant.

Concentrations of radionuclides in seafood generally continued to reflect changes in liquid discharges over the five years. The majority of trends for carbon-14 and cobalt-60 concentrations showed large decreases directly associated with a fall in discharges since 2004. Similarly, technetium-99 concentrations in shellfish declined significantly. Between 2004 and 2008, concentrations of caesium-137 in seafood were relatively constant, with any changes attributable to natural variation

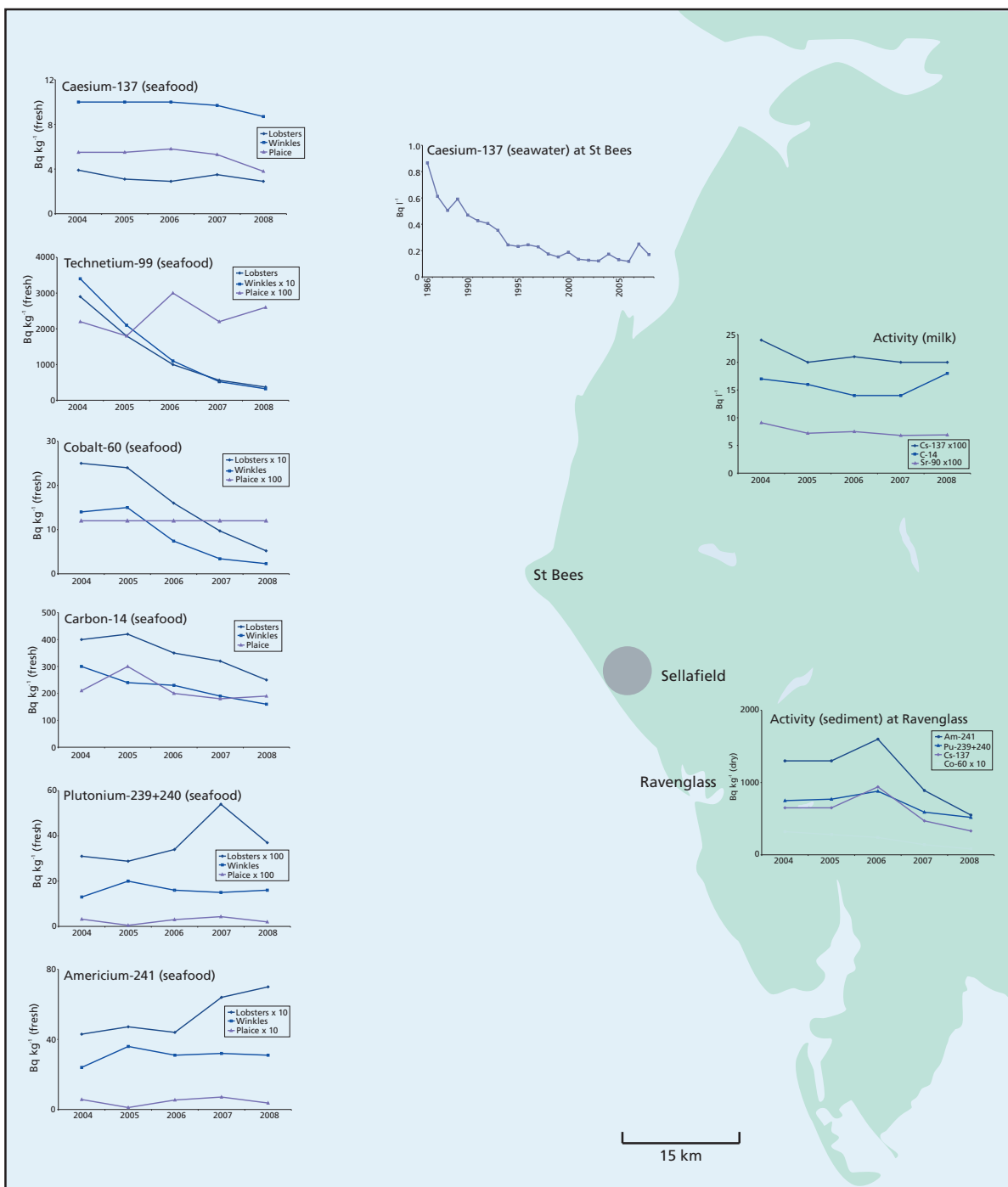


Figure 5. Monitoring of the environment from discharges of radioactive wastes, Sellafield (2004-2008)

in the samples taken from the environment. Caesium-137 concentrations in seafood may be affected by the release of this radionuclide from seabed and estuary sediment. Over the last five years, concentrations of plutonium-239+240 and americium-241 in seafood were relatively constant, with a few slightly elevated concentrations in shellfish in the most recent years.

Figure 5 also shows the trends in concentrations in sediment from Ravenglass (five years) and caesium-137 in seawater (1986-2008) at St Bees. For caesium-137 in seawater, the figure shows (as the rate of decrease is slower, relative to the reduction rate of discharges, over the longer period) that the current sources are liquid discharges from the site and the release of caesium from sediments (from earlier discharges in earlier decades) into the water column. The concentrations of most radionuclides in sediments have decreased over the past two decades, responding to decreases in discharges. Over the five-year period, sediment concentrations of cobalt-60 at Ravenglass followed the changes in discharge levels, with some evidence of a lag time between discharge and sediment concentrations.

Over the last five years, there has been some variability in the concentrations of several radionuclides in sediments at Ravenglass. There is even a suggestion of progressive increases in the concentrations in sediments (peaking over the period 2004–2006). This was followed by a decline to the lowest levels in 2008. This trend in concentrations was most likely due to disturbing, moving and resettling of fine-grained sediments containing higher activity concentrations. For americium-241, increases in concentrations could be due to gradual in-growth from radioactive decay of plutonium-241. This is already present in the environment from past site discharges.

### 2.3 Capenhurst – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

Uranium is main gaseous radionuclide discharged from the two licensed nuclear sites at Capenhurst. Liquid waste discharges to the Rivacre Brook are authorised for tritium, uranium and daughters, technetium-99 and non uranium alpha (mainly neptunium-237).

Figure 6 shows the trends of these discharges over time (2004–2008) for a number of the authorised radionuclides.

The overall trend was a reduction in gaseous and liquid discharges. Most of the reductions were attributed to progress in decommissioning some of the older plant and equipment.

Figure 6 also provides selected monitoring trends to assess the impact on the surrounding environment. The concentrations of technetium-99 in grass were relatively low during the five-year period. Concentrations of Uranium radionuclides in food and the environment were very low.

Concentrations of technetium-99 in sediment (Rivacre Brook) from liquid discharges were detectable close to the discharge point. The increase in 2007 was probably due to the discharge occurring at the same time as environmental sampling. Concentrations of caesium-137 and americium-241 in sediments at Rock Ferry and New Brighton on the Irish Sea coast were from past discharges from Sellafield carried into the area by tides and currents. The concentrations were generally similar over the five years and any fluctuations were most likely due to normal changes in the environment.

### 2.4 Springfields – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

The main radioactive constituent of gaseous discharges from Springfields is uranium with small amounts of other radionuclides from research and development facilities. Authorised discharges of liquid waste (including alpha and beta emitting radionuclides, technetium-99, thorium-230, thorium-232, neptunium-237, uranium and other transuranic radionuclides) are made from the Springfields site to the Ribble Estuary by two pipelines. The largest discharge for a number of years was of short half-life beta emitting radionuclides (mainly thorium-234).

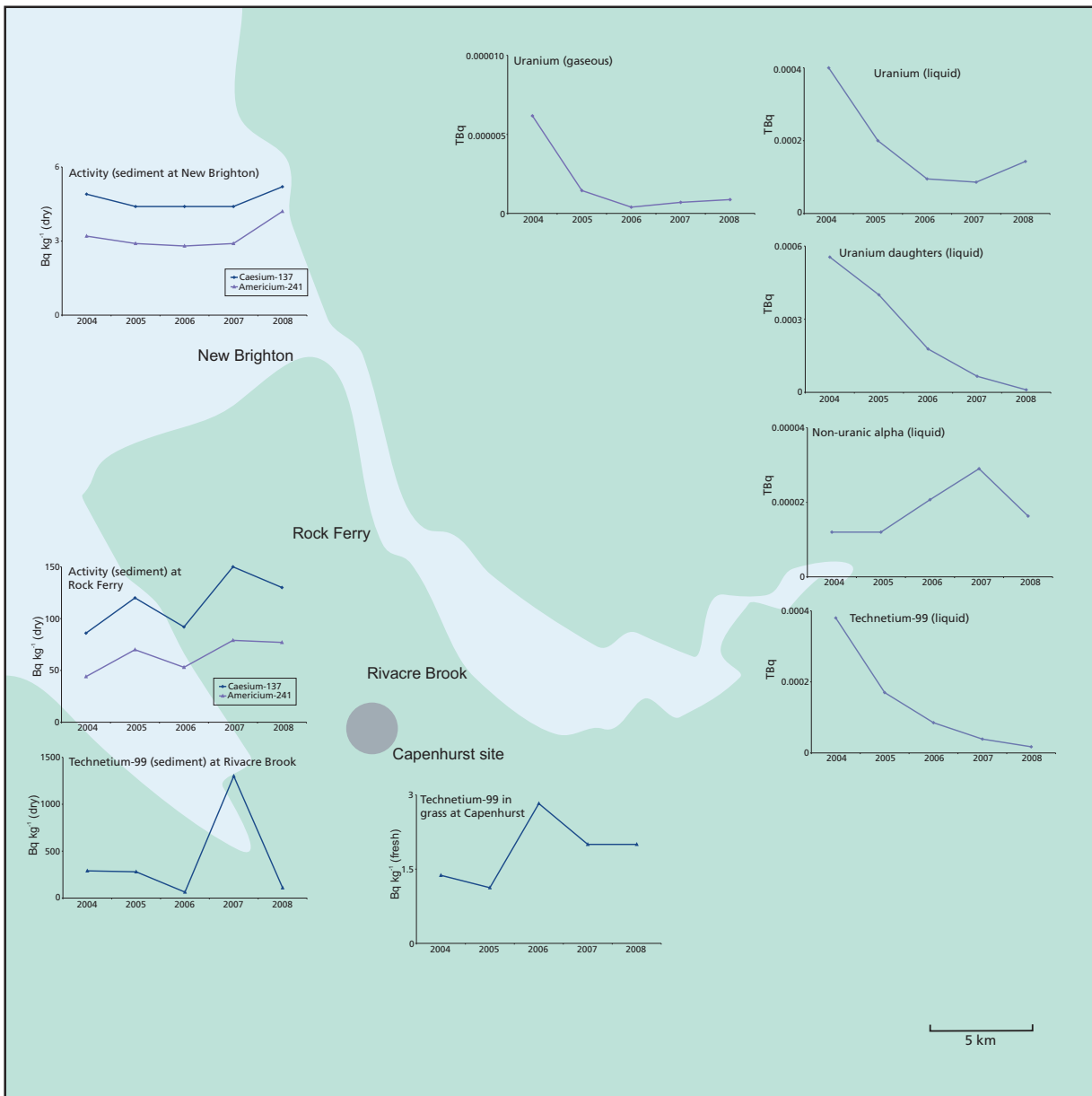
Figure 7 shows the trends of these discharges over time (2004 – 2008) for a number of the authorised radionuclides.

The most significant change in the discharge trends was the step reduction of short half-life beta emitting radionuclides in liquid discharges, mostly thorium-234. The reduction was because the Uranium Ore Concentrate purification process ended in 2006. Liquid discharges of uranium radionuclides steadily decreased over time, whilst other discharges were relatively constant.

Figure 7 also shows the trends of radionuclide concentrations in food (cabbage, shrimps, flounders and salmon) and the environment (sediment) near Springfields.

The concentrations of radionuclides from gaseous discharges were very low. Over the five-year period, concentrations of uranium were found in soil around the site, but the isotopic ratio showed they were naturally-occurring. Total uranium in cabbage samples was also detected during the period (no data in 2006), but the apparent peak in 2007 was very low and significantly less, when compared to concentrations in slightly elevated soil samples.

Concentrations of technetium-99 and caesium-137 were present in flounder, shrimps and salmon around Springfields. These were due to past liquid discharges from Sellafield, carried from the waters off West Cumbria into the Ribble Estuary by sea currents and adsorbed on fine-grained mud. The change in concentrations was due to natural changes in the environment.



**Figure 6.** Discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Capenhurst (2004-2008)

The trends over the five-year period of concentrations in sediments from liquid discharges are shown in Figure 7. The concentration trends were dominated by the reduction of thorium-234 in liquid discharges. Concentrations of caesium-137 and americium-241 in marine life, which have shown a more gradual downward trend, were due to discharges from Sellafield, which have themselves reduced during this period.

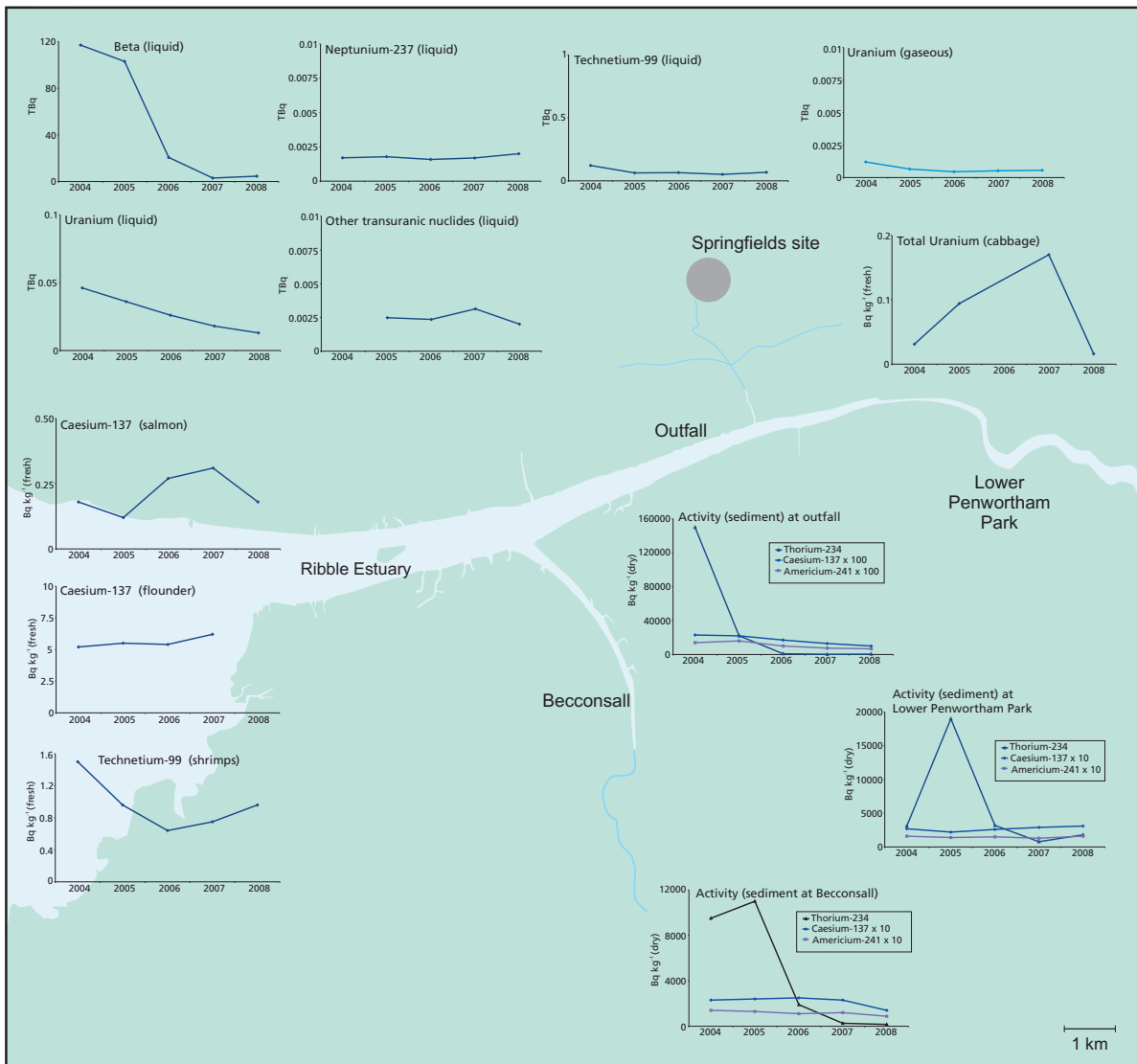


Figure 7. Discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Springfields (2004-2008)

## 2.5 Summary

The information presented in Table 2 gives an overview of trends associated with doses, discharges and environmental concentrations described in Section 2.

Table 2. Summary of trend data for nuclear fuel production and reprocessing sector (2004-2008)\*

Trend data	Downwards	No change	Upwards	Overall	
Gaseous discharges	7	1	1	Majority downward trend	↓
Liquid discharges	13	0	2	Majority downward trend	↓
Overall discharges	20	1	3	Majority downward trend	↓
Environmental concentrations	5	1	3	No overall direction	→
Food concentrations	7	0	4	Majority downward trend	↓
Food and the environment overall	12	1	7	Majority downward trend	↓

All doses were below the dose limit

\* Taken from the number of trend graphs for this sector presented in this report. This is a visual evaluation only.

## 3. Research establishments

This section looks at the trends over the five years (2004–2008) from the UK's research establishments that hold Nuclear Site Licences. The time trends show the public's exposure, discharges of radioactive waste and concentrations of radionuclides in food and the environment. The public's exposure\* (dose) from radioactive waste discharges is assessed using radionuclide concentrations and gamma dose rates in the environment.

There are seven sites associated with research reactors that are currently authorised to discharge radioactive waste in the UK. The main sites are Dounreay in Highland, Harwell in Oxfordshire and Winfrith in Dorset. Other smaller research sites include Culham (Oxfordshire), the Imperial College Reactor Centre (Berkshire), the Scottish Universities' Environmental Research Centre (Lanarkshire), and Windscale (Cumbria) which is on the Sellafield site.

### 3.1 Public's exposure to radiation due to discharges of radioactive waste

The public's exposure to radiation around all research establishment sites was assessed. All doses were much less than the UK and European limit of 1 mSv per year for members of the public.

Figure 8 shows the trends over the five years between 2004 and 2008 of the public's exposure to radiation due to the effects of gaseous and liquid waste discharges at the main research sites.

The figure shows the highest annual dose was at Dounreay from consuming food produced on land around the site. This ranged between 0.008 and 0.047 mSv over the five-year period. The sudden increase in dose in 2005 (and subsequent dose thereafter) was due to dose estimates being more conservative. They were more conservative because higher analytical limits of detection were used in the assessments.

The annual dose from seafood consumption and external exposure over local beaches at Dounreay ranged from less than 0.005 to 0.010 mSv over the five year-period. Between 2004 and 2007, the variations in dose were mostly likely due to normal changes in the environment. In 2008 however, a

### Key points

- All doses were less than the dose limit for members of the public of 1 mSv per year
- Highest annual dose (from artificial radionuclides) was 0.047 mSv at Dounreay
- All authorised discharges were well below the authorised limits
- Overall, gaseous and liquid discharges were low
- Concentrations in the marine and terrestrial environment and food continued to be very low

relatively small increase in dose was attributed to a general increase in gamma dose rates.

At Harwell, the group of people most affected by radioactive waste discharges were anglers on the River Thames, with annual doses from less than 0.005 to 0.013 mSv over the five-year period. This change in dose with time was mainly due to a decrease in gamma dose rates (in 2006) and revised occupancy rates on the river bank (in 2007).

At Winfrith (and all the other smaller sites), all assessed doses were well below 0.005 mSv, which is less than 0.5 per cent of the dose limit for members of the public.

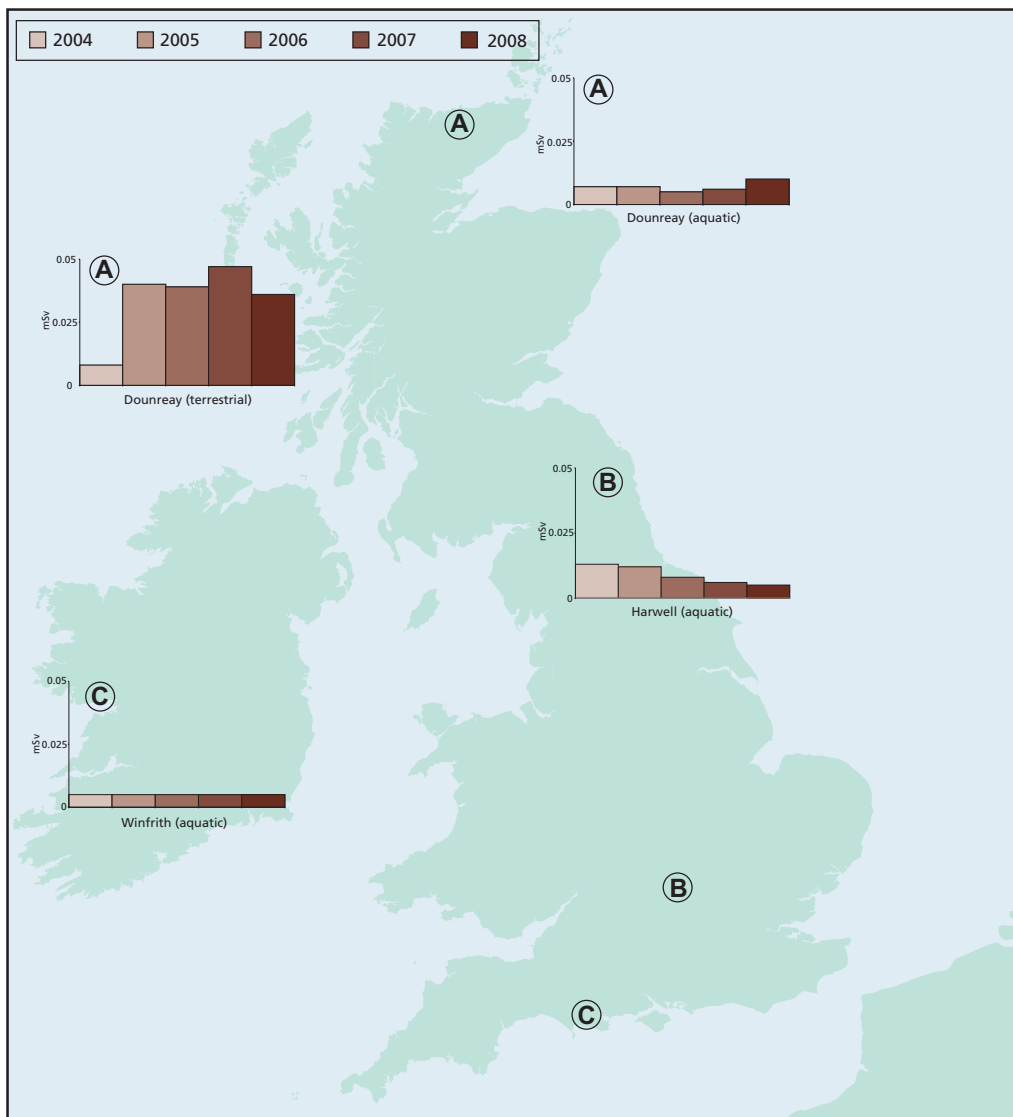
### 3.2 Dounreay – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

Gaseous and liquid discharges are released into the atmosphere and into the sea (Pentland Firth).

Figure 9 shows the trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

The levels of several of the radionuclides from gaseous and liquid discharges appeared to peak in 2005, but then reduced in following years.

\* The monitoring results are interpreted in terms of radiation exposures of the public, commonly termed 'doses'. These people are a group, who generally eat large quantities of locally grown food (high rate consumers) or who spend long periods of time in the locations being assessed. This dose, referred to in Sections 2-6, is an exposure that uses a different assessment method to that of *total dose* in Section 1.



**Figure 8.** Individual radiation exposures to most exposed groups from artificial radionuclides, Dounreay, Harwell and Winfrith (2004-2008)

Figure 9 also provides selected monitoring trends to assess the impact on the surrounding environment. The majority of measurements of radionuclide concentrations in food and the environment were at or below the analytical limits of detection, which made it difficult to produce valuable trend monitoring data that may correspond to discharge data. Nevertheless, concentrations of technetium-99 from Sellafield found in seaweed taken from Sandside Bay, Kinlochbervie and Burwick Pier showed an overall decline over the period. Variations were most likely due to the complexity of how radionuclides move around in the Irish Sea, with technetium-99 being dispersed in varying amounts before arriving at distant locations. Concentrations of caesium-137 in sediments at Sandside Bay, Rennibister and Oigins Geo were likely to include a contribution from Sellafield discharges. The concentrations were generally unchanged over the five-year period, with any fluctuations most likely due to normal variations in the environment.

### 3.3 Harwell – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

Gaseous and liquid releases from Harwell are discharged into the atmosphere and to the River Thames at Sutton Courtenay and to the Lydebank Brook north of the site.

Figure 10 shows trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

The gaseous discharges were low and generally similar over the five-year period. There was an overall reduction in liquid discharges, particularly for cobalt-60, and, to a lesser extent, for caesium-137.

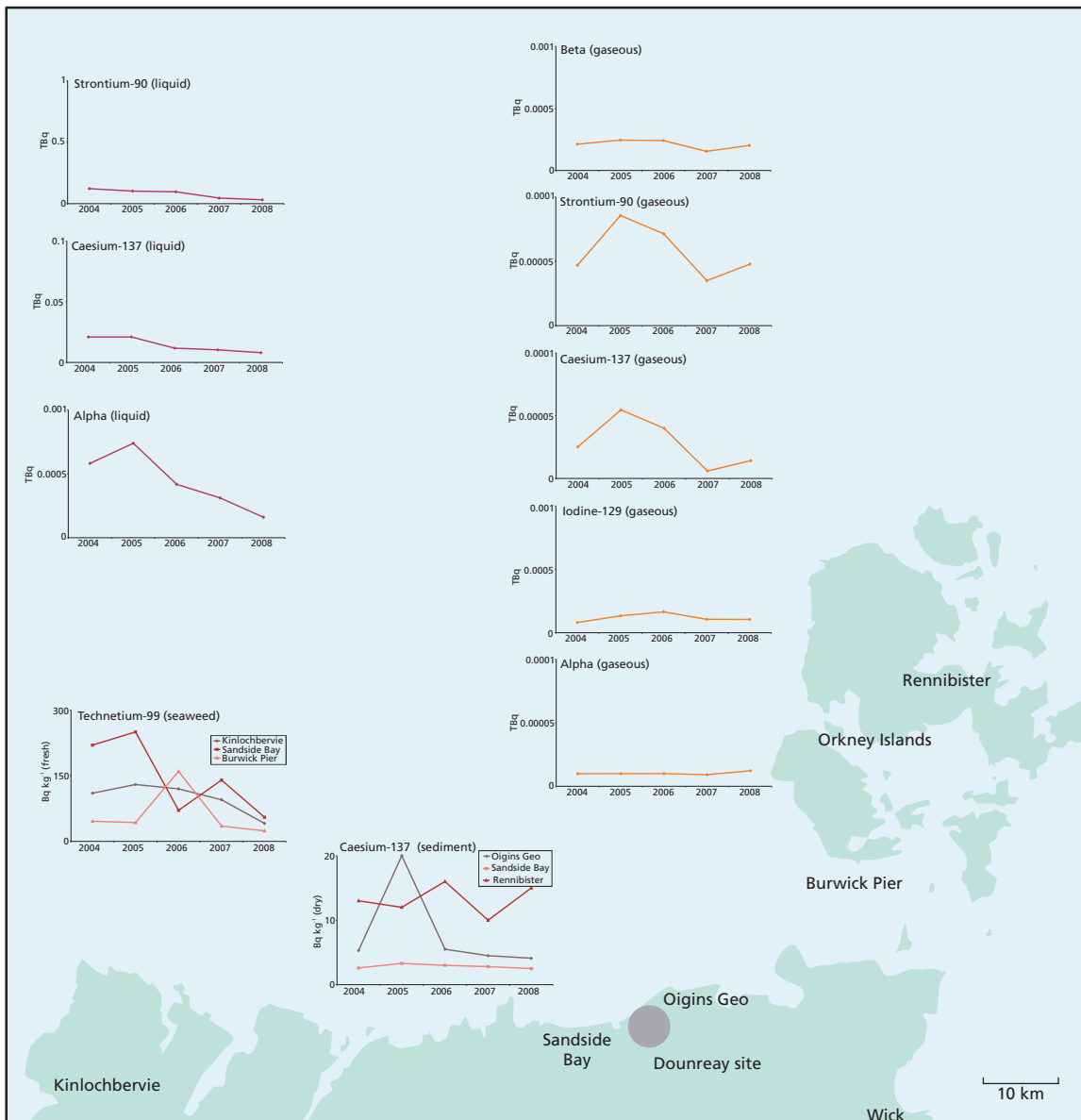


Figure 9. Discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Dounreay (2004-2008)

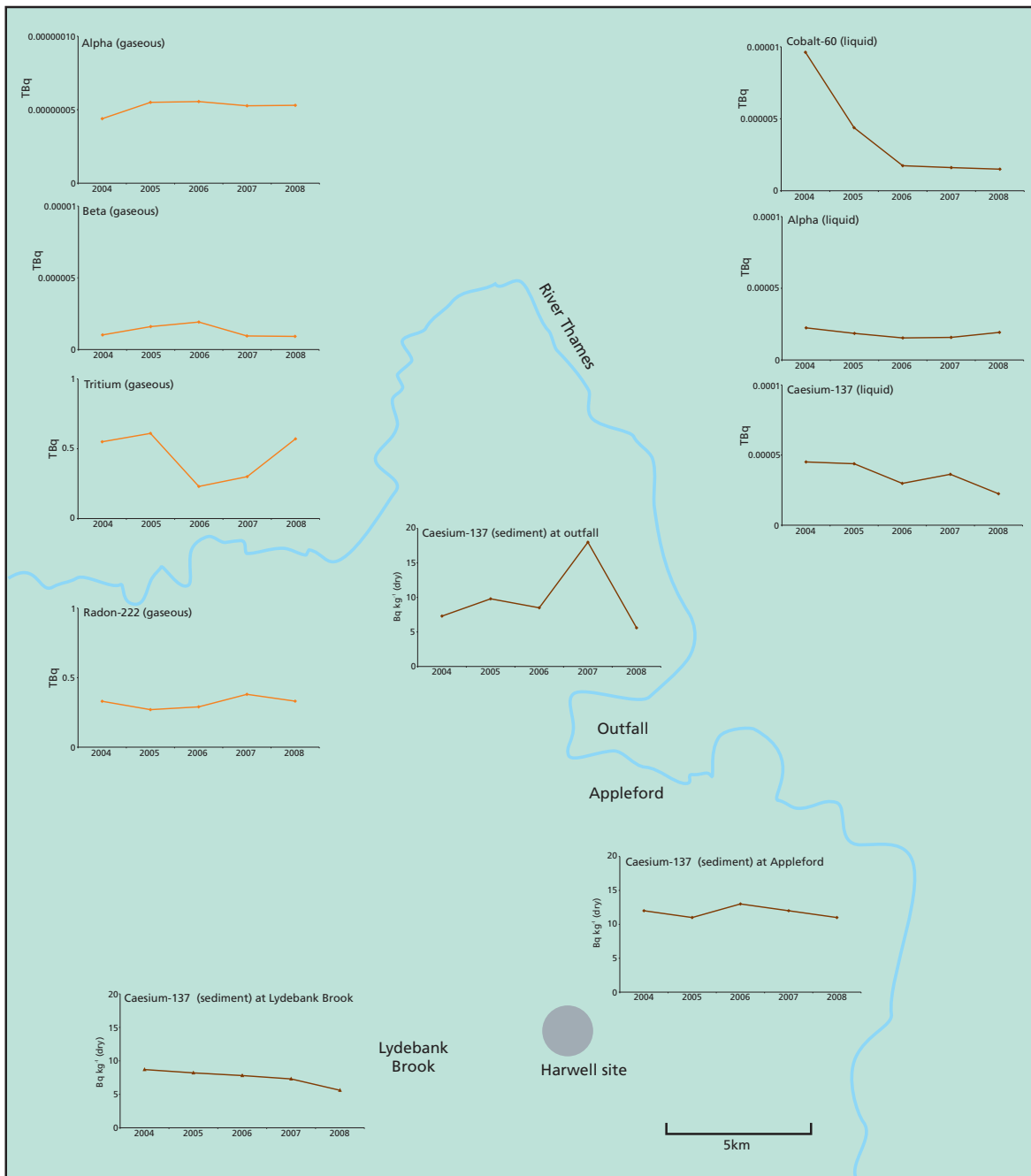
Figure 10 also provides monitoring trends from three locations to assess the impact on the surrounding environment. Concentrations of caesium-137 in sediments from the Harwell outfall, Appleford and Lydebank Brook were generally declining due to reduced liquid caesium-137 discharges. As expected, the biggest difference in concentrations was observed near the discharge point. Discharges from Harwell to the Thames are not continuous but occur in batches when tanks are emptied. The slight increase in 2007 was probably due to the discharge occurring at the same time as environmental sampling.

### 3.4 Winfrith – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

Gaseous emissions from Winfrith are discharged into the atmosphere, and liquids to deep water in Weymouth Bay and to the River Frome.

Figure 11 shows the trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

Gaseous discharges of tritium peaked in 2006 and this coincided with a revised authorisation to increase tritium discharges from the site, for the processing of wastes. Other gaseous and liquid discharges remained at low rates over the period.



**Figure 10.** Discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Harwell (2004-2008)

Figure 11 also provides radionuclide concentrations from four locations, to assess the impact on the surrounding environment. Concentrations of tritium in a stream north of the site showed enhanced levels that slightly increased following the revision of the authorisation in 2006. These concentrations were still relatively low and were less than 10 per cent of the World Health Organisation's screening levels for drinking water.

Plutonium radionuclides and americium-241 concentrations in seafood from the Lulworth Ledges, Lulworth Cove and Poole Bay were very low over the five-year period. Over the last five years, there has been some variability in the concentrations of these radionuclides in some foods, which may indicate that these concentrations had followed the trend in alpha liquid discharges.

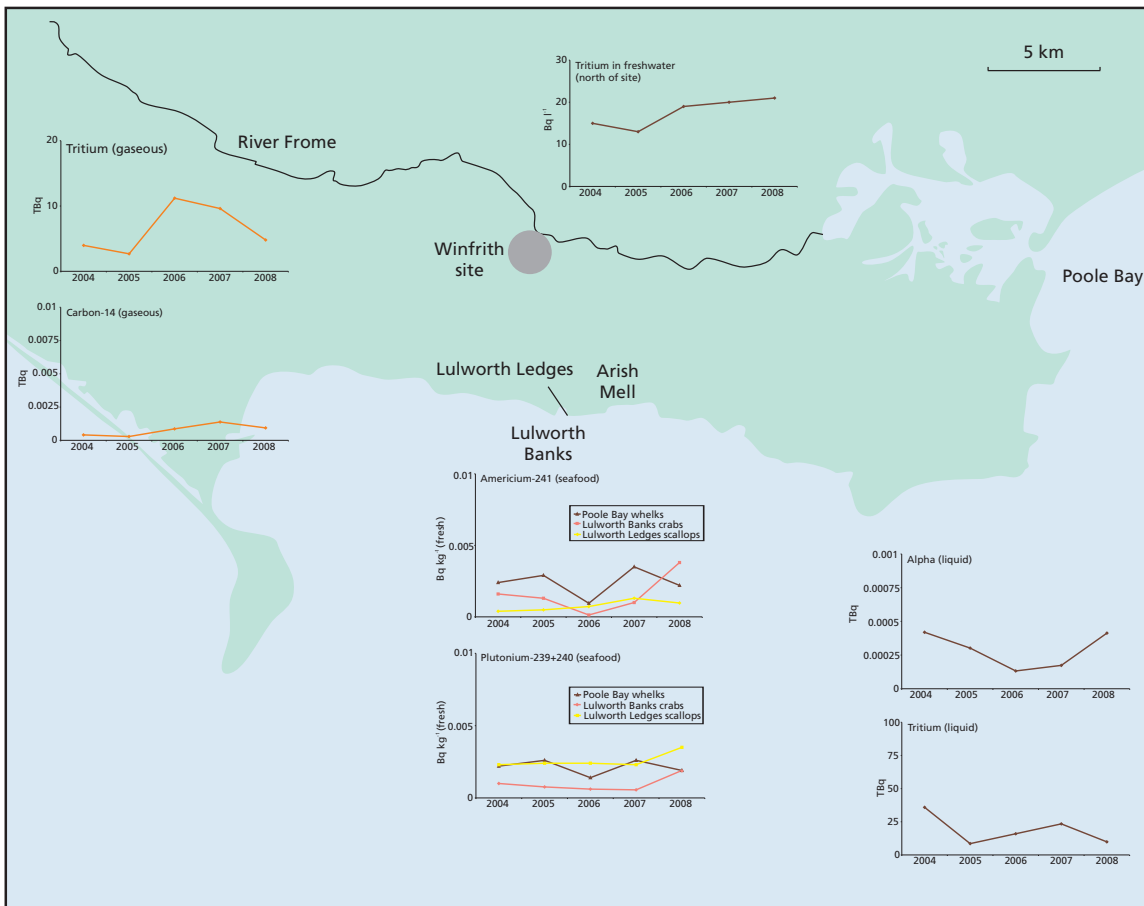


Figure 11. Discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Winfrith (2004-2008)

### 3.5 Summary

The information presented in Table 3 gives an overview of trends associated with doses, discharges and environmental concentrations described in Section 3.

**Table 3. Summary of trend data for research sector (2004-2008)\***

Trend data	Downwards	No change	Upwards	Overall	
Gaseous discharges	1	7	3	No overall direction	→
Liquid discharges	6	2	0	Majority downward trend	↓
Overall discharges	7	9	3	No overall direction	→
Food and the environment overall	2	3	3	No overall direction	→

All doses were below the dose limit

\* Taken from the number of trend graphs for this sector presented in this report. This is a visual evaluation only.

## 4. Nuclear power stations

This section looks at the trends over the five years (2004-2008) from the UK's nuclear power stations. The time trends show the public's exposure, discharges of radioactive waste and concentrations of radionuclides in food and the environment. The public's exposure\* (dose) from radioactive waste discharges is assessed using radionuclide concentrations and gamma dose rates in the environment.

There are a total of 19 nuclear power stations at 14 locations, nine in England (Berkeley, Oldbury, Bradwell, Calder Hall, Dungeness, Hartlepool, Heysham, Hinkley Point and Sizewell), three in Scotland (Chapelcross, Hunterston and Torness) and two in Wales (Trawsfynydd and Wylfa). Eleven of the 19 nuclear power stations are first generation Magnox power stations, seven are more recent advanced gas-cooled reactor (AGR) power stations and one is a pressurised water reactor (PWR) power station. Five out of the original 11 first generation Magnox Power stations were operating in 2004. Over the 5 year-period of this report three more stopped operating. This only left two operational in 2008, at Oldbury and Wylfa.

### 4.1 Public's exposure to radiation due to discharges of radioactive waste

Figure 12 shows the trends over the five years between 2004 and 2008 of the public's exposure to radiation due to the effects of liquid waste discharges at the power stations.

The dose is made up from consuming seafood and external exposure over intertidal areas. External dose from intertidal areas can be important contributor to dose where people spend a lot of time on beach area. At all locations, around these sites, the doses were all less than the UK and European limit for members of the public of 1 mSv per year.

Figure 12 shows the annual dose was highest to a group of local fishermen at Heysham, ranging between 0.037 and 0.068 mSv over the five-year period, and with the highest value in 2004. The doses were affected by past discharges from Sellafield, where radionuclides have travelled with currents around to the area. The decrease in dose after 2004 was due to a reduction in the amount of shellfish eaten (containing americium-241 from past discharges from Sellafield). Most of the dose to this group was affected by external radiation measured above beaches and tidal areas and variations in the

### Key points

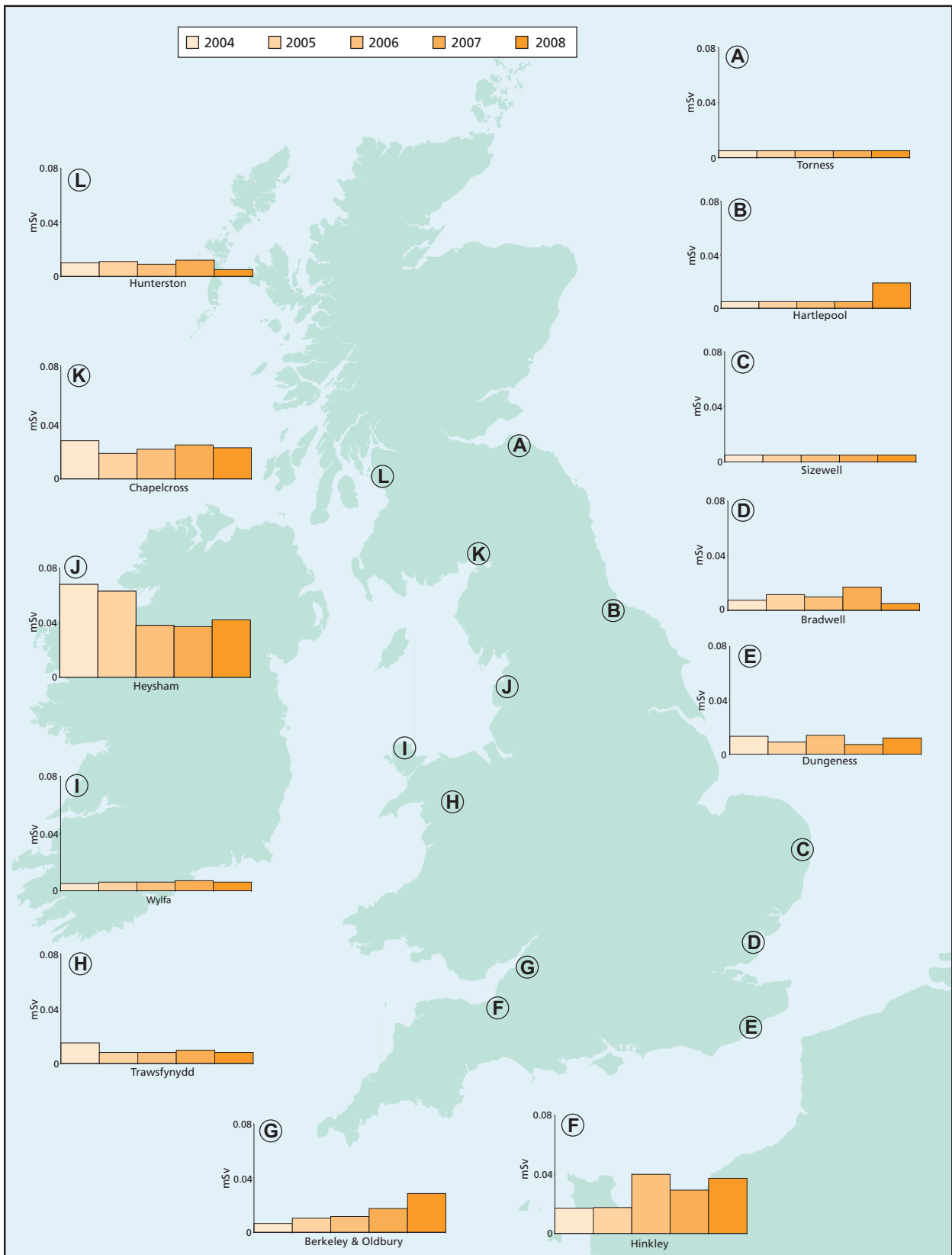
- All doses were less than the dose limit for members of the public of 1 mSv per year
- Highest annual dose (from artificial radionuclides) was 0.068 mSv at Heysham
- Most changes in dose between years resulted from natural changes in the environment
- Overall decline in gaseous and liquid discharges, with all authorised discharges well below the authorised limits
- Two Magnox sites (Oldbury and Wylfa) remained operational whilst stations at Chapelcross, Dungeness and Sizewell stopped generating electricity during the period
- Concentrations on the land continued to be very low and concentrations in the sea were affected by natural changes in the environment and/or influenced by other sources.

trend reflected changes between years in measured gamma dose rates.

The next group of people most affected by radioactive waste discharges was at Hinkley Point. This was also a group of local fishermen, with annual doses ranging between 0.017 and 0.040 mSv over the five-year period. The doses were from external radiation measured above beach sediment and a conservative estimate from tritium and carbon-14 in fish. Carbon-14 and tritium were likely due to discharges from the GE Healthcare facility at Cardiff. The trend graph shows an increase in dose in 2006. The increase was due to slightly enhanced external dose rates above sediments. Variations in these measurements have contributed to the trend in recent years. There was no site related reason to account for the trend in dose rates, and the changes between years was most likely due to variations in natural radiation.

People living near Berkeley and Oldbury received annual doses between 0.006 and 0.028 mSv. This included external radiation, and a conservative estimate due to the tritium from Cardiff. The apparent increase in dose in 2008 was due to a higher gamma dose rate measured in a different type of sediment (mud). Before 2008, the changes in dose were likely due to normal changes in the environment.

\* The monitoring results are interpreted in terms of radiation exposures of the public, commonly termed 'doses'. These people are a group, who generally eat large quantities of locally grown food (high rate consumers) or who spend long periods of time in the locations being assessed. This dose, referred to in Sections 2-6, is an exposure that uses a different assessment method to that of *total dose* in Section 1.



**Figure 12.** Individual radiation exposures around nuclear power stations from aquatic pathways for artificial radionuclides (2004-2008) (Small doses less than or equal to 0.005mSv are recorded as being 0.005mSv)

Local fisherman at Chapelcross received annual doses ranging from 0.018 to 0.024 mSv over the five-year period. The changes in doses were attributed to variations in gamma dose rate measurements over sediments. The discharges from Chapelcross contributed a very small fraction of the dose to the local population. Most of the dose was attributed to historic Sellafield discharges.

At Bradwell, the annual dose ranged from less than 0.005 to 0.017 mSv. The highest dose was in 2007. In 2007, new habits information became available including about occupancy of boats at the main mooring locations. These data were included in the assessment of dose and lead to an increase in the dose calculated for the group. Before 2007, the changes were mainly due to normal changes in the environment. In 2008, a decrease was observed in dose rate above beaches and this lead to a decrease in doses to the group.

At Dungeness, the annual dose to a group of local bait diggers or a group of people living on houseboats ranged between 0.007 and 0.014 mSv. The changes in dose were mainly due to the normal variations in concentrations and dose rates in the environment.

At Hartlepool, between 2004 and 2007, the annual dose to a group of local fishermen was assessed to be less than 0.005 mSv over the period. The apparent increase in 2008 was due to the identification and assessment of a new pathway, for the external exposure of sea coal collectors.

At Hunterston, the annual dose ranged from less than 0.005 to 0.012 mSv. This included a contribution from technetium-99 in shellfish, the activity having been discharged from Sellafield. Over the five-year period, the trend was due to differences in measured gamma dose rates from normal changes in the environment.

At Trawsfynydd, the annual dose ranged between 0.008 and 0.010 mSv over the five years. The assessed dose was for a group of anglers using the lake for fishing. Part of their dose was from external exposure. It has proved difficult to obtain a reliable dose rate from artificial radionuclides by measurement, because of uncertainty in the dose rate from natural radionuclides. So for this assessment, external dose was calculated from radionuclide concentrations (in particular caesium-137) using an external dose rate model. Caesium-137 concentrations in sediments have declined over the 5 year period so the model predicts a reduction in dose rate.

At Wylfa, the annual dose to a group of people who ate a large amount of fish and shellfish ranges from less than 0.005 to 0.007 mSv. The reduction in dose in 2004 at Wylfa was due to new estimates of consumption and occupancy rates. There was no significant trend in doses from marine pathways in recent years.

All assessed doses were much less than 0.005 mSv at both Sizewell and Torness, over the five-year period, with no significant variation in doses to seafood consumers.

## 4.2 Discharges of radioactive waste from nuclear power stations

Authorised discharges of gaseous and liquid waste are made to the atmosphere and into the sea (except at Trawsfynydd where liquid discharges are released into Lake Trawsfynydd – see section 4.4 for discharges). Figures 13 and 14 respectively, show the trends of gaseous and liquid discharges over time (2004–2008) for a number of radionuclides.

For Magnox stations, radionuclide authorisations include tritium and carbon-14 (gaseous), and tritium and caesium-137 (liquid). For operating Magnox stations authorised discharges of argon-41 and sulphur-35 gases are made. For AGR and PWR stations, these include tritium, carbon-14, sulphur-35 and argon-41 (for gaseous discharges), and tritium, sulphur-35, cobalt-60 and caesium-137 (for liquid discharges).

For the sites with only Magnox reactors (excluding Trawsfynydd – see section 4.4), the most significant trend over the five-year period was an overall decline in the gaseous discharges of tritium and carbon-14 and liquid discharges of tritium and caesium-137. There was a pronounced decrease in the discharge of gaseous and liquid tritium from Chapelcross. This is because Chapelcross stopped generating electricity in 2004. Sizewell A and Dungeness A, both showed significant declines in gaseous discharges of argon-41 and sulphur-35 after 2006. This was the year that they were shut down permanently. Gaseous and liquid tritium discharges from Berkeley and Oldbury also reduced with time. Gaseous tritium and carbon-14 discharges at Bradwell were low and liquid discharges of tritium decreased. Gaseous and liquid discharges at Wylfa were reasonably similar over the period (except for gaseous argon-41 which decreased overall and a peak increase in liquid tritium in 2005).

For the sites with AGR or PWR reactors, the overall trend was an overall decline in gaseous and liquid discharges. The most pronounced observation was the decreases of gaseous and liquid discharges in 2008 at Hartlepool. This is because both reactors at Hartlepool were shut down in 2008. Gaseous and liquid tritium discharges from Hinkley Point and from Hunterston also reduced with time. Liquid tritium discharges from Dungeness B and Heysham 1 and 2 also declined with time. In 2008, liquid tritium discharges reduced due to the shutdown of Heysham 1. The most recent decrease Peak discharges occurred for gaseous tritium at Hinkley Point in 2006 and for liquid tritium at Heysham in 2005.

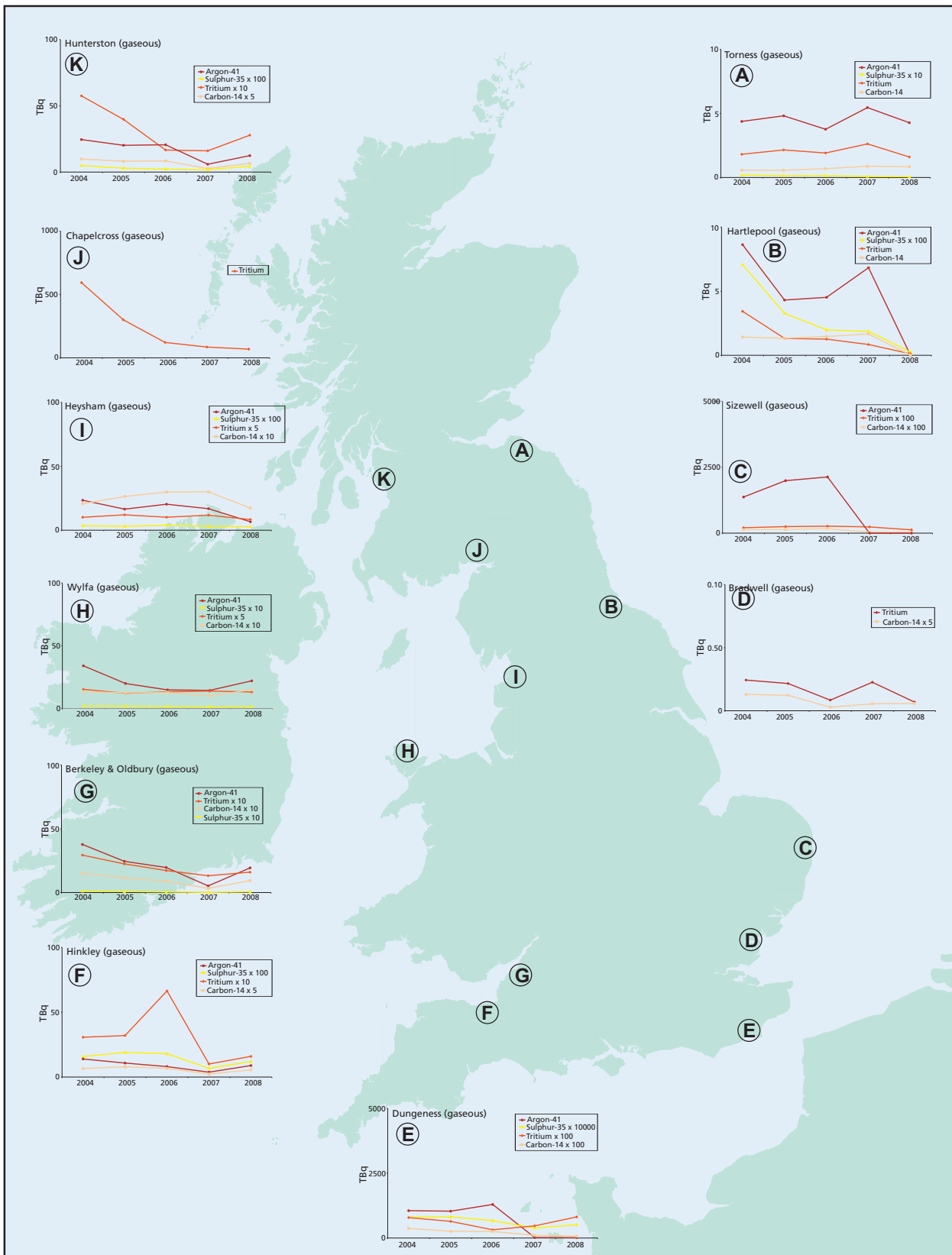


Figure 13. Authorized discharges of gaseous wastes from nuclear power stations (2004-2008)

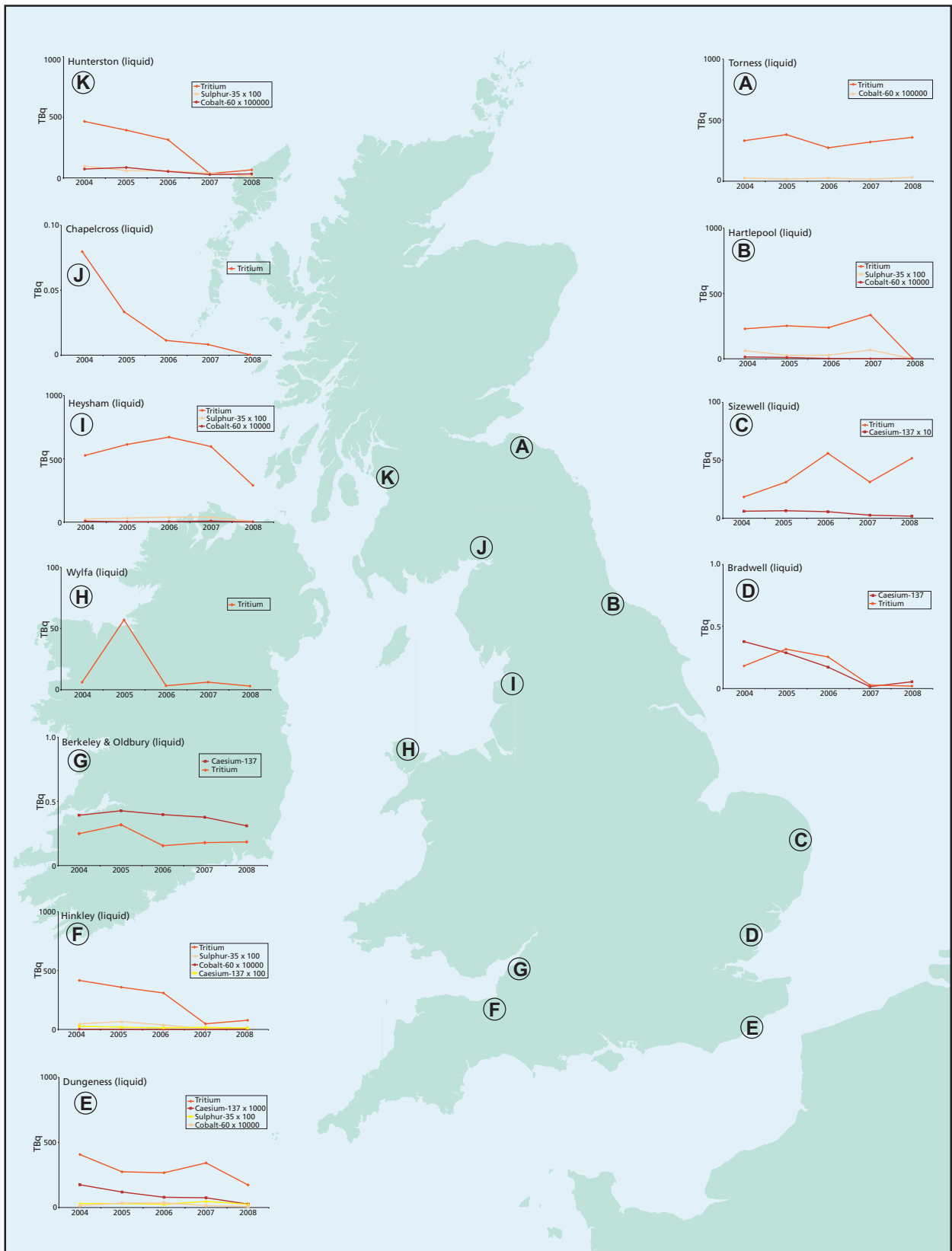


Figure 14. Authorized discharges of liquid wastes from nuclear power stations (2004-2008)

### 4.3 Concentrations of radionuclides in food and the environment

Monitoring of food and the environment is carried out around each of the power stations in the UK. The majority of measurements of radionuclide concentrations were at or below the analytical limits of detection. This meant that it was only possible to establish trends for a few radionuclides in environmental samples. Figure 15 shows monitoring trends of caesium-137 in sediments from marine locations to help assess the overall impact on the surrounding environment. Furthermore, it is difficult to differentiate the low concentrations of activity in marine material between site discharge and other factors such as liquid discharges of nearby sites, fallout from weapons testing and Chernobyl, and long distance contributions (including past discharges) from nuclear reprocessing plants at Sellafield and Cap de la Hague (France).

Overall, the concentrations of caesium-137 in UK sediments were low over time at all locations. Data in Figure 15 show that, although there were minor changes between years for individual sites, the general trends were for activity concentrations to decrease or remain relatively constant over the five-year period. The declining trend was most pronounced at Chapelcross and Heysham; the two power station sites (near the Irish Sea) most influenced by Sellafield. Further afield, the effects of Sellafield were less noticeable, partly due to the influence of releases from other sources and environmental variability.

### 4.4 Trawsfynydd – Discharges of radioactive waste and concentrations of radionuclides in the environment

Trawsfynydd power station is authorised to discharge low levels of liquid waste to Lake Trawsfynydd. All the other power stations make liquid discharges to the coastal environment. Figure 16 shows the trends of gaseous and liquid discharges over time (2004–2008) for a number of the authorised radionuclides. Gaseous tritium discharges from Trawsfynydd slightly increased in recent years, peaking in 2007, whilst liquid tritium discharges reduced with time.

Figure 16 also shows trends of caesium-137 in lake sediments from Trawsfynydd to help assess the overall impact on the surrounding environment. In the lake itself, there remains clear evidence of the effects of caesium-137 discharges from the power station, particularly in sediment. A substantial decline in environmental radionuclide concentrations was observed in the late 1990s in line with reducing discharges. Over the last five years (and more), the observed concentrations were mainly affected by sample variability, including movement of activity on sediments from beneath the sediment surface. Nevertheless, the lowest caesium-137 concentrations in sediments were observed in 2007 and 2008.

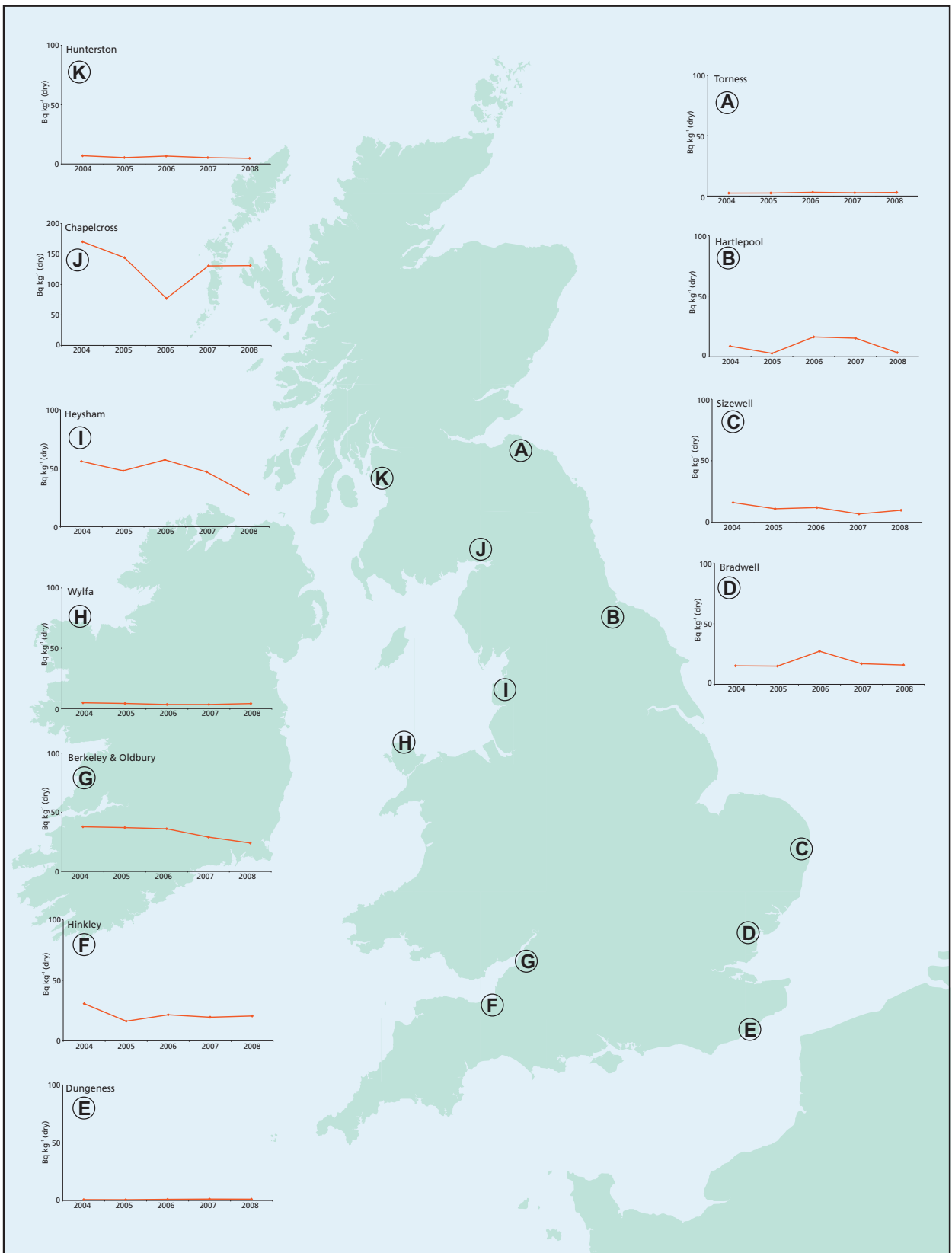
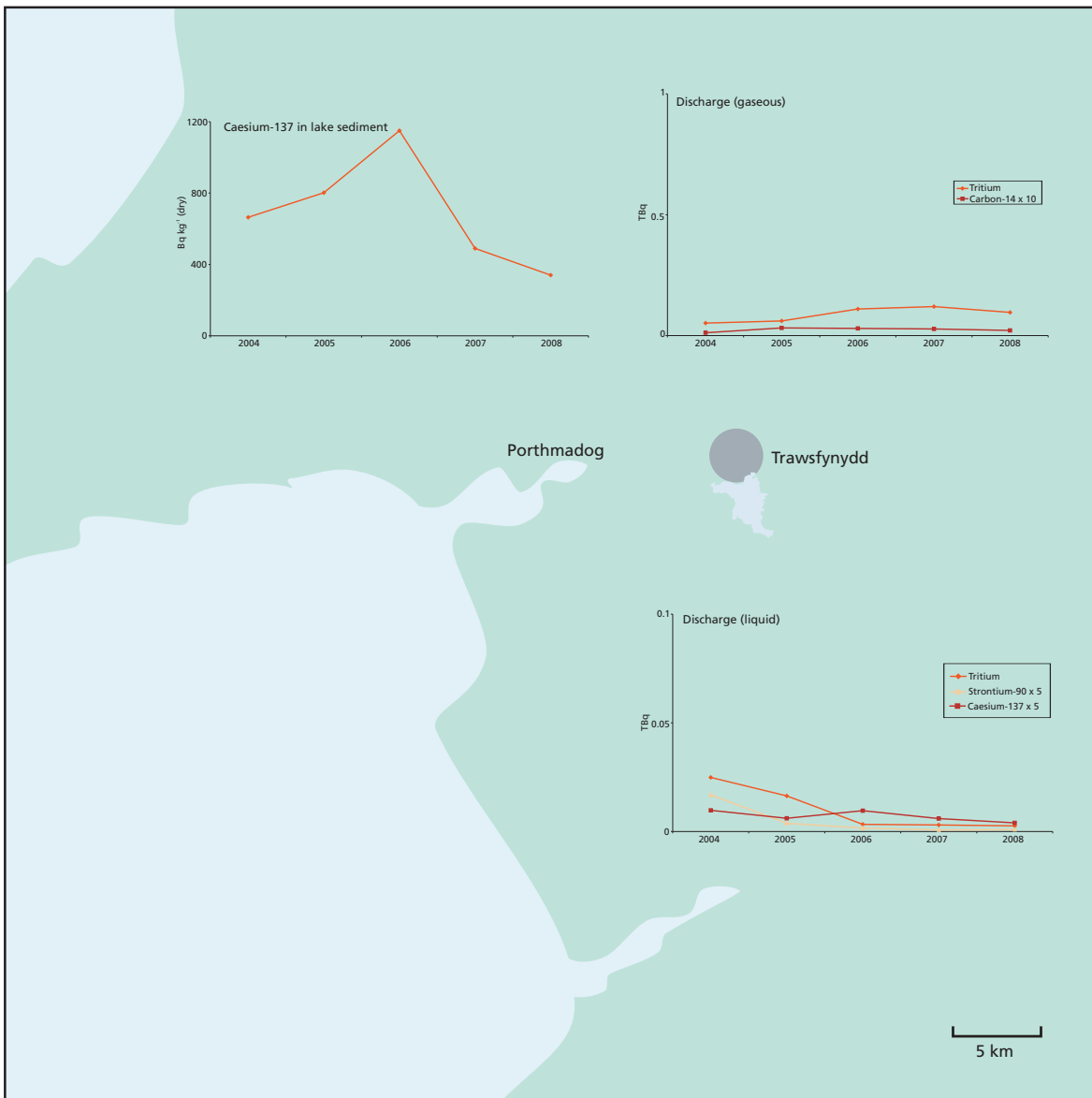


Figure 15. Caesium-137 concentrations in marine sediments near nuclear power stations (2004-2008)



**Figure 16.** Authorised discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Trawsfynydd (2004-2008)

## 4.5 Summary

The information presented in Table 4 gives an overview of trends associated with doses, discharges and environmental concentrations described in Section 4.

**Table 4. Summary of trend data for nuclear power sector (2004-2008)\***

Trend data	Downwards	No change	Upwards	Overall	
Gaseous discharges	8	3	1	Majority downward trend	↓
Liquid discharges	9	2	1	Majority downward trend	↓
Overall discharges	17	5	2	Majority downward trend	↓
Food and the environment overall	6	6	0	No overall direction	→

All doses were below the dose limit

\* Taken from the number of trend graphs for this sector presented in this report. This is a visual evaluation only.

## 5. Defence establishments

This section looks at the trends over the five years (2004-2008) from the UK's defence establishments. The time trends show the public's exposure, discharges of radioactive waste and concentrations of radionuclides in food and the environment. The public's exposure\* (dose) from radioactive waste discharges is assessed using radionuclide concentrations and gamma dose rates in the environment.

There are nine defence-related establishments that are currently authorised to discharge radioactive waste in the UK. The main sites are Aldermaston (and Burghfield) in Berkshire, Devonport in Devon, Faslane and Coulport in Argyll and Bute, and Rosyth in Fife. Other minor defence sites include Barrow (Cumbria), Derby (Derbyshire), Holy Loch (Argyll and Bute) and Vulcan (Highland). These latter smaller sites make small discharges overall, and are not considered in detail here.

### 5.1 Public's exposure to radiation due to discharges of radioactive waste

Figure 17 shows the trend of group doses over time (2004–2008) due to the effects of gaseous and liquid waste discharges. At all locations the doses were all less than 0.005 mSv over the whole five year-period, and much less than the national UK and European limit for members of the public of 1 mSv per year.

### 5.2 Aldermaston, Devonport, Faslane and Coulport, and Rosyth – Discharges of radioactive waste

Gaseous and liquid discharges (mainly tritium, carbon-14 and cobalt-60) are released into the atmosphere and to the sea. Figure 18 shows the trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

Gaseous tritium discharges from Aldermaston significantly declined over the five-year period. Other gaseous radionuclides discharged from the site were very low and reasonably constant with time. The Pangbourne pipeline (which previously discharged liquid waste to the River Thames at Pangbourne) closed in 2005. Consequently, liquid discharges of tritium, alpha emitting radionuclides and plutonium-241 decreased after that. At Devonport, gaseous and liquid discharges were relatively constant for tritium and cobalt-60 over the five years. Gaseous carbon-14 discharges were elevated in 2005 and 2006. Gaseous and liquid discharges at Faslane and Coulport, and

### Key points

- All doses were significantly less than the dose limit for members of the public of 1 mSv per year
- All doses (from artificial radionuclides) were less than 0.005 mSv
- All authorised discharges were well below the authorised limits
- Overall, gaseous and liquid discharges were low
- Concentrations around the sites continued to be very low

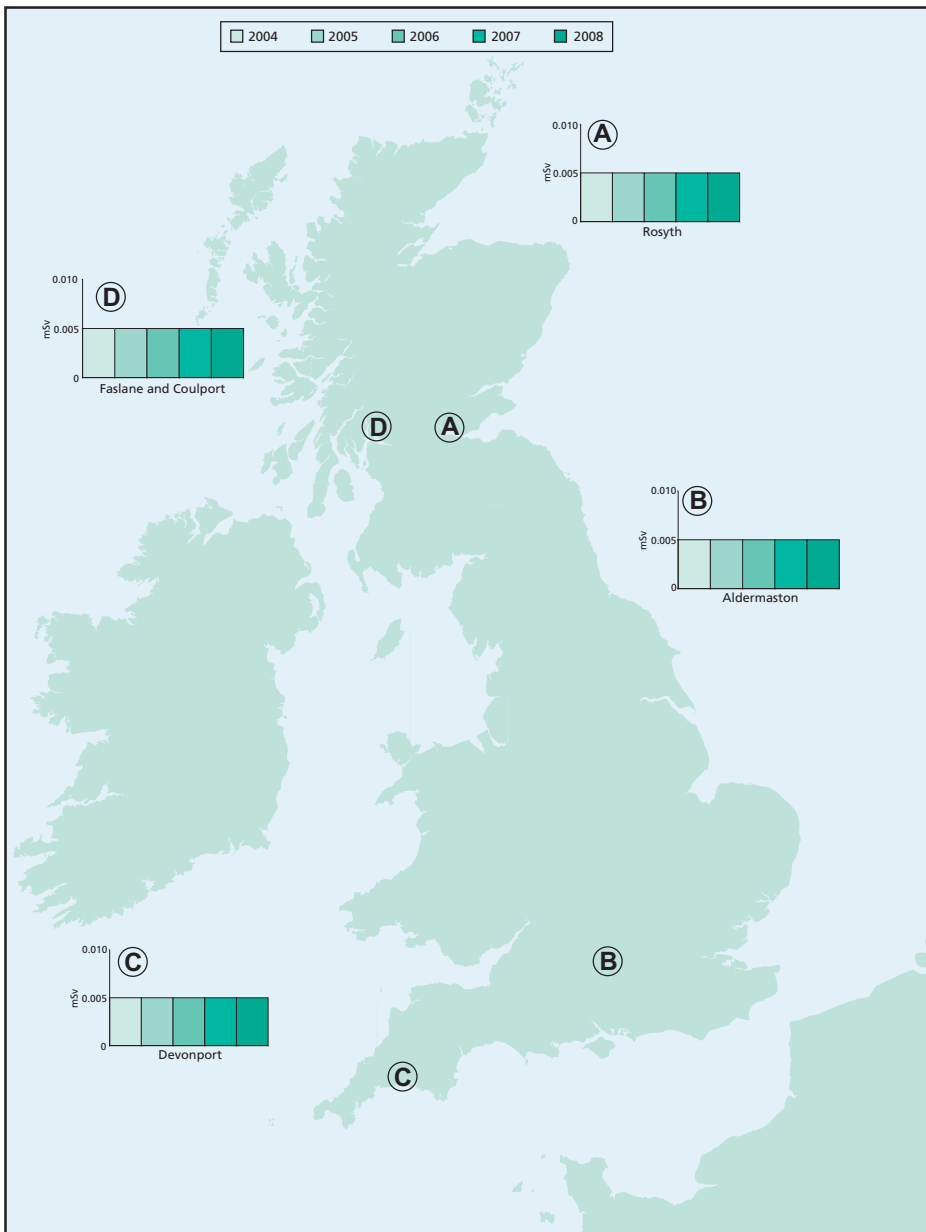
Rosyth (liquid only) showed some minor changes over the period, but the discharges were very low.

### 5.3 Defence establishments – Concentrations of radionuclides in food and the environment

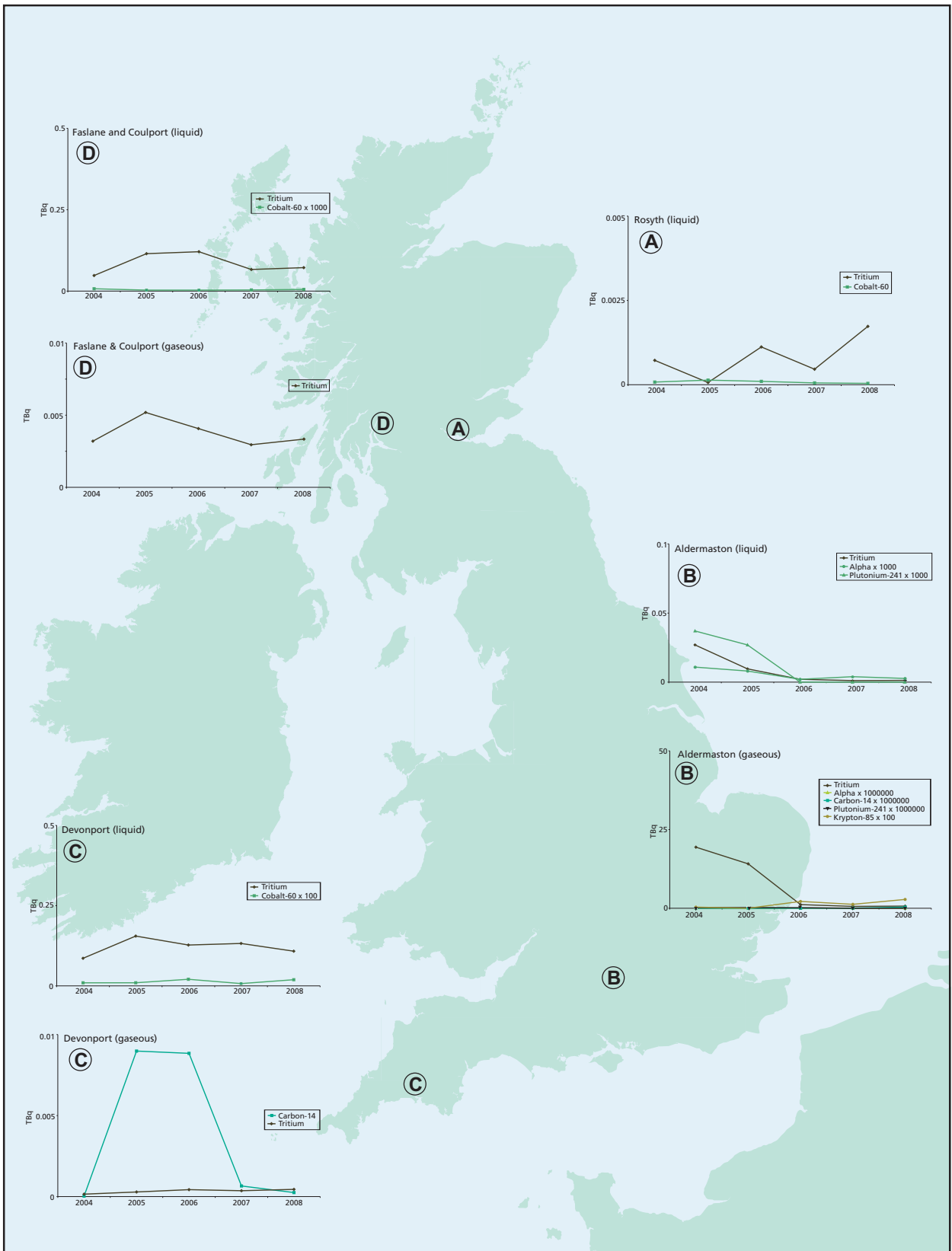
The Atomic Weapons Establishment at Aldermaston provides and maintains fundamental components of the UK's nuclear deterrent on behalf of the Ministry of Defence. Gaseous and liquid discharges are released into the atmosphere and to the sewage works at Silchester and to Aldermaston Stream. The concentrations of all artificially detected radionuclides in the Thames catchment area were very low (or below the limit of detection). The gross alpha (and gross beta) activity concentrations were below the World Health Organisation's screening levels for drinking water over the whole period. Figure 19 provides some monitoring trends to assess the impact on the surrounding environment. Concentrations of plutonium radionuclides and americium-241 (alpha emitting radionuclides) in freshwater crayfish from Ufton Bridge to Theale also showed low levels. Concentrations of alpha emitting radionuclides in sediments at Aldermaston, Mapledurham and Pangbourne were shown to decrease initially. This corresponded with a reduction in liquid alpha emitting radionuclides from 2004. Any fluctuations in recent years, for both food and sediment, were most likely due to normal variations in the environment.

For other defence establishments, the majority of measurements of food and environmental samples were at or below the analytical limits of detection, which made it difficult to produce trend data from monitoring results.

\* The monitoring results are interpreted in terms of radiation exposures of the public, commonly termed 'doses'. These people are a group, who generally eat large quantities of locally grown food (high rate consumers) or who spend long periods of time in the locations being assessed. This dose, referred to in Sections 2-6, is an exposure that uses a different assessment method to that of *total dose* in Section 1.



**Figure 17.** Individual radiation exposures to most exposed groups from artificial radionuclides, Aldermaston, Devonport, Faslane and Coulport, and Rosyth (2004-2008) (Doses less than 0.005mSv are recorded as being 0.005mSv)



**Figure 18.** Authorised discharges of gaseous and liquid radioactive wastes, Aldermaston, Devonport, Faslane and Coulport, and Rosyth (2004-2008)

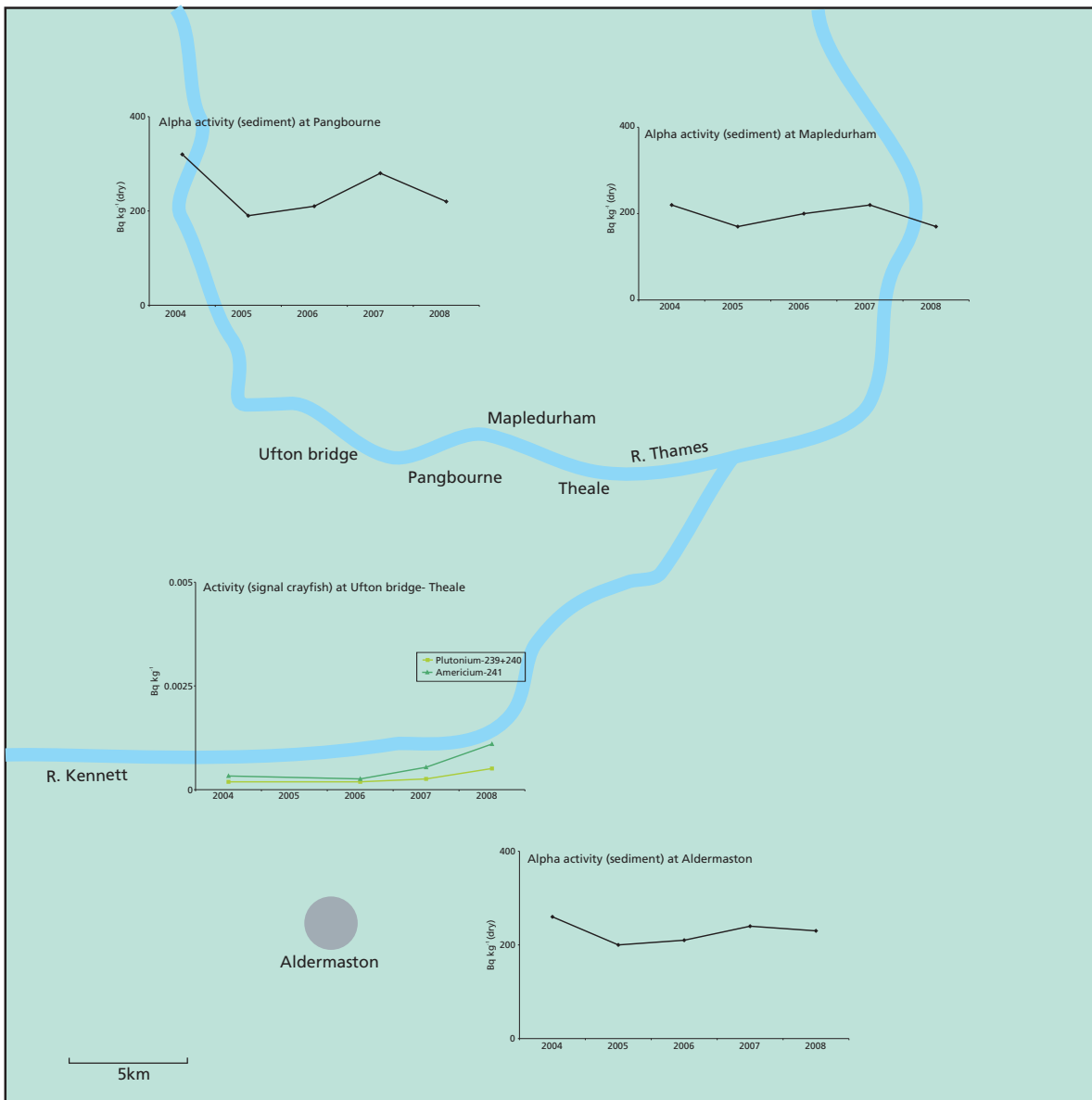


Figure 19. Monitoring of the environment from discharges of radioactive wastes, Aldermaston (2004-2008)

## 5.4 Summary

The information presented in Table 5 gives an overview of trends associated with doses, discharges and environmental concentrations described in Section 5.

Table 5. Summary of trend data for defence sector (2004-2008)\*

Trend data	Downwards	No change	Upwards	Overall	
Gaseous discharges	1	1	1	No overall direction	→
Liquid discharges	1	1	2	No overall direction	→
Overall discharges	2	2	3	No overall direction	→
Food and the environment overall	3	0	1	Majority downward trend	↓

All doses were below the dose limit

\* Taken from the number of trend graphs for this sector presented in this report. This is a visual evaluation only.

## 6. Radiochemical production

This section looks at the trends over the five years (2004-2008) from the UK's radiochemical production sites. The time trends show the public's exposure, discharges of radioactive waste and concentrations of radionuclides in food and the environment. The public's exposure\* (dose) from radioactive waste discharges is assessed using radionuclide concentrations and gamma dose rates in the environment. GE Healthcare is a health science company operating in worldwide commercial healthcare and life science markets, with radiochemical facilities at Amersham, Cardiff and a small legacy waste processing unit at Harwell. The trends of the Harwell facilities are covered under Section 3 (Research establishments).

### 6.1 Public's exposure to radiation due to discharges of radioactive waste

Figure 20 shows the trend over the five years between 2004 and 2008 of the public's exposure to radiation due to the effects of gaseous and liquid waste discharges. For locations near both sites, the doses were all much less than the UK and European limit for members of the public of 1 mSv per year.

The annual dose was highest at Cardiff from consuming fish and shellfish (combined with external exposure), and ranged between 0.012 and 0.029 mSv over the five-year period with a clear decline with time. The reduction in the doses for the Cardiff site was largely due to the continuing reductions in concentrations of tritium (and carbon-14) in seafood, with the most significant reduction of tritium in seafood occurring in 2006.

At the Amersham site, the annual dose to people who ate locally grown food (combined with a contribution of discharged radionuclides in air) ranged between 0.015 and 0.020 mSv over the five years. The changes in trends at this site were mainly due to variations in the estimated air exposure from inhaling gases and emitted radiation of the gaseous discharges.

### Key points

- All doses were less than the dose limit for members of the public of 1 mSv per year
- Highest annual dose (from artificial radionuclides) was 0.029 mSv at Cardiff
- Highest group dose continually decreased with time
- All authorised discharges were well below the authorised limits
- Concentrations on the land continued to be very low and concentrations in the sea declined following reduction in discharges.

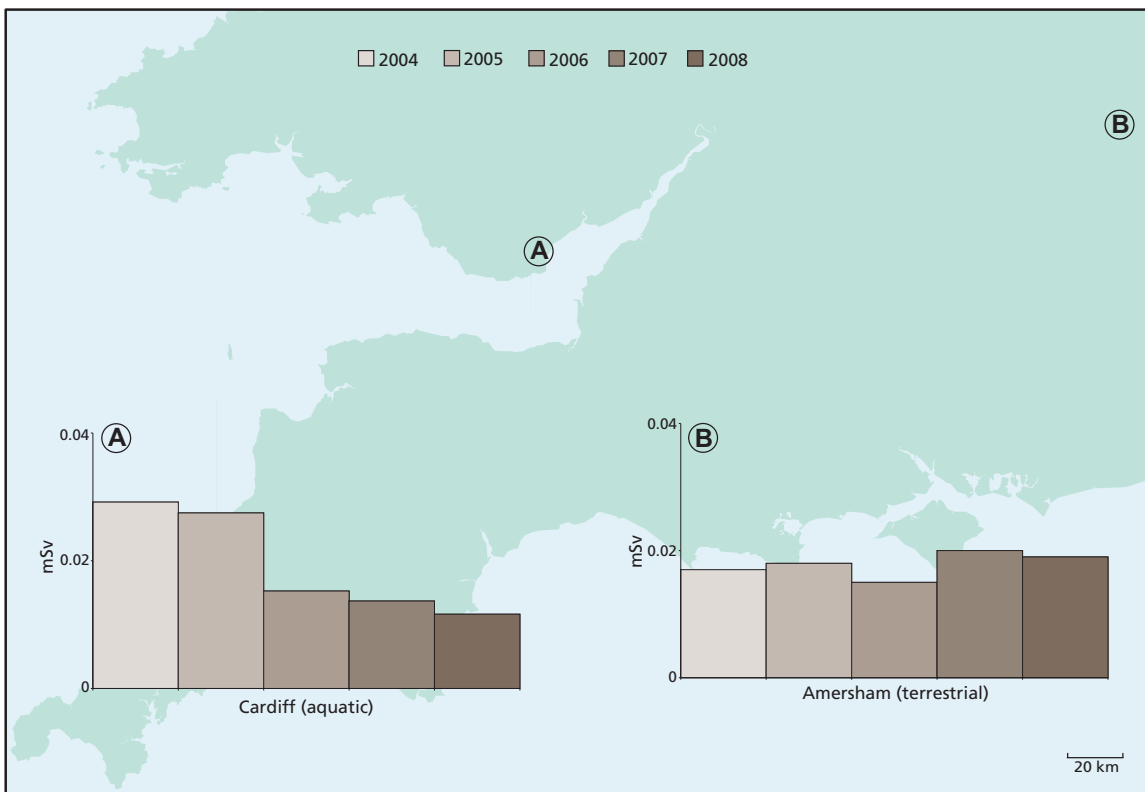
### 6.2 Amersham – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

Gaseous and liquid discharges from Amersham are released into the atmosphere and to sewers serving the Maple Lodge sewage works. Releases subsequently enter the Grand Union Canal and the River Colne. Figure 21 shows the trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

The gaseous discharges were low over the five-year period. Discharges of iodine-125 declined over the period, whilst radon-222 and sulphur-35 generally increased. Limits for selenium-75 were removed in 2008. There was an overall reduction in liquid discharges of tritium, iodine-125 and caesium-137.

Figure 21 also provides monitoring trends of sulphur-35 and caesium-137 in food and in grass and sediment from three locations, to assess the impact on the surrounding environment. Caesium-137 concentrations in sediment were low over the period and changes were attributed to natural variation. Although concentrations appeared to increase over time, at the outfall these were lower than further upstream. Caesium-137 activity was likely due to fallout from weapons testing and Chernobyl. The trend for sulphur-35 concentrations in grass generally followed the pattern of gaseous discharges, although the activity concentrations were very low. In spinach, sulphur-35 concentrations were significantly less than in grass.

\* The monitoring results are interpreted in terms of radiation exposures of the public, commonly termed 'doses'. These people are a group, who generally eat large quantities of locally grown food (high rate consumers) or who spend long periods of time in the locations being assessed. This dose, referred to in Sections 2-6, is an exposure that uses a different assessment method to that of *total dose* in Section 1.



**Figure 20.** Individual radiation exposures to most exposed groups from artificial radionuclides, Amersham and Cardiff (2004-2008)

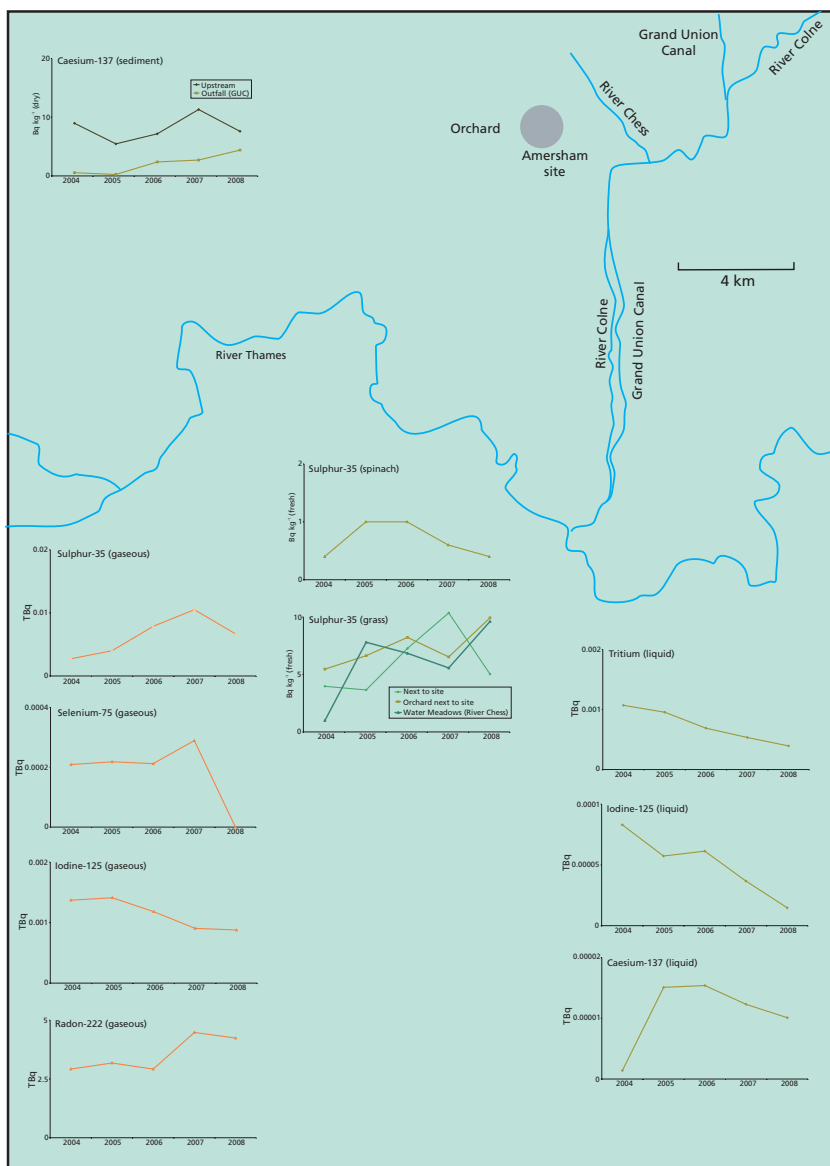
### 6.3 Cardiff – Discharges of radioactive waste and concentrations of radionuclides in food and the environment

The gaseous discharges into the atmosphere from the Maynard Centre, Cardiff, mainly consisted of tritium and carbon-14, with smaller amounts of phosphorus-32+33 and iodine-125 also released. Liquid waste is released into the Ystradyfodwg and Pontypridd public sewer. This joins the Cardiff East sewer, which after passing through a waste water treatment works, discharges into the Severn estuary near Orchard Ledges. Figure 22 shows the trends of discharges over time (2004–2008) for a number of the authorised radionuclides.

In 2004, the Environment Agency issued a new authorisation for the site, which reduced all authorisation limits. Gaseous discharges of iodine-125 and phosphorus radionuclides declined over the five-year period, with a step decrease in 2005. Whilst tritium and carbon-14 showed some minor variations, their trends were broadly similar to each other. Overall, liquid discharges declined over the period for each of the radionuclides, and were much lower by 2008.

Figure 22 also provides monitoring trends of tritium, carbon-14 and caesium-137 in seafood and from three locations, to assess the impact on the surrounding environment. Overall, the trend was for concentrations of tritium in fish, molluscs and sediments to decline over the five years, in line with recent reductions in liquid discharges. This also included the low tritium concentrations being detected in sediment from the Glamorganshire canal, which is not used as a source of water for public water supply.

Over the five-year period, concentrations of carbon-14 and caesium-137 in seafood and sediments were low and relatively constant. Carbon-14 concentrations detected in sediment from the Glamorganshire canal declined after 2005. Changes between years were most likely due to normal changes in the environment, with caesium-137 coming from other nuclear establishments and fallout from weapons testing and Chernobyl.



**Figure 21.** Authorised discharges of gaseous and liquid radioactive wastes and monitoring of the environment, Amersham (2004-2008)

## 6.4 Summary

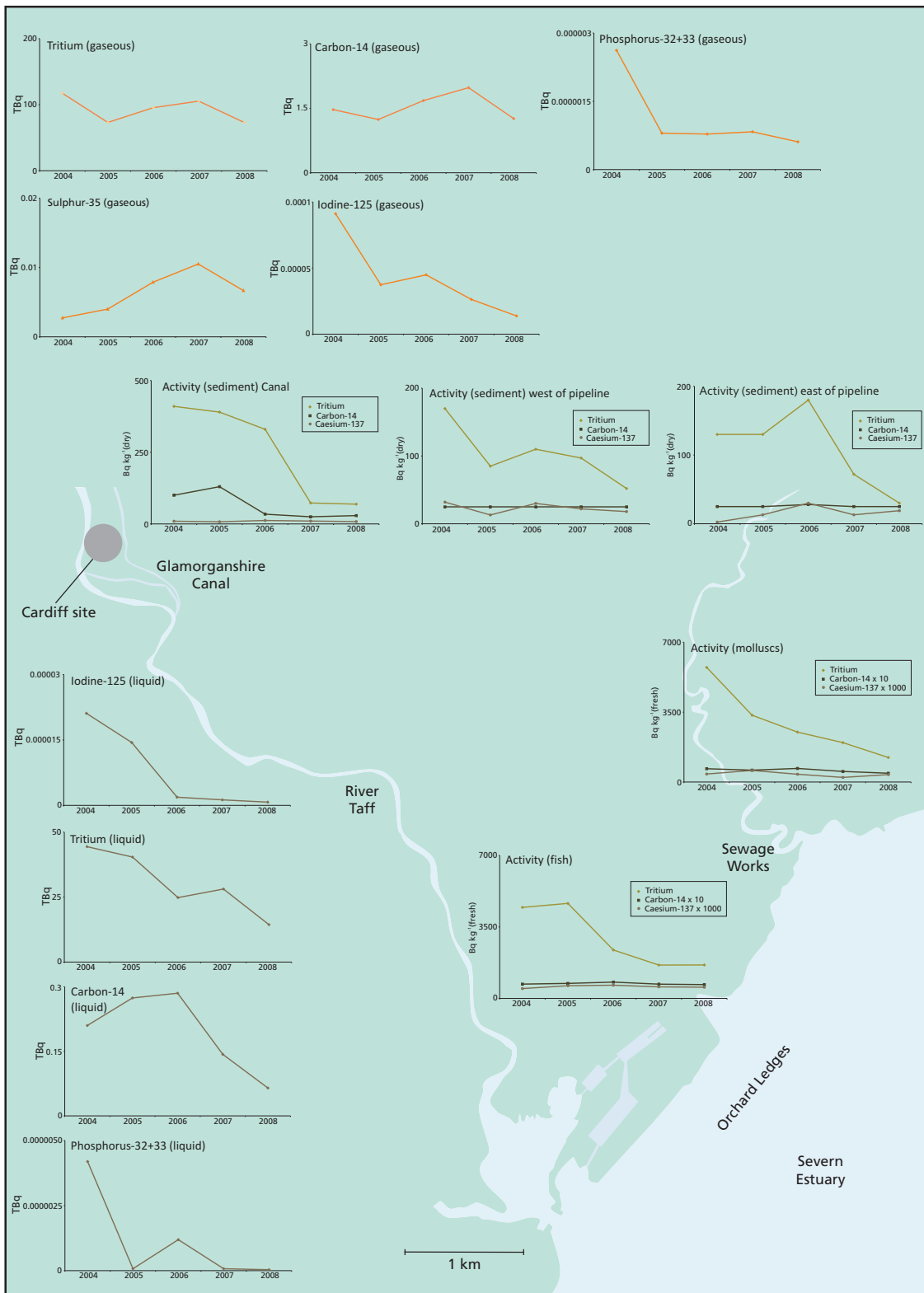
The information presented in Table 6 gives an overview of trends associated with doses, discharges and environmental concentrations described in Section 6.

**Table 6. Summary of trend data for radiochemical production (2004-2008)\***

Trend data	Downwards	No change	Upwards	Overall	
Gaseous discharges	6	0	3	Majority downward trend	↓
Liquid discharges	6	0	1	Majority downward trend	↓
Overall discharges	12	0	4	Majority downward trend	↓
Food and the environment overall	5	2	1	Majority downward trend	↓

All doses were below the dose limit

\* Taken from the number of trend graphs for this sector presented in this report. This is a visual evaluation only.



**Figure 22.** Discharges of gaseous and liquid radioactivity wastes and monitoring of the environment, Cardiff (2004-2008)

## Summary and Conclusions

We have noted that over 2004 to 2008 discharges have shown a distinct decline in three of the five sectors. However, environmental concentrations have responded relatively slowly to these reductions. This is in part due to the legacy of higher environmental concentrations of radionuclides from past higher discharges. As discharges have fallen further, environmental concentrations have reduced more slowly because levels are being sustained from this legacy.

We have not made an assessment of the overall dose trends by sector. This is because doses are dependent on a number of inputs, including the method of assessment, concentrations of radionuclides in food and the environment, measurements of dose rates and data on human activities. All these are subject to variation and changes from year to year which can affect the dose assessment outcomes and produce step changes or false trends over the relatively short time of 5 years. We think that a longer time period of 10 years is required to provide a stronger basis to confirm overall dose trends.

Additional information on past discharges, radionuclide concentrations and doses for each year can be found in the RIFE reports.

### Key points

Information presented in Table 7 gives an overview of trends associated with discharges and environmental concentrations for each of the five nuclear sectors described in Sections 2 – 6. The key points are given below.

- Discharge trends were downward in three of the five sectors with no clear trends in the other two sectors
- Trends of radionuclide concentrations in food and the environment were downward in two of the five sectors with no clear trends in the other three sectors
- Doses at all sites were less than the dose limit, and in most cases much less

**Table 7. Overall summary for nuclear sectors (2004-2008)\***

	Sector	2004-2008 trend	
All sectors	Key Marine Environmental Indicators	Majority downward trend	↓
	Total diet	No change, variation from year to year	→
Nuclear fuel processing	Discharges	Majority downward trend	↓
	Food and environmental concentrations	Majority downward trend.	↓
Research sites	Discharges	No overall trend	→
	Food and environmental concentrations	No overall trend	→
Power production	Discharges	Majority downward trend	↓
	Food and environmental concentrations	No overall trend	→
Defence sites	Discharges	No overall trend	→
	Food and environmental concentrations	Majority downward trend	↓
Radiochemical production	Discharges	Majority downward trend	↓
	Food and environmental concentrations	Majority downward trend	↓

\* Taken from the trends presented in this report. This is a visual evaluation only.





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