Radon in Dwellings in Northern Ireland: 2009 Review and Atlas

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ABSTRACT

This report details the work, funded by the Northern Ireland Environment Agency, to produce a more detailed map of the probability of high radon concentrations in homes throughout Northern Ireland and to bring together all the data held in the UK national radon database on radon levels in homes in Northern Ireland. It updates previous reports and presents the first radon probability map at a resolution of 1-km squares of the Irish Grid.

Data from radon measurements in over 23,000 Northern Ireland homes are presented in tabular format by local authority, by Health Board area and by various divisions of the postcode system. The radon probability maps are based on the Irish grid system and show some geographical detail, such as council boundaries, settlements and major roads.

The areas on the maps with a 1% or greater probability of the radon level in a dwelling exceeding the Action Level are designated radon Affected Areas. It is recommended that the current radon programme should be continued in radon Affected Areas with the twin objectives of identifying homes with radon concentrations at or above the Action Level and encouraging owner-occupiers and landlords to reduce the radon level.

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This study was funded by the Northern Ireland Environment Agency

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Approval: November 2009
Publication: November 2009

ISBN 978-0-85951- 654-9

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1 RADON

Radon is a radioactive gas and isotopes, different forms of the same element, occur in the three naturally-occurring decay chains headed by uranium-238, uranium-235 and thorium-232. Uranium and thorium are found naturally in trace amounts in most rocks and soils; the most abundant isotope of uranium (over 99%) is uranium-238 which includes radon-222 in its decay chain. The higher abundance of radon-222, coupled with a relatively long half-life of 3.8 days, means it is the most important radon isotope as far as risks to human health are concerned. The other two isotopes, radon-219 and radon-220, have half-lives of 3.9 seconds and 54 seconds and are less able to escape from the ground before undergoing further radioactive decay into solid elements. Attention is therefore focussed on radon-222 and it will be referred to as radon in this report.

Radon is measured in becquerels per cubic metre of air (Bq m^{-3}). The average concentration in Northern Ireland homes is 19 Bq m^{-3} but much higher levels can occur: the level in one home can be ten times higher or lower than the home next door.

Radon is one of a group of elements, called the noble gases, that also includes helium and neon. These elements do not readily react to form chemical compounds and are simple gases under most conditions. However radon undergoes radioactive decay by alpha-particle emission to form a short-lived isotope of polonium. Several further short-lived decay products are formed in a series of decays by alpha and beta-particle emission before a long-lived isotope, lead-210 – half-life 22 years, is reached. It is the short-lived decay products of radon that are responsible for its serious health effects.

More information about radon can be found on the web sites operated by the Health Protection Agency (HPA), www.hpa.org.uk and www.ukradon.org and in several of the references listed in section 11, in particular ICRP (1993), NRPB (2000), AGIR (2009), WHO (2009) and UNSCEAR (2009).

2 HEALTH EFFECTS OF EXPOSURE TO RADON AND ITS SHORT-LIVED DECAY PRODUCTS

The Northern Ireland population is exposed to ionising radiation from natural and man-made sources. The first report on radon in dwellings in Northern Ireland concluded that the arithmetic mean doses in Northern Ireland are essentially the same as for the UK (DOE(NI) 1989): the pie chart in figure 1 shows the average exposure from all sources. Radiation of natural origin is responsible for the majority of the exposure and the largest contribution comes from radon. According to the latest review by the Health Protection Agency – Radiation Protection Division (RPD), 84% of the average annual dose to the UK population from all sources comes from the four main components of natural ionising radiation (Watson, 2005). The contributions to the total exposure of the population from the four natural sources of ionising radiation and their contributions are; 9.5% from long-lived natural radionuclides in diet; 12% from cosmic radiation; 13% from terrestrial gamma radiation; 50% from radon and its short-lived decay products.

The detrimental effects of exposure to high radon levels were first observed in sixteenth century silver miners in central Europe who showed high levels of fatal lung disease, later identified as lung cancer in the second half of the nineteenth century. Radon was not identified until the beginning of the twentieth century; the link between radon and lung cancer was made some decades later and the pivotal role of the short-lived decay products in delivering the alpha-radiation dose to the lung not unravelled until the 1950s (ICRP, 1993).

In the second half of the twentieth century, many epidemiological studies of groups of miners in different parts of the world demonstrated a statistically significant increase in the risk of lung cancer and, in the larger studies, a positive trend in lung cancer rates was found with increasing radon exposure. The main studies, involving over 60,000 miners and 2,600 cases of lung cancer, were the subject of combined analyses that point to radon as the most probable cause of the extra cases of lung cancer (BEIR VI Committee, 1999; UNSCEAR, 2009).

In the final decade of the twentieth century, the first substantial epidemiological case-control studies linking radon levels and lung cancer rates in Swedish and English homes were published. These studies showed that the risks from exposure to elevated levels of radon in the home were consistent with the outcomes of previous studies on miners of both uranium and other minerals, who were occupationally exposed to radon. All these studies have consistently shown an increased risk of lung cancer with radon exposure for both smokers and non-smokers. Further studies and, in particular, two international pooling studies in Europe and North America, have now demonstrated and quantified more precisely than before, the risks from exposure to radon in the home and confirmed that the risk from radon is considerably higher for cigarette smokers than for non-smokers (Darby, 2005; Krewski, 2005, 2006). A review of the evidence of the effects of exposure to radon and its immediate decay products on the health of the UK population was published earlier this year by the HPA’s independent Advisory Group on Ionising Radiation (AGIR, 2009). The Group concluded that the available evidence indicates a causal association between lung-cancer and radon at concentrations encountered indoors in ordinary homes and that the dose-response relationship appears linear with no evidence of any threshold radon concentration below which there is no risk. It is estimated that 3.3% of UK lung cancer deaths are attributable to radon. This translates to over a 1,100 deaths a year in the UK and around 30 deaths a year out of the 850 lung-cancer deaths in Northern Ireland (NIE, 2009). About half these deaths occur amongst the quarter of the population who are current smokers.

Global perspectives of the effects of exposure to radon gas are provided by reports published by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2009) and the World Health Organisation (WHO, 2009).

3 CURRENT UK CONTROL STRATEGY

Advice and guidance on exposure to radon in UK dwellings was first provided by the National Radiological Protection Board (NRPB, now the Radiation Protection Division of the Health Protection Agency, HPA) in early 1987 (NRPB, 1987). In January 1990, NRPB published advice to Government on the principles to limit of human exposure to radon in homes (NRPB, 1990a). A supporting document explored the practical implications and provided numerical limits (NRPB, 1990b). The recommendations included an Action Level for radon in existing homes in the UK of 200 Bq m^{-3} averaged over a year; that parts of the country with 1% probability or more of present or future homes being above the Action Level, identified from radiological evidence and periodically reviewed, should be regarded as Affected Areas; and that appropriate Government authorities should delimit localities where precautions against radon should be installed in future homes.

The first Affected Areas in Northern Ireland, in the southeast, were delineated in 1993 (NRPB, 1993a) and assessments were completed for all Northern Ireland in 1999 (NRPB, 1999a). The Building Regulations (Northern Ireland) 2000 came into operation on 1st April 2001 and regulation C2 (2) required measures to prevent or limit the ingress of radon from the ground into any dwelling built in designated areas (BRNI, 2000). More detailed guidance on protective measures for new dwellings in Northern Ireland was published in 2001 by the Building Research Establishment (BRE, 2001).

Reference is made in the previous section to a recently published review of radon and public health (AGIR, 2009). The review found that there is substantial evidence that there is a risk below 200 Bq m^{-3}, the current UK Action Level. In May 2008, HPA recommended that UK Building Regulations and Standards should be changed to ensure that all new property incorporates the basic materials and measures necessary to reduce internal radon levels (HPA, 2008). At the time of writing, HPA is reviewing its advice on the limitation on human exposure to radon and has published a consultation document (HPA, 2009). The consultation document also contains an initial response to the 16 recommendations made in the AGIR document.

4 PREVIOUS RADON PROGRAMMES IN NORTHERN IRELAND

This report is the fourth in a series on radon in dwellings in Northern Ireland and relates specifically to the programme since 1999. The earlier reports detail the initial surveys and the more intensive measurement programme which resulted in the publication of the first definitive radon probability map for the whole of Northern Ireland (DOE(NI), 1989; NRPB, 1993b; NRPB, 1999b). This triggered a further programme to raise the awareness of the health risks from radon amongst householders in the highest risk areas.

5 THE CURRENT PROGRAMME, 1999 TO 2009

In the latter part of 1999 and 2000, all 26,000 domestic addresses without a valid radon measurement in the areas shown on the map with a 5% or greater risk of elevated radon levels received an offer of a free radon measurement. Some 5,500 householders took up the offer, a response rate of 21%. It should be noted that this offer was in addition to offers made before 1999, especially to householders in the south-east of Northern Ireland.

The programme continued with emphasis on a more direct and local approach to inform householders of the radon hazard. In 2000/2001, a series of radon road shows, staffed by officers from EHS and the relevant local council, was located in major shopping centres in the higher risk areas (Armagh, Cookstown, Downpatrick, Enniskillen, Londonderry, Omagh and Strabane). A press release was issued by EHS before each event to ensure good media coverage, a photo-call with the local Lord Mayor or Chair of the Council was held and interviews were arranged on local radio and/or television. Over 1500 people attended these events and free radon measurements were offered to more than 800 householders.

The policy of keeping the issue of exposure to radon in the home in the public eye was maintained by the EHS which provided speakers at a public meeting in Portaferry (2000) and presentations to the Northern Ireland Local Government Association in Ballymena (2003) and at the Annual General Meeting of House Surveyors (2004). An important part of the programme was the continuation of the policy of offering any householder in a radon Affected Area a measurement free of charge on request.

Following a successful pilot, EHS inspectors worked with officials from the Newry and Mourne District Council and the Southern Public Health Group during the autumn of 2003 to visit over 500 homes in areas around Kilkeel with a greater than 30% probability of elevated radon levels. The visits were preceded by a mail-shot and the householders of unmeasured homes were offered a free measurement. This initiative has increased the number of homes in the area with a valid radon measurement to 60%. A similar programme with Strabane District Council was carried out in the Dunnamanagh Area in late 2004. Over 120 homes were visited and 89 free measurements offered.

In early 2004, a mail-shot containing an offer of a free radon measurement was sent to 2,393 unmeasured addresses in areas with the highest risk of elevated radon levels (10% or greater) in the west of Northern Ireland: 490 householders, over 20%, took up the offer.

The final part of the radon programme reported here was a mail-shot in early 2009 to all the households in areas defined on the 1999 map with a less than 1% probability of a high level but which the more detailed map published here (see section 7) shows a greater than 3% probability. The mail-shot also targeted households in areas that the new maps had designated as greater than 10% probability for the first time. Letters offering a free radon measurement were sent to over 4,800 domestic addresses and over 1,000 householders took up the offer (21.7%).

6 RESULTS

By early 2009, valid results were available from measurements in over 23,000 Northern Ireland homes, with over 1,200 at or above the Action Level. More details of the measurement protocol and the method to calculate the annual average radon level in an individual dwelling is given in appendix A.

These data come from the different radon survey programmes carried out by NRPB and HPA in the last twenty-five years. The majority of these programmes and initiatives were on behalf of the Northern Ireland Environment Agency and its predecessor, the Environment and Heritage Service, with a small number of measurements made for individual householders and landlords. The surveys were seldom representative of the housing stock of large areas or regions. Indeed, many were intentionally targeted to areas where higher levels were expected. The initial national survey was the only one designed to obtain a population-weighted sample of homes throughout Northern Ireland (Wrixon et al, 1988). The results of this survey continue to provide the best estimates of the average exposure at both national and local authority level. Obviously as the size of the areas to be analysed decreases, the cumulative results become more representative of the total housing stock of these areas. This limitation on how well the cumulative results presented represent the overall position in an area or region needs to be recognised when consulting the data tables, especially for larger regions. It is the radon probability maps, described below, that provide the best currently available indication of the radon potential for an area.

A series of data tables, summarised below, are contained in appendix B and provide data by local authority, divisions of the postcode (see below) and Health Board area. It should be noted that the estimates of the housing stock are derived from the Pointer® address file maintained by Ordnance Survey for Northern Ireland. This file is cross-checked on a regular basis with the Post Office Address File (PAF®) maintained by the Royal Mail® for the delivery of mail. However the estimates of the housing stock may differ from those derived from other sources.

The postcode is a system used by the Royal Mail® to route post to the appropriate delivery walk. The structure of the postcode contains three established geographic units for the aggregation of data. The largest is postcode area base on the post town and denoted by the first two letters of the postcode (BT for Belfast). The BT postcode area is divided into postcode districts. Districts are denoted by the letters and numbers in the first half of the postcode, see table C3. Districts are in turn divided into postcode sectors which are denoted by the addition of the first number of the second half of the full postcode and shown in table C4.

To avoid undue precision, numerical values other than averages (see glossary for definitions) have been rounded to two or three significant figures. The administrative codes used in the tables are those promulgated by the Office for National Statistics. Finally, to avoid giving misleading averages based on small numbers of results and to preserve confidentiality for individual householders, postcode districts or sectors with fewer than 5 results have been excluded from tables C3 and C4.

Table C1	Overall summary data for Northern Ireland
Table C2	Summary data by local authority. (Not representative, see text)
Table C3	Summary data by postcode district (5 or more results)
Table C4	Summary data by postcode sector (5 or more results)
Table C5	Summary data by Health Board area

A further table, number C6, provides estimates of the number of homes in each division of the radon maps and of the number of homes expected to be at or above the Action Level by Local Authority. These data are included as an aid to planning any future radon programmes and are discussed in more detail in the following sections.

7 MAPPING

Indoor radon concentrations are affected by indoor and outdoor temperatures, by winds, ventilation conditions, and other factors. Correction factors are applied to average out these temporal variations and to allow sensible comparison between results from measurements at different seasons of the year and in different years.

Measurements are made with two passive integrating detectors in each dwelling – one in the main living area and one in a regularly used bedroom. The detectors are placed for three months and the results combined to reflect typical occupancy patterns. Since indoor radon levels are usually higher in cold weather, the results reported to householders are normalised for typical seasonal variations in radon levels to allow the estimated annual radon concentration to be reported (Wrixon et al, 1988) and compared to the Action Level. It has been shown (Miles, 1998) that the seasonal variations correspond to average outdoor temperature variations. To allow for the fact that weather patterns vary from year to year, the annual average radon concentrations in houses used in the mapping reported here were calculated using temperature corrections based on temperature at the time of measurement, rather than seasonal corrections.

The significant increased density of data since the 1999 report has allowed mapping at the finer detail of 1-km squares as opposed to the 5-km grid used in the 1999 maps (Miles, 2002). Otherwise, the techniques used to estimate the fraction of the housing stock exceeding the radon Action Level in grid squares in Northern Ireland were similar to those used previously (NRPB, 1999a). The distribution of radon concentrations in homes is approximately log-normal whether the sample is taken from the whole housing stock or a single grid square. Lognormal modelling of the results of radon measurements in homes allows the proportion above the Action Level to be estimated. The methodology is described in more detail by Miles (1998).

Some of the grid squares had no radon results. Most of these have virtually no population, so it is not meaningful to refer to the fraction of the existing housing stock above the Action Level. It is useful, however, to estimate the percentage of the housing stock that would be above the Action Level in these squares to allow preventive measures against radon to be taken should new houses be constructed. For this reason, blank squares were in-filled using procedures described by Miles (2002).

The results are shown in the following series of figures and maps. Figure 2 gives an overview of the whole of Northern Ireland and shows the estimated proportion of homes in each 1-km grid square with radon concentrations exceeding the Action Level of 200 Bq m^{-3}: the proportions range from below 1% to above 30%. Figure 3 shows the number of measurements made in each 1-km grid square and figure 4 is the key to the following map plates.

The 5 map plates, listed below, show the same data as figure 1 at a larger scale together with geographical detail such as settlements, major roads and administrative boundaries. Note that the settlements are selected to give an even spread of locational information and not on the basis of their populations. Each plate covers approximately 6,000 km^2.

Map 1	Southwest Northern Ireland
Map 2	Southern Northern Ireland
Map 3	Southeastern Northern Ireland
Map 4	Northwestern Northern Ireland
Map 5	Northeastern Northern Ireland

8 DISCUSSION

The data presented give a clearer picture of radon levels in Northern Ireland homes. They confirm that for the majority of the population of Northern Ireland, who live in the Greater Belfast area, radon levels in homes are generally low and are not a cause for concern. However the new, more detailed maps confirm the greater probability of finding homes with radon concentrations above the Action Level in parts of the districts of Newry and Mourne, Down and, to a lesser extent, Banbridge in the south-east; an area in the west centred in Strabane District; areas of the far south-west, south of Lower Lough Erne; a small area east of Upper Lough Erne and several areas in the central districts of Cookstown, Dungannon and Omagh. In contrast, the probability of high radon concentrations is low in most of the north and north-east of Northern Ireland which lies on a basalt shield. The exception is a moderate risk area between Ballycastle and Ballintoy on the north coast.

The parts of Northern Ireland shown in Figure 2 and the following 5 map plates, with a probability of 1% or more of homes being above the Action Level, are radon Affected Areas as defined in the NRPB Statement on radon in homes (NRPB, 1990a). The primary purpose of these maps is to draw attention to the areas where radon exposures should be reduced or future exposures minimised: priority of measurement and remediation should be given to those areas with the higher proportions of affected homes.

The appropriate Government authorities may wish to review the requirements for the provision of precautions against radon entry into new buildings, extensions, refurbishments and conversions under the Building Regulations (Northern Ireland) (BRNI, 2000). If the requirements are reviewed in the light of the more detailed map, consideration should also be given to the recent advice given by HPA to extend radon precautions to all new buildings in all areas (HPA, 2008).

The final table, number C6, in appendix C is provided as an aid to planning surveys and is based on the outcome of the mapping calculations (see above). Data are provided for each local authority; the third column gives the total housing stock taken from the Post Office Address file. The next six columns divide the total housing stock by the probability bands shown on the radon maps. The penultimate column provides the total number of dwellings in radon Affected Areas: note that the numbers are rounded to avoid an appearance of undue precision. The final column is the estimated range of the number of homes expected to be at or above the Action Level of 200 Bq m^{-3} in the district as a whole including the small number in the less than one percent probability band (non-Affected Area).

This tabulation is intended to provide a guide to planning if the programmes aimed at identifying homes with elevated radon levels is continued. Once identified, the owner-occupiers or landlords as appropriate should be encouraged to carry out remedial works to reduce the radon concentration to an acceptable level.

The data in table C6 shows that there are around 81,000 homes in areas of Northern Ireland with a 1% or greater probability of a radon level being at or above the current Action Level of 200 Bq m^{-3} and that the total number of homes at or above the Action Level is estimated to be between 2,400 and 4,400.

9 CONCLUSIONS

i. The parts of Northern Ireland shown in Figure 2 and the following five map plates, with a probability of 1% or more of homes being above the Action Level, are radon Affected Areas as defined in the NRPB Statement on radon in homes (NRPB, 1990).

ii. The current radon programme should be continued in radon Affected Areas with the twin objectives of identifying homes with radon concentrations at or above the Action Level and encouraging owner-occupiers and landlords to reduce the radon to an acceptable level.

10 GLOSSARY

Averages. The numerical radon results in this report are presented in two ways: arithmetic average and geometric average. The arithmetic average (AA) is the normal value used to describe numerical results: it is the sum of all the results divided by the number of results. The geometric average (GA) is the n^{th} root of all the results multiplied together.

Becquerel. Symbol Bq. The unit of the amount or activity of a radionuclide. Describes the rate which transformations occur. 1 Bq = 1 transformation per second.

Becquerel per cubic metre of air. Symbol Bq m^{-3}. The amount of a radionuclide in each cubic metre of air. Often referred to as the activity concentration.

Half-life. The time taken for half the amount of a radioactive element to undergo a radioactive transformation and form a different element.

Isotopes. Chemically identical forms of an element with different masses. The mass is indicated by the number after the element.

Radon Action Level. The recommended upper limit for the activity concentration of radon in UK homes. Its value, expressed as the annual average radon gas concentration in the home, is 200 Bq m^{-3}.

Radon Affected Areas. Parts of the country with a 1% probability or more of present or future homes being above the Action Level.

Radioactivity. The spontaneous disintegration of unstable elements *(radionuclides).* During the process energy is emitted as either *alpha* or *beta particles* or *gamma rays*

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12 ACKNOWLEDGEMENTS

We wish to thank C R Muirhead for his advice on statistical aspects of this work and present and past members of the radon team at HPA and previously NRPB for all their efforts.

The data reported in the tables and used to construct the maps were collected during many surveys carried out by HPA and previously by NRPB on behalf of the Northern Ireland Environment Agency and its predecessors, local councils, landlords and individual householders.

13 FIGURES AND MAPS

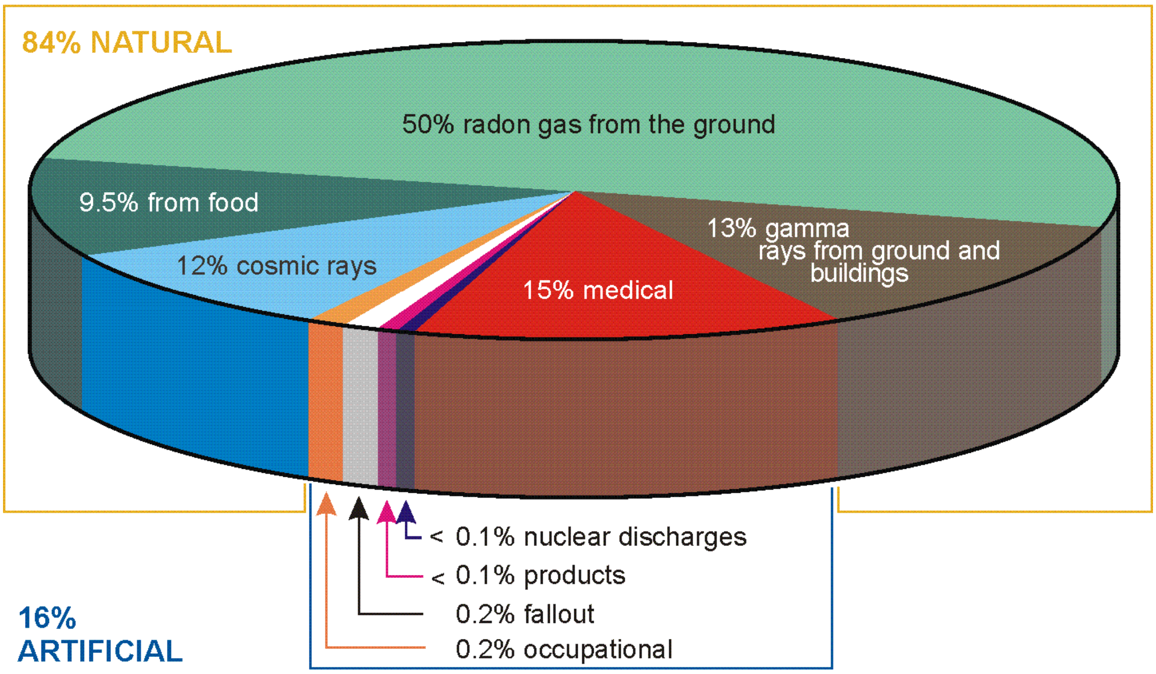


Figure 1 Average radiation exposure to the Northern Ireland population from all sources

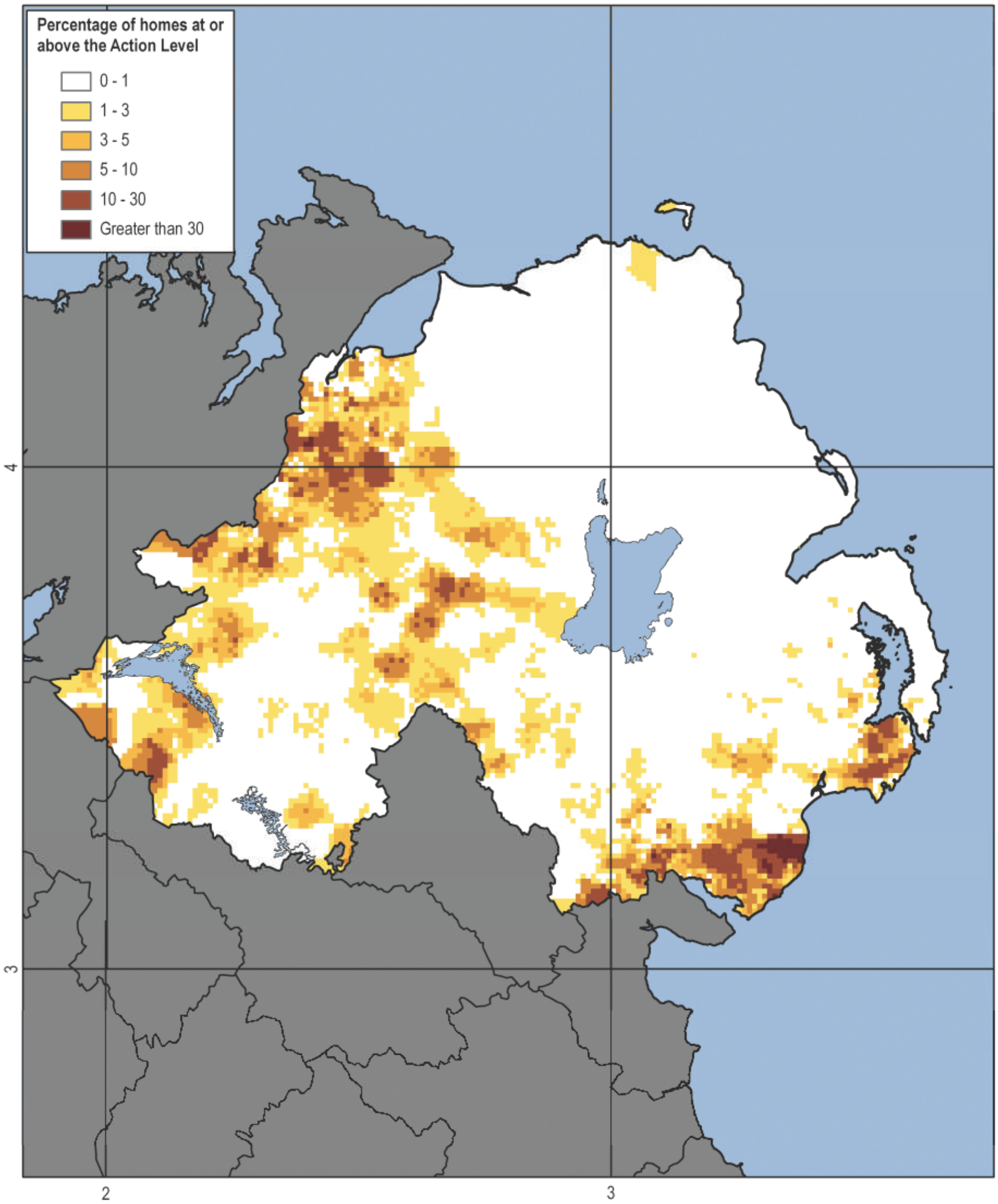


Figure 2 Overall map of radon Affected Areas in Northern Ireland (axis numbers are the 100 km co-ordinates of the Irish Grid)

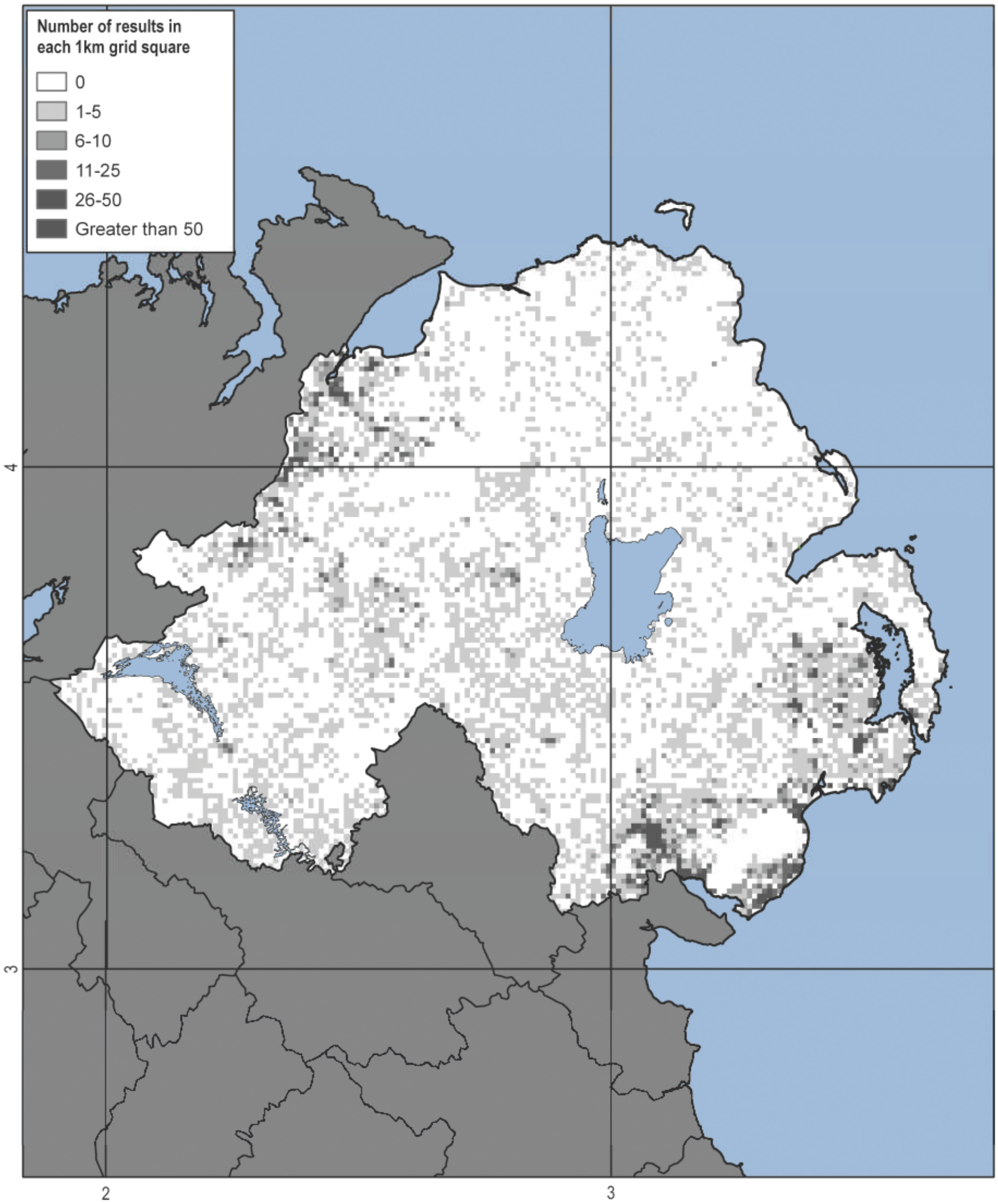


Figure 3 Number of results within each 1-km grid square (axis numbers are the 100 km co-ordinates of the Irish Grid)

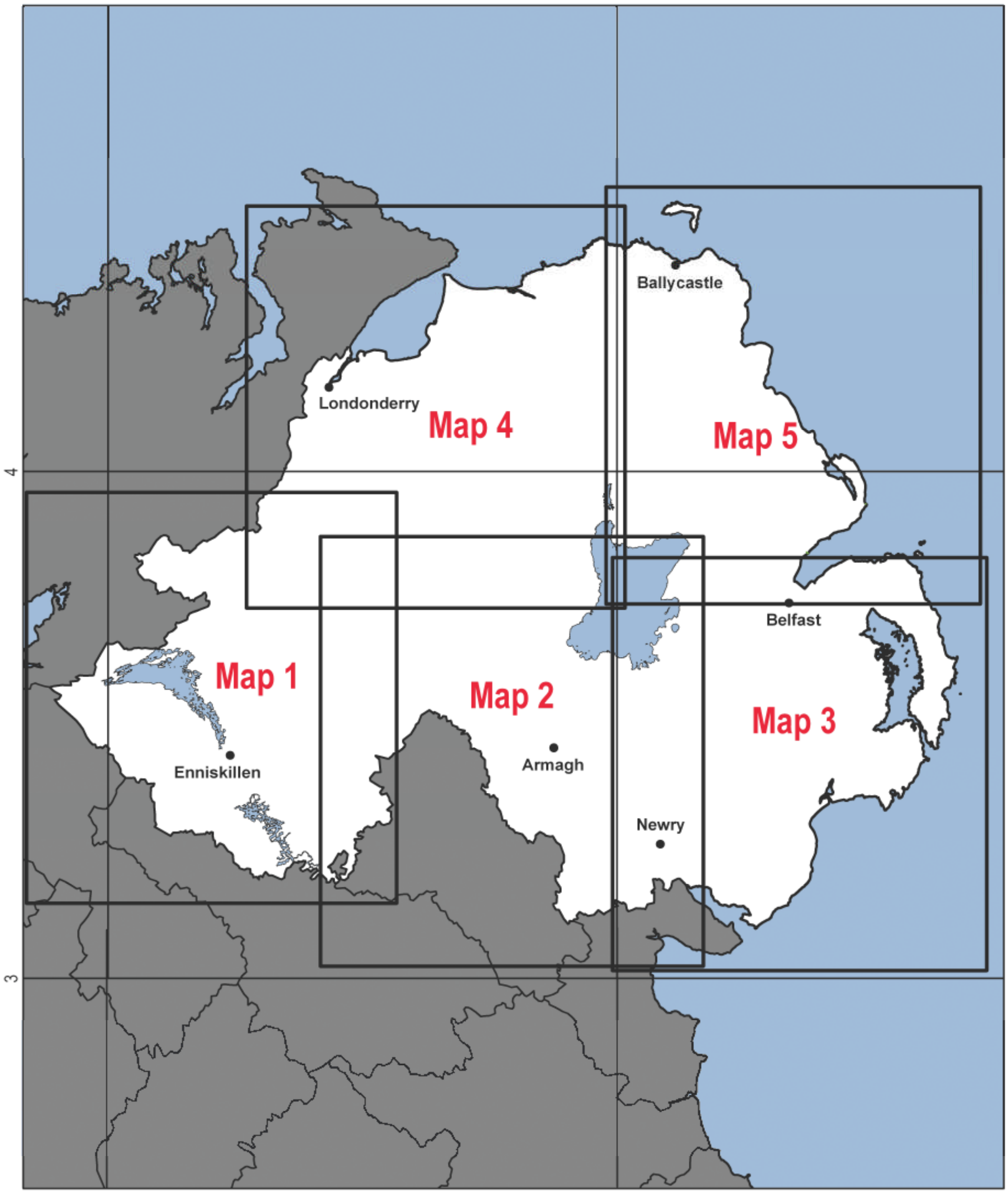
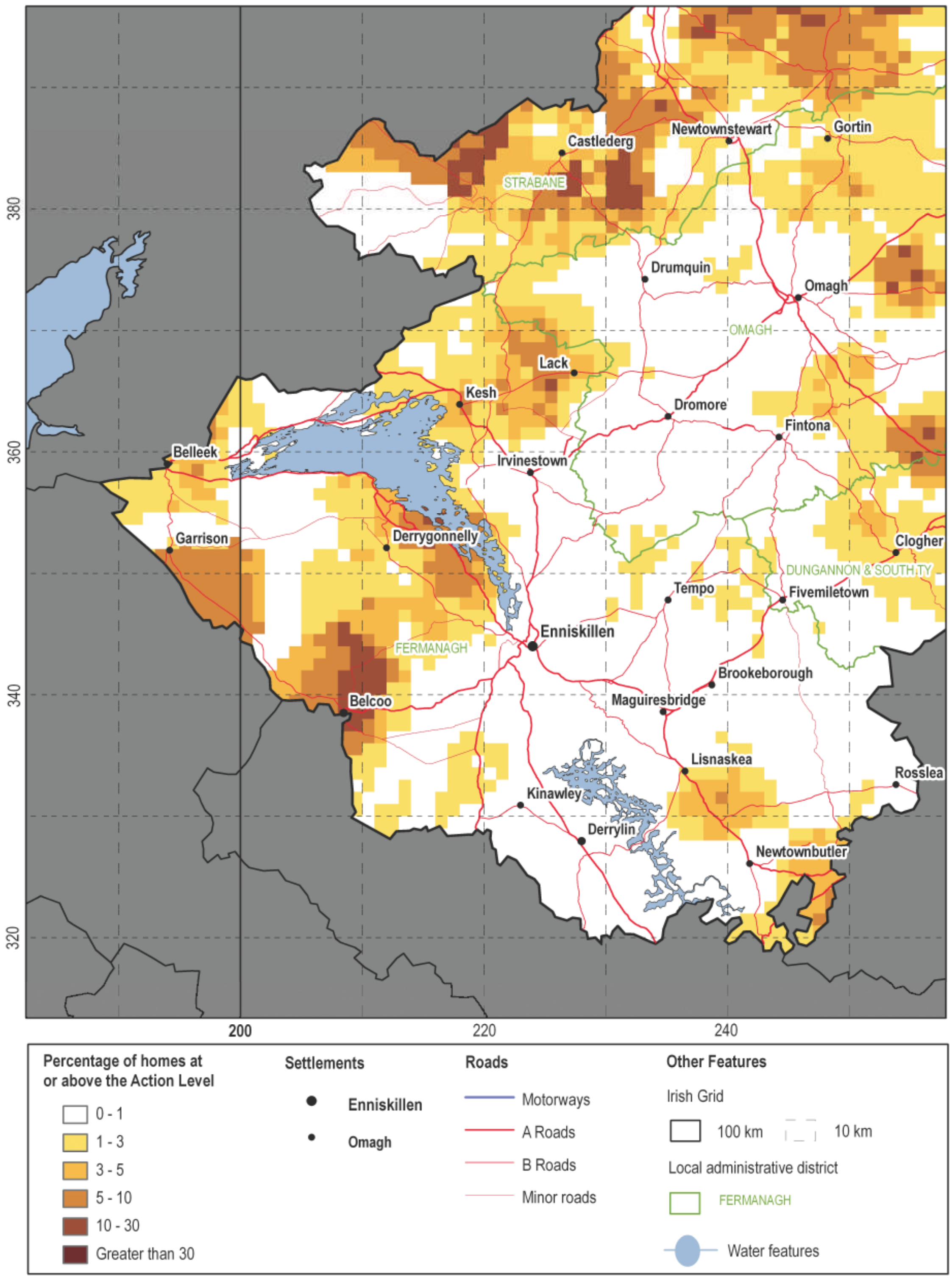
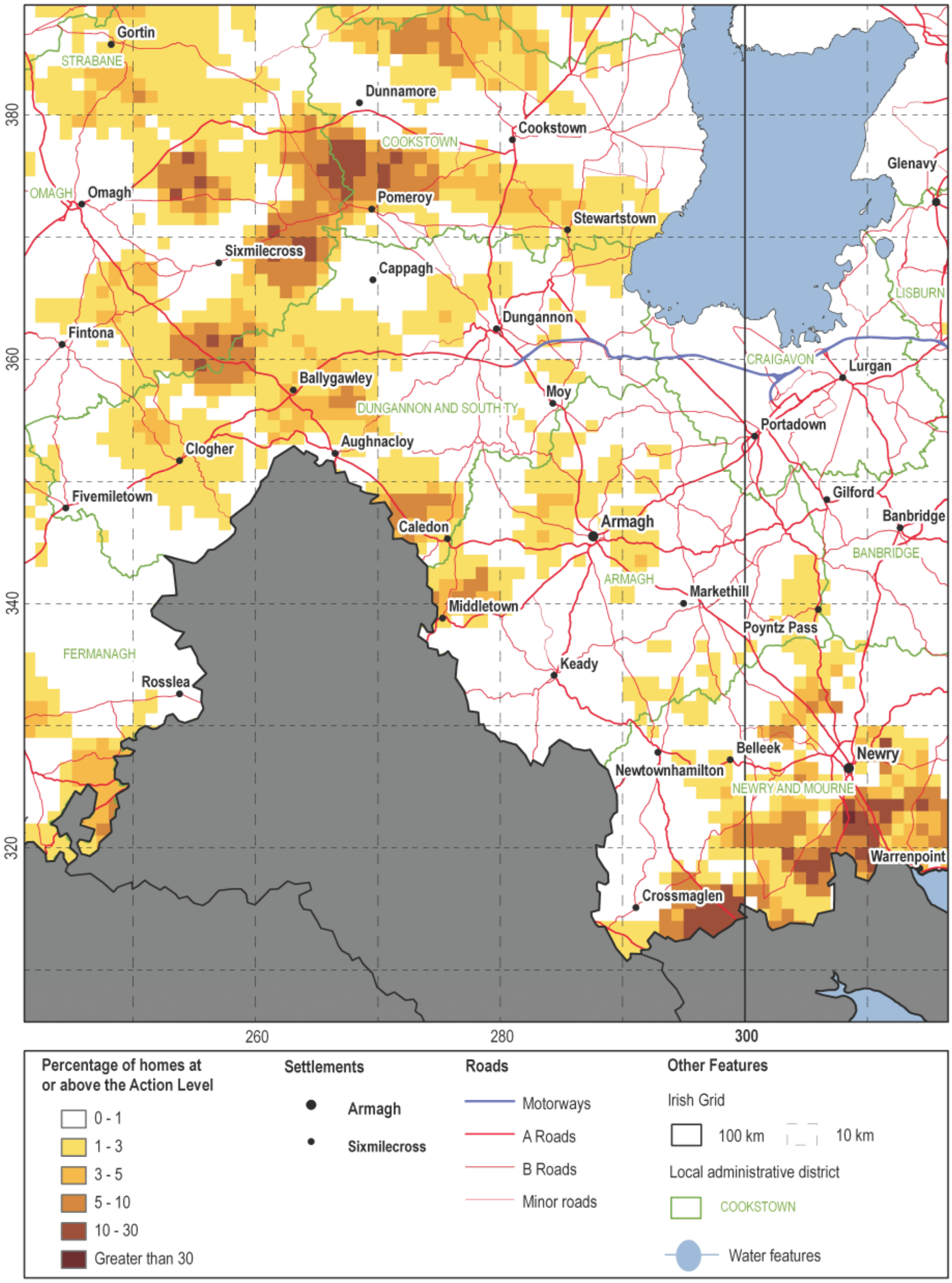


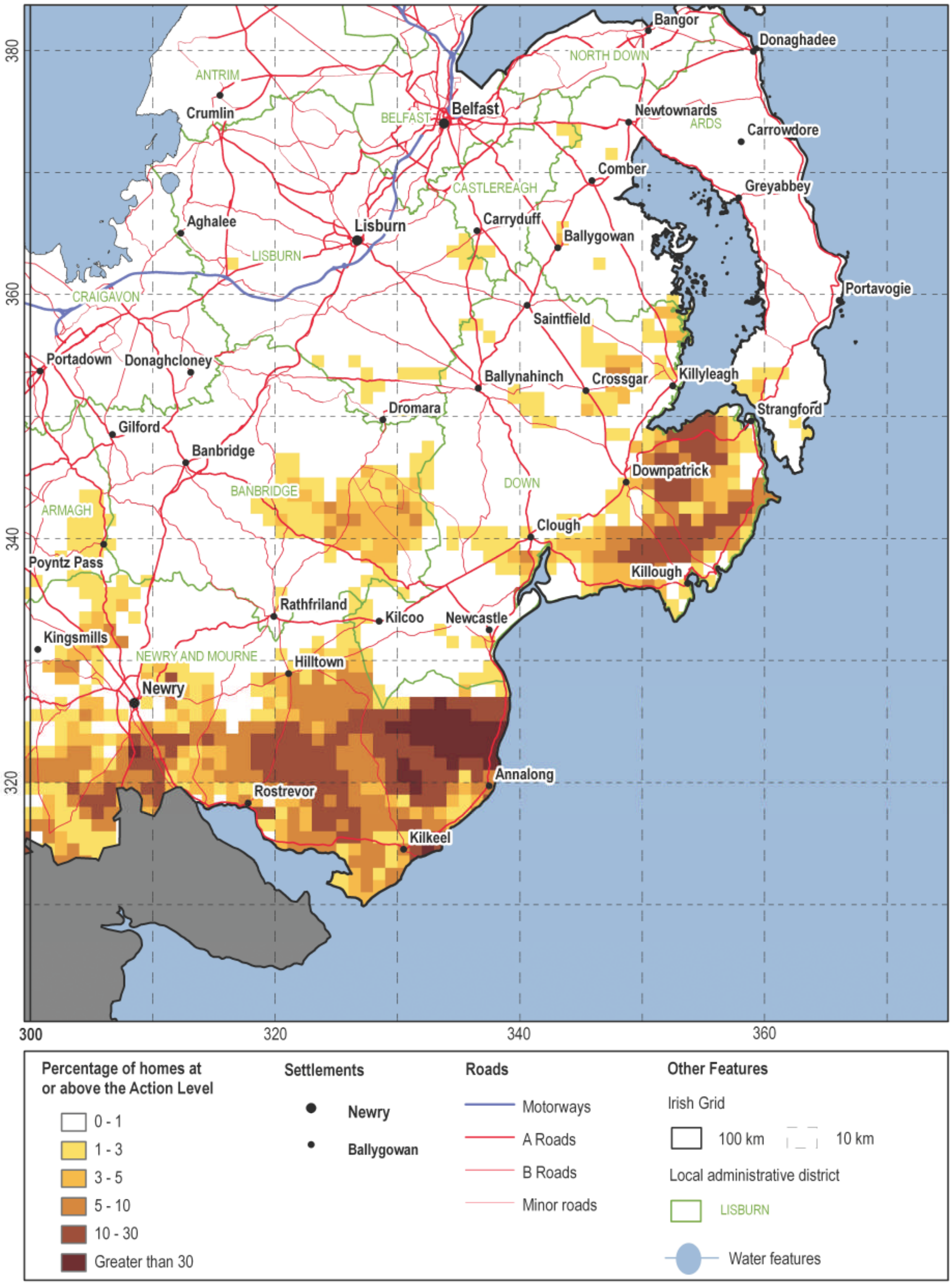
Figure 4 Key to larger scale maps (axis numbers are the 100 km co-ordinates of the Irish Grid)



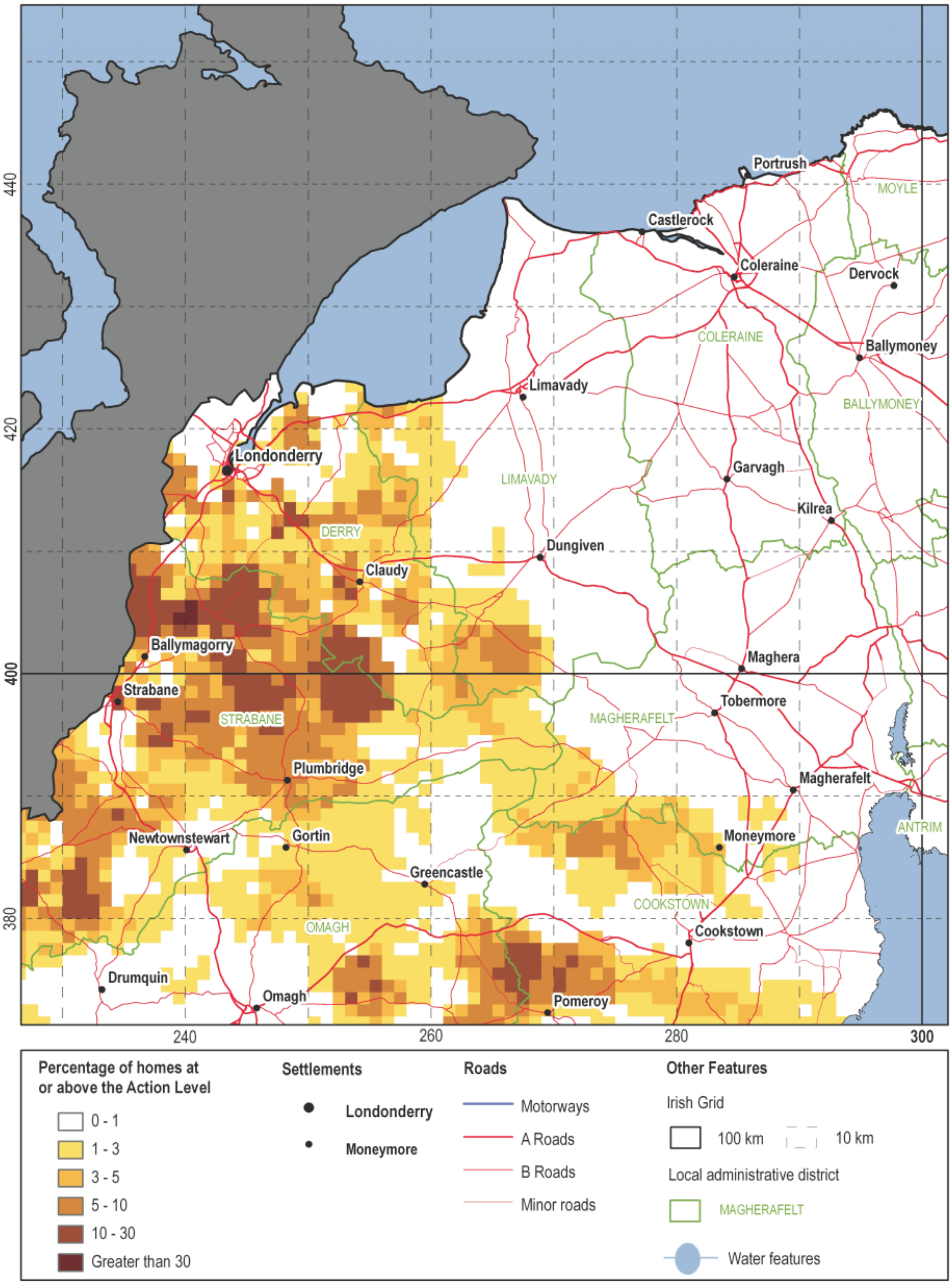
Map 1 Southwest Northern Ireland (axis numbers are the coordinates of the Irish Grid)



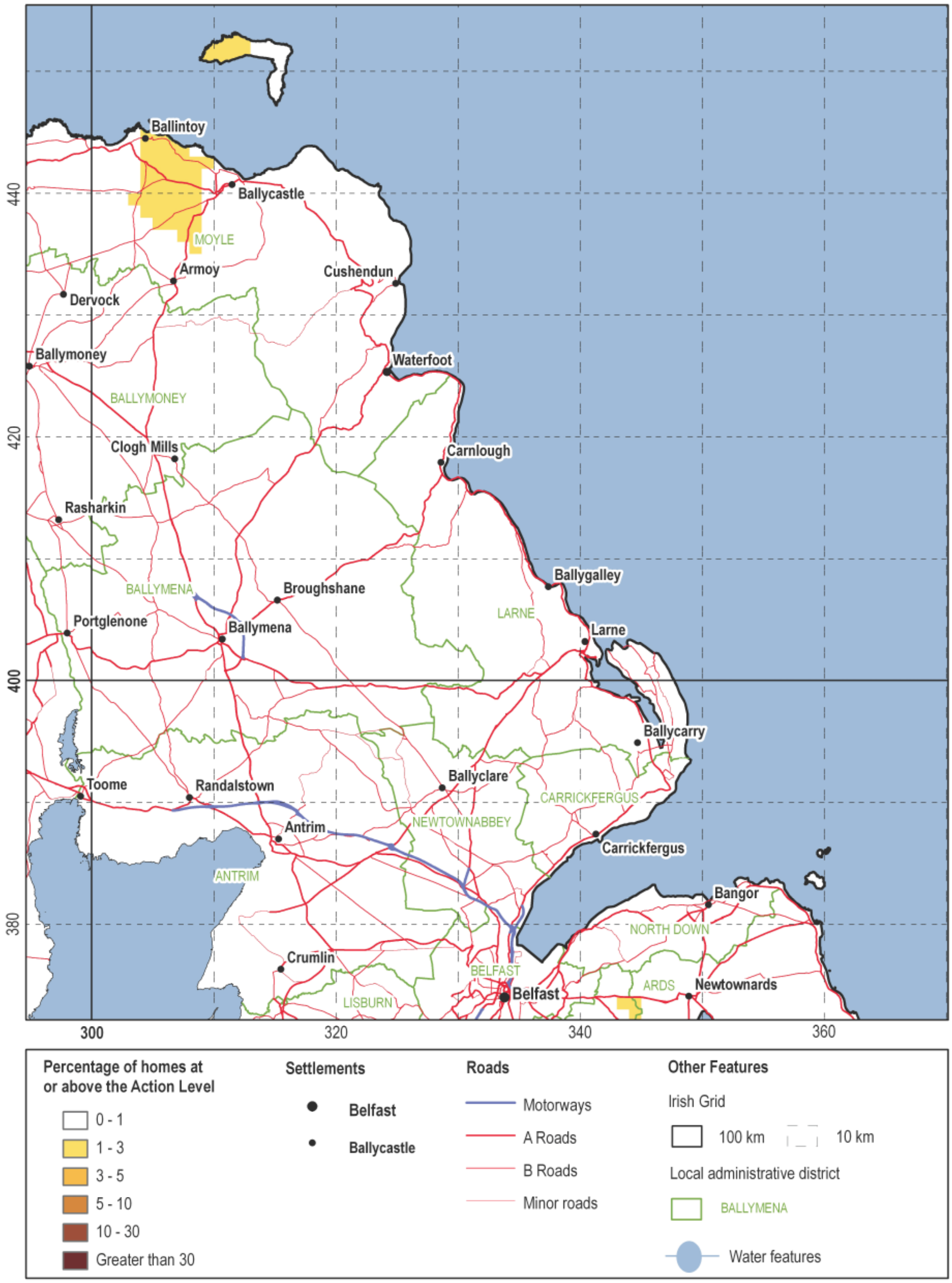
Map 2 Southern Northern Ireland (axis numbers are the coordinates of the Irish Grid)



Map 3 Southeastern Northern Ireland (axis numbers are the coordinates of the Irish Grid)



Map 4 Northwestern Northern Ireland (axis numbers are the coordinates of the Irish Grid)



Map 5 Northeastern Northern Ireland (axis numbers are the coordinates of the Irish Grid)

APPENDIX A Details of the measurement procedures

A1 MEASUREMENT PROCEDURE

Measurements in all the surveys, including the earlier surveys, are made with two passive integrating detectors in each dwelling – one in the main living area and one in a regularly used bedroom. The detectors were sent by post to participating householders together with placement instructions, a short questionnaire to record placement and removal dates and brief details about the dwelling and pre-paid return packaging. The two detectors remain *in situ* for three months and are returned to HPA for analysis. The individual results are combined to reflect typical occupancy patterns. Since indoor radon levels are usually higher in cold weather, the results reported to householders are normalised for typical seasonal variations in radon levels to allow the estimated annual radon concentration to be reported and compared to the radon Action Level (Wrixon et al, 1988; Pinel et al, 1995). Householders are informed by letter of the result and its significance explained: if appropriate, advice on remedial measures is also provided.

The passive radon detectors are the standard clam-shell design described in the first report (NRPB, 1989). A relatively recent innovation has been the use of electrical-conducting carbon-loaded plastic to make the casing. This improves the performance of the detector by greatly reducing the build-up of static electricity which can cause erroneous readings.

Figure A1. Old (yellow) and new (black) passive radon detectors.

APPENDIX B Data tables of measurements in dwellings

Table C1. Overall summary data for Northern Ireland

Dwellings		Results, Bq m^{-3}				Dwellings
Total	Measured	Arithmetic average	Geometric average	Population weighted average*	Highest level found	at or above Action Level
751000	24000	70	46	19	4900	1200

* value from the UK national radon survey (Wrixon et al, 1988)

Table C2. Summary data by local authority. (Not representative, see text)

		Dwellings		Results, Bq m^{-3}			Dwellings
Code	Local authority	Total	Measured	Arithmetic average	Geometric average	Highest	at or above Action Level
95T	Antrim	20000	120	26	19	360	1
95X	Ards	32800	950	44	34	460	7
95O	Armagh	23000	480	49	36	290	11
95G	Ballymena	25900	160	23	19	130	0
95D	Ballymoney	11800	110	21	17	74	0
95Q	Banbridge	18800	460	46	33	920	11
95Z	Belfast	129000	36	24	19	73	0
95V	Carrickfergus	16800	30	20	17	62	0
95Y	Castlereagh	28400	150	52	35	1300	1
95C	Coleraine	27600	140	24	20	79	0
95I	Cookstown	13300	440	63	42	1500	15
95N	Craigavon	37100	130	31	25	190	0
95A	Derry City	40700	2000	73	48	4900	100
95R	Down	27900	4500	59	41	1600	150
95M	Dungannon	20900	540	53	38	440	14
95L	Fermanagh	20600	1200	56	33	3900	48
95F	Larne	13900	120	26	17	220	2
95B	Limavady	12600	290	51	36	400	7
95S	Lisburn	45500	300	42	32	290	2
95H	Magherafelt	15800	230	42	25	2000	3
95E	Moyle	8100	170	39	28	250	1
95P	Newry and Mourne	36400	7300	90	63	2500	590
95U	Newtownabbey	35300	78	23	17	130	0
95W	North Down	34500	43	29	22	93	0
95K	Omagh	19600	1000	63	43	750	50
95J	Strabane	15700	2800	86	55	1600	230

Table C3. Summary data by postcode district (5 or more results)

Postcode district	Dwellings		Results, Bq m^{-3}			Dwellings at or above Action Level
	Total	Measured	Arithmetic average	Geometric average	Highest	
BT14	14000	7	14	13	23	0
BT15	12800	5	16	16	22	0
BT17	12600	11	21	15	74	0
BT18	6500	15	37	30	92	0
BT19	15900	19	30	23	93	0
BT20	12100	10	19	13	46	0
BT21	3700	31	46	32	220	1
BT22	9300	420	37	28	460	4
BT23	22600	550	50	40	210	2
BT24	7000	880	49	41	300	3
BT25	5800	130	42	32	250	1
BT26	3600	79	46	36	180	0
BT27	9300	96	50	40	290	1
BT28	16100	38	28	20	230	1
BT29	5400	40	23	20	64	0
BT30	14100	2400	71	46	1600	130
BT31	3200	190	51	33	920	6
BT32	9900	110	38	29	260	1
BT33	5000	1000	43	32	370	16
BT34	22500	5300	93	66	2500	460
BT35	16700	2400	76	52	1900	130
BT36	18900	24	21	16	66	0
BT37	11600	16	25	15	130	0
BT38	17600	34	20	17	62	0
BT39	9600	67	29	20	360	1
BT40	11700	53	30	21	220	1
BT41	16200	89	22	18	130	0
BT42	14400	86	26	21	150	0
BT43	9200	44	23	20	80	0
BT44	9400	170	27	19	220	1
BT45	12800	190	45	26	2000	3
BT46	3700	53	28	22	120	0
BT47	23700	2100	74	49	4900	110
BT48	22800	190	51	37	490	6
BT49	8900	110	32	24	190	0
BT5	18600	6	31	27	59	0
BT51	10600	100	25	21	77	0
BT52	7600	9	21	19	33	0
BT53	10200	92	24	19	95	0
BT54	3900	73	44	32	250	1

Postcode district	Dwellings		Results, Bq m^{-3}			Dwellings at or above Action Level
	Total	Measured	Arithmetic average	Geometric average	Highest	
BT55	4900	6	28	26	48	0
BT56	4300	11	13	11	35	0
BT57	2700	25	34	25	120	0
BT60	12200	300	49	35	250	7
BT61	6200	99	56	42	290	3
BT62	13200	93	30	24	190	0
BT63	8000	29	42	30	330	1
BT65	3100	5	13	12	23	0
BT66	13300	27	36	29	190	0
BT67	9000	31	36	24	160	0
BT68	390	62	79	61	330	4
BT69	950	59	55	37	290	3
BT70	7400	300	69	45	750	15
BT71	14100	200	48	31	1500	3
BT74	7300	180	48	31	710	5
BT75	1500	55	41	29	160	0
BT76	750	35	54	35	300	1
BT77	520	19	55	41	140	0
BT78	11900	510	53	38	430	12
BT79	10100	740	66	46	960	39
BT8	11900	100	54	35	1300	1
BT80	8900	320	62	45	970	10
BT81	3300	600	81	56	1600	41
BT82	10500	1900	90	56	1500	170
BT9	13000	6	43	38	73	0
BT92	5800	440	46	31	830	13
BT93	3400	430	80	39	3900	31
BT94	4800	210	38	29	290	2

Table C4. Summary data by postcode sector (5 or more results)

Post code sector	Dwellings Total	Dwellings Measured	Results, Bq m^{-3} AA*	Results, Bq m^{-3} GA†	Results, Bq m^{-3} Highest	Dwellings at or above AL
BT14 8	4100	7	14	13	23	0
BT17 0	8700	5	10	8	16	0
BT17 9	3900	6	30	25	74	0
BT18 0	2300	8	46	40	92	0
BT18 9	4200	7	26	22	59	0
BT19 1	6300	6	32	20	93	0
BT19 6	5200	5	26	24	40	0
BT19 7	4400	8	30	25	58	0
BT21 0	3700	31	46	32	220	1
BT22 1	4500	360	39	28	460	4
BT22 2	4800	64	30	24	170	0
BT23 4	5900	10	26	20	56	0
BT23 5	5500	140	58	49	210	2
BT23 6	3000	360	48	39	180	0
BT23 7	3500	10	41	34	92	0
BT23 8	4600	20	35	30	90	0
BT24 7	2100	310	51	43	170	0
BT24 8	4900	570	48	40	300	3
BT25 1	4000	68	44	34	190	0
BT25 2	1900	66	39	30	250	1
BT26 6	3600	79	46	36	180	0
BT27 5	4300	26	49	40	150	0
BT27 6	600	67	51	42	290	1
BT28 2	6300	26	31	22	230	1
BT28 3	5500	8	22	16	56	0
BT29 4	5400	40	23	20	64	0
BT30 6	4600	710	68	46	580	38
BT30 7	3100	740	91	55	1600	65
BT30 8	2400	360	65	42	950	16
BT30 9	4200	640	53	41	470	10
BT31 9	3200	190	51	33	920	6
BT32 3	5100	30	35	26	150	0
BT32 4	3600	32	36	29	100	0
BT32 5	1200	49	40	30	260	1
BT33 0	5000	1000	43	32	370	16
BT34 1	3200	520	70	51	860	26
BT34 2	4300	740	78	55	720	53
BT34 3	5400	1600	95	70	2500	120
BT34 4	6100	1900	114	82	1300	250
BT34 5	3500	540	57	41	610	13
BT35 0	1400	55	41	33	120	0
BT35 6	3300	510	54	41	450	12
BT35 7	3200	390	65	48	860	11
BT35 8	5100	1000	90	60	1900	77
BT35 9	3600	390	87	60	1000	32
BT36 4	1600	6	28	21	66	0
BT36 5	5300	12	20	16	42	0
BT36 6	6500	5	14	11	27	0
BT37 0	6700	12	26	15	130	0
BT38 8	8200	12	19	17	30	0
BT38 9	4300	18	19	17	43	0
BT39 0	3200	27	40	24	360	1
BT39 9	6400	40	22	18	65	0
BT40 1	4000	5	24	18	45	0
BT40 2	5000	20	35	19	220	1
BT40 3	2800	28	28	23	130	0
BT41 2	3800	21	18	17	39	0
BT41 3	3900	43	25	19	130	0
BT41 4	3700	21	23	20	54	0
BT42 1	4500	17	28	23	57	0
BT42 2	3600	20	18	17	36	0
BT42 3	3000	23	34	24	150	0
BT42 4	3300	26	22	19	41	0
BT43 5	2500	7	31	23	80	0
BT43 6	3800	17	23	20	47	0
BT43 7	3000	20	20	18	38	0
BT44 0	3300	110	31	21	220	1
BT44 8	3200	24	21	18	55	0
BT44 9	3000	37	19	16	41	0
BT45 5	2900	42	42	32	320	1
BT45 6	2900	16	34	27	100	0
BT45 7	3700	110	51	26	2000	2
BT45 8	3300	24	28	22	99	0
BT46 5	3700	53	28	22	120	0
BT47 2	5000	460	65	46	780	18
BT47 3	5900	910	75	49	4900	42
BT47 4	4900	580	82	54	2200	46
BT47 5	2400	58	38	28	170	0
BT47 6	5500	79	61	47	290	2
BT48 0	5500	31	34	29	69	0
BT48 6	2000	5	38	31	57	0
BT48 7	3300	14	30	23	73	0
BT48 8	7600	99	47	37	170	0
BT48 9	4400	43	82	52	490	6
BT49 0	5600	55	31	24	190	0
BT49 9	3300	54	32	23	130	0
BT51 3	4400	9	22	18	41	0
BT51 4	3200	51	25	21	77	0
BT51 5	3000	40	25	22	48	0
BT52 1	3800	8	21	20	33	0
BT53 6	3700	17	26	24	49	0
BT53 7	3700	32	22	18	54	0

Post code sector	Dwellings Total	Dwellings Measured	Results, Bq m^{-3} AA*	Results, Bq m^{-3} GA†	Results, Bq m^{-3} Highest	Dwellings at or above AL
BT53 8	2800	43	25	18	95	0
BT54 6	3900	73	44	32	250	1
BT55 7	4900	6	28	26	48	0
BT56 8	4300	11	13	11	35	0
BT57 8	2700	25	34	25	120	0
BT60 1	3600	42	44	31	220	1
BT60 2	2900	66	51	37	200	1
BT60 3	3000	81	32	25	130	0
BT60 4	2700	110	62	48	250	5
BT61 7	1400	8	34	32	57	0
BT61 8	2300	58	61	45	290	2
BT61 9	2500	33	53	39	230	1
BT62 1	4200	47	30	25	73	0
BT62 2	2600	13	21	18	63	0
BT62 3	4300	11	21	19	38	0
BT62 4	2100	22	38	27	190	0
BT63 5	5800	16	32	27	80	0
BT63 6	2200	13	55	32	330	1
BT66 6	3600	13	43	33	190	0
BT66 7	5800	13	31	29	69	0
BT67 0	5300	25	38	25	160	0
BT67 9	3700	6	27	21	62	0
BT68 4	390	62	79	61	330	4
BT69 6	950	59	55	37	290	3
BT70 1	2900	58	54	36	440	2
BT70 2	2500	180	80	50	750	13
BT70 3	2000	67	53	40	190	0
BT71 4	4000	31	34	25	120	0
BT71 5	2100	52	66	33	1500	1
BT71 6	4500	56	38	29	180	0
BT71 7	3500	65	47	35	250	2
BT74 4	1600	18	45	35	110	0
BT74 5	820	30	64	41	710	1
BT74 6	2700	34	32	26	86	0
BT74 7	1700	28	48	33	260	1
BT74 8	230	19	75	49	400	2
BT74 9	260	37	27	20	120	0
BT75 0	1500	55	41	29	160	0
BT76 0	750	35	54	35	300	1
BT77 0	520	19	55	41	140	0
BT78 1	2600	32	38	30	190	0
BT78 2	1700	67	52	38	200	1
BT78 3	2200	73	33	25	130	0
BT78 4	2400	250	63	44	430	11
BT78 5	3000	92	50	40	190	0
BT79 0	3000	200	69	48	490	11
BT79 7	4100	220	60	46	600	8
BT79 8	1100	100	61	37	960	3
BT79 9	1900	220	73	49	660	17
BT8 8	3800	97	55	36	1300	1
BT80 0	1600	19	29	25	65	0
BT80 8	5000	70	52	40	250	2
BT80 9	2300	230	67	49	970	8
BT81 7	3300	600	81	56	1600	41
BT82 0	2400	910	117	71	1500	130
BT82 8	2500	460	81	57	710	32
BT82 9	5600	560	56	37	1300	15
BT92 0	1500	45	50	38	230	1
BT92 1	310	40	62	40	470	3
BT92 2	530	14	33	27	120	0
BT92 3	210	19	44	29	280	1
BT92 4	370	42	26	20	150	0
BT92 5	230	20	78	29	830	2
BT92 6	400	63	59	36	540	3
BT92 7	650	54	42	33	200	1
BT92 8	670	57	44	32	310	1
BT92 9	940	84	35	25	260	1
BT93 0	380	48	93	61	610	4
BT93 1	910	65	54	31	470	4
BT93 2	54	18	40	30	110	0
BT93 3	460	74	66	43	500	4
BT93 4	430	47	86	24	1500	3
BT93 5	360	85	116	41	3900	6
BT93 6	490	45	44	29	290	2
BT93 7	200	30	138	93	660	8
BT93 8	90	16	37	29	94	0
BT94 1	1600	50	48	37	180	0
BT94 2	1000	32	33	28	100	0
BT94 3	490	36	32	24	210	1
BT94 4	970	47	33	26	130	0
BT94 5	760	39	42	30	290	1

* AA = Arithmetic Average (see glossary)

† GA = Geometric Average (see glossary)

Table C5. Summary data by Health Board area

Code	Health Board	Dwellings Total	Dwellings Measured	Results, Bq m^{-3} Arithmetic average	Results, Bq m^{-3} Geometric average	Results, Bq m^{-3} Highest level found	Dwellings at or above the Action Level
ZE0	Eastern Health Board	300000	6000	55	39	1600	160
ZN0	Northern Health Board	191000	1600	39	26	2000	22
ZS0	Southern Health Board	137000	8900	82	56	2500	620
ZW0	Western Health Board	111000	7400	73	46	4900	440

Table C6. Predictive data by Local Authority

Code	Local Authority	Dwellings in each probability banding: Total	Less than 1%	1%-2.9%	3%-4.9%	5%-9.9%	10%-29.9%	More than 30%	In all Affected Areas	Dwellings: Expected numbers above Action Level
95T	Antrim	20000	20000	0	0	0	0	0	0	<10
95X	Ards	32800	32100	420	260	0	0	0	680	10 - 70
95O	Armagh	23000	19300	3500	170	42	0	0	3700	40 - 130
95G	Ballymena	25900	25900	0	0	0	0	0	0	<10
95D	Ballymoney	11800	11800	0	0	0	0	0	0	<10
95Q	Banbridge	18800	17600	710	400	64	0	0	1200	20 - 60
95Z	Belfast	129000	129000	0	0	0	0	0	0	0 - 50
95V	Carrickfergus	16800	16800	0	0	0	0	0	0	<10
95Y	Castlereagh	28400	27400	1100	0	0	0	0	1100	10 - 60
95C	Coleraine	27600	27600	0	0	0	0	0	0	0 - 10
95I	Cookstown	13300	10100	1800	950	300	110	0	3200	70 - 130
95N	Craigavon	37100	37100	0	0	0	0	0	0	0 - 50
95A	Derry City	40700	29300	7700	1200	2400	150	0	11400	250 - 460
95R	Down	27900	17600	6800	1200	1500	720	0	10200	250 - 400
95M	Dungannon	20900	15200	4900	690	110	0	0	5700	70 - 160
95L	Fermanagh	20600	15500	2500	1500	860	220	0	5100	140 - 230
95F	Larne	13900	13900	0	0	0	0	0	0	0 - 50
95B	Limavady	12600	11200	710	680	31	0	0	1400	30 - 70
95S	Lisburn	45500	45200	300	0	0	0	0	300	0 - 70
95H	Magherafelt	15800	15600	230	12	0	0	0	250	0 - 50
95E	Moyle	8100	7700	440	0	0	0	0	440	0 - 50
95P	Newry and Mourne	36400	14800	6200	6200	6700	2100	300	21600	890 - 1300
95U	Newtownabbey	35300	35300	0	0	0	0	0	0	0 - 30
95W	North Down	34500	34500	0	0	0	0	0	0	0 - 70
95K	Omagh	19600	15600	2700	510	640	190	0	4000	90 - 160
95J	Strabane	15700	4800	3600	2800	1700	2800	73	10900	500 - 680
	Totals (rounded)	732000	651000	43600	16500	14300	6300	370	81000	2400 - 4400