



Radiological Habits Survey: Springfields, 2006

Public version



2007

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2007

Peer reviewed by B.D. Smith

The work described in this report was carried out under contract to the Environment Agency, the Food Standards Agency and the Health and Safety Executive.

Cefas contracts C1659, RB103 and C1666 respectively.

EA Project PO070206680, FSA Project RP0183 and HSE Project NS/X/374

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SUMMARY

This report presents the results of a survey conducted in 2006 into the habits and consumption patterns of people living, working and pursuing recreational activities in the vicinity of the Springfields Fuels Ltd, Westinghouse site near Preston in Lancashire. At the time of the survey the site was owned by the Nuclear Decommissioning Authority. Westinghouse Ltd UK had the contract to operate the site.

Springfields manufactures fuels for nuclear reactors. These included Magnox fuel, Advanced Gas-Cooled Reactor fuel and uranium oxide pellets and powder for Pressurised Water Reactor fuel. The site also produced uranium hexafluoride, which is used in the manufacture of uranium fuel elements. A site representative informed Cefas that the production of Magnox fuel will cease in 2007, with the main line operations having already been closed in March 2006. The effect of this closure had been a significant reduction in beta emitting radionuclides in the liquid discharges.

Springfields Fuels Ltd, Westinghouse is authorised under the Radioactive Substances Act, 1993, to discharge liquid wastes into the Ribble Estuary and gaseous wastes via stacks to the local environment. The site is licensed for the purposes of carrying out certain activities prescribed under the Nuclear Installations Act, 1965 (as amended). The Springfields site also contains sources of direct radiation.

The following potential exposure pathways related to the site were investigated:

- Consumption of locally sourced aquatic and terrestrial foods
- The production, use and destination of local produce
- Consumption and use of groundwater and surface water
- Occupancy of buildings and the surrounding areas within one kilometre of the site perimeter
- Occupancy of intertidal areas
- Handling of intertidal sediments and fishing gear

- Activities and occupancy in or on water
- Consumption and/or use of marine plants and seaweed
- Off-site transfer of contamination by wildlife

Site specific requests included:

- Detailed investigation of occupancy rates of boat dwellers
- Detailed investigation of occupancy rates of wildfowlers over mud and salt marsh areas
- Investigation of occupancy rates of people carrying out activities along the lower length of the Millenium Canal

Individuals from the local population were interviewed and data collected for 554 individuals are presented and discussed.

Data from the survey are presented in full for each individual in order to assist in conducting dose assessments for multiple pathways. Additionally, data were analysed in three ways. Firstly by selecting potential critical group habits from the upper end of the distribution of observations (the 'cut-off' method). Secondly by using the 97.5th percentile from the distribution of observations. These methods can be used to identify the highest rates appropriate to discrete habits in the aquatic and terrestrial pathways. Finally, profiles of integrated habits data were created for use in total dose assessments.

In the aquatic survey area, internal and external exposure pathways were investigated because of the potential effects from liquid discharges. Foods consumed from the aquatic survey area were fish, crustaceans, wildfowl and marine plants. For these foods groups, adult mean critical group consumption rates for fish and crustaceans exceeded the respective generic 97.5 percentile rate. Critical group intertidal occupancy rates were recorded for people undertaking houseboat dwelling, angling, bait digging, walking, working on the shore, livestock management and wildfowling. Critical group fishing gear handling was recorded for commercial fishermen and critical group sediment handling rates was recorded for a commercial bait digger and wildfowlers. People were undertaking water based activities such

as boat angling, canoeing, jet skiing and sailing. No use of seaweed as a fertiliser for vegetables was identified.

In the terrestrial survey area the main activity was farming. Farms were producing predominantly beef cattle as well as dairy, sheep, pig and poultry. Farmers and their families were consuming beef, lamb, pork, poultry, milk, eggs, game and vegetables from their own farms. Four allotment sites were identified; the allotment holders were producing a variety of fruit and vegetables. Adult mean critical group consumption rates for root vegetables and milk exceeded the respective generic 97.5 percentile rate. Other local foods consumed were, green vegetables, other vegetables, potatoes, domestic fruit, cattle meat, pig meat, sheep meat, poultry, eggs and wild fungi. No consumption of wild/free foods, rabbits/hares, honey, venison, freshwater fish and cereals was noted. No evidence of the consumption of surface or ground water by people was noted. With the exception of livestock drinking from Deepdale Brook, no other evidence of livestock drinking borehole, spring, and well water was found.

Transfer of radioactive contamination from the site into the surrounding area by wildlife was investigated. Rabbits were considered by the site operators to be a problem within the site fence but no culling programme was in place. Pigeons were also resident on the site. Members of the public who lived in the terrestrial survey area were not noted to be consuming any rabbits, although a small number of pigeons were shot for consumption.

In the direct radiation survey area, external pathways were investigated because of potential effects from ionising radiation emanating directly from the site and from exposure to gases discharged to atmosphere from the site. The highest indoor occupancy rate was for an elderly resident and the highest outdoor occupancy rate was for a farmer spending a large percentage of daylight hours outside.

Comparisons are made with the results from previous aquatic, terrestrial and direct radiation surveys. Suggestions are made for changes to environmental monitoring programmes on the basis of the information collected during the survey.

1 INTRODUCTION

The public may be exposed to radiation as a result of the operations of the Springfields site either from discharges of liquid or gaseous radioactive wastes into the local environment, or from radiation emanating directly from the site. This report provides information about activities carried out by members of the public under everyday circumstances, which may influence their radiation exposure. The study has been funded by the Environment Agency, the Food Standards Agency and the Health and Safety Executive in order to support their respective roles in protecting the public from the effects of radiation.

1.1 Regulatory framework

The Environment Agency regulates discharges of waste under the Radioactive Substances Act 1993 (RSA 93) (UK Parliament, 1993) as amended by: the Environment Act 1995 (EA 95) (UK Parliament, 1995a); by legislation implementing the European Union (EU) Basic Safety Standards (BSS) Directive 96/29/Euratom (CEC, 1996); and by the Energy Act 2004 (EA 04) (UK Parliament, 2004). The Directive takes account of Recommendations of the International Commission on Radiological Protection (ICRP), particularly ICRP 60 (ICRP, 1991). Authorisations under RSA 93 are issued by the Environment Agency after wide-ranging consultation, including the Food Standards Agency. As well as being a Statutory Consultee, the Food Standards Agency has responsibilities for ensuring that any radioactivity present in food does not compromise food safety and that authorised discharges of radioactivity do not result in unacceptable doses to consumers via the food chain. The Food Standards Agency also ensures that public radiation exposure via the food chain is within EU accepted limits. Consultation papers on Statutory Guidance to the Environment Agency on the regulation of radioactive waste discharges were issued by the Department of the Environment, Transport and the Regions (DETR) (now part of the Department for Environment, Food and Rural Affairs (Defra)) in 2000 (DETR, 2000a) and the Welsh Assembly in 2002 (The Welsh Assembly Government, 2002). These draft Guidance documents include, *inter alia*, affirmation that protection of the critical groups of the public is the appropriate radiological

protection methodology to use. This report provides information to support assessments of critical groups.

Installation and operation of certain prescribed activities can only take place on sites if they are licensed under the Nuclear Installations Act 1965 (as amended) (NIA 65) (UK Parliament, 1965). The Nuclear Installations Inspectorate of the Health and Safety Executive implements this legislation and is also responsible for regulating, under the Ionising Radiations Regulations (IRR 99) (UK Parliament, 1999), the restriction of exposure of the public to direct radiation from operations occurring on these sites.

1.2 Radiological protection framework

UK policy on the control of radiation exposure has long been based on the Recommendations of ICRP which embody the principles of justification of practices, optimisation of protection and dose limitation. Radiological protection of the public is based on the concept of a critical group of individuals. This group is defined as those people who, because of where they live and their habits, receive the highest radiation dose due to the operations of a site. It follows that, if the dose to this group is acceptable when compared to relevant dose limits and constraints, other members of the public will receive lower doses, and overall protection is provided for.

Dose standards for the public are embodied in national policy (UK Parliament, 1995b), in guidance from the International Atomic Energy Agency (IAEA) in the Basic Safety Standards for Radiation Protection (IAEA, 1996) and in European Community legislation in the EU BSS Directive 96/29/Euratom. The public dose standards were incorporated into UK law in IRR 99. In order to implement the Directive in England and Wales, the Environment Agency was issued with a direction by the DETR in 2000 (DETR, 2000b). This includes the requirements that the Environment Agency ensure, wherever applicable,

- all public radiation exposures from radioactive waste disposal are kept As Low As Reasonably Achievable (ALARA)

- the sum of such exposures does not exceed the dose limit of 1 mSv a year

The Environment Agency shall have regard for maximum doses to individuals for use at the planning stage:

- 0.3 mSv a year from any source
- 0.5 mSv a year from the discharges from any single site

The Environment Agency is also required to ensure that the dose estimates made are as realistic as possible for the population as a whole and for reference groups of the population. It is required to take all necessary steps to identify the reference groups of the population taking into account the effective pathways of transmission of radioactive substances. Guidance on the principles underlying prospective radiological assessment (i.e. assessments of potential future doses) has been provided by a group of UK Government Bodies (EA, SEPA, DoENI, NRPB and FSA, 2002). The National Dose Assessment Working Group (NDAWG) has also published principles underlying retrospective radiological assessment (i.e. assessment of doses already received from past discharges) (Allot, 2005) and possible methods of carrying out retrospective assessments of doses to the public using information provided by combined habits surveys (Camplin *et al.*, 2005). NDAWG agreed that the optimal method for performing retrospective dose assessments would be to use habits profiles (profiling method). This approach has now been applied around nuclear sites in the UK in recent RIFE publications – as combined habits surveys are completed.

This report provides information that allows the habits of members of the public to be quantified so that the most exposed groups can be identified and doses to the groups can be assessed in a realistic way.

2 THE SURVEY

2.1 Site activity

The site is located approximately 3 km east of the town of Kirkham (see Figure 3) and predominantly manufactures fuel elements for Magnox and Advanced Gas-Cooled (AGR) nuclear reactors and uranium oxide pellets and powder for Pressurised Water Reactor fuel. A site representative informed Cefas that the production of Magnox fuel would cease in 2007. The areas of the site related to Magnox fuel production were major sources of liquid discharges of beta emitting radionuclides. The site had already produced the last billet of uranium for Magnox fuel. Ending of manufacturing of this type of fuel has significantly reduced beta emitting radionuclides in liquid discharges. The site had a contract to produce fuel for AGRs until 2024 with the option of a five years extension. They additionally produce uranium oxide powder and pellets for Light Water Reactor (i.e. Pressurised Water Reactor) fuel. The site was undertaking decommissioning of Magnox fuel production/storage areas. A large volume of building rubble from the decommissioning had been disposed of at Clifton Marsh landfill site.

A site representative informed us that light water fuel will probably be the fuel for future reactors. Springfields Fuels hopes to win contracts to manufacture such fuels lasting for a number of years into the future.

Under NIA 65, the holder of the site licence, which allows the installation and operation of certain activities, is Springfields Fuels Ltd, Westinghouse. Under RSA 93, they are authorised to discharge gaseous radioactive wastes via stacks to the atmosphere and liquid radioactive wastes via pipeline to the Ribble Estuary. Details of the amounts of radioactive waste discharged in 2005 have been published (EA, EHS, FSA and SEPA, 2006). The site also contains sources of direct radiation. Whilst the survey fieldwork was being carried out, the site was conducting normal operations such that nothing took place to increase or decrease the levels of discharges or direct radiation.

2.2 Survey objectives

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook the survey in 2006 on behalf of the Environment Agency, the Food Standards Agency, and the Health and Safety Executive. The aim of the survey was to obtain integrated habits data related to public radiation exposure from the Springfields site via aquatic, terrestrial and direct radiation pathways in order to permit realistic assessments of critical group doses. Fieldwork was undertaken in order to obtain site specific habits survey data. These data were used to establish exposure pathways for the local population and the characteristics of those most exposed. General habits survey information, such as the number and types of farms or number of wildfowling clubs in the areas was also obtained.

Investigations were carried out to ascertain the following:

- The consumption rates of aquatic and terrestrial foods from within the survey areas
- The production, use and destination of local produce
- The consumption and use of groundwater and surface water in the terrestrial survey area
- The extent of occupancy within 1 km of the site perimeter fence
- External exposure activities over intertidal substrates, with particular attention placed on wildfowling and boat dwelling and activities along the lower length of the Millennium Canal
- Handling of intertidal sediments and fishing gear
- Activities and occupancy in and on water
- The extent of any unusual practices, which may have been relevant, such as the use of seaweed as a fertiliser or livestock feed and the transfer of contamination off-site by wildlife

No combined habits surveys have been conducted previously in the Springfields area by Cefas. The last aquatic, terrestrial and direct radiation surveys were in 2000 (Tipple, J.R., and

Sherlock, M., 2001), 2000 (Sherlock, M, Tipple, J. R. and Gough, C., 2002) and 2001 (unpublished data) respectively.

2.3 Survey areas

Three survey areas were defined to encompass the dominant activities expected for aquatic, terrestrial and direct radiation pathways.

The aquatic survey area, shown in Figures 1 and 2, covered the Ribble Estuary, its tributaries and all intertidal areas between the A6 road bridge at Frenchwood (upstream) to Fairhaven on the north bank and Marshside Sands (downstream) on the south bank. This was the same area as that of the 2000 survey. It also included the lower section of Millenium Ribble Link, formerly known as the Savick Brook, between the sea gate and the first lock. Of particular interest was occupancy of houseboats on the Ribble, which, when identified, were targeted and surveyed.

The terrestrial survey area, shown in Figure 3, was defined as the area within a 5 km radius of the site centre (NGR SD 470 314) of the Springfields site to encompass the main areas of potential deposition from gaseous discharges. The same area was also used in the 2000 survey. Additionally in the 2006 survey, activities relating to groundwater and surface water in the terrestrial area were investigated. Watercourses and areas potentially containing contamination only from washout of gaseous discharges are discussed in the terrestrial sections of this report.

For direct radiation, the survey area, also shown in Figure 3, was defined as the area within 1 km of the Springfields site perimeter fence. The same area was used for the 2001 survey.

2.4 Conduct of the survey

Prior to the fieldwork, discussions were held between a member of the Cefas survey team and representatives from Springfields, the Environment Agency, the Food Standards Agency and the Health and Safety Executive. These discussions provided an outline of the main aims of the survey and highlighted areas or items, which required special attention or effort by the team.

As part of the pre-survey preparation, people with a local knowledge of the survey area were contacted for information on any aspects relevant to the various exposure pathways. These included the local council, the Tourist Information Centre, beekeeping representatives, allotment representatives, commercial fishermen and the local Sea Fisheries Committee. A proposed programme for fieldwork was sent to the Environment Agency, the Food Standards Agency, and the Health and Safety Executive before the survey for comment.

The fieldwork component of the survey was carried out from 12th – 22nd June 2006, by a survey team of three people, according to techniques described by Leonard *et al.* (1982). At the start of the fieldwork, on 13th June, a meeting was held between the survey team and representatives of Springfields. This served to provide details about Springfields site operations, including waste disposal, and information about potential pathways and activities in the area. The site representatives were also asked about any wildlife studies and pest control measures in and immediately around the site. Animals could transfer radioactive materials off-site and are also potential food items for some individuals. The following relevant facts emerged from the meeting:

- The site had ceased producing uranium for the production of Magnox fuel. In doing so, it had significantly reduced beta emitting radionuclides in liquid discharges.
- Light water fuel will probably be the fuel for future reactors and Springfields Fuels hopes that this will provide them with contracts lasting for a number of years into the future.

- Rabbits were abundant on the site and were a nuisance by digging into an area of earth which had been a burial site in the 1950s, although it now contained no significant levels of radioactivity. No evidence of rabbits leaving the site by tunnelling under the perimeter fence had been noted. The site rabbit population was not considered to be a big enough problem to justify a culling programme.
- Pigeons were also present on site, which could potentially fly elsewhere, be shot and consumed by members of the public.

During the fieldwork, individuals who were identified in the pre-survey preparation as having the potential to be exposed to radioactivity from the site were contacted and interviewed. Interviews were used to establish individuals' consumption rates of locally grown terrestrial foods and locally caught seafood, their handling rates of intertidal sediments and fishing gear, their occupancy rates relevant to external exposure, and occupancy rates in and on water. Any general information of possible use to the survey was also obtained. Using the information gained in the interviews, a list of occupations and activities was built up to produce a picture of potential exposure pathways. This then enabled emphasis to be placed on those individuals who were likely to be the most exposed, including commercial fishermen, boat owners, anglers, farmers, beekeepers and people living and/or working close to the site.

The survey did not involve the whole population in the vicinity of Springfields, but targeted subsets or groups, chosen in order to identify those individuals potentially most exposed. However, it is possible that even within a subset or group there may have been people not interviewed during the survey. Therefore, to aid interpretation, the number of people for whom data were obtained in each group as a percentage of what is estimated to be complete coverage for that group has been calculated where possible. The results are summarised in Table 1. The 'groups' are described and quantified, and the numbers of people for whom data were obtained are given as percentages of the estimated totals. For certain groups, such as anglers, it can be virtually impossible to calculate the total number of people who undertake the activity in the survey area as many people visit from outside or only visit occasionally during the year. Overall, although the number of potential interviewees in the

terrestrial survey area was estimated to be 36000, and several thousand may use the aquatic survey area, information was obtained for a significantly smaller number than this. The limited fieldwork time was directed at those individuals considered to be the most exposed, such as farmers, allotment tenants, commercial fishermen, anglers, bait diggers, wildfowling, etc. In particular, it should be noted that the survey did not include site employees, or contractors that were working on site. This is because dose criteria applicable to these people whilst at work and the dose assessment methods are different to those for members of the public.

For each of the three survey areas, the survey targeted pathways primarily relevant to that survey area. For example, people in the terrestrial survey were initially questioned because it was known that they grew significant quantities of terrestrial foodstuffs. However, where possible interviewees were asked about habits that might also lead to exposure to liquid discharges and direct radiation. During interviews with representatives from the wildfowling associations, it was not possible to collect data for all pathways (such as consumption of local foods) for each person. In this case, data were limited to occupancy rates on intertidal substrates for association members. In Annexes 1 and 2, these individuals only have data for the pathway of primary interest.

Thirty-six person-days were spent investigating the survey areas and interviewing individuals who were relevant to the survey. Observations for 554 individuals were recorded. During the survey, gamma dose rate measurements were taken to aid assessment of external exposure pathways.

3 METHODS FOR DATA ANALYSIS

3.1 Data recording

Data collected during the fieldwork were recorded in logbooks. On return to the laboratory, the data were examined and any notably high rates were double-checked, where possible, by way of a follow up phone call. In rare cases where follow up phone calls were not possible (e.g. interviewees who wished to remain anonymous), the data were accepted at face value. The raw data were entered into a habits survey database where each individual for whom information was obtained was given a unique identifier (the observation number) to assist in maintaining data quality.

During the interviews, people could not always provide consumption rates in kilograms per year for food or litres per year for milk. In these cases, interviewees were asked to provide the information in a different format. For example, some estimated the size and number of items (e.g. eggs) consumed per year, whereas others gave the number of plants in a crop or the length and number of rows in which the crop was grown per year. The database converted these data into consumption rates (kg/y for food and l/y for milk) using a variety of conversion factors. These factors included produce weights (Hessayon, 1990 and 1997 and Good Housekeeping, 1994), edible fraction data researched by Cefas, and information supplied by the Meat and Livestock Commission. For the purpose of data analysis, foodstuffs were aggregated into food groups as identified in Table 2. Specific food types relevant to this survey are presented in the subsequent tables.

All consumption and occupancy data in the text of this report are rounded to two significant figures to reflect the authors' judgement on the accuracy of the methods used. In the tables and annexes, the consumption rate data are usually presented to one decimal place. Occasionally this rounding process causes the row totals to appear slightly erroneous (± 0.1). Consumption rates less than 0.05 kg/y are presented to two decimal places in order to avoid them appearing as 0.0 kg/y. External exposure data are quoted as integers.

To ensure the quality of the data collected during the survey fieldwork and presented in the report, the following procedures have been employed:

- Experienced scientific staff were used for fieldwork and data assessment. They had been trained in the techniques of interviewing and obtaining data for all pathways that were relevant to the survey being conducted. Where individuals offered information during interview that was unusual, they were questioned further in order to double-check the validity of their claims.
- Where possible, interviewees were contacted again to confirm the results of the initial interview if, when final consumption or occupancy rates were calculated, observations were found to be high in relation to our experience of other surveys, taking into account local factors.
- Data were manipulated in a database using a consistent set of conversion factors.
- Data were stored in a database in order to minimise transcription and other errors.
- Draft reports and data tables were formally reviewed by an experienced consultant in radiological protection.
- Final reports were only issued when the Environment Agency, the Food Standards Agency and the Health and Safety Executive were entirely satisfied with the format and content of the draft.

The habits data are structured into groups of activities with similar attributes. For example, when considering terrestrial food consumption, all types of root vegetables are grouped together in a food group called 'root vegetables'. Similarly, for aquatic food consumption, all crustacean species are grouped as 'crustaceans'. For external exposure over intertidal sediments, occupancy over a common substrate, (e.g. salt marsh) is chosen. The choice of a group of activities is made when it is reasonable to assume that consistent concentrations or dose rates would apply within the group.

In addition to grouping of activities, ingestion data are structured into age groups because different dose coefficients (i.e. the factors which convert intakes of radioactivity into dose) can apply to different ages. These age groups are from 0 to 1.0 y of age (called 3 month old);

more than 1.0 y to 2.0 y (called 1 year old); more than 2.0 y to 7.0 y (called 5 year old); more than 7.0 y to 12.0 y (called 10 year old); more than 12.0 y to 17.0 y (called 15 year old). Individuals over 17 years old are treated as adults. These age groupings are consistent with those used in ICRP 72 (ICRP, 1996). For direct radiation pathways, the data are grouped into distance zones from the site perimeter as a coarse indication of the potential dose rate distribution due to this source of exposure. The bands used were: 0 – 0.25 km, 0.25 – 0.5 km and 0.5 – 1 km. These distance bands are also useful when assessing exposure to gaseous discharges.

3.2 Data analysis

The main outputs of the study are the statements of individuals' consumption, handling and occupancy rates given in Annexes 1 and 2. These can be used by those undertaking radiological assessments of the effects of the operations at the Springfields site – taking into account the concentration and/or dose rate distributions in space and time relevant to the assessment. It is only with the outcome of such an assessment that the critical group can strictly be defined as those most exposed.

Annex 3 contains qualitative and estimated data for pathways where it was not possible to obtain quantifiable data from interviewees. This includes activities that were heard about during the survey i.e. activities which were dormant or were taking place at a different time of year to the survey. Where possible, an estimated rate is given for each exposure pathway based on experience from previous habits surveys or based on information gained during the survey. Annex 3 has been included in this report so the information can be used in dose assessments, to ensure that all potential pathways have been covered that would otherwise be missed.

In addition to providing data in the annexes, we have also analysed them to provide estimates of rates of occupancy, handling and consumption which can be regarded as typical of those

most exposed prior to a formal assessment being undertaken. Three approaches have been used.

Firstly, the 'cut-off' method described by Hunt *et al.* (1982) was used. With the 'cut-off' method, the appropriate high rate was calculated by taking the arithmetic mean of the maximum observed rate and all observed rates within a factor of 3 of the maximum value (termed the lower threshold value). It accords with the principle expressed by ICRP (ICRP, 1984) that the critical group should be small enough to be reasonably homogeneous with respect to age, diet and those aspects of behaviour that affect the doses received. In this report, the term critical group rate is used to represent the data derived by the 'cut-off' method for ease of presentation. A separate critical group rate was calculated for each food group, intertidal substrate and handling pathway identified in the survey. In certain cases, using the 'cut-off' method could result in only one person being in the critical group. In these cases, expert judgement was used to decide whether the critical group should remain as one individual or whether others should be included. If others were included, the second highest rate was divided by three to give a new cut-off value and all observations above this were included in the critical group. When the second highest rate has been used, this is explained in the table notes.

Secondly, 97.5 percentile rates were calculated using the Excel mathematical function for calculating percentiles. This method accords with precedents used in risk assessment of the safety of food consumption. Mean and 97.5 percentile rates based on national statistics have been derived by the Ministry of Agriculture, Fisheries and Food (MAFF) (now part of Defra) and the Food Standards Agency (Byrom *et al.*, 1995 and FSA, 2002), and these are referred to as generic rates in this report.

Thirdly, data has been profiled using the 'cut-off' approach. This gives a complete view of the habits of the individual that might lead to exposure to all the discharges and radiation from the site. The profiled data has been used to assess total dose integrated across all pathways of exposure.

For ingestion pathways, critical group rates for children have been calculated from the survey data. However, because few child consumers were identified, the rates should be viewed with caution. For assessment purposes, an alternative approach may be taken which involves scaling the critical group rates for adults by ratios. These ratios are given in Annex 4 and have been calculated using generic 97.5 percentile consumption rates.

Selection of critical group and 97.5 percentile rates for occupancy is not made for the direct radiation pathway. Such an analysis is of limited value without a detailed knowledge of the spatial extent of dose rates due to direct radiation.

4 AQUATIC RADIATION PATHWAYS

4.1 Aquatic survey area

The aquatic survey area, shown in Figures 1 and 2, covered the Ribble Estuary, its tributaries and all intertidal areas between the A6 road bridge at Frenchwood (upstream) to Fairhaven and Marshside Sands (downstream) on the north and south sides of the estuary respectively. This was the same area as that of the 2000 survey. It also included the lower section of Millenium Ribble Link between the sea gate and the first lock.

Overview of the survey area

Large areas of salt marsh bordered the lower Ribble Estuary and at low water extensive areas of sand were exposed. The salt marsh areas provided livestock grazing in the spring and summer months and excellent wildfowling during the autumn and winter months. The large areas of sand provided reasonable catches of shrimps to tractor fishermen towing nets through shallow water areas. In contrast the upper tidal Ribble Estuary was fresh water and the banks were predominantly mud covered by reeds and undergrowth.

North Bank

Fairhaven to Wrea Brook

Fairhaven marked the western extent of the survey area on the north side of the Ribble Estuary. There is a large lake here that separates the shore from the town. The lake was fed by seawater and so activities taking place on the lake were investigated. The lake was council owned and used for windsurfing, canoeing and pleasure craft such as pedalos. The lake was also used by local schools for water sports lessons, by the Ribble Cruising Club for sailing lessons and by the Lytham sea cadets. No intertidal activities were noted to be taking place

on the shore, although the occasional angler fished at high water from the promenade, which separates the lake from the shore.

East of Fairhaven is Granny's Bay which was composed of areas of mud, sand, and mixtures of mud and sand. Anglers, bait diggers, a stake netter, Royal Society for the Protection of Birds (RSPB) guides, a samphire (*Salicornia europaea*) collector and a beachcomber were noted at this location. Granny's Bay was managed by the RSPB who had a visitor's centre there. RSPB guides led walks around the bay and ran nature activities for groups of school children.

Between Granny's Bay and the Seafield slipway, the intertidal foreshore was composed of mud and no activities were noted. Four commercial fishermen kept their boats at the slipway, above the high water mark, using tractors to launch and retrieve them. Boat anglers and hobby fishermen (one shrimp fisherman and one gill net fisherman) were noted also to launch their boats from this location. Individuals shore angling, bait digging, walking and maintaining their boats were also noted at this location.

East of the slipway following the Lytham promenade to the lifeboat station, the substrate changed to sand on the upper intertidal area with mud on the lower intertidal area. The occasional walker and angler were noted using the upper intertidal areas. The Ribble Cruising Club's clubhouse, jetty and boat compound were located just to the east of the lifeboat station. The compound held yachts and dinghies during the winter. In summer the yachts were transferred to Lytham Dock but the dinghies were still parked in the compound and launched from the jetty.

Between the lifeboat station and the mouth of Wrea Brook the upper shore substrate was salt marsh and the lower shore substrate was mud. This area, known as Lytham Marsh, was occasionally used by the Lytham and District Wildfowling Association, which had 83 adult members and 10 junior members. The wildfowling season on the Ribble Estuary was 1st September to 20th February for all wildfowling associations.

Two creeks flowed into the Wrea Brook from the Lytham side, one of which was Lytham Dock where the yachts from the Ribble Cruising Club were moored in the summer months. The second creek also served as a mooring for a few small yachts. No individuals were identified to be living on boats in either creek, though some individuals were noted to spend time on their boats in summer for recreational purposes such as picnics, barbeques and socialising. In previous surveys, people had been identified living on boats in these creeks.

Wrea Brook to Millenium Ribble Link

The Wrea Brook drains Warton Marsh – a large salt marsh area partly owned and managed by the Lytham and District Wildfowling Association. As well as wildfowling, some club members spend additional time on the marsh maintaining the artificial duck ponds. Samphire grew on the marsh and one wildfowler reported consuming small quantities of it whilst out wildfowling. Warton Marsh was used for grazing livestock during the spring and summer by a local farmer. The remaining area of Warton Marsh was managed under the guidance of English Nature since it is part of the Ribble Estuary Site of Special Scientific Interest (SSSI), a Special Protection Area (SPA) and a National Nature Reserve (NNR). The lower shoreline substrate was again mud over which the wildfowlers also spent time. From the eastern end of Warton Marsh to the confluence of Freckleton Brook, the upper intertidal substrate was a narrow belt of salt marsh and the lower intertidal substrate was mud. The belt of salt marsh was also used for grazing livestock during the spring and summer. A boatyard was located on the banks of the Freckleton Brook in the south-east portion of Freckleton Village. The boatyard was used as a mooring for several boats but investigation revealed that none were used as residences. One commercial fisherman kept and launched his salmon fishing boat from Naze Point, located at the confluence of the brook with the estuary. From Freckleton Brook upstream to Frenchwood, elver (*Anguilla anguilla*) fishing by a few individuals took place at several locations over intertidal mud during March and April. From Freckleton Brook to The Millenium Ribble Link the substrate was predominantly mud with small areas of salt marsh. This salt marsh was again used for grazing livestock. Another area, Clifton Marsh, which historically was salt marsh, has now been transformed into a landfill site, where very

low level rubble from the decommissioning areas of the Springfields site was being disposed of.

The Millennium Ribble Link forms an important waterway for boats as it connects the Ribble Estuary to the Lancaster Canal. It was deepened and widened by dredging during 2001 and opened for recreational boating traffic in 2002. A sea lock was constructed just to the north of its confluence with the Ribble Estuary, allowing boats to enter at high water and progress through a series of locks, towards Preston and then enter the Lancaster Canal. There was easy access along most of the south east bank of Millennium Ribble Link. The first lock now prevents the Millennium Ribble Link from being tidal upstream of it. Angling took place between the A583 Road Bridge and the first lock; this wasn't on intertidal areas but on the grass bank above it. Access to the north west bank of the Millennium Ribble Link was not possible for most of its length because it was bordered by fences and thick hedgerows, with only the occasional footpath giving access to the high, overgrown banks.

The spoils from the dredging operation were not removed from the area, but used to 'hard landscape' the north west bank of the brook. Beta doses rate measurements over the spoil deposited areas were taken and are discussed in Section 4.8. The survey team spent time investigating any activities, which may have been taking place along the length of the Millennium Ribble Link between the A583 Road Bridge and the sea lock. With the exception of one angler fishing from the concrete sea lock into the brook for freshwater species, no other activities were observed and there were no obvious signs of public occupancy such as litter or recent footprints on the banks.

Millennium Ribble Link to the A59 Road Bridge

To the east of the Millennium Ribble Link was Lea Marsh, another area of salt marsh with mud as the lower shore substrate owned by a local farmer and used for grazing livestock. From Lea Marsh to Bull Nose, the estuary intertidal substrate was mud over which angling was noted to be occurring. Bull Nose, which served as a concrete entrance structure to the

marina and Preston Docks, was a popular spot for angling. The main species caught were flounders, eels and the occasional bass. From Bull Nose to the A59 Road Bridge were dockland roads and associated structures with no intertidal activities noted.

For all the above sections of the estuary, council employees were responsible for maintaining the navigation posts from Bull Nose downstream to the sea. This involved spending time on a boat on the river and also time on the muddy riverbank areas.

A59 Road Bridge to Frenchwood (north and south banks)

This section of the River Ribble, although still tidal, was predominantly freshwater. Over the years, fine sediment with radionuclides adsorbed on it from further downstream has been transported upstream on very large tides and deposited on the riverbanks during slack water periods. The main activity noted along this section was coarse angling. Angling locations were over this intertidal mud with the anglers, for the most part, sitting on low tackle boxes. Annual occupancy times on this occasion were significantly less than those noted in the previous survey with diminishing fish stocks being the cause according to the anglers interviewed. The River Darwen confluences with the River Ribble in this section on the southern side. In previous surveys, the River Darwen had also been a popular angling stretch of river. On this survey, the overgrown riverbank indicated that no anglers had fished this location so far this season.

South Bank

A59 Road Bridge to Hutton Marsh

The Ribble Way tracks along the river wall, which was a grassed earth embankment designed to act as a barrier against the highest spring tides. The intertidal substrate was mud, with small patches of salt marsh. With the exception of walkers and dog walkers using the Ribble Way path, no other activities were noted.

Hutton Marsh to the River Douglas

Hutton and Longton Marshes were effectively the same combined area of salt marsh to the east of the River Douglas. They were typical of all the main salt marsh areas adjoining the Ribble Estuary, being a wide expanse of tide washed grassland intersected by many mud filled gulleys (locally termed gutters) that fill with water on every high tide. The grassland only floods occasionally on the highest tides of the year, usually during autumn and winter. For this reason, farmers tend to restrict grazing of livestock on the Ribble Estuary salt marshes to the spring and summer months, which was the case with Hutton and Longton Marshes. Cattle and sheep were generally introduced to the salt marshes at the beginning of May and taken off during the first week of October. The wildfowling rights of Hutton and Longton marshes belonged to the Preston and District Wildfowling Association. Wildfowling took place both lying and kneeling on the salt marsh and in the muddy gulleys. The main narrow intertidal area was again mud, which the wildfowlers sometimes used during the shooting season.

The River Douglas separates Hutton and Longton Marshes from Beconsall and Hesketh Marshes to the west. It is tidal upstream to Tarleton Lock where it merges with the Rufford Canal. Since the opening of the Millennium Ribble Link, pleasure craft could cruise from the Rufford Canal to the Lancaster Canal, via the River Douglas, the Ribble Estuary and Millennium Ribble Link.

From Tarleton Lock to the Ribble estuary, the River Douglas flows past the villages of Beconsall and Hesketh Bank. There was a boatyard adjacent to the river at Beconsall, providing moorings for privately owned pleasure cruisers and yachts. During earlier surveys, three or four of the boats in this boat yard had been used for full time occupancy. On this occasion only one boat, moored over mud, was occupied full time. It only floated on rare occasions on exceptionally high tides. The two elderly occupants, well known for many years to Cefas staff, were interviewed and gamma dose rate measurements were taken at three positions on board their boat and over the mud beneath it.

Beaconsall Marsh borders the west shore of the River Douglas from Beaconsall village downstream to Hesketh Marsh. It is only a narrow strip of salt marsh again separated from the river by mud. It also provided limited summer grazing. A small amount of angling took place in the river from the salt marsh, with flounders and eels being the main species caught.

River Douglas to Banks Marsh

Hesketh Marsh and Banks Marsh both have the same main activities as Hutton and Longton Marshes; grazing and wildfowling for the same duration/season of the year. Both marshes were part of the Ribble Estuary NNR and were owned and managed by English Nature. Southport and District Wildfowling Association had the shooting rights over most of the areas of these marshes. Hesketh Bank Wildfowling Association, a small club with only ten members, had the shooting rights over a small eastern portion of Hesketh Marsh. Wildfowling was not permitted on a section of Banks Marsh, which was designated as a wetland bird sanctuary.

A large area of reclaimed land, Hesketh Out Marsh West, had recently been acquired by the RSPB from funding provided by the Environment Agency and the Northwest Regional Development Agency. The RSPB plan to remake the area intertidal in March 2007 by breaching the sea defences in several places. The area, which is 170 hectares in extent, was reclaimed 25 years ago when caesium levels originating from Sellafield discharges were significantly greater than those of present day. This might justify some gamma and beta dose rate measurements and turf samples over/from the area when the project has been completed because radionuclide levels may still be high, not having been able to leach out as has been the case with tide washed areas. Both marshes were separated from the Ribble Estuary by intertidal mud banks, which were again used by the wildfowlers in addition to the marsh. Two herdsman spent significant amounts of time over these marshes managing beef cattle and sheep.

Banks Marsh to Crossens Marsh

Adjoining Banks Marsh is Crossens Marsh, which was also used by the Southport and District Wildfowling Association. This salt marsh area extended to the western limit of the aquatic survey area. Samphire grew abundantly on this area and although not observed during this survey, it was reported by the English Nature warden that it was frequently collected for local consumption and transportation in larger quantities to outlets in Manchester and Birmingham.

Marshside Sands is a large area of sand (at low tide) offshore of Crossens Marsh. A sand excavation company based at Marshside, operated on Marshside Sands. This sand is of a high quality and is used in large quantities by glass production industries. The manager of the company was interviewed and occupancy times for his two employees over the sand were obtained. Marshside Sands was also one of the main areas worked by commercial shrimp fishermen and a set net fisherman catching fish for his personal consumption.

4.2 Commercial fisheries

Commercial fishing activity in the survey area was very limited. On the north side of the estuary, four small fishing boats operated from the shore in front of the Seafield slipway. One boat only trawled for brown shrimps (*Crangon crangon*) all year round and the others alternated between shrimp trawling in the winter months and drift netting for bass (*Dicentrarchus labrax*) and grey mullet (*Chelon labrosus*) in the summer months.

On the south side of the estuary, seven fishermen were tractor fishing for brown shrimps. They fished mainly working on Marshside Sands at low tide using tractors towing nets through shallow water. All were interviewed and they were in agreement that it was a dying industry because of the dwindling catches. Most were pensioners and they said that when they gave up fishing they doubted if anybody would keep this element of fishing alive. Small by-catches of plaice (*Pleuronectes platessa*), turbot (*Scophthalmus maximus*) and Dover sole (*Solea solea*) were caught. Three of these fishermen also used set nets in addition to shrimp fishing.

The target species were bass in the summer months and cod (*Gadus morhua*) in the winter months.

Further up the estuary, between Warton Marsh and the Millennium Ribble Link, six licensed salmon fishermen fished with gill nets for salmon (*Salmo salar*) and sea trout (*Salmo trutta*). The season for operating salmon nets was 1st June to 31st August. During March and April, a small number of individuals fished for the seasonal run of elvers. One fisherman who was interviewed said that most of the elver fishing took place between Freckleton and Frenchwood and that four or five people were involved. The elvers were sold to a buyer in Gloucester.

The Fisheries Officer for this area informed us that raking for cockles (*Cerastoderma edule*) was now non-existent because of very low stocks and that this fishery would be closed between 1st September 2006 to 30th April 2007. He said that commercial mussel (*Mytilus edulis*) gathering from the river training walls took place during the winter by a small number of visiting collectors. He also informed us that there was a potential razor shell (*Ensis arcuatus*) fishery offshore of Lytham St Annes, although this would be just outside the aquatic survey area.

4.3 Angling

Shore angling for saltwater species was noted at Fairhaven and in the saltwater tidal section of the River Douglas. The most popular location however, was Bull Nose with 10 to 20 anglers usually being present at any one time. The most abundant fish species caught by shore anglers in the area were flounders (*Platichthys flesus*) and eels (*Anguilla anguilla*). Occasionally a few bass were also caught.

Freshwater angling took place from the between the A59 and the A6 road bridges. No edible species were noted as being caught. The anglers interviewed were, for the most part, seated on tackle boxes over mud.

4.4 Wildfowling

Four wildfowling clubs were identified as being active in the aquatic survey area. Most of the Ribble area marshes were used by these clubs, with each club having their own specific locations as described in Section 4.1.

The Southport and District Wildfowling Association secretary said that the main species of duck shot were widgeon (*Anas penelope*) (85%) with 5% each of mallard (*Anas platyrhynchos*), pintail (*Anas acuta*) and teal (*Anas crecca*). The main species of geese shot were pink-footed (*Anser brachyrhynchos*) with some greylags (*Anser anser*). Small numbers of common snipe (*Gallinago gallinago*) were also shot.

The wildfowling clubs permitted their members three shooting sessions on the salt marshes per week. The keenest members were doing this number of visits throughout the 25-week season (1st September to 20th February). The duration of an average shooting session was 3 to 4 hours although one retired club member said that his average session was 5 hours.

4.5 Other Pathways

No one was identified using seaweed as fertilizer or animal feed. Two individuals were identified who consumed small amounts of samphire and sea beet (*Beta vulgaris*) collected from the Warton Marsh. Other people were reported to consume samphire collected from Crossens Marsh although they were not observed during the survey. No unusual pathways were noted.

4.6 Wholesalers and retailers

Most of the bass and some of the salmon and sea trout from the survey area were sold to a retailer in Lytham. He also bought half the shrimps caught by the Seafield slipway boats. The other half was processed by the full-time shrimp fisherman and sold from his own premises.

Whenever possible, the salmon anglers sold their catches privately from their homes as they could obtain a better price per kilogram by doing so.

The fishermen who fished on Marshside Sands and lived in Southport, Marshside and Banks, either sold their shrimp catches to one of two local wholesalers in Marshside and Banks or processed them at home to be sold from their houses.

4.7 Food consumption data

Consumption data for locally caught aquatic foodstuffs are presented in Tables 3 to 6 for adults and in Tables 7 to 9 for children. The tables include the mean consumption rates of the critical groups together with the observed 97.5 percentile rates calculated as described in Section 3.2. For purposes of comparison, the data are summarised in Table 10 for adults and Tables 11 to 13 for children (15 year olds, 10 year olds and 5 year olds respectively). The summary tables also include mean rates and 97.5 percentile rates based on national data (referred to as 'generic' data in this report). No generic data are available for the 5 year old age group.

Adult consumption rates

Adults were found consuming foods from four food groups; fish, crustaceans, wildfowl and marine plants and algae, but not molluscs. The people consuming the greatest quantities of food from the aquatic survey area were commercial fishermen, shore anglers and families of these people.

The predominant species of fish consumed by adults were bass, cod, Dover sole and flounder with smaller quantities of dab (*Limanda limanda*), mackerel (*Scomber scombrus*), plaice, salmon, turbot and whiting (*Merlangius merlangus*). A critical group of four individuals was identified with a maximum consumption rate of 72 kg/y and a mean of 54 kg/y. The observed 97.5 percentile rate based on 54 observations was 60 kg/y. This compares with the adult

generic mean and 97.5 percentile consumption rates for fish of 15 kg/y and 40 kg/y respectively. The percentage breakdown, to the nearest 5%, of species eaten by the critical group was 50% bass, 35% Dover sole and 15% cod.

The only species of crustacean consumed from the survey area was brown shrimp. A critical group of two individuals was identified with a maximum consumption rate of 26 kg/y and a mean of 21 kg/y. The observed 97.5 percentile rate based on 30 observations was 18 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for crustaceans of 3.5 kg/y and 10 kg/y respectively.

Marine plants consumed were samphire and sea beet. A critical group of two individuals was identified with a maximum consumption rate of 1.0 kg/y and a mean of 0.73 kg/y. The observed 97.5 percentile rate based on two observations was 1.0 kg/y. No generic data are available for this food group. The percentage breakdown, rounded to the nearest 5%, of species eaten by the critical group was 85% samphire and 15% sea beet.

Wildfowl consumed by adults were ducks, geese and common snipe. A critical group of seven individuals was identified with a maximum consumption rate of 27 kg/y and a mean of 21 kg/y. The observed 97.5 percentile rate based on 52 observations was 24 kg/y. No generic data are available for this food group. The percentage breakdown, rounded to the nearest 5%, of species eaten by the critical group was 75% ducks and 25% geese. In addition, a very small percentage of common snipe was consumed (1%).

Children's consumption rates

15 year old age group

Children in the 15 year old age group were noted to be consuming, wildfowl only. None were identified who consumed fish, crustaceans, molluscs and marine plants or algae.

For wildfowl, a critical group of two individuals was identified with a maximum consumption rate of 1.9 kg/y and a mean of 1.4 kg/y. The observed 97.5 percentile rate based on two observations was 1.8 kg/y. No generic data are available for this food group. The only wildfowl these individuals consumed were ducks.

10 year old age group

Children in the 10 year old age group were noted to be consuming, wildfowl only. None were identified who consumed fish, crustaceans, molluscs and marine plants or algae.

For wildfowl, only one consumer appeared in this age group. The critical group consumption rate was 2.9 kg/y. No generic data are available for this food group. The only wildfowl this individual consumed were ducks.

5 year old age group

Children in the 5 year old age group were noted to be consuming fish and crustaceans. None were identified who consumed molluscs, marine plants and algae or wildfowl.

For fish, only one consumer appeared in this age group. The critical group consumption rate was 2.7 kg/y. No generic data have been derived for this age group. The only fish this individual consumed was cod.

For crustaceans, only one consumer appeared in this age group. The critical group consumption rate was 1.4 kg/y. No generic data have been derived for this age group. The only crustaceans this individual consumed were brown shrimps.

1 year old age group

No children in the 1 year old age group were noted to be consuming any local aquatic foodstuffs.

3 month old age group

No children in the 3 month old age group were noted to be consuming any local aquatic foodstuffs.

4.8 Intertidal occupancy

Intertidal occupancy rates for adults and children are presented in Table 14. The table includes data on occupancy over four different types of substrate. These were mud, mud and sand, salt marsh, and sand. Potential critical occupancies are shown in bold. Data for two adults living on a houseboat positioned over mud was also obtained. In the following sections, occupancy during boat dwelling is treated separately.

As usual, occupancy has been considered for people standing, walking and riding over substrates. However, some individuals spend much of their time closer to substrates, for example, sitting, kneeling or lying down. Further consideration has been given to these individuals.

For all activities over mud, the maximum occupancy rate recorded was 640 h/y for an individual who was working, wildfowling and angling. Seventeen other individuals, working, walking, wildfowling, angling and/or maintaining boats had occupancy rates within a factor of

three of this. This gives a mean occupancy rate for this group of 350 h/y. As appropriate, individuals' occupancy rates included times in close proximity to the mud.

Freshwater anglers and wildfowlers have been considered as a separate occupancy group, because they spend much of their occupancy time in close proximity to the mud, either sitting on fishing tackle boxes or kneeling. It has been assumed that that all of their time over mud was spent in close proximity. The maximum occupancy rate recorded was 340 h/y, and 25 other individuals had occupancy rates within a factor of three of this. This gives a mean occupancy rate for this group of 250 h/y.

The maximum occupancy rate recorded over mud and sand was 1100 h/y for an angler and commercial bait digger. No other individuals had occupancy rates within a factor of three of this, so this is taken as the critical group occupancy rate.

For all activities over salt marsh, the maximum occupancy rate recorded was 1300 h/y for a herdsman tending livestock. Two other individuals, walking and wildfowling, had occupancy rates within a factor of three of this. This gives a mean occupancy rate for this group of 750 h/y. As appropriate, individuals' occupancy rates included times in close proximity to the salt marsh.

Wildfowlers have been considered as a separate occupancy group, because they spend much of their occupancy time in close proximity to salt marsh either lying down, sitting or kneeling. It has been assumed that that all of their time over salt marsh was spent in close proximity. The maximum occupancy rate recorded was 470 h/y, and five other wildfowlers had occupancy rates within a factor of three of this. This gives a mean occupancy rate for this group of 390 h/y.

The maximum occupancy rate recorded over sand was 1900 h/y for two men employed by a sand extraction company driving sand moving vehicles. One other individual, a fisherman

checking set nets, had an occupancy rate within a factor of three of this. This gives a mean occupancy rate for this group of 1600 h/y.

Occupancy in houseboats

The maximum occupancy rate recorded for dwelling in houseboats over mud was 8400 h/y for one adult. One other adult, living on the same boat, had an occupancy rate within a factor of three of this. This gives a mean occupancy rate for this group of 8300 h/y.

The amount of time that the boat was afloat during the last 12 months was said by the occupants to have been negligible, possibly for one hour on an exceptionally high spring tide in March. Therefore, the mean occupancy rate needed no adjustment to allow for shielding by water between the boat's hull and the mud.

This occupancy time on the boat has been converted to an equivalent time spent over unshielded mud for ease of calculation of the annual effective dose. This is calculated by considering two equations. Firstly, the total annual dose, D (μSv), received by the critical group on board the boat has been calculated using the formula;

$$D = R_{OCC} * R_{\gamma} * F,$$

where R_{OCC} is the mean occupancy rate (8300 h/y) on board the boat in the living/sleeping berth,

R_{γ} is the mean gamma dose rate measurement in the berth minus an appropriate background ($0.088 - 0.07 = 0.018 \mu\text{Gy/h}$),

F is the factor for converting μGy to μSv (0.85 Sv/Gy).

This gives a total annual dose of 127 μSv .

The equivalent time (h) required to receive this annual dose over unshielded boatyard mud (T_{EQ}) was calculated using the formula;

$$T_{EQ} = D / (R_{Y,MUD} * F),$$

where $R_{Y,MUD}$ is the gamma dose rate measurement directly over mud under the boat's hull minus an appropriate background ($0.109 - 0.07 = 0.039 \mu\text{Gy/h}$),

D is the total annual dose, as above,

F is the factor for converting μGy to μSv (0.85 Sv/Gy), as above.

This gives an equivalent annual occupancy time over unshielded boatyard mud of 3800 h/y.

The total dose of $127 \mu\text{Sv/y}$ (approximately three and a half times that of $36 \mu\text{Sv/y}$ calculated from the 2000 survey measurements) is a preliminary value, to be viewed with caution because only one set of gamma dose rate measurements was taken (on the same day) inside and under the boat during 2006. Earlier work carried out by Cefas has shown that the on-board gamma dose rates can vary as can be seen in Annex 6 and quarterly gamma dose rate measurements have shown that there can also be significant differences within a single year over Becconsall boatyard mud. The gamma dose rate measurements, relating to this houseboat, taken during the 2000 survey, shown in Annex 6, appear to be low when compared to the measurements taken in earlier years and during the 2006 survey. This could be due to the height of the tide at the time the measurements were taken. Even though water was not beneath the hull of the boat when the gamma dose rate measurements, shown in Annex 6, were taken, the amount of additional mud exposed behind the boat could influence them. Following the 2006 survey, Cefas has taken further gamma dose rate measurements on the houseboat and over the mud beneath it in February 2007 at different states of the tide to support the 2006 survey results. The day was added to the Cefas, Whitehaven, team's scheduled quarterly monitoring in the Springfields area. The results, which compare favourably with those of the 2006 survey, were issued as a separate fieldwork report in March 2007 and a table of these results can be seen in Annex 7.

Gamma and beta dose rate measurements

Representative gamma dose rate measurements at 1 m above the substrate were taken over mud, salt marsh and tide washed grass. These measurements (shown in Table 16) ranged from 0.073 to 0.130 $\mu\text{Gy/h}$ over mud, 0.093 to 0.160 $\mu\text{Gy/h}$ over salt marsh and 0.074 $\mu\text{Gy/h}$ over tide washed grass. Natural levels of around 0.05 $\mu\text{Gy/h}$ over mud and 0.07 $\mu\text{Gy/h}$ over mud or salt marsh are expected. A value of 0.06 $\mu\text{Gy/h}$ is expected for all other substrate types. Measurements taken on boats over mud ranged from 0.078 $\mu\text{Gy/h}$ taken on a fibreglass boat in Lytham Creek to 0.089 $\mu\text{Gy/h}$ in a plywood boat in Becconsall Boatyard.

Representative beta dose rate measurements at contact with the substrates and fishing gear were taken over mud, mud and sand, salt marsh, tide washed grass and salmon nets. These measurements (shown in Table 16) ranged from 0.438 to 2.723 $\mu\text{Sv/h}$ over mud, 0.924 $\mu\text{Sv/h}$ over mud and sand, 0.312 to 0.589 $\mu\text{Sv/h}$ over salt marsh, 0.543 $\mu\text{Sv/h}$ over tide washed grass and 0.096 $\mu\text{Sv/h}$ over salmon nets. The highest measurements over mud and a mixture of mud and sand were recorded on the east bank of the Millenium Ribble Link south of the sea lock and could probably be related to the 2001 dredging activity depositing spoil on the bank at these locations.

4.9 Handling of sediment, fishing gear and nets

Handling sediment, while bait digging or mollusc collecting, or handling commercial fishing gear, which has become entrained with fine sediment particles can give rise to skin exposure from beta radiation. Doses to the skin need consideration as there is a separate dose limit for skin for members of the public. There is also a contribution to effective dose due to skin exposure (ICRP, 1991).

Handling of angling equipment was not considered to be a significant pathway. Therefore, as in previous surveys, data for this pathway were not collected.

Fishing gear can also be a source of whole body gamma exposure due to occupancy in the vicinity of the gear. However, this pathway is minor compared with the same exposure received during occupancy over intertidal areas and it has therefore been omitted from the report.

Table 15 shows the times spent handling fishing gear and intertidal sediment recorded during the survey.

The maximum fishing gear handling rate recorded was 1100 h/y for a commercial fisherman. Eight other commercial fishermen had fishing gear handling rates that came within a factor of three of this. This gives a mean handling rate for this group of 690 h/y.

The maximum sediment handling rate recorded was 830 h/y for a commercial bait digger. Fifteen wildfowlers had sediment handling rates that came within a factor of three of this. This gives a mean handling rate for this group of 390 h/y.

4.10 Water based activities

Activities taking place in or on the water can lead to ingestion of water and/or inhalation of spray. These pathways are generally considered to be minor in comparison with other exposure pathways such as the ingestion of foods produced in the vicinity of a nuclear site. However, in order to allow for their assessment, relevant data have been collected.

Occupancy rates for activities taking place on water potentially affected by liquid discharge around Springfields are shown in Table 17. With the exception of one 5 year old (Observation Number 325), all observations are for adults. Activities where there is a high potential of the individual's face going under the water, such as diving and swimming, are classified as activities in water since they are likely to lead to ingestion of water. None were observed in the survey area.

No further manipulation of the data (for example, calculating critical group rates) has been carried out.

Activities on water

Activities taking place on the water around Springfields included commercial fishing, hobby fishing, working on boats, boat angling, sailing and jet skiing. Forty-two observations were recorded. The highest occupancy rate was 1200 h/y for a commercial fisherman.

5 TERRESTRIAL RADIATION PATHWAYS

5.1 Terrestrial survey area

The terrestrial survey area covered all land and watercourses within 5 km of the site centre (NGR SD 470 314) as shown in Figure 3.

Within the survey area, some of Preston is located in the east, part of the town of Kirkham is located to the west of the site and part of the village of Freckleton is located to the south-west. Two smaller villages, Clifton and Newton-with-Scales were located to the south and south west of the site respectively. The remaining parts of the survey area were rural and mostly agricultural.

Interviews were conducted at 28 working farms in the survey area. Of these:

- four produced beef cattle
- three produced dairy cattle
- five produced beef cattle and sheep
- three produced beef cattle and dairy cattle
- one produced beef cattle, dairy cattle and pigs
- two produced beef cattle, dairy cattle and turkeys
- one produced beef cattle, lambs and pigs
- one produced beef cattle, lamb, chicken and barley and wheat
- one produced beef cattle, lamb and chicken eggs
- one produced chicken eggs and pigs
- one produced dairy cattle and lamb
- four produced chicken eggs and chicks to be sold on for egg production (one also reared pheasants and ducks for release to shoots.)
- one produced swedes and potatoes

Arable crops that were grown and kept on the farms for winter feed included wheat, barley, grass, silage, maize, beans and oil seed rape.

Beef cattle from the survey area were sold to livestock auctions at Lancaster, Preston and Gisburn in Lancashire and to an abattoir in Preston. Lamb was sold to livestock auctions at Lancaster, Preston and Gisburn. Pigs were sold to abattoirs in Cheshire and Norfolk and to a farmer at Warton, Lancashire. Chickens were sold to Grampian Country Foods. Milk was sold to Arla Foods, Dairy Farmers of Britain and Wisemans Dairy. Chicken eggs were sold to outlets around north England. None of the foods were sold to places within the survey area except turkeys which were sold to local butchers and local customers.

Three smallholdings were identified in the survey area. One reared piglets and lambs, which were sold to an abattoir in Preston, and eggs (chicken, duck and goose), which were sold from the door to local customers. One reared lamb and beef and sold them to local customers. One reared replacement dairy cows, which were sold on to other farmers.

Farmers and their families were noted to be consuming beef, lamb, pork, poultry, milk, eggs, game and vegetables from their own farms.

Four allotment sites (marked on Figure 3) were located in the survey area at Salwick, Kirkham, Freckleton and Haslam Park in Preston. People were growing a range of fruit and vegetables at the allotment sites. At the Kirkham site, we were told that poultry were kept for egg production, although no-one was available for interview during the survey.

Two beekeepers were identified in the survey area, however, both declined to be interviewed so no information was available.

The consumption of wild foods from within the survey area was limited to mushrooms, game, including pheasant, partridge and pigeon. The only organised shoot identified was one for 12 people who shot on farmland to the north of the site.

No households were identified as drinking ground water or surface water.

Deepdale Brook originated to the north-west of the Springfields site, flowed south through the site itself and then into Millenium Ribble Link. To the north of the Springfields site no livestock used the brook for drinking since the banks were too steep. However, sheep and cows were observed drinking from the brook to the south of the site; the banks are much shallower along this stretch and were often unfenced. No other livestock were identified as drinking borehole, well, spring or other surface water.

No consumption of freshwater fish from watercourses in the survey area was identified.

5.2 Unusual pathways

The transfer of contamination from Springfields by wildlife was investigated. Representatives from the Springfields site were asked about wildlife that could act as carriers for the transfer of radioactivity off site. Rabbits were numerous within the Springfields site. In the past, cats have been used to cull the rabbits but this is not taking place at present because the site does not consider the rabbits to be a problem. However, the perimeter of the site and areas to the north east of the site are checked by site employees for ground that had been disturbed by rabbits. Pigeons were observed on site but were not considered to be a problem. The site did not analyse rabbit or pigeon flesh for radionuclides. No one was noted to be consuming rabbits from within the survey area, although small numbers of pigeons were shot and eaten.

5.3 Wholesalers and retailers

One farm shop sold chicken eggs, and another sold chicken eggs and lamb. No other outlets of local terrestrial produce were identified.

5.4 Food consumption data

Consumption data for locally produced foodstuffs potentially affected by gaseous discharges are presented in Tables 18 to 29 for adults and Tables 30 to 41 for children. These tables include the mean consumption rates of the critical groups together with the observed 97.5 percentile rates calculated as described in Section 3.2. For purposes of comparison, the data are summarised in Table 10 for adults and in Tables 11 to 13 for children (15 year olds, 10 year olds and 5 year olds respectively). No children in the 1 year old and 3 month old age groups were noted to be consuming locally produced foods potentially affected by gaseous discharges.

In order to provide information relevant to surveillance and assessments studies, the consumption rate data collected during the survey were analysed to indicate which food types most commonly contributed to each food group. The data are summarised in Table 42. Those food types shown in bold and labelled with an asterisk were sampled as part of the 2005 Food Standards Agency monitoring programme (EA, EHS, FSA and SEPA, 2006).

Adults' consumption rates

Consumption of locally produced foods was identified in the following 12 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, milk, cattle meat, pig meat, sheep meat, poultry, eggs and wild fungi. No consumption of wild/free foods, rabbits/hares, honey, venison, freshwater fish or local cereals was identified.

The critical group mean consumption rate exceeded the generic 97.5 percentile consumption rate for only milk. A further nine critical group mean consumption rates exceeded the generic mean consumption rates. These were for green vegetables, other vegetables, root vegetables, domestic fruit, cattle meat, pig meat, sheep meat, poultry and eggs. Two observed 97.5 percentile consumption rates exceeded the generic 97.5 percentile consumption rates. These were for root vegetables and milk.

Children's consumption rates

15 year old age group

Seven children in this age group were identified to be eating locally produced food. Consumption was identified in the following seven food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, milk and eggs. No consumption was identified for cattle meat, pig meat, sheep meat, poultry, wild/free foods, rabbits/hares, honey, wild fungi, venison, freshwater fish and local cereals. The critical group mean consumption rate exceeded the generic 97.5 percentile consumption rate for only milk. A further two critical group mean consumption rates exceeded the generic mean consumption rates. These were for root vegetables and domestic fruit. The observed 97.5 percentile consumption rate only exceeded the generic 97.5 percentile consumption rate for milk.

10 year old age group

Nine children in this age group were identified as eating locally produced food. Consumption was identified in the following 11 food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, cattle meat, pig meat, sheep meat, poultry, eggs and wild fungi. No consumption was identified for the following food groups: milk, wild/free foods, rabbits/hares, honey, venison, freshwater fish and local cereals. No critical group mean consumption rates exceed the generic 97.5 percentile consumption rates. In four food groups, the critical mean consumption rates were higher than the generic mean consumption rates, these were pig meat, sheep meat, poultry and eggs. No observed 97.5 percentile consumption rates were greater than the generic 97.5 percentile consumption rates.

5 year old age group

Three children in this age group were identified as eating locally produced food. Consumption was identified in the following eight food groups: green vegetables, other

vegetables, root vegetables, potato, domestic fruit, sheep meat, eggs and wild fungi. No consumption was identified for the following food groups: milk, cattle meat, pig meat, poultry, wild/free foods, rabbits/hares, honey, venison, freshwater fish and local cereals. No generic 97.5 percentile or generic mean consumption rates have been determined for this age group so no comparisons with the corresponding observed rates are possible.

6 DIRECT RADIATION PATHWAYS

6.1 Direct radiation survey area

The direct radiation survey area is shown in Figure 3. It covered all land within 1 km of the Springfields site perimeter fence. The survey took place during a time of normal production operations and activities on the site. The direct radiation survey overlaps with direct exposure to gaseous releases from the site. Information on habits from the direct radiation survey also applies to gaseous releases from the site.

A railway track runs east-west across the survey area adjacent to the northern boundary of the site. A permanently manned signal box and the railway station were located adjacent to the north west corner of the site. Beyond the railway track were the village of Salwick, with residential properties spread out over a large area, farmland and the Lancaster Canal. To the south of the site is farmland with the village of Clifton lying to the south west. A portion of Lea Town is also within the eastern sector. Adjacent to the eastern boundary was a chemical plant and the BNFL Social Club. To the immediate west of the site is Station Road, which had residences and farms and a single allotment plot. Two small schools and two public houses were also located within the survey area.

6.2 Residential activities

The direct radiation survey area was sparsely populated, with the exception of Lea Town and Clifton. Effort was concentrated on the residences closest to the site and also to the north of the site to take account for the prevailing wind direction. Interviews were conducted at 24 residences. These included three working farms, one smallholding, a residence within a pub and the BNFL Social Club, which had one resident. Of the 24 residences where interviews were conducted, 18 were within the 0 – 0.25 km zone, five were within the 0.25 – 0.5 km zone and one was within the 0.5 – 1.0 km zone. In addition to observations for adults, 10 observations were obtained for children living in the survey area.

6.3 Leisure activities

Several leisure activities were noted in the vicinity of the site. They included dog walking, maintenance of an allotment plot, church activities, BNFL Social Club activities, customers visiting the two public houses and boating and angling on the Lancashire Canal. Data were collected for 18 adults and two children involved in leisure pursuits.

6.4 Commercial activities

Employees worked at the chemical plant, on railway operations and worked in the two schools, the two public houses and the BNFL Social Club. Other than this, employment in the immediate area was mostly confined to farming. Children's time spent at the schools was also recorded. Employees and contractors of the Springfields site were not included in the survey. Data were collected for 82 adults involved in commercial activities and for 113 children attending schools in the survey area.

6.5 Occupancy rates

Table 43 presents indoor, outdoor and total occupancy data for adults and children and includes distances from the site perimeter fence where these occupancies took place. An analysis of the data by distance zones and occupancy rates is shown in Table 44. It should be noted that a number of observations (e.g. for schools) were obtained from interviewees who provided data for other individuals. Furthermore, in these cases, habits data for other pathways (e.g. food consumption) were rarely obtained. This is explained further in Section 2.4.

0 - 0.25 km from the site perimeter fence

Occupancy data were collected for 158 individuals in the 0.0 to 0.25 km zone. The observations were for residents, public house staff, rail track workers and a school's

employees and pupils. Two adults residents had the highest total occupancy rates of 8760 h/y and two child residents (eight and six years old) had total occupancy rates of 8000 h/y. For leisure activities, a family composed of two adults and two 16 year old children staying in their holiday home had the highest total occupancy rates of 1400 h/y. For work activities, three chefs at the Windmill Pub had the highest total occupancy rates (all indoors) of 2100 h/y and 18 school children had the highest total occupancy rates of 1100 h/y.

>0.25 – 0.5 km from the site perimeter fence

Occupancy data were collected for 133 individuals in the 0.25 to 0.5 km zone. The observations were mainly for residents and another school's employees and pupils. Two children (seven and nine years old) who lived and attended school in this zone had the highest total occupancy rates of 8700 h/y and the highest total occupancy rate for an adult resident was 8400 h/y. For leisure activities, one adult had the highest total occupancy rate of 12 h/y walking. No child leisure activities were noted. For work activities four school workers had the highest occupancy rates of 1500 h/y and 93 school children had the highest total occupancy rates of 1300 h/y.

>0.5 – 1.0 km from the site perimeter fence

Occupancy data were collected for six individuals in the 0.5 to 1.0 km zone. These observations were for five residents and a farm shop employee. An adult resident had the highest total occupancy rate of 7700 h/y. No child observations and leisure activities were noted in this zone. For work activities, a farm shop employee had the highest occupancy rate of 520 h/y.

6.6 Gamma dose rate measurements

Table 45 presents gamma dose rate measurements for the Springfields direct radiation survey. Representative gamma dose rate measurements were taken at a height of 1 metre

both inside and outside a selection of residences and at outdoor background locations outside the area. Outdoor measurements were taken approximately 5 to 15 metres from the nearest buildings. It should be noted that the measurements have not been adjusted for natural background dose rates.

In the survey area, outdoor measurements taken over grass ranged from 0.072 to 0.089 $\mu\text{Gy/h}$, over concrete ranged from 0.077 to 0.104 $\mu\text{Gy/h}$ and over gravel/stones ranged from 0.067 to 0.104 $\mu\text{Gy/h}$. Indoor measurements ranged from 0.071 to 0.104 $\mu\text{Gy/h}$. Some indoor measurements were higher than the corresponding outdoor measurements. This was more than likely due to natural radioactivity in the building materials than to any artificial sources.

Outside the survey area, background readings over grass and pasture ranged from 0.072 to 0.073 $\mu\text{Gy/h}$. At the time of the survey, the outdoor measurements over grass in the survey area were mainly higher than the background measurements over grass outside the area.

Comprehensive studies of background radiation have been carried out on a national scale by the National Radiological Protection Board (since 1st April 2005 the Radiation Protection Division of the Health Protection Agency), the most recent of these being a review conducted during 1999 (Hughes, 1999). The results from these could be used for comparison.

Table 45 also presents gamma dose rate measurements taken along the north site perimeter fence along the railway track over rail ballast. The measurements were taken 1 meter above the ground, over rail track ballast. They ranged from 0.095 to 0.167 $\mu\text{Gy/h}$.

7 COMBINED PATHWAYS

In determining habits data for the purposes of assessing radiological doses to the public, it may be necessary to consider a combination of pathways. Data are provided in Annexes 1 and 2 so that the full effect of combining pathways can be assessed for individual observations, given the concentrations and dose rates for a particular assessment. In some circumstances, it will be possible to make simplifying assumptions and define the consumption and external exposure rates appropriate to a series of potential critical groups. Such assumptions will depend on the assessment in question but some initial observations are provided here as a starting point for those undertaking assessments.

The most extensive combinations of pathways for adult dose assessment are shown in Table 46. Each of the 26 combinations shown in Table 46 represents an actual individual (or individuals) from Annex 1 who has positive data (irrespective of the magnitude), for each pathway marked with an asterisk. It should be noted that combination numbers in Table 46 do not correlate directly with observation numbers in Annex 1. Other individuals from Annex 1 have combinations that are not listed in Table 46 because they have fewer pathways and a dose assessment for them would be adequately covered by one of the 26 listed combinations.

Qualitative and estimated data shown in Annex 3 have not been included in Table 46. This is because the data in Annex 3 is a rate for the mollusc consumption pathway that was noted during the 2000 survey, but not quantified by interviewees on this occasion because the cockle beds had been virtually destroyed and no mussel consumption was noted this time.

Combinations of pathways at critical group rates may be achieved by considering the data in Annexes 1 and 2. Although critical group rates are not given in the annexes, the rates for individuals making up the groups are shown emboldened. Possible combinations of pathways and their associated critical group rates are therefore apparent.

7.1 Use of the data for assessing total dose

The Environment Agencies and the Food Standards Agency have considered ways of using habits data to calculate total dose retrospectively. The adopted approach is to use the adult consumption and occupancy data collected in each habits survey to create a matrix with a series of habits profiles for each site. The relevant matrix for the Springfields adults' profiled habits data is shown in Annex 5. The National Dose Assessment Working Group (NDAWG) has considered this approach to assessing retrospective total doses (Camplin *et al*, 2005) and has agreed that using habits profiles is an appropriate approach. Retrospective total doses around Springfields will in future be made using these profiles and reported in the Radioactivity in Food and the Environment Reports (See Appendix 7 in EA, EHS, FSA and SEPA, 2006). Data from Annex 3 are not included in Annex 5.

8 CONCLUSIONS AND SUGGESTIONS

8.1 Survey findings

The survey investigated the three potential sources of public radiation exposure from the Springfields site, which were:

- Discharges of liquid radioactive waste to the Ribble Estuary
- Discharges of gaseous radioactive waste to the atmosphere
- Emissions of direct radiation

Data were collected for 554 individuals including commercial fishermen, anglers, wildfowlers, boat dwellers, farmers, allotment holders and people spending time within 1 km of the site. These people were targeted because their habits and where they live may cause them to be exposed to radioactivity from the site. However, it should be noted that the most exposed people can only be defined with the outcome of a dose assessment.

All consumption rates recorded in this report are only for locally produced or caught foods.

The adult mean critical group rates (as defined in Section 3.2) for the separate local aquatic consumption pathways were:

- 54 kg/y for fish
- 21 kg/y for crustaceans
- 0.73 kg/y for marine plants
- 21 kg/y for wildfowl

The predominant aquatic species consumed by the respective critical groups were bass, Dover sole and cod; brown shrimps; samphire and sea beet; duck and geese. No consumption of molluscs was noted.

The mean critical group occupancy rates over the separate intertidal substrates and a houseboat were:

- 350 h/y for mud
- 1100 h/y for mud and sand
- 750 h/y for salt marsh
- 1600 h/y for sand
- 8300 h/y for houseboat over mud. This gives an equivalent annual occupancy time over unshielded boatyard mud of 3800 h/y

For individuals spending time close to the substrate, for example, through sitting, kneeling or lying down, the mean critical group occupancy rates were:

- 250 h/y for mud
- 390 h/y for salt marsh

The mean critical group rate for handling fishing gear was 690 h/y and for handling sediment was 390 h/y.

The highest occupancy rate for time spent on water was 1200 h/y. No observations for occupancy in water were noted.

The adult mean critical group rates for the separate local consumption pathways for foods affected by gaseous discharges were:

- 29 kg/y for green vegetables
- 29 kg/y for other vegetables
- 28 kg/y for root vegetables
- 48 kg/y for potato
- 24 kg/y for domestic fruit
- 440 l/y for milk
- 31 kg/y for cattle meat

- 25 kg/y for pig meat
- 16 kg/y for sheep meat
- 19 kg/y for poultry
- 12 kg/y for eggs
- 0.45 kg/y for wild fungi

No consumption of wild/free foods, rabbits/hares, honey, venison, freshwater fish or local cereals was identified. Consumption of foodstuffs by children was also recorded. Combinations of food groups (both aquatic and terrestrial) consumed at critical group rates, together with external pathway exposures, may be derived from the data for individuals in Annexes 1 and 2. Rates for individuals making up the critical groups are presented in bold type.

No consumption of groundwater or surface water by people was identified. Livestock were observed drinking water from Deepdale Brook.

Transfer of radioactive contamination from the site into the surrounding area by wildlife was investigated. Pigeons and rabbits were present on site, but as the numbers were not considered to be a problem no culling programmes were planned. Members of the public who lived in the survey area were consuming pigeons from within the terrestrial survey area. No rabbit consumption was identified.

For occupancy by members of the public within 1 km of the Springfields site perimeter fence, the highest rates (indoors plus outdoors) were:

- 8760 h/y for the 0 to 0.25 km zone
- 8700 h/y for the >0.25 to 0.5 km zone (these were children)
- 7700 h/y for the >0.5 to 1.0 km zone

In all three zones, the highest occupancy rates were for residents.

The highest indoor occupancy rates were:

- 8760 h/y for the 0 to 0.25 km zone
- 7600 h/y for the >0.25 to 0.5 km zone
- 6400 h/y for the >0.5 to 1.0 km zone

The highest outdoor occupancy rates were:

- 3000 h/y for the 0 to 0.25 km zone
- 3300 h/y for the >0.25 to 0.5 km zone
- 1400 h/y for the >0.5 to 1.0 km zone

8.2 Comparisons with previous surveys

The results from this survey can be compared with results from the last aquatic and terrestrial habits surveys undertaken at Springfields in 2000 and the last direct radiation survey in 2001. The same areas were used in this survey as for the previous surveys.

Aquatic survey

All comparisons for consumption pathways include data for adults only. All comparisons for occupancy and handling pathways include data for both adults and children.

In 2000, the critical group mean consumption rate for fish was 37 kg/y for a group of 12 people, and the maximum consumption rate was 69 kg/y. The main species of fish consumed by the critical group were 50% flounder and similar amounts of whiting, eels, grey mullet, plaice, bass and salmon. In 2006, the critical group consumption rate had increased to 54 kg/y for four individuals, with a similar maximum rate of 72 kg/y. The species consumed by the critical group were 50% bass 35% Dover sole and 15% cod.

In 2000, the critical group mean consumption rate for crustaceans was 15 kg/y, the maximum consumption rate was 26 kg/y and the number of people in the critical group was eight. In

2006, the critical group consumption rate had increased to 21 kg/y. The maximum consumption rate remained the same at 26 kg/y. The number in the critical group had decreased to two individuals. Both in 2000 and 2006, the only crustacean species consumed was brown shrimps.

In 2000, the critical group mean consumption rate for molluscs was 10 kg/y, the maximum consumption rate was 11 kg/y and the number of people in the critical group was four. The mollusc species consumed by the critical group were 80% cockles and 20% mussels. In 2006, no consumption of molluscs was noted; cockle stocks were virtually non-existent and nobody was identified who consumed mussels. Annex 3 acknowledges this situation, which could change over the next two or three years with the recovery of the cockle stocks. As no mussel consumption was identified this survey, even though mussels were present on the estuary training walls, any mollusc consumption this survey would have been 100% cockles if the species had been in abundance.

In 2000, the critical group mean consumption rate for marine plants was 1.2 kg/y, the maximum consumption rate was 1.8 kg/y and the number of people in the critical group was four. The only marine plant species consumed by the critical group was samphire. In 2006, the critical group consumption rate had decreased to 0.73 kg/y. The maximum consumption rate had also decreased to 1.0 kg/y. The number in the critical group was two. The marine plant species consumed by the critical group were 85% samphire and 15% sea beet.

In 2000, the critical group mean consumption rate for wildfowl was 22 kg/y for 10 observations and the maximum consumption rate was 31 kg/y. The wildfowl species consumed by the critical group were 55% geese and 45% ducks. In 2006, the critical group consumption rate had decreased slightly to 21 kg/y for seven observations. The maximum consumption rate had also decreased slightly to 27 kg/y. The wildfowl species consumed by the critical group were 75% ducks and 25% geese and a small amount of common snipe (1%).

For external pathways, it should be noted that the methodology for determining the critical group has changed since the 2000 survey (see Section 3.2) so care is needed when comparing results. In the following paragraphs, the critical group rates from the 2000 survey have been recalculated using the current method and the rates in brackets were calculated using the original method.

The 2000 critical group mean and maximum intertidal occupancy rates over mud were 800 and 1600 h/y respectively for nine freshwater anglers (mean of 1400 h/y for two freshwater anglers). The 2006 critical group mean and maximum intertidal occupancy rates over mud were significantly lower at 350 and 640 h/y respectively for 18 observations. These were people who were working, walking, wildfowling, angling and/or working on boat maintenance. The main reason for the decrease was the decline in the quality of freshwater angling on the upper tidal Ribble, leading to fewer anglers who spent significantly less time at this location.

Freshwater anglers and wildfowlers have been considered as a separate occupancy group, because they spent much of their occupancy time in close proximity to the mud, either sitting on fishing tackle boxes or kneeling. In 2000, only the occupancy of freshwater anglers over mud was considered separately (no wildfowlers were noted spending time over mud).

The 2000 critical group mean and maximum occupancy rates for close occupancy over mud were 800 and 1600 h/y respectively for nine freshwater anglers (mean of 1400 h/y for two freshwater anglers). The 2006 critical group mean and maximum occupancy rates for freshwater angling and wildfowling over mud were 250 and 340 h/y respectively for 26 individuals.

The 2000 critical group mean intertidal occupancy rate over mud and sand was 160 h/y for three sea anglers, five commercial fishermen and a wildfowler, the maximum rate being 260 h/y (mean of 240 h/y for three anglers). The 2006 critical group mean intertidal occupancy rate over mud and sand was 1100 h/y for one individual who was a commercial bait digger and angler.

The 2000 critical group mean and maximum intertidal occupancy rates over salt marsh were 470 and 910 h/y respectively for seven individuals; a herdsman, two marsh wardens, two sea anglers, a dog walker and a wildfowler (mean of 910 h/y for a herdsman). The 2006 critical group mean and maximum intertidal occupancy rates over salt marsh were 750 and 1300 h/y respectively for a herdsman and two wildfowlers.

Wildfowlers have been considered as a separate occupancy group, as they were for the 2000 survey, because they spend much of their occupancy time over salt marsh in close proximity to this substrate.

The 2000 critical group mean and maximum occupancy rates for wildfowling over salt marsh were 250 and 310 h/y respectively for 18 individuals (mean of 270 h/y for 15 individuals). The 2006 critical group mean and maximum occupancy rates for wildfowling over salt marsh were 390 and 470 h/y respectively for six individuals.

The 2000 critical group mean and maximum intertidal occupancy rates over sand were 1300 and 1900 h/y respectively for a sand excavation employee and three commercial fishermen (mean of 1500 h/y for a sand excavation employee and two commercial fishermen). The 2006 critical group mean intertidal occupancy rate over sand was 1600 h/y for two sand excavation employees and a fisherman, the maximum rate again being 1900 h/y for the sand excavation employees.

The 2000 critical group maximum and mean occupancy rate for boat dwelling over mud was 8200 h/y for two individuals. This equates to an equivalent mean rate over unshielded mud of 1800 h/y (the change in methodology has not effected the results). The 2006 critical group maximum and mean occupancy rates for boat dwelling over mud were 8400 h/y and 8300 h/y respectively for two individuals on the same boat. This equates to an equivalent mean rate over unshielded mud of 3800 h/y. This increase was not due to an actual increase of the individuals' occupancy time on board their boat, but to increases in the gamma dose rate measurements (see Section 4.8).

In 2000, the critical group mean handling rate for commercial fishing gear was 620 h/y for 15 fishermen (mean of 810 h/y for seven fishermen), with a maximum handling rate of 940 h/y. The 2006 critical group mean handling rate for commercial fishing gear was similar at 690 h/y for nine fishermen, the maximum rate being 1100 h/y.

In 2000, the critical group mean handling rate for sediment was 210 h/y for a RSPB officer, a boat dweller and a bait digger (mean of 260 h/y for a RSPB officer and a boat dweller), with a maximum handling rate of 290 h/y. The 2006 critical group mean handling rate for sediment was 390 h/y for one commercial bait digger and 15 wildfowlers, the maximum rate being 830 h/y for the commercial bait digger.

A comparison of occupancy rates on water cannot be made because this pathway was not investigated in the 2000 survey.

Terrestrial survey

For terrestrial food groups the data in the 2000 survey were not used to calculate critical group rates. Therefore, for the purpose of comparison these rates have been calculated from the original data. The critical group mean consumption rates (kg/y and l/y) in the 2000 survey are tabulated below, together with those of the 2006 survey:

	2000	2006
• Green vegetables	50	29
• Other vegetables	63	29
• Root vegetables	41	28
• Potato	150	48
• Domestic fruit	60	24
• Milk	420	440
• Cattle meat	49	31
• Pig meat	25	25

• Sheep meat	12	16
• Poultry	31	19
• Eggs	22	12
• Wild/free foods	7.9	Nil
• Rabbits/hares	5.1	Nil
• Honey	2.5	Nil
• Wild fungi	7.5	0.45
• Venison	Nil	Nil

Consumption rates had increased in 2006 in only two food groups: milk and sheep meat. Consumption rates had decreased in 2006 in the following food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, cattle meat, poultry, eggs, wild/free foods, rabbits/hares, honey and wild fungi. Consumption of pig meat remained the same and no venison was noted in either year.

Direct radiation survey

Data in the 2001 survey were not analysed in distance zones as in the 2006 survey. To enable comparisons to be made, the original 2001 data have been re-assessed. In 2001 the highest recorded occupancy rate was 8760 h/y for two individuals who lived in the 0 – 0.25 km zone. In the 2006 survey, the highest occupancy rate was again 8760 h/y for two individuals who lived in the 0 – 0.25 km zone.

Commercial activities noted in 2001 and still being carried out in 2006 were people working in schools, public houses and a chemical plant, farming and railway operations. Leisure activities in both surveys included BNFL social club activities and public house activities.

Gamma dose rate measurements for one residence in 2006 can be compared with gamma dose rate measurements taken at the same location in 2001. For this location, gamma dose

measurements in 2001 were 0.107 $\mu\text{Gy/h}$ indoors and 0.092 $\mu\text{Gy/h}$ outdoors. Gamma dose measurements in 2006 were 0.093 $\mu\text{Gy/h}$ indoors and 0.086 $\mu\text{Gy/h}$ outdoors.

8.3 Suggestions for environmental monitoring

The 2005 monitoring programmes operated by the Environment Agency and the Food Standards Agency included the following samples and measurements (EA, EHS, FSA and SEPA, 2006):

Aquatic surveillance

- Flounder from Ribble Estuary
- Salmon from Ribble Estuary
- Sea trout from Ribble Estuary
- Grey mullet from Ribble Estuary
- Shrimps from the Ribble Estuary
- Cockles from Ribble Estuary
- Mussels from Ribble Estuary
- Samphire from Marshside Sands
- Grass (washed) from Hutton Marsh
- Grass (unwashed) from Hutton Marsh
- Soil from Hutton Marsh
- Sediment from River Ribble outfall
- Sediment from Lower Penwortham Park
- Sediment from Penwortham rail bridge
- Sediment from Penwortham rail bridge – West bank
- Sediment from Penwortham position 1
- Sediment from Penwortham position 2
- Sediment from Lytham Yacht Club
- Sediment from Becconsall
- Sediment from Freckleton

- Sediment from Hutton Marsh
- Sediment from Longton Marsh

Gamma dose rate measurements at 1 metre unless stated otherwise

- Mud at Lytham Yacht Club
- Mud at Warton Marsh
- Mud at Warton Marsh at 15 cm
- Salt marsh at Warton Marsh
- Salt marsh at Naze Point
- Mud at Banks Marsh at 15 cm
- Salt marsh at Banks Marsh
- Salt marsh at Hesketh Bank
- Mud at Freckleton
- Grass and mud at Beconsall
- Grass and mud at Beconsall house boat area
- Salt marsh at Longton Marsh
- Grass and salt marsh at Hutton Marsh
- Mud at River Ribble outfall
- Grass and mud at River Ribble outfall
- Mud at Savick Brook, confluence with Ribble
- Grass and mud at Savick Brook, confluence with Ribble
- Salt marsh at South bank opposite outfall
- Grass and mud at Penwortham Bridge cadet hut
- Grass and mud at Lower Penwortham Park
- Grass at Lower Penwortham Park
- Mud at Lower Penwortham Railway Bridge
- Sand at Lower Penwortham Railway Bridge
- Grass and mud at Lower Penwortham Railway Bridge
- Grass and mud at River Darwen
- Grass at River Darwen

- Grass and mud at Riverbank angler location 1
- Grass and mud at Riverbank angler location 2
- Grass at Ulmes Walton, BNFL area survey

Beta dose rate measurements

- Mud and sand at Lytham – Granny's Bay
- Gill net at Ribble Estuary
- Shrimp net at Ribble Estuary
- Mud at Banks Marsh
- Salt marsh at Banks Marsh
- Mud at Warton Marsh
- Salt marsh at Warton Marsh

Terrestrial surveillance

- Milk
- Apples
- Beetroot
- Blackberries
- Cabbage
- Duck
- Potatoes
- Runner beans
- Sediment from Deepdale Brook
- Grass from six locations
- Silage
- Soil from seven locations
- Freshwater from Deepdale Brook

The following lists are suggestions for changes to the current environmental monitoring programmes. It should be noted that the suggestions are based on the findings of this survey. They are not the outcome of any form of assessment. It is suggested that samples

currently monitored, which are not listed below, remain unchanged in the monitoring programme.

Environment Agency monitoring

- Gamma and beta dose rate measurements could be introduced at two or three locations on Hesketh Out Marsh West when it has been returned to an intertidal area
- Sediment samples could be introduced at two or three locations on Hesketh Out Marsh West when it has been returned to an intertidal area
- Gamma and beta dose rate measurements could be introduced at Millenium Ribble Link, south of the sea lock (SD 479 294) as the beta dose rate measurement at this location was relatively high

Food Standards Agency monitoring

- Replace flounder with Dover sole as a flat fish species, which were consumed by members of the critical group and flounder were not
- Add bass or codling, which were round fish species consumed by members of the critical group
- A sample of sea beet from Warton Marsh could be introduced as it was consumed in small amounts
- A sample of wildfowl (widgeon or pink foot goose which graze on salt marsh grass) could be introduced as they were consumed.
- Domestic duck could be replaced with chicken for the terrestrial poultry sample as it was consumed in greater quantities

9 ACKNOWLEDGEMENTS

Gratitude is expressed to representatives of local authorities and associations and members of the public who offered helpful advice and information during the survey. This survey was undertaken on behalf of the Environment Agency, the Food Standards Agency and the Health and Safety Executive. The project officers for these organisations gave considerable help during the planning of the survey and the drafting of the report.

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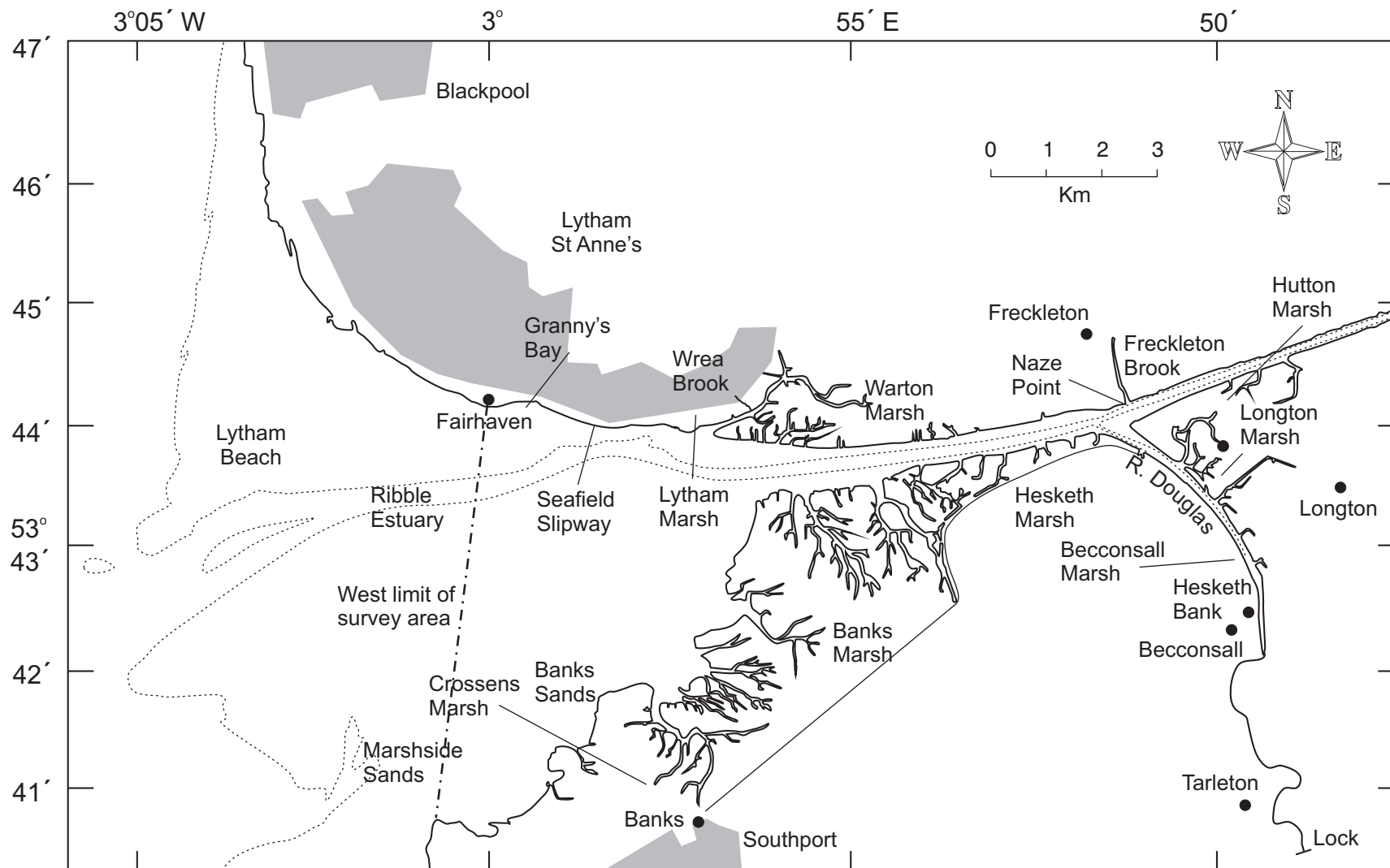


Figure 1. Lower River Ribble estuary

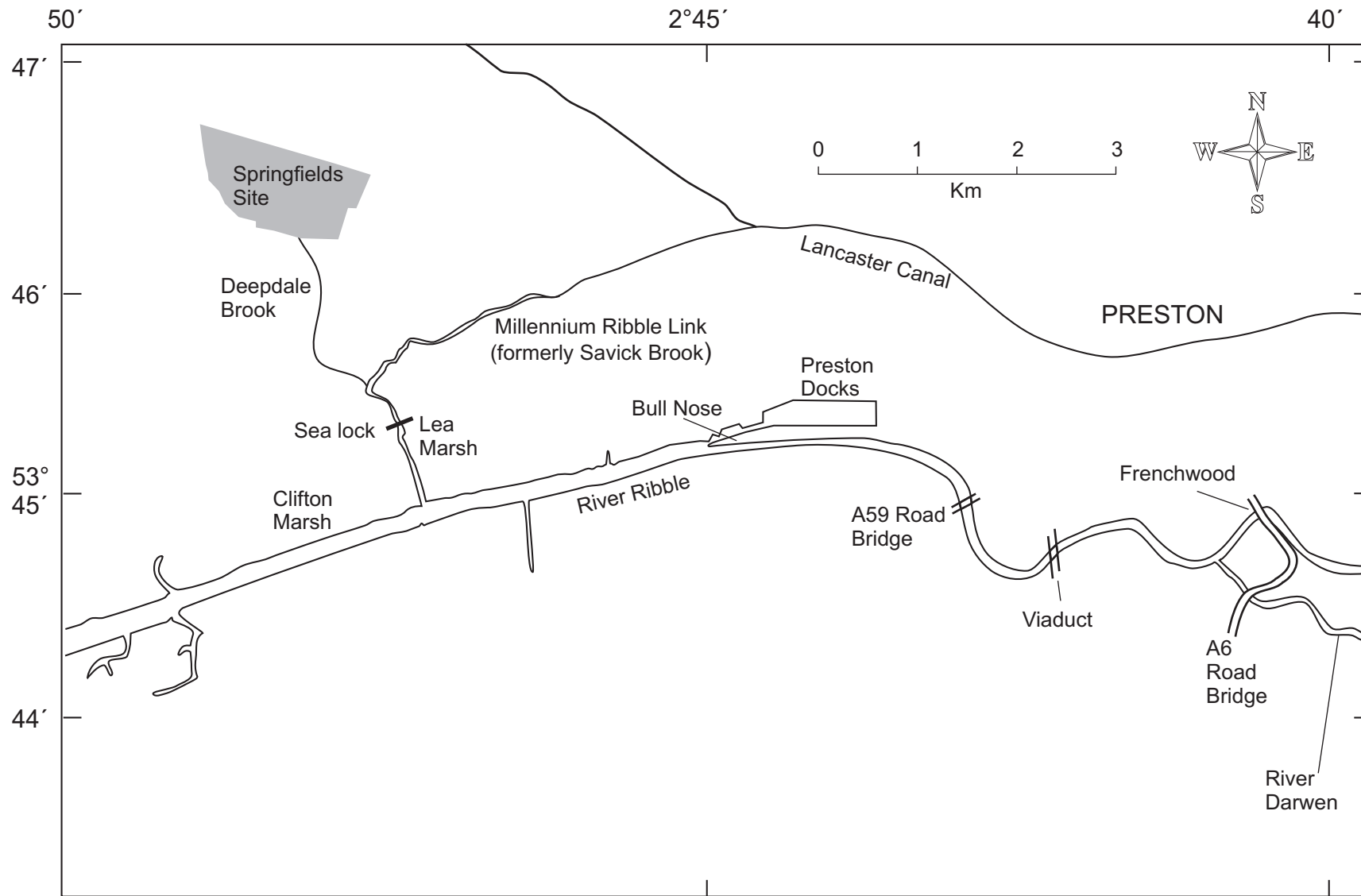
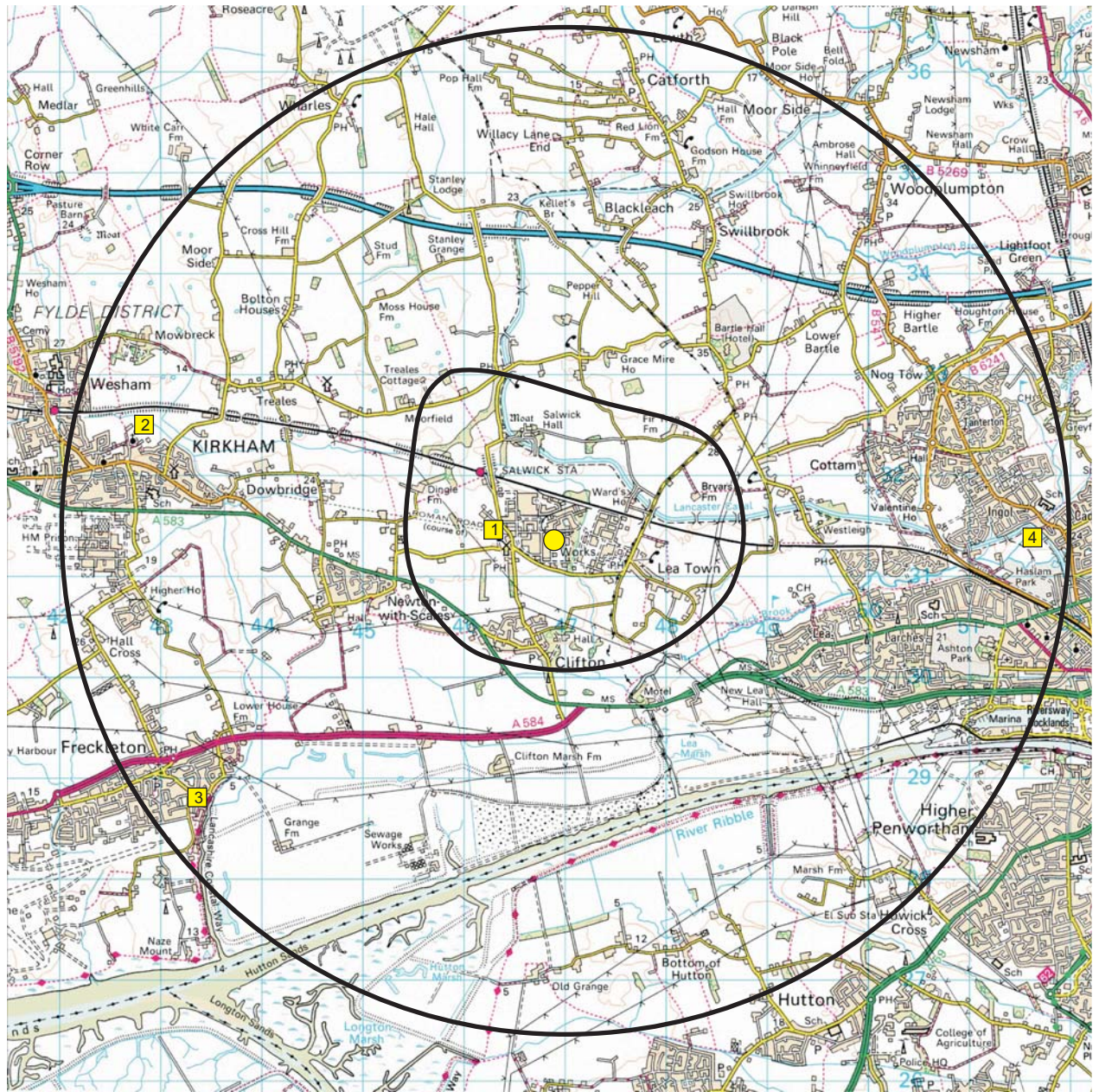


Figure 2. Upper River Ribble estuary



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Figure 3. The Springfields terrestrial (outer ring) and direct radiation (inner ring) survey areas

- Springfields site centre
- 1 Salwick allotments
- 2 Kirkham allotments
- 3 Freckleton allotments
- 4 Haslam Park allotments

Table 1. Survey coverage

Group	Criteria	Estimate of complete coverage	Number for whom positive data was obtained	Coverage for positive observations	Notes
SUMMARY OF ALL PATHWAYS					
All potential people in Springfields aquatic, terrestrial and direct radiation survey areas	Number of people resident in terrestrial survey area (excluding those resident in the direct radiation survey area) (See (B) terrestrial pathways)	36,000 [^]	108 ^{^^}	0-20%	The survey targeted individuals who were potentially the most exposed (Section 2.4), mostly producers of local food such as farmers and allotment tenants.
	Number of people resident in the direct radiation survey area (See (C), direct radiation pathways)	500	70	0-20%	
	Number of people working in, at schools or visiting, but not resident in the direct radiation survey area (See (C), direct radiation pathways)	U	227	U	Excluding employees and contractors of Springfields Fuels Ltd and people living in the direct radiation survey area.
	Number of people affected by liquid discharges (excluding people resident in the terrestrial survey area) (See (A) aquatic pathways)	U	149 ^{^^}	U	
	Total number of observations for the aquatic, terrestrial and direct radiation survey areas	U	554 ^{^^}	U	In the All Pathways section each interviewee has only been counted once. This is in the section where their predominant activities took place.
(A) AQUATIC PATHWAYS					
Commercial fishermen	Number spoken to during survey	16	13	80-100%	This includes all methods of fishing, both by boat and tractor.
Boat anglers and hobby fishermen	Number spoken to during survey	U	5	U	Regular anglers using boats.
Shore anglers	Number spoken to during survey	U	15	U	Six anglers fishing at Bull Nose with no consumption data will not appear in any tables since the structure is man made.
Wildfowlers	Number of wildfowling associations contacted	4	4	80-100%	Generic data obtained for the keenest members. In addition personal information was obtained for 12 individuals and their families consumption.
Boat dwellers	Number spoken to during survey	2	2	80-100%	There has been more boat dwellers in earlier surveys who have now left the boatyards.
Yachters	Number of sailing clubs	1	1	80-100%	Generic data collected for the keenest members from the club secretary

Table 1. Survey coverage

Group	Criteria	Estimate of complete coverage	Number for whom positive data was obtained	Coverage for positive observations	Notes
(B) TERRESTRIAL PATHWAYS					
Farms and smallholdings	Number of farmers and their family members consuming farm produce from the survey area	100	74	60-80%	Estimate of 30 working farms or smallholdings in the area, 22 of which were interviewed. Five additional working farms interviewed in shine area not included here.
Allotments	Number of allotment tenants and their family members consuming allotment produce from the survey area	U	27	U	Three sets of allotment plots were in the terrestrial survey area. An additional allotment plot was in the shine area. These data are not included here.
(C) DIRECT RADIATION PATHWAYS					
Occupancy of area	Number with occupancies > 100 hours	U	293	U	Data was also obtained for four adults in the survey area with <100 h/y occupancy
Residents	Number of residents in the survey area	U	70	U	
Employees and school children	Number of people predominantly based in survey area (>500 hours)	300	209	60-80%	Data was also obtained for 18 adults in the survey area with <500 h/y occupancy
BREAKDOWN OF AGE GROUPS					
Adults	Individuals over 17	U	415	U	
15 year old	More than 12.0 year old to 17.0 year old	U	9	U	
10 year old	More than 7.0 year old to 12.0 year old	U	83	U	
5 year old	More than 2.0 year old to 7.0 year old	U	46	U	
1 year old	More than 1.0 year old to 2.0 year old	U	0	U	
3 month old	From 0 to 1.0 year old	U	1	U	

Notes

^ - Data from www.statistics.gov.uk were used to estimate this figure for people resident in the 5 km survey area

^^ - The number of people for whom positive data was obtained, for pathways (A) and (B), will not equal the relevant totals in the summary.

This is because some individuals, for example someone who fishes from a boat and the shore and digs their own bait, will be counted three times within the pathway, whereas others, such as the families of fishermen, will not be counted at all.

U - Unknown

Table 2. Typical food groups used in habits surveys

Green vegetables	Globe artichoke, asparagus, broccoli, brussel sprout, cabbage, calabrese, cauliflower, chard, courgettes, cucumber, gherkin, herbs, kale, leaf beet, lettuce, marrow, spinach
Other vegetables	Aubergine, broad bean, chilli pepper, french bean, mangetout, pea, pepper, runner bean, sweetcorn, tomato
Root vegetables	Jerusalem artichoke, beetroot, carrot, celeriac, celery, chicory, fennel, garlic, kohlrabi, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip
Potato	
Domestic fruit	Apple, apricot, blackberry, blackcurrant, boysenberry, cherry, damson, fig, gooseberry, grapes, greengages, huckleberry, loganberry, melon, nectarines, peach, pear, plum, pumpkin, raspberry, redcurrants, rhubarb, rowanberry, strawberry, tayberry, whitecurrant
Milk	Milk, butter, cream, cheese, yoghurt, goats milk
Cattle meat †	
Pig meat †	
Sheep meat †	
Poultry	Chicken, duck, goose, grouse, guinea fowl, partridge, pheasant, pigeon, snipe, turkey, woodcock
Eggs	Chicken egg, duck egg, goose egg
Wild/free foods	Blackberry, blackcurrant, chestnut, crab apple, damson, dandelion root, elderberry, nettle, raspberry, rowanberry, samphire, sloe, strawberry, watercress, wild apple
Honey	
Wild Fungi	Mushrooms
Rabbits/Hare	Hare, rabbit
Venison †	
Fish (sea)	Bass, brill, cod, common ling, dab, Dover sole, flounder, gurnard, haddock, hake, herring, lemon sole, mackerel, monkfish, mullet, plaice, pollack, witch saithe, salmon, sea trout, squid*, cuttlefish*, rays, turbot, whitebait, whiting
Fish (freshwater)	Brown trout, rainbow trout, perch, pike, salmon (river), eels
Crustaceans	Brown crab, spider crab, crawfish, lobster, <i>Nephrops</i> , squat lobster, prawn, shrimp
Molluscs	Cockles, limpets, mussels, oysters, queens, scallops, razor shell, whelks, winkles

Notes:

* Although squid and cuttlefish are molluscs, radiologically they are more akin to fish

† Including offal

Table 3. Adults' consumption rates of fish in the Springfields area (kg/y)

Observation number	Bass	Cod	Dab	Dover sole	Flounder	Mackere	Mixed fish	Plaice	Salmon	Turbot	Whiting	Total
240-241	36.1			36.1								72.2
262-263	17.7	17.7										35.4
342	1.1				15.2							16.3
343	1.1				15.2							16.3
238							11.2		2.8			14.0
239							11.2		2.8			14.0
273-282							11.9					11.9
249-250				5.9						5.9		11.8
345				10.5								10.5
59-60										9.3		9.3
287-288		2.9		2.9				2.9				8.8
259-261				4.3						4.3		8.6
94					8.1							8.1
313	6.8											6.8
159-161					3.4			3.3				6.7
311-312					5.9							5.9
264-265		5.4										5.4
474-475	2.6										1.9	4.5
314	4.4											4.4
508	2.6											2.6
506, 511-513			0.3			1.9						2.2
322					2.0							2.0
242-245									1.6			1.6
92-93					0.5			0.4				0.9
323-324					0.5							0.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of fish based on the 4 highest adult consumers is 53.8 kg/y

The observed 97.5 percentile rate based on 54 observations is 60.3 kg/y

Table 4. Adults' consumption rates of crustaceans in the Springfields area (kg/y)

Observation number	Brown shrimp
238	26.2
239	15.0
344	8.5
259-261	5.7
254-258	4.2
273-282	3.4
264-265	2.7
249-250	2.0
262-263	0.7
508	0.5
267-268	0.1

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of crustaceans based on the 2 highest adult consumers is 20.6 kg/y

The observed 97.5 percentile rate based on 30 observations is 18.1 kg/y

Table 5. Adults' consumption rates of marine plants/algae in the Springfields area (kg/y)

Observation number	Samphire	Sea beet	Total
311	1.0		1.0
506	0.2	0.2	0.5

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of marine plants based on the 2 highest adult consumers is 0.7 kg/y
 The observed 97.5 percentile rate based on 2 observations is 1.0 kg/y

Table 6. Adults' consumption rates of wildfowl in the Springfields area (kg/y)

Observation number	Mixed duck	Geese	Mallard	Pintail	Snipe	Teal	Wigeon	Total
506		4.4	7.9	3.5	1.3	6.8	3.5	27.3
511		4.4	7.9	3.5	0.2	4.7	3.5	24.1
512		4.4	7.9	3.5	0.2	4.7	3.5	24.1
513		4.4	7.9	3.5	0.2	4.7	3.5	24.1
287	5.4	11.0						16.4
288	5.4	11.0						16.4
146			10.8			1.3	2.8	14.9
273-282	2.3	5.5						7.8
246-248	7.5							7.5
289-296	7.1							7.1
267-268	4.5	2.2						6.7
300-303			5.0			0.7		5.7
508			5.4		0.1			5.5
24			4.5					4.5
499-500						0.8	2.3	3.1
264	2.7							2.7
43			2.3					2.3
147			1.4			0.2	0.4	1.9
17-18			1.4					1.4
19-20			0.9					0.9
5-11			0.8					0.8

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of wildfowl based on the 7 highest adult consumers is 21.0 kg/y
 The observed 97.5 percentile rate based on 52 observations is 24.1 kg/y

Table 7. Children's consumption rates of fish in the Springfields area (kg/y)

5 year old age group

Observation number	Age	Cod
266	6	2.7

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of fish based on the only 5 year old age group consumer is 2.7 kg/y
 The observed 97.5 percentile rate is not applicable for 1 observation

Table 8. Children's consumption rates of crustaceans in the Springfields area (kg/y)

5 year old age group

Observation number	Age	Brown shrimp
266	6	1.4

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of crustaceans based on the only 5 year old age group consumer is 1.4 kg/y
 The observed 97.5 percentile rate is not applicable for 1 observation

Table 9. Children's consumption rates of wildfowl in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Mallard	Teal	Wigeon	Total
148	15	1.4	0.2	0.4	1.9
21	15	0.9			0.9

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of wildfowl based on the 2 highest 15 year old age group consumers is 1.4 kg/y
 The observed 97.5 percentile rate based on 2 observations is 1.8 kg/y

10 year old age group

Observation number	Age	Mallard	Teal	Wigeon	Total
304	10	2.5	0.4		2.9

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of wildfowl based on the only 10 year old age group consumer is 2.9 kg/y
 The observed 97.5 percentile rate is not applicable for 1 observation

Table 10. Summary of adults' consumption rates in the Springfield area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	54	4	72.2	35.4	53.8	60.3	15.0	40.0
Crustaceans	30	2	26.2	15.0	20.6	18.1	3.5	10.0
Molluscs	NC	NC	NC	NC	NC	NC	3.5	10.0
Marine plants/algae	2	2	1.0	0.5	0.7	1.0	ND	ND
Wildfowl	52	7	27.3	14.9	21.0	24.1	ND	ND
Green vegetables	45	19	43.8	17.3	29.2	43.8	15.0	45.0
Other vegetables	50	31	48.3	16.8	28.6	48.3	20.0	50.0
Root vegetables	49	24	50.8	18.5	28.0	48.3	10.0	40.0
Potato	51	23	89.2	33.3	47.8	68.3	50.0	120.0
Domestic fruit	54	13	38.3	13.3	23.9	36.6	20.0	75.0
Milk	29	17	657.0	311.1	440.7	657.0	95.0	240.0
Cattle meat	28	26	42.0	15.6	30.7	42.0	15.0	45.0
Pig meat	5	5	25.3	25.3	25.3	25.3	15.0	40.0
Sheep meat	27	11	20.0	11.3	15.5	20.0	8.0	25.0
Poultry	20	4	19.2	19.2	19.2	19.2	10.0	30.0
Eggs	39	27	17.8	5.9	12.4	16.8	8.5	25.0
Wild/free foods	NC	NC	NC	NC	NC	NC	7.0	25.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	6.0	15.0
Honey	NC	NC	NC	NC	NC	NC	2.5	9.5
Wild fungi	4	4	0.5	0.5	0.5	0.5	3.0	10.0
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	15.0	40.0

Notes

ND = not determined

NC = not consumed

Table 11. Summary of 15 year old children's consumption rates in the Springfields area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	NC	NC	NC	NC	NC	NC	6.5	20.0
Crustaceans	NC	NC	NC	NC	NC	NC	2.5	6.0
Molluscs	NC	NC	NC	NC	NC	NC	2.5	6.0
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Wildfowl	2	2	1.9	0.9	1.4	1.8	ND	ND
Green vegetables	2	2	1.0	1.0	1.0	1.0	9.0	25.0
Other vegetables	3	3	8.2	3.6	6.6	8.2	10.0	30.0
Root vegetables	2	2	10.9	10.9	10.9	10.9	7.5	20.0
Potato	2	2	21.8	21.8	21.8	21.8	60.0	130.0
Domestic fruit	2	2	38.3	38.3	38.3	38.3	15.0	50.0
Milk	2	2	365.0	365.0	365.0	365.0	110.0	260.0
Cattle meat	NC	NC	NC	NC	NC	NC	15.0	35.0
Pig meat	NC	NC	NC	NC	NC	NC	10.0	30.0
Sheep meat	NC	NC	NC	NC	NC	NC	5.5	15.0
Poultry	NC	NC	NC	NC	NC	NC	6.5	20.0
Eggs	2	2	1.0	1.0	1.0	1.0	7.0	25.0
Wild/free foods	NC	NC	NC	NC	NC	NC	3.0	13.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	2.0	5.0
Wild fungi	NC	NC	NC	NC	NC	NC	2.0	5.5
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Freshwater fish	NC	NC	NC	NC	NC	NC	6.5	20.0

Notes

ND = not determined

NC = not consumed

Table 12. Summary of 10 year old children's consumption rates in the Springfields area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	NC	NC	NC	NC	NC	NC	6.0	20.0
Crustaceans	NC	NC	NC	NC	NC	NC	2.5	7.0
Molluscs	NC	NC	NC	NC	NC	NC	2.5	7.0
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Wildfowl	1	1	2.9	2.9	2.9	NA	ND	ND
Green vegetables	3	3	3.0	1.7	2.5	3.0	6.0	20.0
Other vegetables	3	1	4.5	4.5	4.5	4.3	8.0	25.0
Root vegetables	3	2	3.4	2.3	2.8	3.3	6.0	20.0
Potato	3	2	15.4	10.2	12.8	15.1	45.0	85.0
Domestic fruit	4	4	15.0	5.4	9.6	14.6	15.0	50.0
Milk	NC	NC	NC	NC	NC	NC	110.0	240.0
Cattle meat	3	3	21.0	11.8	14.9	20.6	15.0	30.0
Pig meat	2	2	12.6	12.6	12.6	12.6	8.5	25.0
Sheep meat	6	6	8.2	2.8	4.7	7.8	4.0	10.0
Poultry	3	1	9.6	9.6	9.6	9.2	5.5	15.0
Eggs	7	7	13.9	5.0	9.0	13.9	6.5	20.0
Wild/free foods	NC	NC	NC	NC	NC	NC	3.0	11.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	2.0	7.5
Wild fungi	1	1	0.5	0.5	0.5	NA	1.5	4.5
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Freshwater fish	NC	NC	NC	NC	NC	NC	6.0	20.0

Notes

ND = not determined

NC = not consumed

NA = not applicable

For 1 observation, the terms maximum, minimum and mean are not strictly valid

Table 13. Summary of 5 year old children's consumption rates in the Springfields area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical group consumption rate	Observed minimum critical group consumption rate	Observed mean critical group consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	1	1	2.7	2.7	2.7	NA	ND	ND
Crustaceans	1	1	1.4	1.4	1.4	NA	ND	ND
Molluscs	NC	NC	NC	NC	NC	NC	ND	ND
Marine plants/algae	NC	NC	NC	NC	NC	NC	ND	ND
Wildfowl	NC	NC	NC	NC	NC	NC	ND	ND
Green vegetables	3	2	3.0	1.0	2.0	2.9	ND	ND
Other vegetables	3	1	4.5	4.5	4.5	4.3	ND	ND
Root vegetables	3	2	1.4	0.5	0.9	1.3	ND	ND
Potato	3	3	6.1	2.0	4.2	6.1	ND	ND
Domestic fruit	3	2	7.9	6.0	6.9	7.8	ND	ND
Milk	NC	NC	NC	NC	NC	NC	ND	ND
Cattle meat	NC	NC	NC	NC	NC	NC	ND	ND
Pig meat	NC	NC	NC	NC	NC	NC	ND	ND
Sheep meat	1	1	2.8	2.8	2.8	NA	ND	ND
Poultry	NC	NC	NC	NC	NC	NC	ND	ND
Eggs	2	2	3.8	1.3	2.5	3.7	ND	ND
Wild/free foods	NC	NC	NC	NC	NC	NC	ND	ND
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	ND	ND
Wild fungi	1	1	0.5	0.5	0.5	NA	ND	ND
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Freshwater fish	NC	NC	NC	NC	NC	NC	ND	ND

Notes

ND = not determined

NC = not consumed

NA = not applicable

For 1 observation, the terms maximum, minimum and mean are not strictly valid

Table 14. Intertidal occupancy rates in the Springfields area (h/y)

Observation number	Location*	Activity*	Mud**	Mud***	Mud and sand	Salt **** marsh	Salt***** marsh	Sand	House boat
283	Beaconsall Boatyard	Boat dwelling (tide out)							8421
284	Beaconsall Boatyard	Boat dwelling (tide out)							8187
285-286	Marshside Sands	Sand extraction						1880	
251	Banks Marsh and Hesketh Marsh	Tending livestock				1303			
262	Marshside Sands	Set netting						1107	
95	Granny's Bay	Seawater angling and bait digging			1090				
508	Ribble Estuary, Seafield slipway and Warton Marsh	Working, seawater angling and wildfowling/marsh warden	636	264		32			
246	Banks Marsh	Wildfowling, walking				471	363		
267	Hesketh Marsh	Wildfowling				470	470		
269-270	Hesketh Marsh	Wildfowling				409	409		
287	Banks Marsh	Wildfowling				406	406		
149-158	Longton Marsh	Wildfowling and walking	375	340					
509-510	Ribble Estuary	Working on the shore	360						
253	Banks Marsh	Walking				333			
507	Warton Marsh	Wildfowling/marsh warden	264	264		32			
271-272	Hesketh Marsh	Vermin control				286			
273	Banks Marsh	Wildfowling				260	260		
318	Viaduct to A6 road bridge	Freshwater angling	234	234					
319 ^c -320 ^c	Viaduct to A6 road bridge	Freshwater angling	234	234					
474	Seafield slipway/Granny's Bay	Seawater angling/bait digging and angling	173		61				
345	Seafield slipway	Boat maintenance	217						
506	Warton Marsh	Wildfowling	198	198		12	12		
342-343	Lytham Beach to Naze Point	Seawater angling						208	
545-554	Warton Marsh	Wildfowling/marsh warden	165	165		16			
310	Lea Marsh	Tending livestock				120			
240	Lytham Beach	Working	100						
252	Banks Marsh and Hesketh Marsh	Marsh warden				100			
89	Viaduct to A6 road bridge	Freshwater angling	90	90					
315-316	Granny's Bay	Beach warden	70					20	
174	Granny's Bay	Stake netting						88	
242	Hesketh Marsh	Walking				85			
146	Lytham Beach Marsh and Longton Marsh	Wildfowling and walking	72	72		12			
238	Lytham Beach	Working	80						
317	Granny's Bay	Beach warden	70						
499	Warton Marsh	Wildfowling	66	66					
321	Granny's Bay and Naze Point	Seawater angling and bait digging	61						
501	Naze Point	Working	54						
344	River Ribble	Eiver fishing	45						
94	Viaduct to A6 road bridge	Freshwater angling	36	36					
300,303,305	Clifton Marsh	Tending livestock				34			

Table 14. Intertidal occupancy rates in the Springfields area (h/y)

Observation number	Location*	Activity*	Mud**	Mud***	Mud and sand	Salt **** marsh	Salt***** marsh	Sand	House boat
311	Granny's Bay/Lytham Beach	Collecting on the shore/walking				3		26	
90	Viaduct to A6 road bridge	Freshwater angling	24	24					
91	Viaduct to A6 road bridge	Freshwater angling	24	24					
259-260	Ribble Estuary	Bait digging			24				
313	Seafield slipway	Working	17						
148 ^c	Lytham Beach Marsh and Longton Marsh	Wildfowling	15	15					
338-341	Lytham Beach	Working						15	
92	Lytham Beach	Seawater angling						10	
306, 309	Warton Marsh	Tending livestock				10			

Notes

Emboldened observations are the critical group members

**The critical group intertidal occupancy rate over mud based on 18 observations for all activities is 349 h/y

**The observed 97.5 percentile rate based on 46 observations for mud for all activities is 375 h/y

***The critical group intertidal occupancy rate over mud based on 26 observations for freshwater angling and wildfowling is 249 h/y

***The observed 97.5 percentile rate based on 33 observations for mud for freshwater angling and wildfowling is 340 h/y

The critical group intertidal occupancy rate over mud and sand based on 1 observations is 1090 h/y

The observed 97.5 percentile rate based on 4 observations for mud and sand is 1013 h/y

****The critical group intertidal occupancy rate over salt marsh based on 3 observations for all activities is 748 h/y

****The observed 97.5 percentile rate based on 33 observations for salt marsh for all activities is 637 h/y

*****The critical group intertidal occupancy rate over salt marsh based on 6 observations for wildfowling is 386 h/y

*****The observed 97.5 percentile rate based on 7 observations for salt marsh for wildfowling is 461 h/y

The critical group intertidal occupancy rate over sand based on 3 observations is 1622 h/y

The observed 97.5 percentile rate based on 14 observations for sand is 1880 h/y

The critical group intertidal occupancy rate over houseboat based on 2 observations is 8304 h/y

The observed 97.5 percentile rate based on 2 observations for houseboat is 8415 h/y

*The forward slash (/), separates the locations of, and activities taking place on, the separate substrates for that individual

^c denotes a child observation

Table 15. Handling rates of fishing gear and sediment in the Springfields area (h/y)

Observation number	Location	Activity*	Fishing gear	Sediment
262	Marshside Sands	Gear handling	1107	
240	Lytham	Gear handling	900	
238	Ribble Estuary	Gear handling	889	
264	Ribble Estuary	Gear handling	858	
95	Granny's Bay	Bait digging		830
249	Ribble Estuary	Gear handling	710	
259-260	Ribble Estuary	Gear handling/Bait digging	450	24
267	Hesketh Marsh	Wildfowling		470
254	Ribble Estuary	Gear handling	450	
242	Ribble Estuary	Gear handling	423	
269-270	Hesketh Marsh	Wildfowling		409
287	Banks Marsh	Wildfowling		406
246	Banks Marsh	Wildfowling		363
345	Ribble Estuary	Gear handling	350	
149-158	Longton Marsh	Wildfowling		340
507	Warton Marsh	Wildfowling		264
508	Warton Marsh	Wildfowling		264
273	Banks Marsh	Wildfowling		260
501	Ribble Estuary	Gear handling	240	
506	Warton Marsh	Wildfowling		210
545-554	Warton Marsh	Wildfowling		165
174	Granny's Bay	Gear handling	132	
146	Lytham Marsh & Longton Marsh	Wildfowling		72
499	Warton Marsh	Wildfowling		66
344	Ribble Estuary	Gear handling	65	
321	Naze Point	Bait digging		36
474	Granny's Bay	Bait digging		18
148 ^c	Lytham Marsh & Longton Marsh	Wildfowling		15

Notes

Emboldened observations are the critical group members

The critical group fishing gear handling rate based on 9 observations is 693 h/y

The observed 97.5 percentile rate based on 13 observations for fishing gear is 1045 h/y

The critical group sediment handling rate based on 16 observations is 393 h/y

The observed 97.5 percentile rate based on 37 observations for sediment is 506 h/y

*The forward slash (/), separates the activities taking place for that individual

^c denotes a child observation

Table 16. Gamma and beta dose rate measurements over intertidal substrates, boats and nets in the Springfields area

Location	NGR	Substrate	Gamma dose rate at 1 metre ($\mu\text{Gy/h}$)	Beta dose rate at contact ($\mu\text{Sv/h}$)
Seafield slipway	SD 357 268	Mud	0.085	N/M
Crossens Marsh	SD 357 213	Salt marsh	0.093	0.312
Banks Marsh	SD 390 230	Salt marsh	0.118	0.357
Banks Marsh	SD 383 226	Salt marsh	0.160	0.589
Hesketh Marsh	SD 430 267	Salt marsh	0.094	0.377
Hesketh Marsh	SD 430 266	Salt marsh	0.146	0.483
Longton Marsh	SD 455 256	Salt marsh	0.140	0.477
Warton Marsh	SD 396 271	Mud	0.130	0.438
Warton Marsh	SD 394 270	Salt marsh	0.141	N/M
Confluence of River Ribble/M. Ribble Link	SD 481 288	Mud and sand	N/M	0.924
M. Ribble Link - south of lock	SD 479 294	Mud	"	2.723
River Ribble, north bank	SD 498 292	Mud	"	1.515
River Ribble, north bank	SD 498 292	Tide washed grass	"	0.543
River Ribble, north bank	SD 500 293	Tide washed grass	0.074	N/M
River Ribble, north bank	SD 500 293	Mud	0.090	"
River Ribble, south bank	SD 535 283	Mud	N/M	1.008
River Ribble, south bank	SD 542 286	Mud	0.086	0.784
Beaconsall Boatyard	SD 452 232	Mud	0.109	N/M
Beaconsall boat - port bunk	SD 452 232	Plywood boat	0.089	"
Beaconsall boat - starboard bunk	SD 452 232	Plywood boat	0.087	"
Beaconsall boat - rear cabin	SD 452 232	Plywood boat	0.083	"
Lytham Creek	SD 381 277	Mud	0.083	"
Lytham Creek boat - deck	SD 381 277	Fibreglass boat	0.078	"
M. Ribble Link	SD 479 302	Mud	0.073	"
Salmon nets	SD 435 267	Nets	N/M	0.096

Notes

N/M = Not measured

Table 17. Occupancy rates on water in the Springfields area (h/y)

Observation number	Location	Activity	On water
240	Ribble Estuary	Commercial fishing	1200
264	Ribble Estuary	Commercial fishing	1144
238	Ribble Estuary	Commercial fishing	1125
249	Ribble Estuary	Commercial fishing	710
287	Ribble Estuary	Commercial fishing	504
254	Ribble Estuary	Commercial fishing	450
259	Ribble Estuary	Commercial fishing	450
260	Ribble Estuary	Commercial fishing	450
242	Ribble Estuary	Commercial fishing	423
501	Ribble Estuary	Commercial fishing	400
313	Ribble Estuary	Boat angling, gill netting and bird watching	295
345	Ribble Estuary	Hobby fishing	250
508	Ribble Estuary and Seafield slipway	Working on a boat and angling	152
273	Ribble Estuary	Boat angling	150
525-534	Ribble Estuary	Sailing	140
325 ^c	Ribble Estuary	Jet skiing	128
509	Ribble Estuary	Working on a boat	120
510	Ribble Estuary	Working on a boat	120
344	Ribble Estuary	Commercial fishing	53
326-337	Ribble Estuary	Working on a boat	50
502	Ribble Estuary	Commercial fishing	30
506	Granny's Bay	Boat angling	10

Notes

^c denotes a child observation

Table 18. Adults' consumption rates of green vegetables in the Springfields area (kg/y)

Observation number	Artichoke	Asparagus	Broccoli	Brussel sprout	Cabbage	Calabrese	Cauliflower	Courgettes	Cucumber	Herbs	Lettuce	Marrow	Rocket	Spinach	Total
189-191				4.6	39.3										43.8
202-204			7.2	4.4	2.9		1.8	5.9	6.8		1.0	0.6			30.5
198, 200			7.2	4.4	2.9		1.8	5.9	6.8		1.0	0.6			30.5
170		5.4			4.9						16.0			2.7	29.0
205-207			8.7			4.4	2.2	5.9	4.5		1.9				27.6
196-197			7.5	8.0	7.9									3.4	26.8
162			2.4	12.7		5.7	3.8				1.7				26.3
167-168	1.9	0.8	1.9	6.4	3.6	2.9	1.2	1.3						2.4	22.3
110-111			4.5	5.5	7.3										17.3
231-232									8.5		5.0				13.5
159-161										1.3	6.0			5.1	12.4
192-195			3.3		4.1		3.3								10.6
171-173			2.5					6.7							9.2
31-33					3.4			3.7			0.8		0.5		8.4
169			1.6								3.6				5.2
96-99					2.4			2.2			0.2				4.8
100-101				1.4	2.1										3.5
514-515			1.5								1.5				3.0
175-176											1.0				1.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 19 highest adult consumers is 29.2 kg/y

The observed 97.5 percentile rate based on 45 observations is 43.8 kg/y

Table 19. Adults' consumption rates of other vegetables in the Springfields area (kg/y)

Observation number	Aubergine	Broad bean	French bean	Mange-tout	Pea	Pepper	Runner bean	Squash	Sweet-corn	Tomato	Total
189-191		12.3								36.0	48.3
196-197		14.8	5.4		3.4		20.4				44.0
167-168		7.2	1.8		3.2				1.6	22.7	36.4
162		3.2	2.5				5.7			22.7	34.1
159-161	6.1					2.9				21.6	30.7
169		8.7	0.1				13.1			8.6	30.6
110-111		3.2			2.7		8.7			12.8	27.4
205-207		0.4	2.3			2.6	4.4	0.4	1.5	15.4	26.9
192-195		3.6	0.7		1.8	0.4	4.1			14.4	25.0
198, 200	1.6		0.6			1.1	6.5		2.1	8.6	20.6
202-204	1.6		0.6			1.1	6.5		2.1	8.6	20.6
231-232										18.0	18.0
171-173		1.2	7.2		6.0		2.4				16.8
170		14.6						0.2			14.7
64-66					3.8		4.5				8.3
96-99		4.6							0.7	2.9	8.2
175-176		5.5			2.7						8.2
31-33		3.0	0.8	1.5			2.7				8.1
514-515										4.5	4.5
19-20										3.6	3.6
100-101		1.3			0.05						1.3
101		1.3			0.05						1.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the 31 highest adult consumers is 28.6 kg/y

The observed 97.5 percentile rate based on 50 observations is 48.3 kg/y

Table 20. Adults' consumption rates of root vegetables in the Springfields area (kg/y)

Observation number	Beetroot	Carrot	Celeriac	Celery	Garlic	Leek	Onion	Parsnip	Radish	Salsify	Shallot	Spring onion	Swede	Turnip	Total
170	6.6	0.7	0.9		0.5		34.6				7.7				50.8
196-197		3.4		5.4	1.0		27.0	2.7			4.8			4.1	48.3
189-191						12.8	13.0	9.7							35.5
171-173	16.4	3.0				6.0	4.8				3.2				33.4
169	15.7				1.3	4.3	3.5				3.1	1.8			29.6
96-99	1.6					3.2	15.1				1.3	1.0			22.3
167-168		1.6					13.2	0.6		2.8	3.4				21.5
198, 200	0.7	0.4			0.5	1.5	10.1		0.1		6.6				19.8
202-204	0.7	0.4			0.5	1.5	10.1		0.1		6.6				19.8
110-111	4.9	4.1						3.2	1.1		5.8				19.1
162	4.6	6.3				6.9	0.8								18.5
205-207	2.6						10.2							1.7	14.5
51-54													11.3		11.3
175-176	4.9					2.7	3.2								10.9
64-66							10.0								10.0
192-195	3.3	2.7			0.1				0.1			0.4			6.5
100-101							4.5								4.5
31-33							3.6								3.6
231-232												2.0			2.0
514-515												0.2			0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 24 highest adult consumers is 28.0 kg/y

The observed 97.5 percentile rate based on 49 observations is 48.3 kg/y

Table 21. Adults' consumption rates of potato in the Springfields area (kg/y)

Observation number	Potato
162	89.2
196-197	68.3
51-54	56.3
110-111	49.1
198, 200	43.7
202-204	43.7
189-191	43.2
169	34.9
167-168	33.4
64-66	33.3
171-173	24.3
96-99	21.8
175-176	21.8
100-101	20.5
346-348	18.1
170	14.6
31-33	9.1
205-207	6.5
514-515	4.6
45, 163-166	3.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the 23 highest adult consumers is 47.8 kg/y

The observed 97.5 percentile rate based on 51 observations is 68.3 kg/y

Table 22. Adults' consumption rates of domestic fruit in the Springfields area (kg/y)

Observation number	Apple	Blackberry	Blackcurrant	Gooseberry	Loganberry	Pear	Plum	Raspberry	Redcurrants	Rhubarb	Strawberry	Whitecurrant	Total
175-176	22.7	4.0	1.4	3.1		1.4					5.7		38.3
44	22.7	4.5		1.4				4.5					33.1
43	22.7			1.4				4.5					28.6
179-182	6.2						17.0						23.3
100-101			4.3	2.0				5.1		3.5	5.1		19.9
64-66			3.3	3.3				3.3				3.3	13.3
31-33										0.8	11.3		12.1
167-168				1.6							10.2		11.8
231-232	11.3												11.3
170			2.2		0.7			5.4			2.9		11.2
198, 200				1.5	0.2					5.5	3.9		11.1
202-204				1.5	0.2					5.5	3.9		11.1
196-197			1.8						1.8	2.3	4.5		10.4
514-515							6.0				1.9		7.9
171-173			0.9	1.5				4.5			0.5		7.4
189-191										6.9			6.9
192-195		0.7		4.0						1.4			6.1
205-207											6.0		6.0
162											5.7		5.7
300-303	2.7					2.7							5.4
110-111											2.9		2.9
96-99			1.3										1.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 13 highest adult consumers is 23.9 kg/y

The observed 97.5 percentile rate based on 54 observations is 36.6 kg/y

Table 23. Adults' consumption rates of milk in the Springfields area (l/y)

Observation number	Milk
34-38	657.0
25-27	414.9
12-14	365.0
41-42	311.1
55-58	311.1
17	207.4
28	207.4
5-11	177.8
64-66	79.6

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of milk based on the 17 highest adult consumers is 440.7 l/y
The observed 97.5 percentile rate based on 29 observations is 657.0 l/y

Table 24. Adults' consumption rates of cattle meat in the Springfields area (kg/y)

Observation number	Beef
300-303	42.0
34-38	37.8
46-50	37.8
306-308	31.5
59-63	18.9
1-4	15.6
502-503	11.8

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of cattle meat based on the 26 highest adult consumers is 30.7 kg/y
The observed 97.5 percentile rate based on 28 observations is 42.0 kg/y

Table 25. Adults' consumption rates of pig meat in the Springfields area (kg/y)

Observation number	Pork
476-480	25.3

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of pig meat based on the 5 highest adult consumers is 25.3 kg/y
The observed 97.5 percentile rate based on 5 observations is 25.3 kg/y

Table 26. Adults' consumption rates of sheep meat in the Springfields area (kg/y)

Observation number	Lamb
228-230	20.0
300-303	16.3
28-29	11.3
41-42	11.3
476-480	5.7
502-503	5.7
59-63	3.4
514-515	2.8
231-232	0.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of sheep meat based on the 11 highest adult consumers is 15.5 kg/y

The observed 97.5 percentile rate based on 27 observations is 20.0 kg/y

Table 27. Adults' consumption rates of poultry in the Springfields area (kg/y)

Observation number	Chicken	Duck	Goose	Partridge	Pheasant	Pigeon	Total
300-303	16.7				2.5		19.2
22-23					2.5		2.5
43					2.3		2.3
476-480	1.3	0.3	0.4				1.9
59-60					1.1	0.6	1.7
17-18					1.4		1.4
506, 511-513				0.3	0.7		1.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of poultry based on the 4 highest adult consumers is 19.2 kg/y

The observed 97.5 percentile rate based on 20 observations is 19.2 kg/y

Table 28. Adults' consumption rates of eggs in the Springfields area (kg/y)

Observation number	Chicken egg	Duck egg	Total
30	17.8		17.8
179-182	16.8		16.8
476-480	11.9	2.9	14.8
502-503	13.9		13.9
100-101	12.5		12.5
45	12.5		12.5
163-166	12.5		12.5
64-66	9.1		9.1
185-186	8.2		8.2
159-161	5.9		5.9
346-348	5.7		5.7
297-298	5.0		5.0
46-50	2.5		2.5
187-188	1.0		1.0

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of eggs
 based on the 27 highest adult consumers is 12.4 kg/y
 The observed 97.5 percentile rate based on 39 observations is 16.8 kg/y

Table 29. Adults' consumption rates of wild fungi in the Springfields area (kg/y)

Observation number	Mushrooms
231	0.5
232	0.5
514	0.5
515	0.5

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of wild fungi
 based on the 4 highest adult consumers is 0.5 kg/y
 The observed 97.5 percentile rate based on 4 observations is 0.5 kg/y

Table 30. Children's consumption rates of green vegetables in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Broccoli	Brussel sprout	Cabbage	Lettuce	Total
177-178	16				1.0	1.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 2 highest 15 year old age group consumers is 1.0 kg/y

The observed 97.5 percentile rate based on 2 observations is 1.0 kg/y

10 year old age group

Observation number	Age	Broccoli	Brussel sprout	Cabbage	Lettuce	Total
516	8	1.5			1.5	3.0
105	11		1.0	1.6		2.6
104	7		0.7	1.1		1.7

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 3 highest 10 year old age group consumers is 2.5 kg/y

The observed 97.5 percentile rate based on 3 observations is 3.0 kg/y

5 year old age group

Observation number	Age	Broccoli	Brussel sprout	Cabbage	Lettuce	Total
517	6	1.5			1.5	3.0
103	5		0.4	0.6		1.0
102	2		0.1	0.2		0.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 2 highest 5 year old age group consumers is 2.0 kg/y

The observed 97.5 percentile rate based on 3 observations is 2.9 kg/y

Table 31. Children's consumption rates of other vegetables in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Broad bean	Pea	Tomato	Total
177-178	16	5.5	2.7		8.2
21	15			3.6	3.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the 3 highest 15 year old age group consumers is 6.6 kg/y

The observed 97.5 percentile rate based on 3 observations is 8.2 kg/y

10 year old age group

Observation number	Age	Broad bean	Pea	Tomato	Total
516	8			4.5	4.5
105	11	0.9	0.05		1.0
104	7	0.6	0.05		0.7

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the highest 10 year old age group consumers is 4.5 kg/y

The observed 97.5 percentile rate based on 3 observations is 4.3 kg/y

5 year old age group

Observation number	Age	Broad bean	Pea	Tomato	Total
517	6			4.5	4.5
103	5	0.4	0.05		0.4
102	2	0.1	0.05		0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the highest 5 year old age group consumer is 4.5 kg/y

The observed 97.5 percentile rate based on 3 observations is 4.3 kg/y

Table 32. Children's consumption rates of root vegetables in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Beetroot	Leek	Onion	Spring onion	Total
177-178	16	4.9	2.7	3.2		10.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 2 highest 15 year old age group consumers is 10.9 kg/y

The observed 97.5 percentile rate based on 2 observations is 10.9 kg/y

10 year old age group

Observation number	Age	Beetroot	Leek	Onion	Spring onion	Total
105	11			3.4		3.4
104	7			2.3		2.3
516	8				0.2	0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 2 highest 10 year old age group consumers is 2.8 kg/y

The observed 97.5 percentile rate based on 3 observations is 3.3 kg/y

5 year old age group

Observation number	Age	Beetroot	Leek	Onion	Spring onion	Total
103	5			1.4		1.4
102	2			0.5		0.5
517	6				0.2	0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 2 highest 5 year old age group consumers is 0.9 kg/y

The observed 97.5 percentile rate based on 3 observations is 1.3 kg/y

Table 33. Children's consumption rates of potato in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Potato
177-178	16	21.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato

based on the 2 highest 15 year old age group consumers is 21.8 kg/y

The observed 97.5 percentile rate based on 2 observations is 21.8 kg/y

10 year old age group

Observation number	Age	Potato
105	11	15.4
104	7	10.2
516	8	4.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato

based on the 2 highest 10 year old age group consumers is 12.8 kg/y

The observed 97.5 percentile rate based on 3 observations is 15.1 kg/y

5 year old age group

Observation number	Age	Potato
103	5	6.1
517	6	4.6
102	2	2.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato

based on the 3 highest 5 year old age group consumers is 4.2 kg/y

The observed 97.5 percentile rate based on 3 observations is 6.1 kg/y

Table 34. Children's consumption rates of domestic fruit in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Apple	Blackberry	Blackcurrant	Gooseberry	Pear	Plum	Raspberry	Rhubarb	Strawberry	Total
177-178	16	22.7	4.0	1.4	3.1	1.4				5.7	38.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 2 highest 15 year old age group consumers is 38.3 kg/y

The observed 97.5 percentile rate based on 2 observations is 38.3 kg/y

10 year old age group

Observation number	Age	Apple	Blackberry	Blackcurrant	Gooseberry	Pear	Plum	Raspberry	Rhubarb	Strawberry	Total
105	11			3.2	1.5			3.8	2.6	3.8	15.0
104	7			2.1	1.0			2.5	1.7	2.6	10.0
516	8						6.0			1.9	7.9
304	10	2.7				2.7					5.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 4 highest 10 year old age group consumers is 9.6 kg/y

The observed 97.5 percentile rate based on 4 observations is 14.6 kg/y

5 year old age group

Observation number	Age	Apple	Blackberry	Blackcurrant	Gooseberry	Pear	Plum	Raspberry	Rhubarb	Strawberry	Total
517	6						6.0			1.9	7.9
103	5			1.3	0.6			1.5	1.0	1.5	6.0
102	2			0.4	0.2			0.5	0.3	0.5	2.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 2 highest 5 year old age group consumers is 6.9 kg/y

The observed 97.5 percentile rate based on 3 observations is 7.8 kg/y

Table 35. Children's consumption rates of milk in the Springfields area (l/y)

15 year old age group

Observation number	Age	Milk
15	14	365.0
16	12	365.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of milk

based on the 2 highest 15 year old age group consumers is 365.0 l/y

The observed 97.5 percentile rate based on 2 observations is 365.0 l/y

Table 36. Children's consumption rates of cattle meat in the Springfields area (kg/y)

10 year old age group

Observation number	Age	Beef
304	10	21.0
504	11	11.8
505	7	11.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of cattle meat

based on the 3 highest 10 year old age group consumers is 14.9 kg/y

The observed 97.5 percentile rate based on 3 observations is 20.6 kg/y

Table 37. Children's consumption rates of pig meat in the Springfields area (kg/y)

10 year old age group

Observation number	Age	Pork
482	9	12.6
481	7	12.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of pig meat

based on the 2 highest 10 year old age group consumers is 12.6 kg/y

The observed 97.5 percentile rate based on 2 observations is 12.6 kg/y

Table 38. Children's consumption rates of sheep meat in the Springfields area (kg/y)

10 year old age group

Observation number	Age	Lamb
304	10	8.2
504	11	5.7
505	7	5.7
482	9	2.8
516	8	2.8
481	7	2.8

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of sheep meat based on the 6 highest 10 year old age group consumers is 4.7 kg/y
 The observed 97.5 percentile rate based on 6 observations is 7.8 kg/y

5 year old age group

Observation number	Age	Lamb
517	6	2.8

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of sheep meat based on the only 5 year old age group consumer is 2.8 kg/y
 The observed 97.5 percentile rate is not applicable for 1 observation

Table 39. Children's consumption rates of poultry in the Springfields area (kg/y)

10 year old age group

Observation number	Age	Chicken	Duck	Goose	Pheasant	Total
304	10	8.3			1.3	9.6
482	9	0.6	0.2	0.2		1.0
481	7	0.6	0.2	0.2		1.0

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of poultry based on the highest 10 year old age group consumer is 9.6 kg/y
 The observed 97.5 percentile rate based on 3 observations is 9.2 kg/y

Table 40. Children's consumption rates of eggs in the Springfields area (kg/y)

15 year old age group

Observation number	Age	Chicken egg	Duck egg	Total
199	15	1.0		1.0
201	13	1.0		1.0

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of eggs based
 based on the 2 highest 15 year old age group consumers is 1.0 kg/y
 The observed 97.5 percentile rate based on 2 observations is 1.0 kg/y

10 year old age group

Observation number	Age	Chicken egg	Duck egg	Total
504	11	13.9		13.9
505	7	13.9		13.9
105	11	9.4		9.4
482	9	5.9	1.5	7.4
481	7	5.9	1.5	7.4
104	7	6.3		6.3
299	8	5.0		5.0

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of eggs
 based on the 7 highest 10 year old age group consumers is 9.0 kg/y
 The observed 97.5 percentile rate based on 7 observations is 13.9 kg/y

5 year old age group

Observation number	Age	Chicken egg	Duck egg	Total
103	5	3.8		3.8
102	2	1.3		1.3

Notes

Emboldened observations are the critical group consumers
 The critical group consumption rate of eggs
 based on the 2 highest 5 year old age group consumers is 2.5 kg/y
 The observed 97.5 percentile rate based on 2 observations is 3.7 kg/y

Table 41. Children's consumption rates of wild fungi in the Springfields area (kg/y)

10 year old age group

Observation number	Age	Mushrooms
516	8	0.5

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of wild fungi
based on the only 10 year old age group consumer is 0.5 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

5 year old age group

Observation number	Age	Mushrooms
517	6	0.5

Notes

Emboldened observations are the critical group consumers
The critical group consumption rate of wild fungi
based on the only 5 year old age group consumer is 0.5 kg/y
The observed 97.5 percentile rate is not applicable for 1 observation

Table 42. Percentage contribution each food type makes to its terrestrial food group for adults

Domestic fruit		Other vegetables		Eggs	
*Apple	24.0 %	Tomato	47.7 %	Chicken egg	96.1 %
Strawberry	22.9 %	Broad bean	17.0 %	Duck egg	3.9 %
Plum	12.9 %	*Runner bean	16.5 %		
Rhubarb	10.9 %	Pea	5.9 %	Poultry	
Gooseberry	8.7 %	French bean	5.3 %	Chicken	70.5 %
Raspberry	7.8 %	Aubergine	2.6 %	Pheasant	24.0 %
Blackcurrant	5.6 %	Pepper	2.3 %	Goose	1.8 %
*Blackberry	2.5 %	Sweetcorn	2.1 %	*Duck	1.4 %
Pear	2.2 %	Mangetout	0.4 %	Partridge	1.2 %
Whitecurrant	1.6 %	Squash	0.1 %	Pigeon	1.1 %
Redcurrant	0.6 %				
Loganberry	0.3 %				
Green vegetables		Root vegetables		Wild fungi	
*Cabbage	28.6 %	Onion	42.9 %	Mushrooms	100.0 %
Broccoli	15.6 %	*Beetroot	14.7 %		
Brussel sprout	12.0 %	Leek	10.8 %		
Courgette	11.9 %	Shallot	10.0 %		
Lettuce	9.0 %	Carrot	5.4 %		
Cucumber	8.6 %	Swede	5.2 %		
Cauliflower	4.6 %	Parsnip	4.9 %		
Spinach	3.9 %	Turnip	1.5 %		
Calabrese	3.2 %	Spring onion	1.4 %		
Asparagus	0.9 %	Celery	1.3 %		
Herbs	0.5 %	Garlic	0.8 %		
Artichoke	0.5 %	Salsify	0.6 %		
Marrow	0.4 %	Radish	0.4 %		
Rocket	0.2 %	Celeriac	0.1 %		

Notes

Food types astrisked and emboldened were monitored by FSA in 2005 (EA, EHS, FSA and SEPA, 2006)

Other foods monitored were milk and potatoes

Percentages are based on the consumption of all adults in the survey consuming that particular food group

Table 43. Occupancy rates in the Springfields direct radiation survey area for adults and children (h/y)

Observation Number	Age (in years) (U if unknown)	Distance from site perimeter fence (km)	Indoor occupancy	Outdoor occupancy	Total occupancy
0 to 0.25 km zone					
106	U	0.05	8660	100	8760
107	U	0.05	8760		8760
228	60	0.20	5404	2933	8337
87	79	0.10	8232	100	8332
75	36	0.05	8054	240	8294
76	37	0.05	8134	160	8294
88	79	0.10	6236	1960	8196
516	8	0.10	7028	1000	8028
517	6	0.10	7028	1000	8028
179	48	0.10	6557	1456	8013
361	31	0.10	7580	260	7840
185	61	0.10	7238	490	7728
186	60	0.10	7238	490	7728
514	35	0.10	7274	400	7674
518	0.25	0.10	7274	400	7674
483	48	0.05	7159	365	7524
484	46	0.05	7159	365	7524
485	22	0.05	7159	365	7524
515	40	0.10	4524	3000	7524
230	31	0.20	5565	1677	7242
233	39	0.05	7090	92	7182
234	36	0.05	7090	92	7182
45	56	0.20	5872	1232	7104
86	52	0.10	6377	700	7077
231	50	0.20	6524	544	7068
229	55	0.20	6237	795	7032
181	21	0.10	6192	608	6800
182	18	0.10	6698	102	6800
226	58	0.10	6345	399	6744
108	47	0.05	6130	440	6570
109	49	0.05	5905	440	6345
165	24	0.20	5347	821	6168
187	48	0.10	5227	883	6110
188	47	0.10	5409	701	6110
235	10	0.05	5916	138	6054
236-237	7	0.05	5916	138	6054
487	17	0.05	5760	208	5968
347	U	0.10	4938	1020	5958
199	15	0.10	5248	701	5949
201	13	0.10	5248	701	5949
232	50	0.20	5484	396	5880
164	24	0.20	5048	821	5869
180	49	0.10	5284	576	5860
227	56	0.10	5682	156	5838
346	U	0.10	4480	1310	5790
166	25	0.20	4631	821	5452
163	52	0.20	4754	462	5216
348	23	0.10	4008	432	4440
77-79	U	0.05	2064		2064
488-495	U	0.05	2016		2016
217	46	0.15		1874	1874
218-219	U	0.15		1874	1874
349	U	0.10	1824		1824
350	U	0.10	1824		1824
175	51	0.05	917	451	1368
176	53	0.05	917	451	1368

Table 43. Occupancy rates in the Springfields direct radiation survey area for adults and children (h/y)

Observation Number	Age (in years) (U if unknown)	Distance from site perimeter fence (km)	Indoor occupancy	Outdoor occupancy	Total occupancy
0 to 0.25 km zone					
177	16	0.05	917	451	1368
178	16	0.05	917	451	1368
112-114	U	0.15	1292	38	1330
115-124	U	0.15	1330		1330
519-520	U	0.10		1152	1152
521	U	0.10		1152	1152
127	U	0.15	1140		1140
128-135	6	0.15	1120	20	1140
136-139	8	0.15	1120	20	1140
140-144	10	0.15	1120	20	1140
145	12	0.15	1120	20	1140
208-216	U	0.15		900	900
351-352	U	0.10	864		864
522-523	U	0.10		728	728
524	U	0.10		728	728
80-85	U	0.05	720		720
125	U	0.15	570		570
220-225	U	0.15		504	504
486	19	0.05	440		440
353-358	U	0.10	384		384
359-360	U	0.10	384		384
126	U	0.15	380		380
183	U	0.05	248	112	360
184	U	0.05	248	112	360
535-544	U	0.10	312		312
110	74	0.05		300	300
111	73	0.05		300	300
496-498	U	0.05	52		52
>0.25 to 0.5 km zone					
481	7	0.50	7567	1095	8662
482	9	0.50	7567	1095	8662
479	U	0.50	5516	2912	8428
476	U	0.50	6435	1825	8260
477	U	0.50	7347	913	8260
480	U	0.50	7623	365	7988
73	71	0.40	7342	600	7942
41	60	0.50	4494	3290	7784
42	57	0.50	7209	365	7574
44	59	0.30	5188	2224	7412
40	58	0.40	5912	1380	7292
72	70	0.40	6644	140	6784
478	U	0.50	5302	1092	6394
43	59	0.30	4315	1849	6164
74	44	0.40	5350	140	5490
39	57	0.40	4417	690	5107
362	U	0.30	1404	78	1482
363-365	U	0.30	1404	78	1482
381-387	4	0.30	878	390	1268
388-400	5	0.30	878	390	1268
401-413	6	0.30	878	390	1268
414-426	7	0.30	878	390	1268
427-439	8	0.30	878	390	1268
440-452	9	0.30	878	390	1268
453-465	10	0.30	878	390	1268
466-473	11	0.30	878	390	1268
366-372	U	0.30	1053	39	1092

Table 43. Occupancy rates in the Springfields direct radiation survey area for adults and children (h/y)

Observation Number	Age (in years) (U if unknown)	Distance from site perimeter fence (km)	Indoor occupancy	Outdoor occupancy	Total occupancy
>0.25 to 0.5 km zone					
34	52	0.50		365	365
35	48	0.50		365	365
36	26	0.50		365	365
37	17	0.50		365	365
373-380	U	0.30		195	195
508	49	0.50		12	12
>0.5 to 1 km zone					
68	57	0.60	6370	1350	7720
70	17	0.60	6780	100	6880
69	19	0.60	4475	480	4955
71	18	0.60	4475	480	4955
67	56	0.60	4405	350	4755
30	67		494	26	520

Table 44. Analysis of occupancy rates in the Springfields direct radiation survey area

0 to 0.25 km zone	
Number of hours per year	Number of observations
8000 to 8760	10
7000 to 8000	16
6000 to 7000	11
5000 to 6000	11
4000 to 5000	1
3000 to 4000	0
2000 to 3000	11
1000 to 2000	44
0 to 1000	54

>0.25 to 0.5 km zone	
Number of hours per year	Number of observations
8000 to 8760	5
7000 to 8000	6
6000 to 7000	3
5000 to 6000	2
4000 to 5000	0
3000 to 4000	0
2000 to 3000	0
1000 to 2000	104
0 to 1000	13

>0.5 to 1 km zone	
Number of hours per year	Number of observations
8000 to 8760	0
7000 to 8000	1
6000 to 7000	1
5000 to 6000	0
4000 to 5000	3
3000 to 4000	0
2000 to 3000	0
1000 to 2000	0
0 to 1000	1

Table 45. Gamma dose rate measurements for the Springfields direct radiation survey ($\mu\text{Gy/h}$)

Location	Distance from site perimeter (km)	NGR	Outdoor substrate	Gamma dose rate at 1 metre	Indoor substrate	Gamma dose rate at 1 metre
Properties						
Farm 1	0.05	SD 463 315	Grass	0.089	N/M	N/M
House 1	0.10	SD 462 319	Grass	0.086	Tiles	0.093
House 2	0.10	SD 462 319	Stones	0.104	N/M	N/M
Farm 2	0.20	SD 462 317	Grass	0.082	"	"
House 3	0.05	SD 474 309	Grass	0.081	Tiles	0.071
Farm 3	0.10	SD 476 317	Grass	0.082	Concrete	0.098
School		SD 462 315	Grass	0.080	N/M	N/M
School		SD 462 315	Concrete	0.104	"	"
House 4	0.05	SD 464 313	Grass	0.086	"	"
House 5	0.10	SD 476 311	Grass	0.082	Concrete	0.088
House 6	0.40	SD 480 319	Grass	0.078	Concrete	0.104
Farm 4	0.60	SD 475 323	Grass	0.079	Tiles	0.102
House 7	0.40	SD 464 324	Grass	0.072	Inside	0.088
Farm 5	0.50	SD 466 325	Grass	0.088	N/M	N/M
Farm 6	0.30	SD 479 314	Concrete	0.077	"	"
Railway car park	0.05	SD 463 319	Gravel	0.067	"	"
Signal box	0.05	SD 463 320	Gravel	0.084	Wood	0.073

Perimeter Fence				
100 m east of signal box	0.01	SD 464 319	Ballast	0.098
200 m east of signal box	0.01	SD 465 319	Ballast	0.111
300 m east of signal box	0.01	SD 465 319	Ballast	0.139
400 m east of signal box	0.01	SD 466 318	Ballast	0.167
500 m east of signal box	0.01	SD 467 318	Ballast	0.095

Backgrounds				
Background 1	5.50	SD 475 254	Pasture	0.073
Background 2	6.20	SD 491 375	Grass	0.072
Background 3	5.60	SD 433 367	Grass	0.073

Notes

N/M = Not measured

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years (U if unknown)	Distance from site	Fish	Crustaceans	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud in a houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over sand	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence
39	M	57	0.4																									4417	690
40	F	58	0.4																									5912	1380
41	M	60	0.5										311.1			11.3												4494	3290
42	F	57	0.5										311.1			11.3												7209	365
43	M	59	0.3				2.3					28.6					2.3											4315	1849
44	F	59	0.3									33.1																5188	2224
45	M	56	0.2								3.6							12.5										5872	1232
46	F	U	4.4											37.8				2.5											
47	F	U	4.4											37.8				2.5											
48	M	U	4.4											37.8				2.5											
49	M	U	4.4											37.8				2.5											
50	M	U	4.4											37.8				2.5											
51	M	U	4.0							11.3	56.3																		
52	U	U	4.0							11.3	56.3																		
53	U	U	4.0							11.3	56.3																		
54	U	U	4.0							11.3	56.3																		
55	F	U	4.2										311.1																
56	M	U	4.2										311.1																
57	U	U	4.2										311.1																
58	U	U	4.2										311.1																
59	M	U	4.4	9.3										18.9		3.4	1.7												
60	F	U	4.4	9.3										18.9		3.4	1.7												
61	U	U	4.4											18.9		3.4													
62	U	U	4.4											18.9		3.4													
63	U	U	4.4											18.9		3.4													
64	M	U	3.8						8.3	10.0	33.3	13.3	79.6					9.1											
65	F	U	3.8						8.3	10.0	33.3	13.3	79.6					9.1											
66	U	U	3.8						8.3	10.0	33.3	13.3	79.6					9.1											
67	M	56	0.6																									4405	350
68	F	57	0.6																									6370	1350
69	M	19	0.6																									4475	480
70	M	17	0.6																									6780	100
71	F	18	0.6																									4475	480
72	F	70	0.4																									6644	140
73	M	71	0.4																									7342	600

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years (U if unknown)	Distance from site	Fish	Crustaceans	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud in a houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over sand	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence	
113	U	U	U																									1292	38	
114	U	U	U																										1292	38
115	U	U	U																										1330	
116	U	U	U																										1330	
117	U	U	U																										1330	
118	U	U	U																										1330	
119	U	U	U																										1330	
120	U	U	U																										1330	
121	U	U	U																										1330	
122	U	U	U																										1330	
123	U	U	U																										1330	
124	U	U	U																										1330	
125	U	U	U																										570	
126	U	U	U																										380	
127	U	U	U																										1140	
146	M	61	U				14.9															72		12		72				
147	F	50	U				1.9																							
149	M	U	U																				375				340			
150	M	U	U																				375				340			
151	M	U	U																				375				340			
152	M	U	U																				375				340			
153	M	U	U																				375				340			
154	M	U	U																				375				340			
155	M	U	U																				375				340			
156	M	U	U																				375				340			
157	M	U	U																				375				340			
158	M	U	U																				375				340			
159	M	30	3.8	6.7				12.4	30.7									5.9												
160	M	50	3.8	6.7				12.4	30.7									5.9												
161	F	50	3.8	6.7				12.4	30.7									5.9												
162	M	84	U					26.3	34.1	18.5	89.2	5.7																		
163	F	52	0.2															12.5											4754	462
164	M	24	0.2															12.5											5048	821
165	M	24	0.2															12.5											5347	821
166	M	25	0.2															12.5											4631	821

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years (U if unknown)	Distance from site	Fish	Crustaceans	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud in a houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over sand	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence	
205	F	55	U					27.6	26.9	14.5	6.5	6.0																		
206	M	62	U					27.6	26.9	14.5	6.5	6.0																		
207	F	26	U					27.6	26.9	14.5	6.5	6.0																		
208	M	U	U																										900	
209	M	U	U																										900	
210	M	U	U																										900	
211	M	U	U																										900	
212	M	U	U																										900	
213	M	U	U																										900	
214	M	U	U																										900	
215	M	U	U																										900	
216	M	U	U																										900	
217	M	46	U																										1874	
218	M	U	U																										1874	
219	M	U	U																										1874	
220	M	U	U																										504	
221	M	U	U																										504	
222	M	U	U																										504	
223	M	U	U																										504	
224	M	U	U																										504	
225	M	U	U																										504	
226	M	58	0.1																										6345	399
227	F	56	0.1																										5682	156
228	M	60	0.2												20.0														5404	2933
229	F	55	0.2												20.0														6237	795
230	M	31	0.2												20.0														5565	1677
231	M	50	0.2					13.5	18.0	2.0		11.3			0.9				0.5									6524	544	
232	F	50	0.2					13.5	18.0	2.0		11.3			0.9				0.5									5484	396	
233	M	39	0.1																										7090	92
234	F	36	0.1																										7090	92
238	M	50	U	14.0	26.2																	80				889		1125		
239	F	49	U	14.0	15.0																									
240	M	52	U	72.2																		100				900		1200		
241	F	44	U	72.2																										
242	M	55	8.0	1.6																										
243	F	50	8.0	1.6																					85	423		423		

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years (U if unknown)	Distance from site	Fish	Crustaceans	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud in a houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over sand	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence
280	F	U	U	11.9	3.4		7.8																						
281	F	U	U	11.9	3.4		7.8																						
282	F	U	U	11.9	3.4		7.8																						
283	F	89	8.0																		8421								
284	M	80	8.0																		8187								
285	M	U	U																				1880						
286	M	U	U																				1880						
287	M	70	U	8.8			16.4																	406		406	504		
288	F	70	U	8.8			16.4																						
289	M	U	U				7.1																						
290	M	U	U				7.1																						
291	M	U	U				7.1																						
292	M	U	U				7.1																						
293	F	U	U				7.1																						
294	F	U	U				7.1																						
295	F	U	U				7.1																						
296	F	U	U				7.1																						
297	M	U	1.5															5.0											
298	F	U	1.5															5.0											
300	M	43	2.5				5.7					5.4		42.0		16.3	19.2							34					
301	F	43	2.5				5.7					5.4		42.0		16.3	19.2												
302	F	77	2.5				5.7					5.4		42.0		16.3	19.2												
303	M	74	2.5				5.7					5.4		42.0		16.3	19.2								34				
305	M	U	U																						34				
306	M	U	4.3											31.5											10				
307	F	U	4.3											31.5															
308	F	U	4.3											31.5															
309	M	U	4.3																										
310	M	U	2.1																										
311	M	65	7.5	5.9		1.0																	26	3					
312	F	60	7.5	5.9																									
313	M	45	U	6.8																		17				295			
314	F	74	U	4.4																									
315	F	U	U																			70	20						
316	U	U	U																			70	20						

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years (U if unknown)	Distance from site	Fish	Crustaceans	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud in a houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over sand	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence	
355	F	U	U																											
356	F	U	U																										384	
357	F	U	U																										384	
358	F	U	U																										384	
359	M	U	U																										384	
360	M	U	U																										384	
361	M	31	0.1																										7580	260
362	M	U	U																										1404	78
363	F	U	U																										1404	78
364	F	U	U																										1404	78
365	F	U	U																										1404	78
366	F	U	U																										1053	39
367	F	U	U																										1053	39
368	F	U	U																										1053	39
369	F	U	U																										1053	39
370	F	U	U																										1053	39
371	F	U	U																										1053	39
372	F	U	U																										1053	39
373	F	U	U																											195
374	F	U	U																											195
375	F	U	U																											195
376	F	U	U																											195
377	F	U	U																											195
378	F	U	U																											195
379	F	U	U																											195
380	F	U	U																											195
474	M	36	U	4.5																	61	173				18				
475	F	30	U	4.5																										
476	M	U	0.5												25.3	5.7	1.9	14.8											6435	1825
477	F	U	0.5												25.3	5.7	1.9	14.8											7347	913
478	M	U	0.5												25.3	5.7	1.9	14.8											5302	1092
479	F	U	0.5												25.3	5.7	1.9	14.8											5516	2912
480	M	U	0.5												25.3	5.7	1.9	14.8											7623	365
483	M	48	0.1																										7159	365
484	F	46	0.1																										7159	365

Annex 1. Adults' consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years (U if unknown)	Distance from site	Fish	Crustaceans	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud in a houseboat	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over sand	Intertidal occupancy over salt marsh	Handling fishing gear	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence		
525	U	U	U																												
526	U	U	U																									140			
527	U	U	U																									140			
528	U	U	U																									140			
529	U	U	U																									140			
530	U	U	U																									140			
531	U	U	U																									140			
532	U	U	U																									140			
533	U	U	U																									140			
534	U	U	U																									140			
535	U	U	U																										312		
536	U	U	U																										312		
537	U	U	U																										312		
538	U	U	U																										312		
539	U	U	U																										312		
540	U	U	U																										312		
541	U	U	U																										312		
542	U	U	U																										312		
543	U	U	U																										312		
544	U	U	U																										312		
545	M	U	U																			165		16		165					
546	M	U	U																			165		16		165					
547	M	U	U																			165		16		165					
548	M	U	U																			165		16		165					
549	M	U	U																			165		16		165					
550	M	U	U																			165		16		165					
551	M	U	U																			165		16		165					
552	M	U	U																			165		16		165					
553	M	U	U																			165		16		165					
554	M	U	U																			165		16		165					

Notes

Emboldened observations are rates included in the critical groups.

Annex 2. Children's consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years	Distance of residence from site (km) (U if unknown)	Fish	Crustaceans	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence
15 year old age group																							
177	M	16	0.1				1.0	8.2	10.9	21.8	38.3											917	451
178	F	16	0.1				1.0	8.2	10.9	21.8	38.3											917	451
21	M	15	4.7			0.9		3.6															
148	M	15	U			1.9													15	15			
199	M	15	0.1														1.0					5248	701
15	F	14	3.0									365.0											
201	M	13	0.1														1.0					5248	701
16	F	12	3.0									365.0											
145	U	12	U																			1120	20
10 year old age group																							
105	M	11	U				2.6	1.0	3.4	15.4	15.0						9.4						
320	M	11	U																234				
466-473	U	11	U																			878	390
504	F	11	4.6										11.8		5.7		13.9						
140-144	U	10	U																			1120	20
235	F	10	0.1																			5916	138
304	F	10	2.5			2.9				5.4		21.0			8.2	9.6							
319	M	10	U																234				
453-465	U	10	U																			878	390
440-452	U	9	U																			878	390
482	F	9	0.5											12.7	2.8	1.0	7.4					7567	1095
136-139	U	8	U																			1120	20
299	M	8	1.5														5.0						

Annex 2. Children's consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Springfields area

Observation number	Sex (U if unknown)	Age in years	Distance of residence from site (km) (U if unknown)	Fish	Crustaceans	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Milk	Cattle meat	Pig meat	Sheep meat	Poultry	Eggs	Wild fungi	Intertidal occupancy over mud	Handling sediment	Occupancy on water	Indoor occupancy within 1 km of the perimeter fence	Outdoor occupancy within 1 km of the perimeter fence
10 year old age group																							
427-439	U	8	U																			878	390
516	M	8	0.1				3.0	4.5	0.2	4.6	7.9				2.8			0.5				7028	1000
104	M	7	U				1.7	0.7	2.3	10.2	10.0						6.3						
236-237	M	7	0.1																			5916	138
414-426	U	7	U																			878	390
481	M	7	0.5											12.7	2.8	1.0	7.4					7567	1095
505	F	7	4.6										11.8		5.7		13.9						
5 year old age group																							
128-135	U	6	U																			1120	20
266	F	6	U	2.7	1.4																		
401-413	U	6	U																			878	390
517	F	6	0.1				3.0	4.5	0.2	4.6	7.9				2.8			0.5				7028	1000
103	M	5	U				1.0	0.4	1.4	6.1	6.0						3.8						
325	M	5	U																		128		
388-400	U	5	U																			878	390
381-387	U	4	U																			878	390
102	M	2	U				0.3	0.2	0.5	2.0	2.0						1.3						
3 month old age group																							
518	M	0.25	0.1																			7274	400

Notes

Emboldened observations are rates included in the critical groups.

Annex 3. Qualitative and estimated data for use in dose assessment

	Details of activity	Exposure pathways involved	Estimated rate
1	Collection of molluscs	Consumption of molluscs	2000 survey critical group mean mollusc consumption rate was 10 kg/y

Annex 4. Ratios for determining consumption and occupancy rates for children

Group	Ratio child/adult ⁽¹⁾	
	1 yr old	10 yr old
Fish ⁽²⁾	0.050	0.200
Crustaceans ⁽²⁾	0.050	0.250
Molluscs ⁽²⁾	0.050	0.250
Green vegetables	0.222	0.444
Other vegetables	0.200	0.500
Root vegetables	0.375	0.500
Potatoes	0.292	0.708
Domestic fruit	0.467	0.667
Milk	1.333	1.000
Cattle meat	0.222	0.667
Pig meat	0.138	0.625
Sheep meat	0.120	0.400
Poultry	0.183	0.500
Eggs	0.600	0.800
Wild/free foods ⁽³⁾	0.110	0.490
Game ⁽⁴⁾	0.140	0.500
Honey	0.789	0.789
Wild fungi	0.150	0.450
Freshwater fish ⁽²⁾	0.050	0.250
Direct radiation	1.000	1.000
External exposure	0.500	0.030
Plume	1.000	1.000

Notes

1. The age groups suggested for assessment in this table are those relating to dose coefficients representing 1 to 2 yr olds (labelled 1 yr old) and 7 to 12 yr olds (labelled 10 yr old). Excepting notes 2 and 3, ratios were derived from Byrom et al., (1995) for 1yr old (6 - 12 months) and 10 yr old children (10 - 11 yrs).
2. Ratios were derived from Smith and Jones, (2003) which presented data for infants and children.
3. Ratios were derived from FSA data for wild fruit and nuts for infants and 10 yr old children.
4. Game includes rabbits/hares and venison.

Annex 5. Summary of adults' profiled habits data in the Springfields area

Profile Name	Number of Individuals	Crustacea	Direct ¹	Eggs	Fish - Sea	Fruit - Domestic	Gamma Ext - Houseboat	Gamma ext - Sediment ²	Marine plants and algae	Meat - Cattle	Meat - Game ³	Meat - Pig	Meat - Poultry	Meat - Sheep	Milk	Mushrooms	Occupancy on water	Plume (IN; 0-0.25km) ⁴	Plume (MID; 0.25-0.5km) ⁴	Plume (OUT; 0.5-1km) ⁴	Vegetables - Green	Vegetables - Other Domestic	Vegetables - Potatoes	Vegetables - Root
		kg	-	kg	kg	kg	h	h	kg	kg	kg	kg	kg	kg	l	kg	h	h	h	h	kg	kg	kg	kg
Crustacean consumers	2	20.6			14			40								563								
Occupants for direct radiation	53		1	1.5		1.6			0.9			0.7	0.1	0.7	18.7			2130	680	170	0.4	0.7	1.3	0.4
Egg consumers	27		0.6	12.4	0.7	6.4			0.9			4.7	0.4	1.5	8.8		1	2690	1460	20	1.6	4.4	5.9	1.4
Sea fish consumers	4	0.3			53.8			302								300								
Domestic fruit consumers	13		0.6	9.2		23.9				0.2		0.2		18.4			2320	1040		0.7	3.4	14.2	4.7	
Occupants for exposure - Houseboat	2						8300																	
Occupants for exposure - Sediment	6	0.2	0.2		6.3			1321		0.9						25								
Marine plants/algae consumers	2				4			120	0.7	13.7		0.5				5								
Cattle meat consumers	26		0.2	0.5	0.7	0.8		3	30.7	0.9		3.1	3.2	126.3				60						
Game meat consumers	7				3.8			100	0.1		21		0.6			73								
Pig meat consumers	5		1	14.8								25.3	1.9	5.7				7870						
Poultry meat consumers	4					5.4		17	42	5.7		19.2	16.3											
Sheep meat consumers	11		0.5			2		6	15.3	2.1		7	15.5	75.4			2060	1400						
Milk consumers	17		0.4						11.1				1.3	440.7				990						
Mushroom consumers	4		1			9.6							1.9		0.5		7040			8.2	11.3	2.3	1.1	
Occupants on water	10	4.7			13.1			77		1.9						686								
Occupants for plume pathways (inner area)	8		1	4		3.2							1.6				6970			0.8	1.1	2	0.1	
Occupants for plume pathways (middle area)	9		1	5.3		4.4				0.2	9	0.8	3.6	44.4										
Occupants for plume pathways (outer area)	19		1																	5850				
Green vegetable consumers	19		0.1			8.5											30			29.2	31.2	40.7	26.1	
Other domestic vegetable consumers	31		0.1	0.6	0.6	7.1							0.1				440			21.5	28.6	27.9	19.5	
Potato consumers	23		0.1	1.2		7.5								10.4			30			19.5	24	47.8	22	
Root vegetable consumers	24		0.1			7.1											30			21.8	26.1	39.5	28	

Notes

1. Expressed as proportion of group who are present within 1km of site
2. Gamma ext - Sediment includes occupancy over mud, mud & sand, salt marsh and sand
3. Game meat includes wildfowl
4. Plume times are the sums of individuals' indoor and outdoor times

Annex 6. Ribble houseboat and sediment gamma dose rate measurements ($\mu\text{Gy/h}$) and associated annual dose to the occupants ($\mu\text{Sv/y}$)

Year	On-board	On-board ¹ -background	Mud	Mud ¹ -background	Annual ² dose
1991	NM	NA	0.130	0.060	NM
1992	0.120	0.050	0.140	0.070	353
1993	0.100	0.030	0.130	0.060	212
1994	0.090	0.020	0.110	0.040	141
1995	0.088	0.018	0.120	0.050	127
1996	0.083	0.013	0.120	0.050	92
1997	0.091	0.021	0.110	0.040	148
1998	NM	NA	NM	NA	NM
1999	NM	NA	NM	NA	NM
2000	0.075	0.005	0.090	0.020	35
2001	NM	NA	NM	NA	NM
2002	NM	NA	0.120	0.050	NM
2003	NM	NA	0.095	0.025	NM
2004	NM	NA	0.093	0.023	NM
2005	NM	NA	NM	NA	NM
2006	0.088	0.018	0.109	0.039	127

Notes

¹ = appropriate background gamma dose rate over mud is 0.07 $\mu\text{Gy/h}$

² = Annual total dose to boat occupants assuming 8300 h/y

NM = not measured

NA = not applicable

**Annex 7. 2007 Ribble houseboat and sediment gamma dose rate measurements ($\mu\text{Gy/h}$)
and associated annual dose to the occupants ($\mu\text{Sv/y}$)**

Time	Starboard berth readings	Port berth readings	Mean of berth readings	Starboard mud	Port mud	Mean mud	Annual dose when boat was not shielded by water	Annual total dose	EA monitoring position
Measurements taken for part of the tidal period when the boat was unshielded by water									
11.30	0.091	0.092	0.092	0.102	0.093	0.098			0.085
12.30	0.096	0.097	0.097	0.097	0.095	0.096			
13.30	0.091	0.096	0.094	0.101	0.096	0.099			
13.40	0.086	0.097	0.092	0.102	0.090	0.096			
13.50	0.094	0.095	0.095	0.093	0.098	0.096			
14.20	0.091	0.097	0.094	0.087	0.092	0.090			
15.40	0.090	0.094	0.092	0.081	0.082	0.082			
15.50	Not measured	Not measured	Not measured	0.094	0.090	0.092			
		Mean	0.093		Mean	0.093	148.7	155.8	
							Annual dose when boat was shielded by water		
Measurements taken for the tidal period when the boat was partly and fully shielded by water									
14.40	0.089	0.086	0.088	0.087	0.088	0.088			
14.50	0.077	0.080	0.079	0.083	0.074	0.079			
15.00	0.078	0.078	0.078	0.071	0.067	0.069			
15.10	0.077	0.080	0.079	0.073	0.074	0.074			
15.20	0.082	0.081	0.082	0.078	0.071	0.075			
15.30	0.089	0.085	0.087	0.078	0.076	0.077			
		Mean	0.082		Mean	0.077	7.1		



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