Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-65:
The development of a hazard map to inform an environmental AMR monitoring programme in Welsh rivers.

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Abbreviations Used in this Report

AMR	Antimicrobial resistance
ARB	Antibiotic resistant bacteria
ARDC	Antimicrobial resistance driving chemicals
ARG	Antibiotic resistance genes
CSO	Combined sewer overflow
Defra	Department for Environment, Food & Rural Affairs
EA	Environment Agency
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
GIS	Geographic Information System
NERC	Natural Environment Research Council
NRW	Natural Resources Wales
OPCAT	Operational Catchment
PE	Position Equivalent
RNAGS	Reasons for Not Achieving Good Status
UKCEH	UK Centre for Ecology & Hydrology
WFD	Water Framework Directive
WWTP	Waste Water Treatment Plant

Contents

1 SUMMARY

Antimicrobial resistance (AMR) one of the most serious global health threats facing society. Anthropogenic sources of pollution, e.g., human, animal and industrial wastewater and agriculture, have been implicated in the dissemination, selection and transmission of AMR in the environment.

This project was commissioned by the Welsh Government as a response to recommendations suggested in the Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)-55 report (Singer et al., 2021). This project aimed to undertake an evidence-gathering phase compiling data on sources of AMR and AMR driving chemicals (ARDCs) to the environment, and to use these data to inform the creation of hazard maps investigating the effects of catchment-scale pollution on AMR in Welsh river environments. This report details the outcomes of this project.

For the evidence-gathering phase of this project, data was sourced that would influence AMR in the natural environment. This included data on anthropogenic sources with the potential to release and/or elevate concentrations of ARDCs, antibiotic resistance genes (ARGs), and antibiotic resistant bacteria (ARB). Datasets were collated by searching government websites, asking key experts in the field and generating datasets that were previously non-existent (or not publicly available). A total of 54 datasets of relevance were identified and compiled in a spreadsheet along with their attributes (including URL, description, relevance to environmental monitoring of AMR, and spatial and temporal completeness).

Hazard maps were produced from the number of datasets included in the data register, attributing a level of AMR hazard to each catchment within Wales.

Firstly, a map showing catchments with potentially elevated levels of AMR in the environment was produced. This map was influenced by data indicating total population equivalents served by wastewater treatment plants, combined sewer overflows spills and duration, hospital bed numbers, and the presence of various agricultural inputs. The catchment with the highest unadjusted hazard score, indicative of having the highest likelihood of elevated levels of AMR in the environment, was the Dee Estuary catchment.

Secondly, a map ranking catchments by likelihood of human exposure to environmental AMR was produced. This map was driven by the location of designated recreational bathing waters and wild swimming in catchments. The catchments with the highest potential likelihood of exposure of humans to AMR in the environment, were the Dwyfor, Dyfi Lower and Gwyrafi Seiont catchments.

Finally, both the AMR abundance hazard map and the exposure map were combined to create a map showing the hazard posed by AMR abundance in catchments where human exposure is likely to occur. Notably, the Gwyrafi Seiont catchment had the highest adjusted hazard score for potential for AMR abundance in catchments where human exposure is most likely to occur (i.e. using these metrics, human exposure to high levels of AMR is most likely to occur).

These hazard maps can inform and guide future AMR monitoring campaigns, as well as to test and refine our understanding of the drivers of AMR in the Welsh aquatic environments.

The conclusions presented in this report are constrained by the availability of data. The availability of more granular, and temporally and spatially complete data will result in more refined estimations of AMR hazard. The hazard maps are to be used to test assumptions about AMR drivers in the aquatic environment in Wales.

2 INTRODUCTION

2.1 Background

Antimicrobial resistance (AMR) has been predicted to cause 10 million deaths by 2050 if the challenge is not addressed, rising from 700,000 deaths in 2014 (O'Neill, 2016). A recent publication used predictive statistical models and estimated that globally there were 1.27 million deaths directly attributed to bacterial AMR in 2019 (Murray et al., 2022). In recent years, anthropogenic sources such as farming, agriculture, air pollution and sewage have been implicated in the dissemination (Gao et al. 2022), selection (Murray et al., 2021), and transmission (Stanton et al., 2021), of AMR.

In 2021, an ERAMMP evidence review (Singer et al., 2021) was commissioned by the Welsh Government to identify how AMR: 1) enters and spreads via the rural water environment; 2) impacts on animal and human health; and 3) can be tackled at a Welsh level using an integrated policy approach to ensure the effectiveness of antibiotics for future generations. This review evaluated the available evidence, identified knowledge gaps and made seven recommendations for reducing the burden of environmental AMR and antimicrobial-resistance driving chemicals (ARDCs) in Wales. The recommendations made in the evidence review were as follows:

1) Source reduction of ARDCs;
2) Eliminate the need for combined sewer overflows (CSOs);
3) Reduce the antimicrobial resistance gene (ARG)/ARDC load in sewage and farm waste;
4) Improve wastewater treatment and the removal of antimicrobial resistant bacteria (ARB), ARGs and ARDCs;
5) Establishing discharge endpoints for ARDCs and ARGs;
6) Establish routine freshwater and wastewater monitoring; and
7) Research knowledge gaps identified in the review.

Based on these recommendations and other information provided in the ERAMMP review, the Welsh Government commissioned this work to investigate the effects of catchment-scale pollution on AMR in Welsh river environments. This report details the results of an evidence-gathering and hazard mapping exercise. This will provide support for proposed future work (see Section 5) and environmental AMR surveillance programmes in Wales.

2.2 Aims

Based on the recommendations made in the 2021 evidence review (Singer et al., 2021), the current work package detailed in this report aims to act as an evidence-gathering phase to understand the sources and sinks of ARDCs and ARGs on a national scale in Wales. The geospatial datasets will help to inform future AMR monitoring campaigns within Wales. The datasets will also provide a foundation upon which to build a more comprehensive AMR drivers map that can help support future environmental monitoring and inform science-led policy

interventions. Similar work was recently published by the Environment Agency for river catchments in England[1].

This evidence-gathering phase has two main deliverables:

1. To report the available datasets and their attributes (description, spatial and temporal completeness, etc.), and assess their suitability to inform AMR monitoring in freshwater.
2. To develop Wales-wide AMR hazard maps indicating areas with potentially high levels of AMR, and areas where the risk of transmission of AMR to humans from the environment is elevated.

[1] Environment Agency. Antimicrobial resistance surveillance pilot site selection and database extension. 2022. https://www.gov.uk/government/publications/antimicrobial-resistance-surveillance-pilot-site-selection-and-database-extension

3 DATA REGISTER CREATION

3.1 Introduction

Aim: Compile available datasets (both anthropogenic and environmental) that represent factors which may influence AMR in the Welsh aquatic environment for use in the creation of the hazard map in Section 4 of this report and to support future monitoring efforts.

Many factors are known to drive AMR in environmental settings (and potentially, additional unknown factors). These sources may contain ARDCs, ARGs and ARB, for example, treated and untreated sewage discharges (i.e., WWTP effluents and CSOs), aquaculture, agricultural runoff (e.g., from manure application, animal husbandry, slurry leakage and antibiotic crop treatment), landfill, mining and road runoff, septic tank leakage, and industrial waste (Singer et al., 2021). These factors make addressing the issue of AMR in the environment complex and multifaceted, with apportionment of diffuse and point sources a challenging task. A data register of these potential sources of ARDCs, ARGs and ARB was created to inform the following hazard mapping exercises.

3.2 Methods

3.2.1 Data sourcing

A data register containing spatial datasets that were deemed relevant for assessing AMR hazards in the aquatic environment in Wales was created. Datasets were included in the register if they represented potential sources of ARDCs, ARB and ARGs in the environment or potential exposure routes of humans to AMR in the environment. Datasets were acquired from a range of sources, including government websites[2], Natural Environment Research Council (NERC)'s "Environmental Information Data Centre"[3], consultation with the ERAMMP team[4], who forwarded requests to specialists in the area, and web searching. Datasets that had particular relevance to Wales and industrial history (e.g., coal mining) were also included.

A data request was submitted to the water company Dŵr Cymru Welsh Water, which they responded to on 22nd April 2022, providing up-to-date data on their wastewater treatment plants. Attributes provided in the dataset included: functional location name; type; treatment level; permit type; permit number(s); asset national grid reference; discharge national grid reference(s); total population equivalent; and population equivalent minus non-residents. Equivalent data for the catchments that the water company Hafren Dyfrdwy serve were previously held within UKCEH.

All data and datasets were either publicly available (some upon request) or held at UKCEH.

[2] e.g., www.gov.uk, http://lle.gov.wales/home and www.naturalresources.wales
[3] https://eidc.ac.uk/
[4] https://erammp.wales

3.2.2 Data extraction and Data Register creation

Metadata were extracted and imported into a spreadsheet, included here as Appendix-E. Metadata extracted from each dataset in the register were: title, URL, dataset description; use in AMR surveillance; temporal extent; spatial extent; data format; whether the data was geospatial; and whether the data needed to be updated.

3.2.3 New Dataset - Hospitals

A hospital dataset was constructed as hospitals can be a significant source of ARDCs and ARGs. The number of beds held by each hospital was used as a proxy of hospital size, and thus ARDC and AMR impact. Hospital names and postcodes were collated using the NHS directory[5]. Day hospitals and clinics that had no overnight bed space were excluded, as were those specified as care homes, “Elderly Mental Infirm” hospitals and “Psychiatric Learning Disability” hospitals, as these were deemed long-term care facilities, thus not within the scope of this dataset. However, standard psychiatric hospitals were included, as they may potentially be locations of high pharmaceutical use.

Where available, hospital bed number data were collected from online resources. NHS websites, publicly available freedom of information requests and data from Health Inspectorate Wales were prioritised as reputable sources for these data. Data were obtained from Wikipedia (n = 12/82) if not available elsewhere. No information on bed numbers could be found for 12 hospitals, all of which were either small community hospitals or psychiatric hospitals, as such, they were excluded from the data analysis. The newly created hospital dataset can be found in Appendix-F

3.2.4 New Dataset - Wild Swimming Locations

A dataset was compiled for wild swimming locations, which are defined as locations where people swim in rivers, pools, and lakes. They are not designated bathing areas, and thus are not monitored for bathing water quality. Wild swimming could potentially result in exposure to high levels of environmental AMR.

This dataset was created using the list of wild swimming locations from the “Wild Swimming” website[6], which signposts interested members of the public to key waterbodies. However, a limitation is that the public may swim in water bodies wherever they can gain access, irrespective of designated bathing water status or signposting by key websites. Using Google Maps, the geographical coordinates were extracted for each wild swimming location. These coordinates were used to create a geospatial dataset. This dataset can be found in Appendix G.

[5] http://www.wales.nhs.uk/ourservices/directory/ hospitals
[6] http://www.wildswimming.co.uk/wales/?multi_region=wales

3.3 Outputs and Limitations

3.3.1 Data register

We developed a data register that is included as Appendix-E.

A total of 54 datasets were included that could help inform the creation of an AMR hazard map and the undertaking of a freshwater AMR monitoring programme in Wales.

3.3.2 Dataset limitations

As datasets were sourced from different organisations, quality in terms of spatial and temporal completeness varied. To highlight this, information relating to temporal extent, spatial extent, and whether an update was required was collated in the data register (see Appendix-E).

3.3.2.1 Spatial quality

One dataset did not cover all of Wales ("Wales Activity Mapping" only covered Pembrokeshire). In addition, for WWTPs, both Dŵr Cymru Welsh Water and Hafren Dyfrdwy own treatment work assets within Wales, thus both datasets were recorded in the data register to provide Wales-wide coverage of WWTP locations and total population equivalents.

3.3.2.2 Temporal quality

Of the 54 datasets, 24 date from 2019 or earlier; as a result, some datasets might benefit from being updated. Eight of the 54 datasets did not contain information on when they were generated, making it impossible to know how up-to-date they might be. The temporal extent for these datasets was classed as "No information" in the data register. These datasets were:

- Coal authority
- Hospitals in Wales
- Low Flows 2000-Water Quality Extension (wastewater concentrations across England and Wales)
- Wild swimming
- Pets UK
- Septic tanks
- Urban waste water treatment directive
- Wales activity mapping

Of the 24 datasets that were not up to date (i.e., from 2019 or earlier), we identified three that we considered priority datasets (used in the hazard map in Section 4) that would benefit from being updated, these included: "Estimates of manure volumes by livestock type and land use for England and Wales," "Bathing Water Quality at Designated Beaches" and the dataset held by UKCEH for Hafren Dyfrdwy WWTP location.

3.3.2.3 Other considerations

Datasets have been obtained from publicly accessible sources, such as government websites and research institutions. However, as the majority datasets have been generated externally, we cannot guarantee the accuracy of these. The maps presented in Section 4 and Section 5 are only as reliable as the publicly accessible data used to create them.

3.3.3 Conclusions

This data register was created to inform on AMR hazards in aquatic environments in Wales, particularly focusing on potential drivers of environmental AMR and potential exposure routes of humans to AMR in the environment. A number of the 54 datasets identified here have been used in the following section (Section 4: Hazard Map Creation) to create hazard maps representing potential locations of increased abundance of AMR in Welsh rivers and potential locations of increased chance of human exposure to AMR in Welsh rivers. The remaining datasets provided here (i.e., not used in Section 4: Hazard Map Creation) could be used to help support future investigations into the drivers of AMR in the environment and environmental AMR monitoring efforts.

4 HAZARD MAP CREATION

4.1 Introduction

Aim: Create hazard maps of Welsh river catchments ranking the potential for increased AMR abundance in river catchments and the potential for human exposure to AMR in the rivers within the catchment. These maps could be used as a baseline to inform future monitoring efforts.

As discussed in the data register creation section (Section 3), numerous different anthropogenic factors will influence the prevalence of AMR in the environment. It is critical to understand the factors that will influence the hazard of AMR abundance and exposure risk of humans in the environment.

4.2 Methods

4.2.1 Databases

Nine of the 54 datasets identified in Section 3 were used in this section to create two hazard maps. Of these nine datasets, 12 attributes were extracted for use in the hazard maps (see Table 4.1).

Datasets and attributes used for the creation of the AMR abundance hazard map were those thought to increase the abundance of AMR in rivers and the river catchment. These data included CSO spill count and duration, private consented discharges, WWTP population equivalents, hospital beds, manure, slurry and excreta loads, aquaculture and consented discharges, and arable land cover.

For data showing WWTP location, which was ranked by population equivalent (PE), we combined two datasets from the two water treatment companies that serve Wales (Dŵr Cymru Welsh Water and Hafren Dyfrdwy). Although datasets were merged, the same data were provided by each company (total PE) and no WWTP was counted twice as the private companies own different plants. “Discharge national grid reference (NGR)” was preferentially used as the location for where the wastewater effluent enters the environment. Where discharge NGR was not available, “Asset NGR” was used (where the plant is located). The main limitation of merging these two datasets was that Dŵr Cymru Welsh Water data were up to date as of April 2022, whereas Hafren Dyfrdwy was last updated in ~2012, making it approximately 10 years out of date. However, it is unlikely that this infrastructure would have changed significantly during this time.

Datasets and attributes used for the creation of the AMR exposure hazard map were those thought to increase the risk of human exposure to environmental AMR. These included designated bathing sites and wild swimming sites.

Table 4.1: Dataset information, including database ID, the attributes of the dataset used, the rationale for its use and the map it was used in.

Dataset (ID)	Attribute	Rationale	Map
Event Duration Monitoring – Storm Overflows – 2021 (England and Wales) (17)	CSO spill count	Discharge of untreated wastewater will include ARB, ARGs and ARDCs.	Abundance
Event Duration Monitoring – Storm Overflows – 2021 (England and Wales) (17)	CSO spill duration	Discharge of untreated wastewater will include ARB, ARGs and ARDCs.	Abundance
Consented discharges to controlled waters with conditions (11)	Private consented discharges	Discharge of untreated wastewater will include ARB, ARGs and ARDCs.	Abundance
Dŵr Cymru Welsh Water (53) Hafren Dyfrdwy (Severn Trent) WWTPs (18)	WWTP location ranked by total PE	Discharge of treated wastewater will include ARB, ARGs and ARDCs.	Abundance
Hospitals in Wales (20): Created for this project – AdditionalFile_Datasets.xlsx	Number of hospital beds	Prescription drugs, including antimicrobials, from patients treated in hospitals and biocides used in cleaning, will be released into the downstream river environment and select and co-select for AMR.	Abundance
Estimates of manure volumes by livestock type and land use for England and Wales (16)	Manure load	Application of manure on land may result in leaching of ARB, ARGs and ARDCs into the environment.	Abundance
Estimates of manure volumes by livestock type and land use for England and Wales (16)	Slurry load	Application of slurry on land may result in leaching of ARB, ARGs and ARDCs into the environment.	Abundance
Estimates of manure volumes by livestock type and land use for England and Wales (16)	Excreta load	Animal excretion onto land may result in leaching of ARB, ARGs and ARDCs into the environment.	Abundance
Consented discharges to controlled waters with conditions (11)	Aquaculture and shellfish consented discharges	Animal excretion into water and animal treatments in aquaculture/shellfisheries may result in the release ARB, ARGs and ARDCs into downstream water environments and select for AMR.	Abundance
Land Cover 2020 (24)	Arable land cover	The use of ARDCs on crops (e.g., pesticides/fertilisers) may result in selection and co-select for AMR.	Abundance
Bathing Water Quality at Designated Beaches (7)	Designated bathing water sites	Designated bathing water sites may present a pathway of exposure of humans to environmental AMR, particularly at failing sites.	Exposure
Wild swimming (54): Created for this project – AdditionalFile_Datasets.xlsx	Wild swimming sites (and one coasteering site)	Wild swimming sites are not regulated or monitored for water quality. People bathing in these sites may be at risk of exposure to environmental AMR.	Exposure

4.2.2 Catchment characterisation using a GIS

The relevant attributes within each dataset were extracted per catchment using ArcMap v10.6.1 software (ESRI, 2022). Water Framework Directive (WFD) operational catchments were used to define the catchments for the hazard maps (found in the WFD Operational

Catchments Cycle 2 data layer[7]). The number of discrete points (e.g., hospitals/wild swimming sites/CSO sites, etc.) were calculated per operational catchment.

Most river catchments were located exclusively in Wales. However, 17 river catchments spanned the Wales/England border, including: Wye; Monnow; Wye H and W – Ithon to Hay; Arrow, Lugg and Frome; Lugg; Teme Upper; Clun River; Severn Upper Montfort East; Rea Brook; Severn Upper Montfort North; Morda and Severn North Shropshire; Severn Upper and Tanat River; Ceiriog; Perry Roden and Tern North Shropshire; Worthenbury; Dee Lower Chester Weir to Ceiriog; and Dee Estuary.

Sources of pollution originating from England (i.e., from over the border) that could impact AMR abundance within Welsh catchments were included in the AMR abundance map. These English pollution sources included CSO spills, consented discharges (water company, private, aquaculture and fisheries), number of hospital beds, manure, slurry and excreta load, and arable land cover. Designated bathing waters and wild swimming sites outside of Wales were not included, hence, the exposure hazard map was exclusively Wales-centric.

The datasets used for the variables CSOs, arable land cover, manure, slurry and excreta all included some English data points for the catchments that crossed the border. The hospital dataset was created from the "Health in Wales" NHS directory[8]. The hospitals that were listed in this directory that were in England under the Welsh NHS trusts were included. The consented discharges data (used for private water discharges and aquaculture and shellfish discharges) did not extend to the English sections of the catchments. The English equivalent of this dataset[9] was used to ensure coverage of these Welsh-impacting English river catchments.

4.2.3 Creation of hazard maps

4.2.3.1 Catchment ranking model

Once the chosen datasets were linked to operational catchments, the data were imported into Excel. Here, the attributes were normalised by catchment size (in km^2), allowing for comparison across all catchments.

The 20th, 40th, 60th and 80th percentiles were then calculated for each attribute and catchments were assigned an attribute-specific hazard rank (1 to 5) depending on which percentile the particular catchment fell into, with 5 being the most hazardous category and 1 being the least. For all attributes, the higher the value (e.g., the higher the number of hospital beds, or the

[7] Natural Resources Wales. Water Framework Directive (WFD) Operational Catchments Cycle 2. 2022. https://data.gov.uk/dataset/00396e40-dfeb-45e5-af28-03346b932258/water-framework-directive-wfd-operational-catchments-cycle-2

[8] http://www.wales.nhs.uk/ourservices/directory/hospitals

[9] https://data.gov.uk/dataset/55b8eaa8-60df-48a8-929a-060891b7a109/consented-discharges-to-controlled-waters-with-conditions

larger the arable land cover area), the higher the hazard score assigned. Examples of attribute-specific hazard scores can be found in Figure 4.1.

To create the AMR abundance and exposure hazard maps, these attribute-specific hazard scores were summed to provide an overall unadjusted hazard score for each catchment. This hazard score was then adjusted by further ranking into percentiles (e.g., for the AMR abundance map, unadjusted summed hazard scores above 27 would become a final adjusted hazard score of 5 (highest hazard rank), to be used in the final map). The tables provided in Technical Annex 1[10]) show all the raw data and calculations used to calculate these hazard scores.

OPCAT information		CSO spill count			CSO spill duration			Hospital beds		
OpCatName	Area_km2	count	count/area	hazard	duration	duration/area	hazard	beds	beds/area	hazard
Aeron	164.2252	194	1.18130458	2	1752.75	10.67284331	2	0	0	1
Afan	118.9743	1021	8.581686005	5	6122.5	51.46069791	4	0	0	1
Alaw Goch	169.7018	373	2.197972791	2	3300	19.44587188	2	0	0	1
Alwen	201.0048	85	0.422875474	1	443.75	2.207658723	1	0	0	1
Alyn	246.949	1240	5.021279697	4	6080	24.62046819	3	40	0.161977	4
Arrow, Lugg a	910.4094	1208	1.326875579	2	7610.5	8.35942599	2	0	0	1
Arth and Wyr	127.4897	424	3.325759745	3	5094.75	39.96206241	4	0	0	1
Artro	117.9437	442	3.747549552	3	3743.25	31.73759019	3	0	0	1
Braint Cadnar	154.0281	1483	9.628112095	5	14280.75	92.71521362	5	0	0	1
Cefni	144.4057	459	3.178544782	3	3527.5	24.42770527	2	0	0	1
Ceiriog	158.3538	214	1.351404261	2	974.75	6.155520108	1	0	0	1
Clun River	271.2708	169	0.622993702	1	1271.348	4.686639075	1	0	0	1
Clwyd Lower	310.6663	887	2.855153128	3	5154	16.59014568	2	40	0.128755	4
Clwyd Upper	205.4602	371	1.805702516	2	4365.75	21.24864086	2	0	0	1
Clywedog - De	103.1803	884	8.567526941	5	4827	46.78218613	4	800	7.753418	5
Coastal strean	123.3723	435	3.525913928	3	4941.5	40.05357167	4	0	0	1
Coastal strean	184.6698	912	4.938545027	4	12115.25	65.60494258	5	0	0	1
Coastal strean	72.9194	400	5.485508785	4	3683.5	50.51467903	4	0	0	1

Figure 4.1: Example calculations for AMR abundance hazard map showing attribute-specific hazard scores (green). OPCAT = operational catchment. CSO = combined sewer overflow. (Full table is provided in Technical Annex 1[10])

4.2.3.2 Model weighting

The majority of attributes within each dataset used in the hazard maps were weighted equally. However, some data were weighted, as follows:

a) Manure, slurry and excreta, hazard scores were averaged. It was not apparent whether there were overlaps within this dataset, and the relative impact of these diffuse sources on a waterbody is uncertain.

b) Private (based on number of permits per catchment) and commercial WWTP (based on population equivalents for each WWTP) hazard scores were used as separate

[10] Stanton, I.C., Tipper, H.J. & Singer, A.C. (2022). Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP). ERAMMP Report-65TA1 The development of a hazard map to inform an environmental AMR monitoring programme in Welsh rivers – Abundance and exposure data (Contract C210/2016/2017)(UK Centre for Ecology & Hydrology Projects 06297 & 06810) www.erammp.wales/65TA1

entries in the hazard map, as they represent distinct inputs to the freshwater environment with expected impacts.

c) CSO spill count and duration were included as separate entries. This decision was made because neither fully captures the core attribute which would have been “volume of raw sewage input.” In addition, both were included as CSO discharge to rivers was seen as a particularly important input with respect to AMR, thus was weighted more strongly than other attributes in the model. These decisions essentially gave CSOs and wastewater each a double weighting. The higher weighting for sewage input is supported by the literature, as WWTP effluent has been shown to significantly increase a proxy for AMR (class 1 integron) in downstream river environments (Amos et al., 2018) and untreated wastewater (such as that discharged during a CSO spilling event) has been shown to carry high abundances of ARGs and ARB (Guo et al., 2021). As such, the hazard map should be understood as primarily representing the degree to which Welsh rivers might be impacted by wastewater.

5 RESULTS AND CONCLUSIONS

5.1 Hazard maps

The data tables provided in Technical Annex 1[11], shows the processed data for each dataset used, and the hazard ranks for each dataset used as an attribute in both the unadjusted and adjusted AMR abundance and exposure hazard scores for the final hazard maps.

Figure 5.1 shows the final AMR abundance hazard map for Wales. In addition, a table showing catchment name, unadjusted hazard score and adjusted hazard score can be found in the Appendix-D– Table 10.1. Hazard is ranked 1 to 5, with 1 being the least hazardous and 5 being the most hazardous for the potential presence of high abundances of AMR in the river catchment. For each contributing attribute used in this map, individual maps hazard maps were created (see Appendix-B – Figures 8.1 – 8.10).

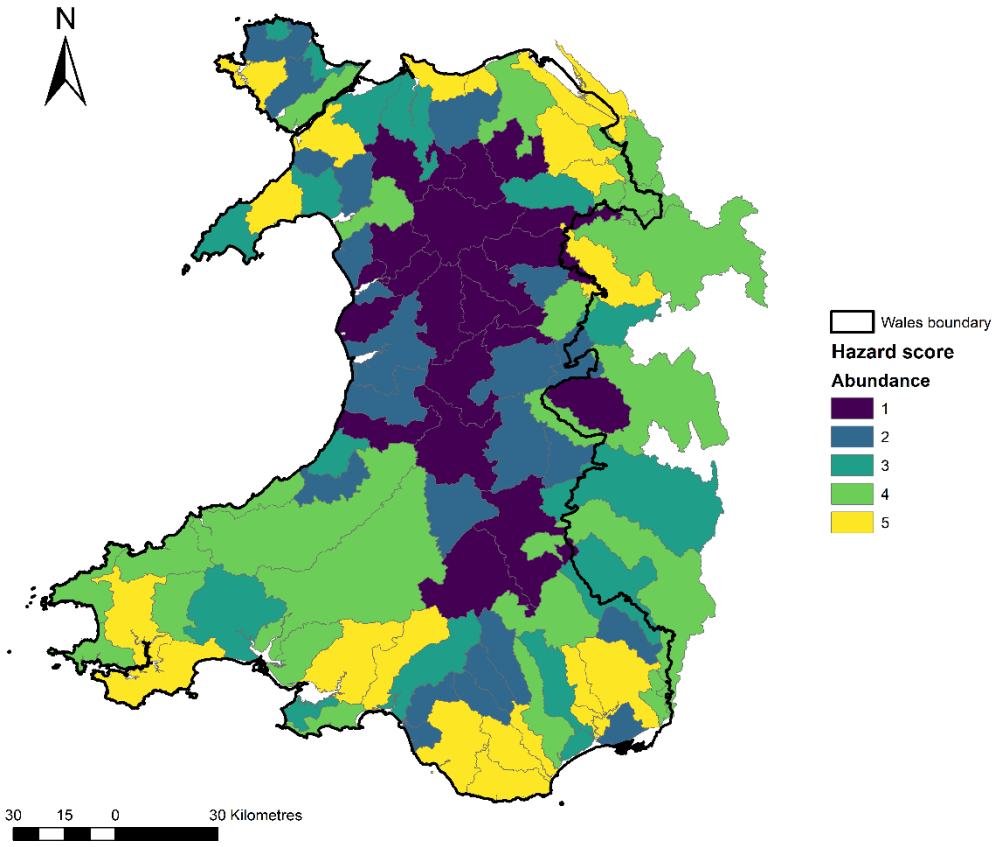

Figure 5.1: Abundance Hazard Map for Wales. See Appendix-D – Table 10.1 for more details.

[11] Stanton, I.C., Tipper, H.J. & Singer, A.C. (2022). Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP). ERAMMP Report-65TA1 The development of a hazard map to inform an environmental AMR monitoring programme in Welsh rivers – Abundance and exposure data (Contract C210/2016/2017)(UK Centre for Ecology & Hydrology Projects 06297 & 06810) www.erammp.wales/65TA1

Figure 5.2 shows the final exposure hazard map for Wales. In addition, a table showing catchment name, unadjusted hazard score and adjusted hazard score can be found in the Appendix-D – Table 10.2. Adjusted hazard scores are ranked 1 to 5, with 1 being the least hazardous and 5 being the most hazardous for the potential increased risk of human exposure to AMR in each river catchment. For both contributing attributes used in this map (designated bathing waters and wild swimming locations), individual maps hazard maps were created (see Appendix-C – Figures 9.1 and 9.2).

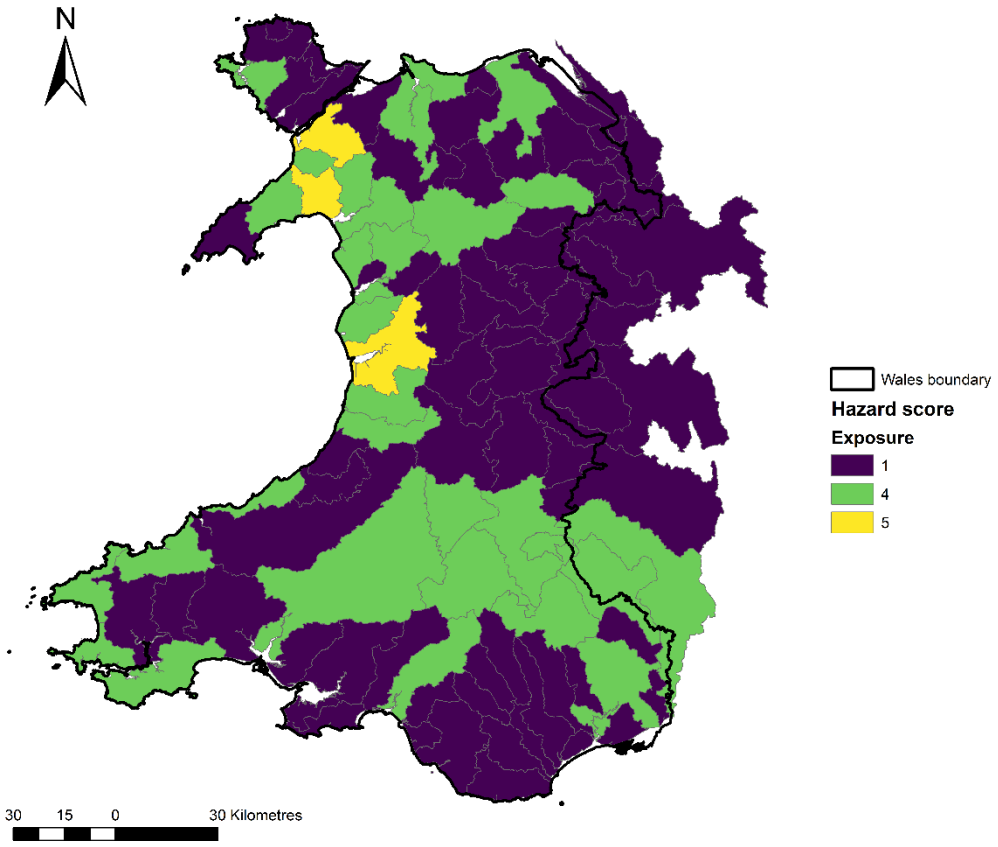

Figure 5.2: Exposure Hazard Map for Wales. See Appendix-D – Table 3 for more details.

Figure 5.3 shows the combination of both the final AMR abundance and exposure hazard maps for Wales. Hazard is ranked 1 to 5, with 1 being the least hazardous and 5 being the most hazardous for the potential presence of high abundances of AMR in river catchments where human exposure to AMR is likely to occur. Notably, the Gwyrafi Seiont catchment had the highest adjusted hazard score for potential for AMR abundance in catchments where human exposure is most likely to occur (i.e. using these metrics, human exposure to high levels of AMR is most likely to occur).

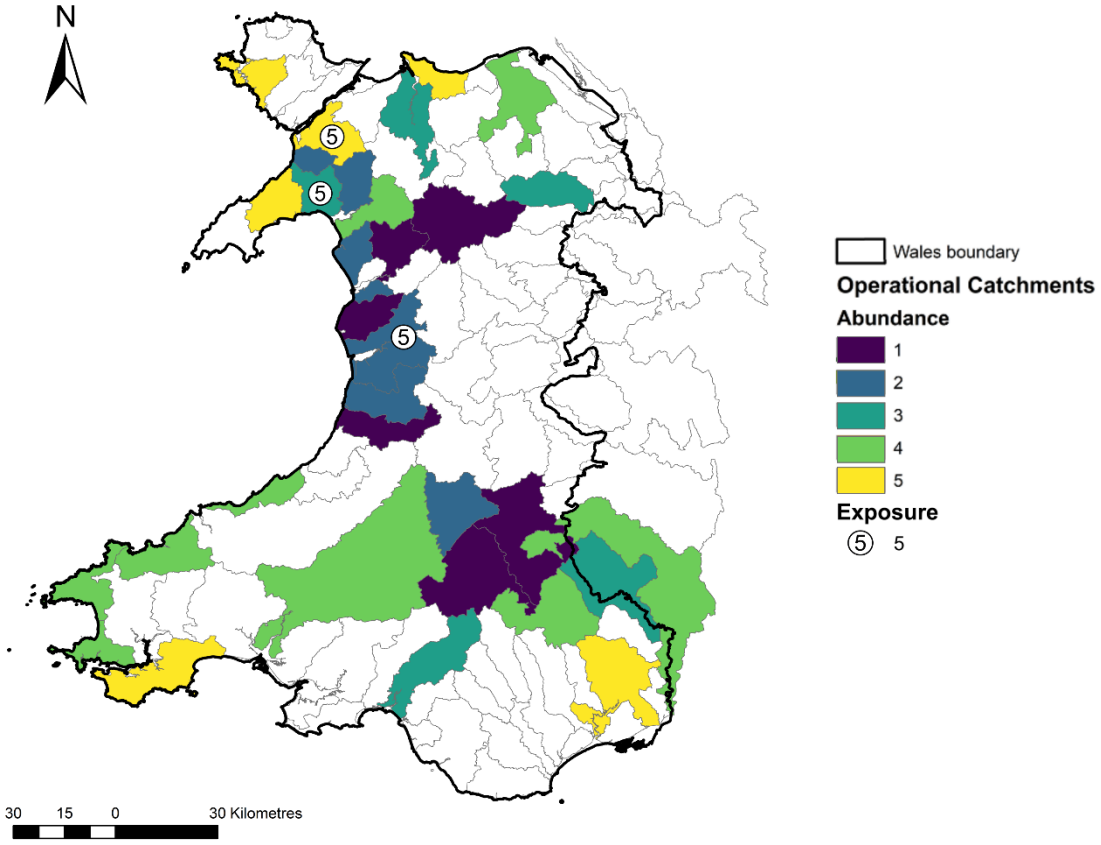

Figure 5.3: Combination of both the final AMR abundance and exposure hazard maps for Wales. Coloured catchments indicated catchments where exposure may occur (exposure hazard score of 4 or 5 (i.e., catchment contains bathing waters or wild swimming sites)). Non-coloured catchments indicate where exposure is unlikely to occur (exposure hazard score of 1 (i.e., catchment contains no bathing waters or wild swimming sites)). Catchments are coloured by potential for increasing AMR abundance hazard score. Catchments with a white circle with a 5 in it indicate exposure hazard scores of 5 (human exposure to AMR most likely to occur).

5.2 Conclusions

The hazard maps created here will be useful for informing on future priority catchments of interest relating to AMR and providing a baseline of data for future monitoring efforts of AMR in Welsh aquatic environments. However, the completeness of these hazard maps is constrained by the data used to create them. Obtaining the most up-to-date and accurate data is critical for the accuracy and use of these maps.

6 FUTURE WORK

As identified in the ERAMMP Report-55 evidence review (Singer et al., 2021), a significant knowledge gap exists relating to the effects of CSOs on AMR in the environment. The Welsh Government also consider this to be a priority research area. Therefore, we propose that future work should investigate this, focusing on the effects of CSOs on AMR in Welsh rivers. For regulatory context, we have included a background discussion of CSOs as Appendix-A.

Monitoring the effects of CSOs on AMR in Welsh rivers

We propose that future work should include a monitoring campaign of the effects of CSOs on AMR in Welsh rivers. The AMR abundance hazard map created in this project could be used to inform such a campaign. A campaign focused on the impact of CSOs would facilitate insight into what is likely the most impactful input into the aquatic environment with respect to AMR.

To inform sampling site selection, the use of CSO spill duration data would ensure coverage of a range of different spilling duration risks. Spilling duration may be preferable to inform site selection, as opposed to spill count as it is a more accurate measure of the severity of spills, as the CSO spill count raw data is transformed using the 12/24 method[12]. Figure 6.1 shows the CSOs that discharged in 2021 categorised into three (low-, medium- and high-risk) percentiles. Figure 6.2 shows the CSOs that did not discharge in 2021 (363/2427, 14% of CSO sites).

The proximity to WWTP discharge location should also be considered when selecting sampling sites, to ensure distinguishable CSO discharge from WWTP effluent, as well as the population equivalent served, to ensure sites do not only serve relatively small or large populations. We also advise that sampling sites cover a geographical spread across Wales. Finally, accessibility will play a key role in the selection of sites.

[12] https://www.gov.uk/government/publications/water-companies-environmental-permits-for-storm-overflows-and-emergency-overflows/water-companies-environmental-permits-for-storm-overflows-and-emergency-overflows

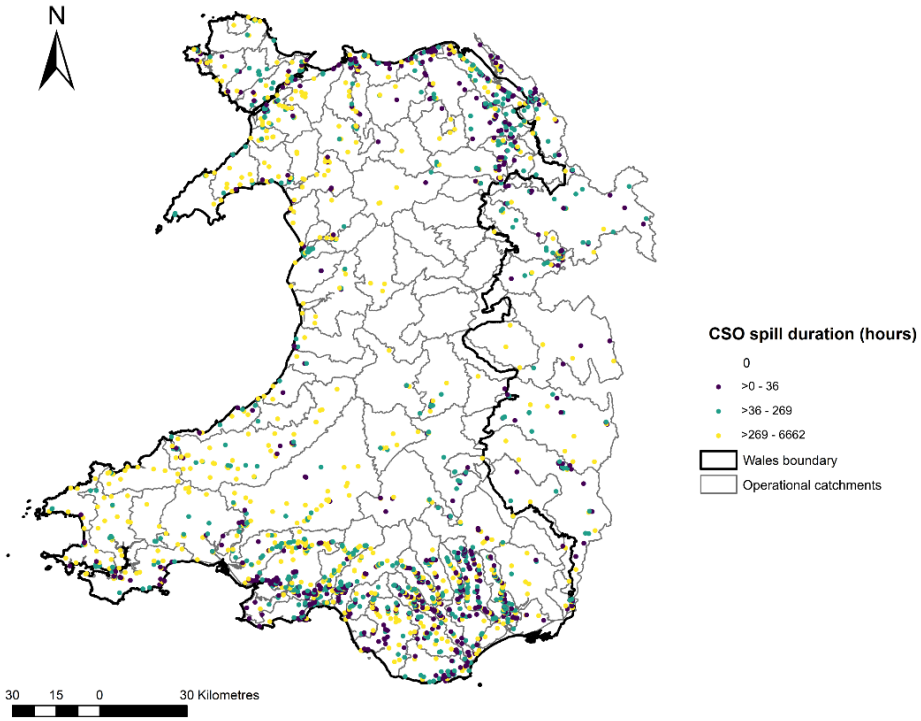

Figure 6.1: Welsh CSO sites that discharged in 2021. CSO spill duration is categorised into three percentiles.

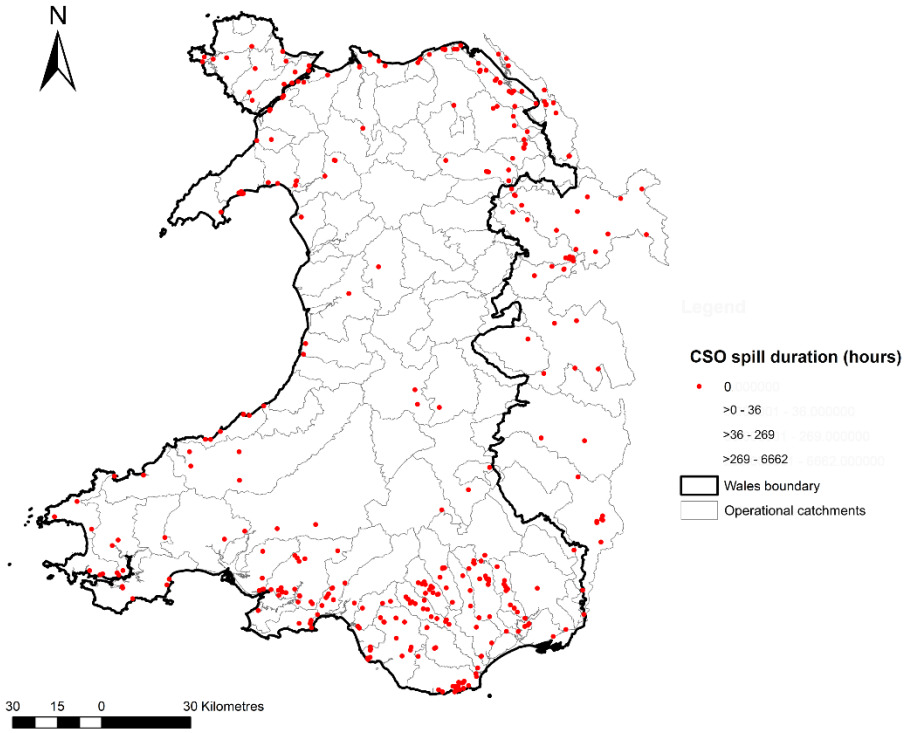

Figure 6.2: Welsh CSO sites that did not discharge in 2021. CSO spill duration is categorised into three percentiles.

7 Appendix-A: An Introduction to Combined Sewer Overflows (CSOs)

7.1.1 Background

CSOs were designed to prevent the backing up of sewage into homes and businesses and to alleviate the pressure of heavy rainfall on the wastewater treatment system, by allowing for the release of untreated sewage directly into downstream waterbodies (i.e., rivers) following storming events. However, many factors, such as groundwater ingress to pipes, sewage network age and expanding network populations, cause CSO spilling events to happen frequently, even during light rainfall. In Wales in 2021, there were 92,334 spills from CSOs, comprising 773,462 hours of total spilling duration[13].

7.1.2 Legislative context and rationale for prioritising CSOs

Discharges from CSOs are regulated under The Environmental Permitting (England and Wales) Regulations 2016, which stipulates that regulators, such as the Environment Agency (EA) in England and Natural Resources Wales (NRW) in Wales, must permit discharges to ensure compliance of CSOs with design and water quality standards, and the protection of receiving water bodies (i.e., no deterioration in water quality from the current state)[14].

In 2021, the Wales Better River Water Quality Taskforce was established and comprises representatives from NRW, Ofwat, Dŵr Cymru Welsh Water, Hafren Dyfrdwy (Severn Trent in Wales), the Consumer Council for Water and Afonydd Cymru (Welsh Rivers Trust). In July 2022, the taskforce published action plans laying out commitments for tackling five areas for change and improvement, including: reducing the visual impact of CSOs, improving effluent quality and river quality, environmental regulation of overflows, long-term network capacity planning, and public understanding and engagement[15].

Improved monitoring of discharges with EDM (beginning in 2012 in Wales) has allowed for transparency relating to the issue of CSOs. Dŵr Cymru Welsh Water monitor 2,142 CSOs (as of 2021)[16] of the “over 2,500 CSOs in Wales” (actual numbers are not reported), whereas Hafren Dyfrdwy monitor 100% of their 50 CSOs[17] (although these may be on the English side of border spanning catchments). However, the number of CSOs that are not permitted at all (i.e., unpermitted by NRW), remains unknown.

In March 2022, the Welsh Parliament Climate Change, Environment and Infrastructure Committee published a report on their short inquiry into water quality and sewage discharges

[13] Welsh Water Publish 2021 CSO Data | Afonydd Cymru. https://afonyddcymru.org/welsh-water-publish-2021-cso-data/

[14] Office for Environmental Protection. The Environmental Permitting (England and Wales) Regulations 2016. https://www.legislation.gov.uk/uksi/2016/1154/introduction/made?view=plain

[15] Natural Resources Wales. Storm Overflows in Wales. 2022. https://naturalresources.wales/about-us/news-and-events/statements/storm-overflows-in-wales/?lang=en

[16] The Rivers Trust. Event Duration Monitoring - Storm Overflows - 2021 (England and Wales). https://data.catchmentbasedapproach.org/datasets/event-duration-monitoring-storm-overflows-2021-england-and-wales/explore?location=52.770475%2C-3.144202%2C7.97

[17] Climate Change, Environment, and Infrastructure Committee. Report on Storm Overflows in Wales. Welsh Parliament; 2022. https://senedd.wales/media/v4apg5wb/cr-ld15015-e.pdf

in Wales. The report detailed letters to the Minister for Climate Change, Julie James MS, and evidence given to the Committee by Ofwat, NRW, and the water companies acting in Wales, Dŵr Cymru Welsh Water and Hafren Dyfrdwy. The report following this inquiry offered ten recommendations, one of which was aimed at NRW and the water companies, encouraging them to publish data on unpermitted CSOs and their associated spills[17]. During the inquiry, the Committee were informed that CSOs are not the main driver of water quality issues in Welsh rivers. Dŵr Cymru Welsh Water stated that approximately 5% of the 'Reasons for Not Achieving Good Status' (RNAGS; a WFD metric) are from CSOs in their controlled waterbodies. Hafren Dyfrdwy said 7% of RNAGS in their controlled waterbodies were caused by water company activity (not explicitly CSOs)[17]. The WFD focuses on the average condition of waterbodies, which may result in minimising or missing the acute effects of localised CSO spilling incidents. Therefore, although CSOs contribute to a small overall percentage of failures they are likely an important contributor to localised exposure to pollution. Notably, the requirements for the WFD do not include any metrics relating to AMR. The inquiry also stated a need to know more of the environmental effects of CSOs. Ofwat disclosed that the current levels of sewage discharge were unacceptable and that although "we know the duration and the number of spill incidents, or at least we have the data on that now […] there's not enough known about the harm of those incidents"[17].

7.1.3 CSOs and environmental AMR

CSOs are a mechanism by which untreated wastewater that is rich in ARDCs, ARBs and ARGs enters freshwater and coastal environments. Recently, Professor Chris Whitty, Chief Medical Officer for England, and representatives from Ofwat and the EA gave a joint statement on the public health problem of sewage in water[18], where they described the urgency of keeping human faeces – likely containing AMR – out of water that people might ingest, such as recreational waters, and that this responsibility rests "squarely with the water companies and their directors". In the absence of significant sources of dilution, the impact on the receiving environment is expected to be significant, in terms of the prevalence of ARDCs, ARBs and ARGs.

However, currently there is no empirical evidence quantifying the unique effects of CSOs on AMR in the environment. The study of the effects of CSOs on AMR in the environment will provide the scientific underpinning to inform not only the environmental regulators to monitor and regulate the issue, but also the users of these waterways, whose health may potentially be at risk.

[18] Department of Health and Social Care. Sewage in water: a growing public health problem. 2022. https://www.gov.uk/government/news/sewage-in-water-a-growing-public-health-problem

8 ADDENDIX-B: ABUNDANCE MAP VARIABLES

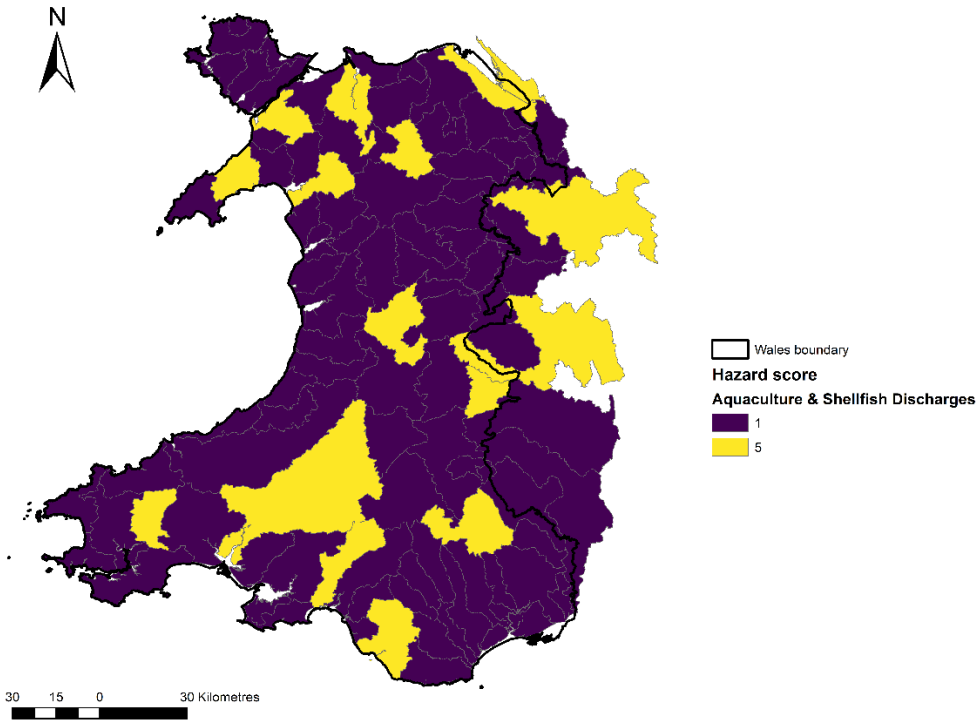

Figure 8.1: Hazard map of Wales showing the hazard associated with aquaculture and shellfish consented discharges.

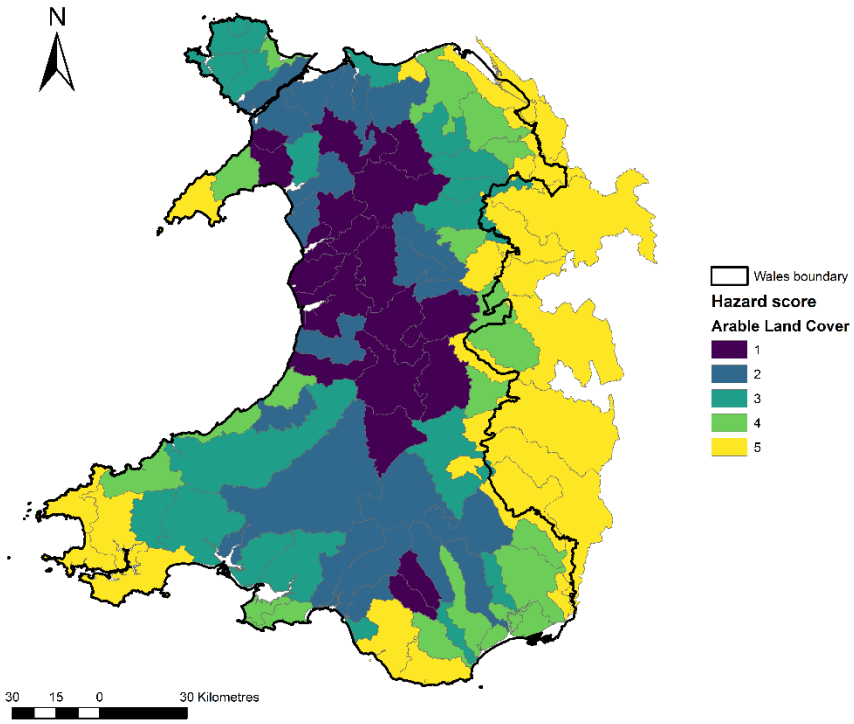

Figure 8.2: Hazard map of Wales showing the hazard associated with arable land cover.

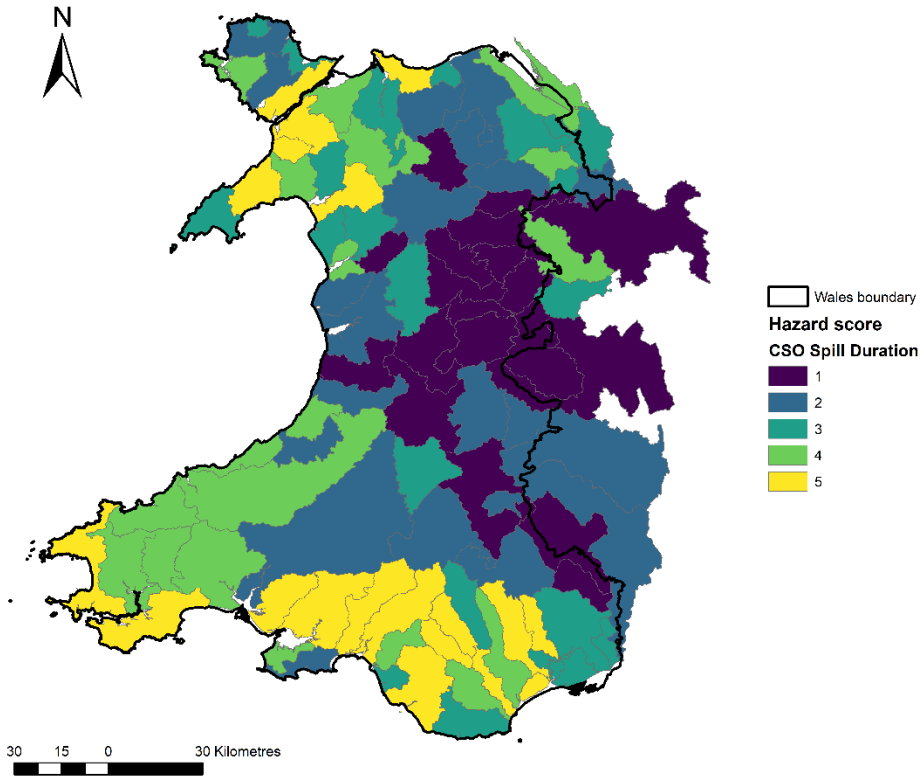

Figure 8.3: Hazard map of Wales showing the hazard associated with CSO spill duration.

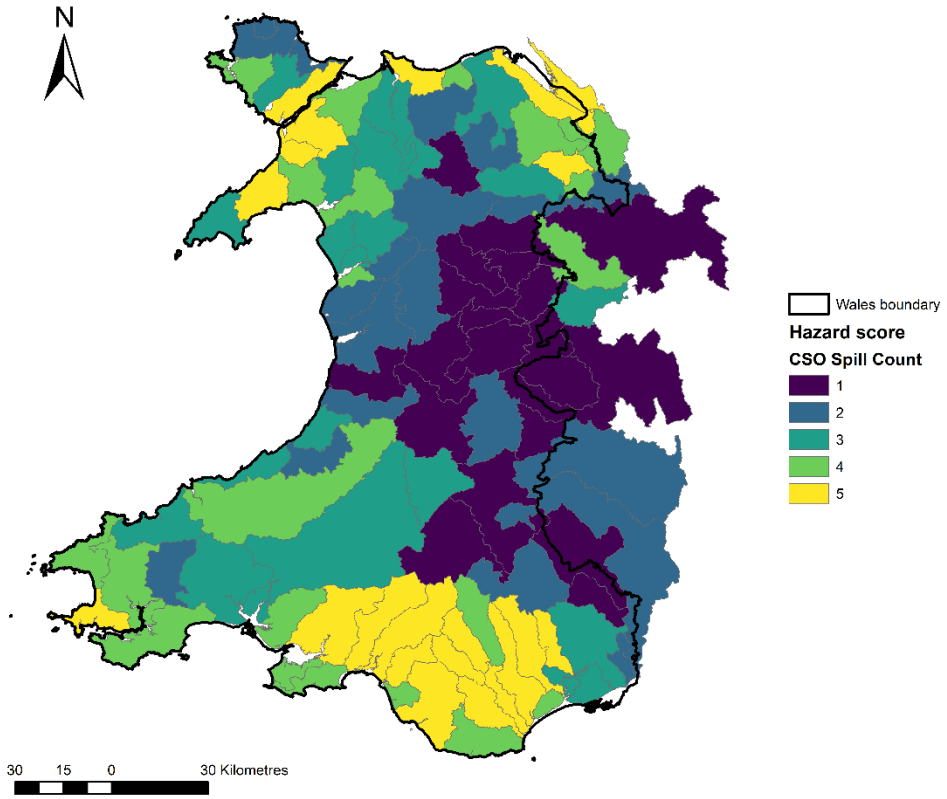

Figure 8.4: Hazard map of Wales showing the hazard associated with CSO spill count.

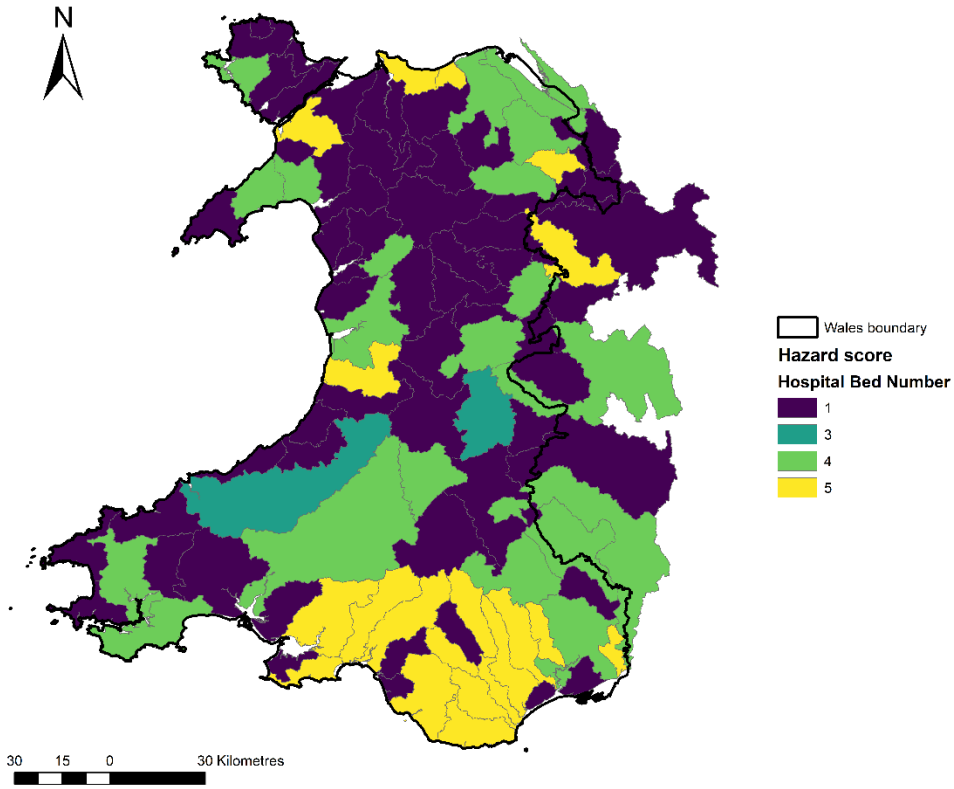

Figure 8.5: Hazard map of Wales showing the hazard associated with hospital beds.

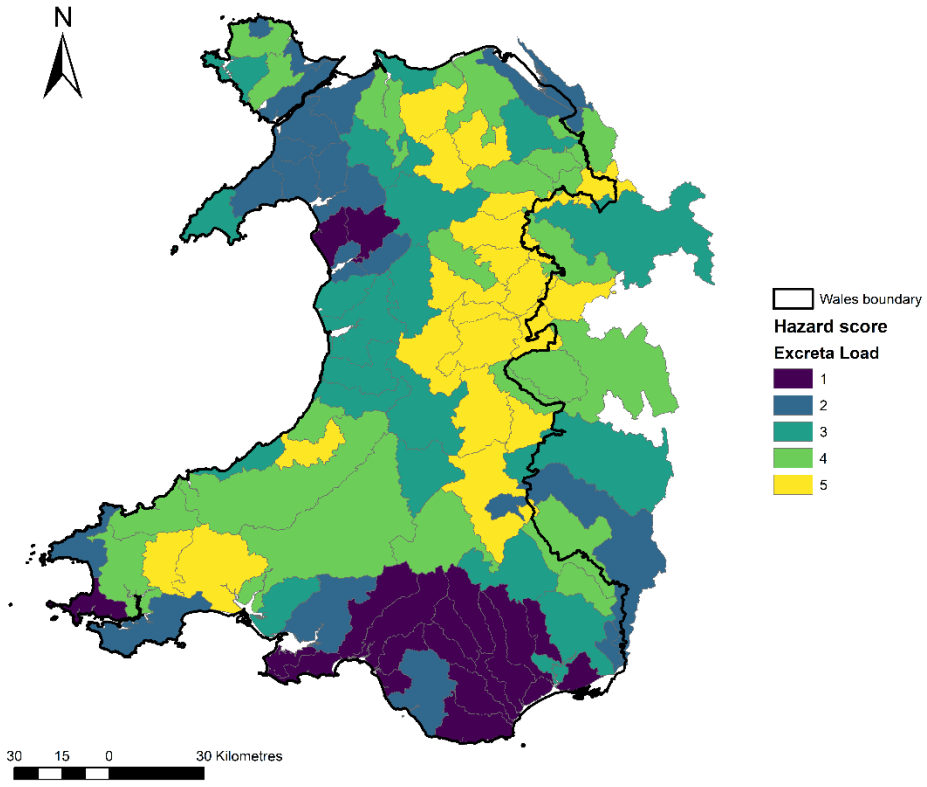

Figure 8.6: Hazard map of Wales showing the hazard associated with animal excreta.

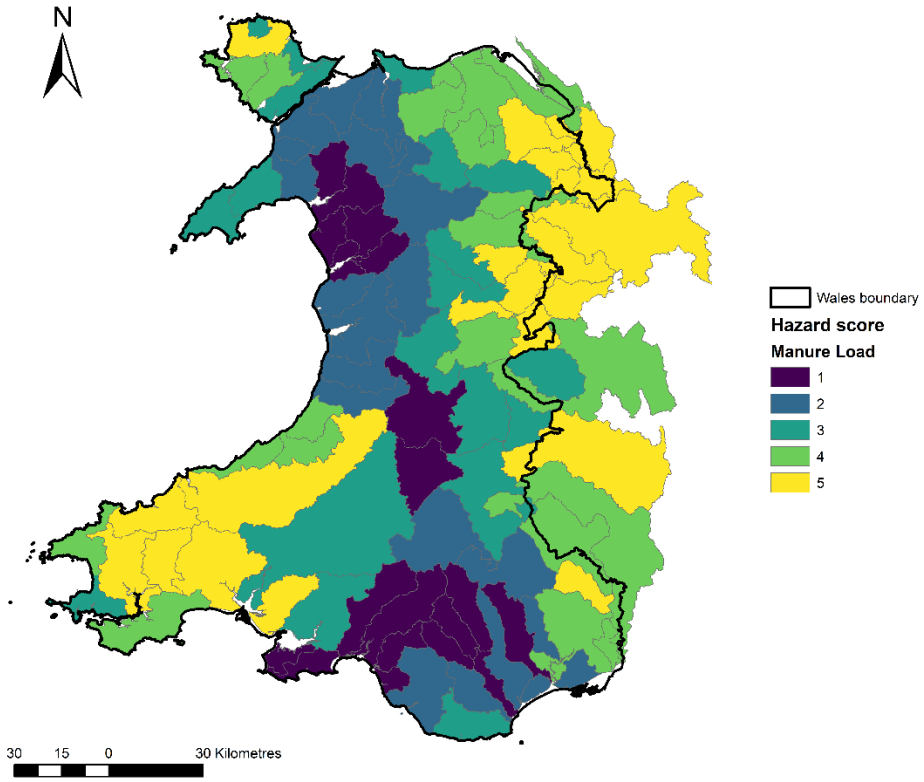

Figure 8.7: Hazard map of Wales showing the hazard associated with manure load.

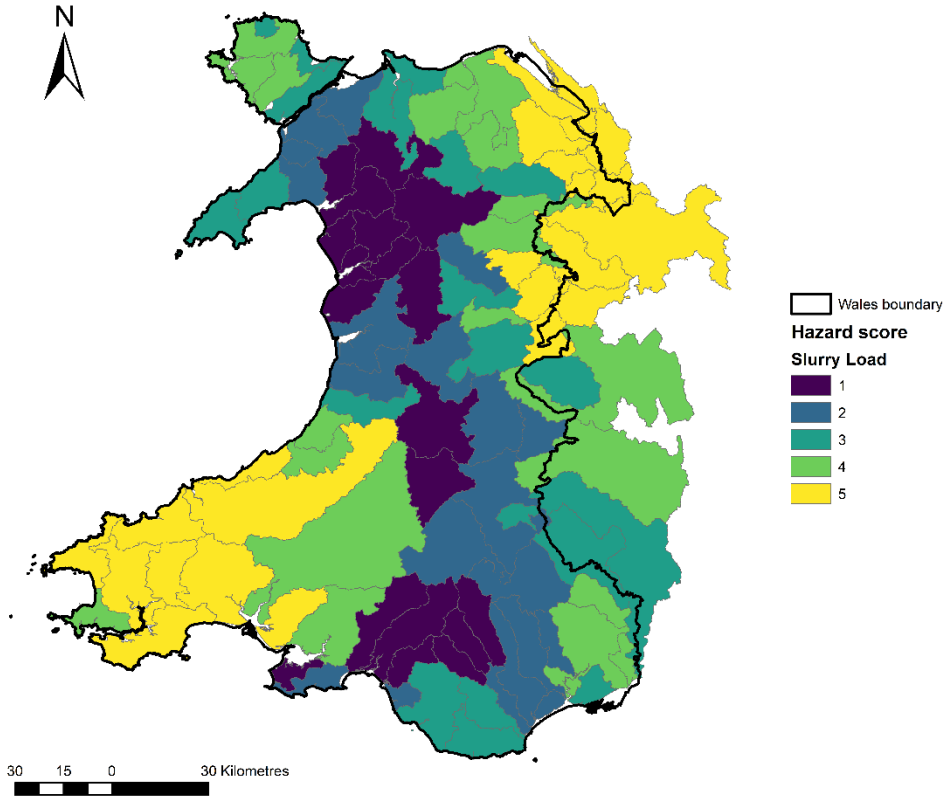

Figure 8.8: Hazard map of Wales showing the hazard associated with slurry load.

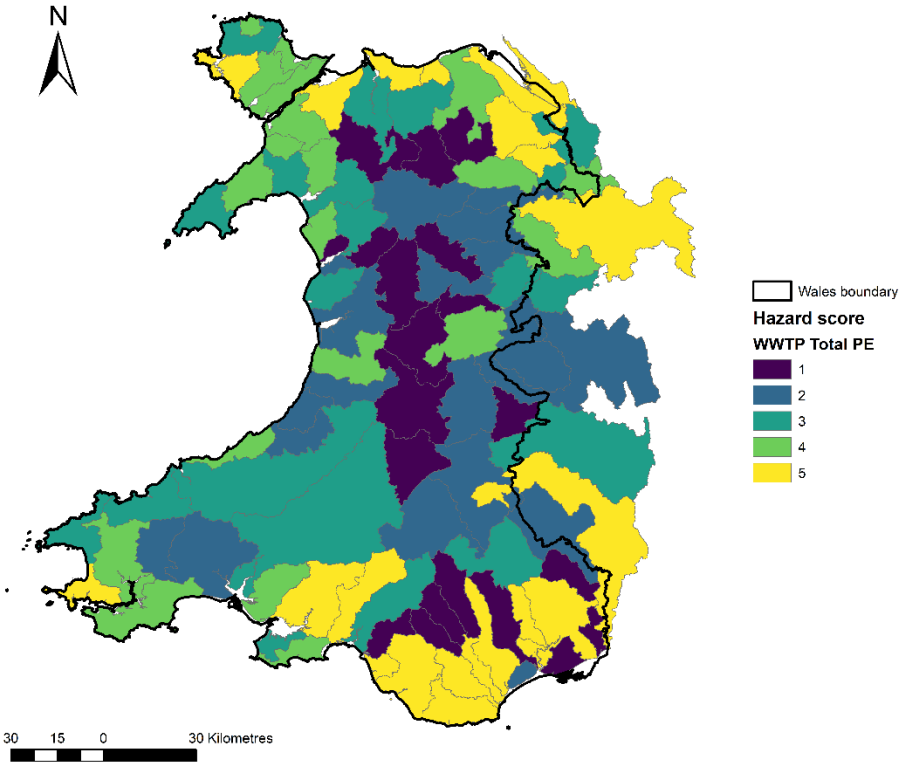

Figure 8.9: Hazard map of Wales showing the hazard associated with total population equivalents from the water companies Dŵr Cymru Welsh Water and Hafren Dyfrdwy.

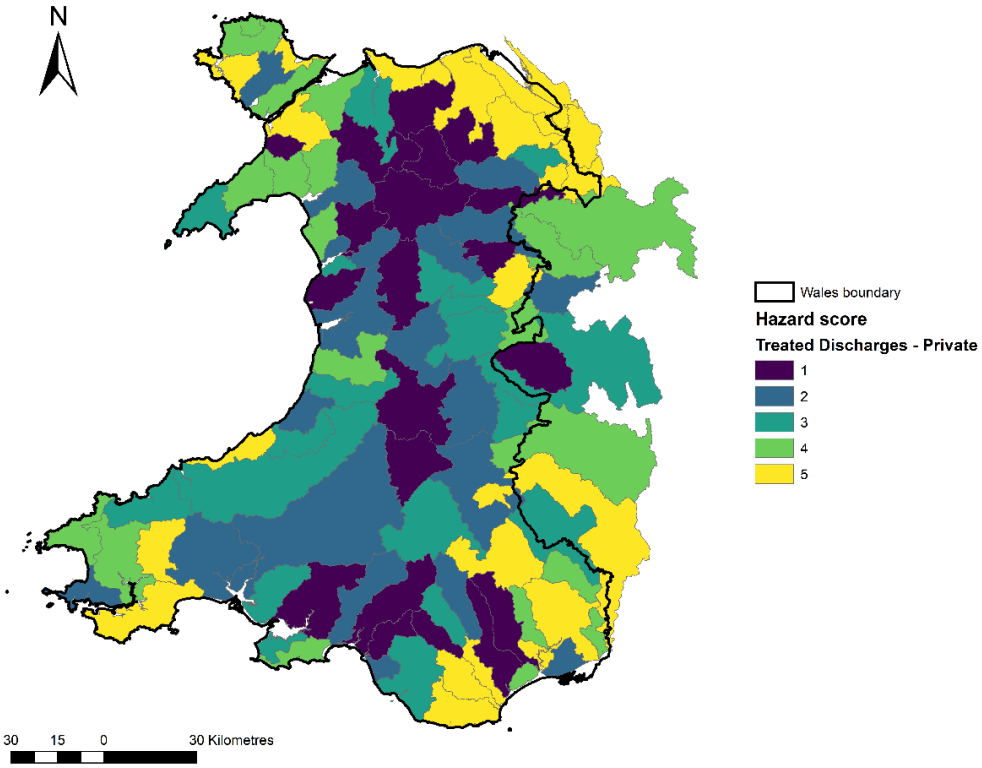

Figure 8.10: Hazard map of Wales showing the hazard associated with consented treated discharges from private WWTPs.

9 APPENDIX-C: EXPOSURE MAP VARIABLES

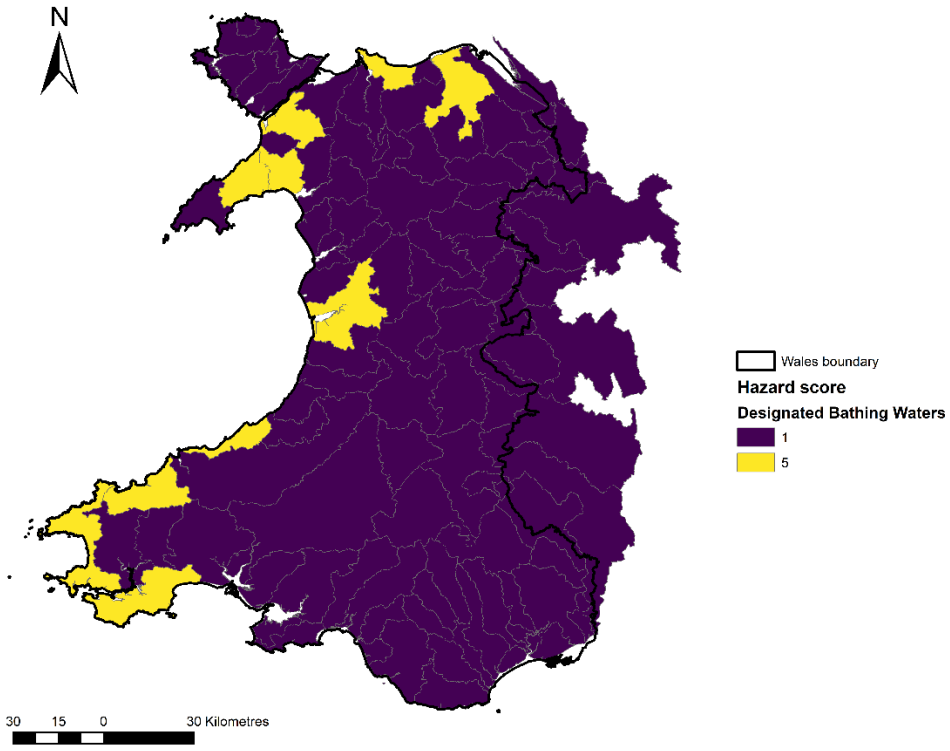

Figure 9.1: Hazard map of Wales showing the hazard associated with designated bathing waters.

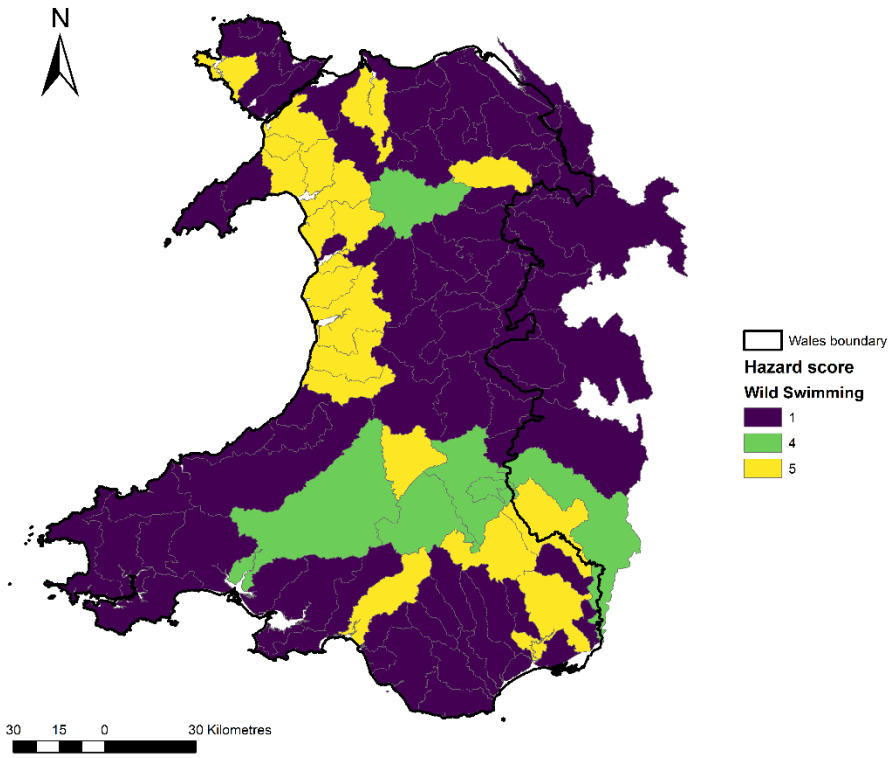

Figure 9.2: Hazard map of Wales showing the hazard associated with wild swimming sites.

10 APPENDIX-D: HAZARD SCORE TABLES

Table 10.1: AMR abundance map hazard scores. Hazard scores shown were summed from all attribute-specific hazard scores (unadjusted) and re-ranked into final hazard scores (adjusted). Hazard scores are shown to one decimal place where appropriate.

Operational catchment	Unadjusted hazard score	Adjusted hazard score
Dee Estuary	36.7	5
Ogmore	35.3	5
Erch	33.7	5
Gwyrfai Seiont	33	5
Dulas Ganol	32	5
Gele	32	5
Clywedog - Dee	31.7	5
Coastal streams of South Pembs and South Milford Haven - Pendine to Landshipping	31.7	5
Morda and Severn North Shropshire	31.7	5
Ely	31	5
Western Cleddau	30.7	5
Thaw and Cadoxton	30.3	5
Alyn	30.3	5
Taff d s Cynon	30.3	5
Tawe	30	5
Llwyd	29.7	5
Crigyll Caradog	29.7	5
Usk Lower Abergavenny	28.7	5
Loughor	28	5
Clwyd Lower	27	4
Eastern Cleddau	27	4
Wye	27	4
Dee Lower Chester Weir to Ceiriog	26.7	4
Coastal streams - Druidston to Fishguard Bay	26.7	4
Coastal streams of North Milford Haven - Llangwm Pill to St Anne's Head	26.7	4
Rhymney	26.7	4
Perry Roden and Tern North Shropshire	26.3	4
Coastal streams - Cardigan to Aberaeron	26	4
Teifi	25.7	4
Coastal streams - South Gower	25.3	4
Usk Brecon to Abergavenny	25.3	4
Gwendraeth Fach and Fawr	25.3	4
Severn Upper Montfort North	25	4
Teme Upper	25	4
Worthenbury	25	4
Braint Cadnant Lleiniog	24.7	4
Tywi	24.7	4
Wye H and W d s Lugg	24.3	4
Coastal streams and Nevern - Fishguard Bay to Cardigan	23.7	4

Operational catchment	Unadjusted hazard score	Adjusted hazard score
Dwyryd	23.3	4
Conwy Lower	23	3
Dwyfor	23	3
Neath	23	3
Ogwen Ddu	23	3
Rea Brook	23	3
Lligwy - Ynys Mon	22.7	3
Reens West	22.7	3
Dee Middle Ceiriog to Alwen	22.3	3
Arrow, Lugg and Frome	22	3
Soch	22	3
Ebbw Sirhowy	21.3	3
Arth and Wyre	21	3
Coastal streams - North Gower	21	3
Taf	21	3
Monnow	20.7	3
Wygyr	20.7	3
Glaslyn	20.3	2
Kenfig	20.3	2
Lugg	20.3	2
Rheidol and Clarach	20.3	2
Alaw Goch	20.3	2
Cefni	20	2
Llynfi	20	2
Rhondda	20	2
Artro	19	2
Severn Upper Montfort East	19	2
Severn Upper Montfort South	19	2
Taff u s Cynon	19	2
Cynon	18	2
Mawddach Estuary South	17.3	2
Aeron	17.3	2
Trothy	17.3	2
East Reens	17	2
Dyfi Lower	16.3	2
Ithon	16.3	2
Elwy	16.3	2
Afan	16	2
Severn Upper and Cain River	16	2
Irfon	15.7	2
Severn Up Trannon Clywedog	15.3	1
Ceiriog	15.3	1
Clwyd Upper	15.3	1
Severn Upper and Tanat River	15.3	1
Severn Upper and Rhiw River	14.7	1
Alwen	14.7	1

Operational catchment	Unadjusted hazard score	Adjusted hazard score
Severn Up Twrch and Banwy	14.7	1
Usk Upper Brecon	14.7	1
Ystwth	14.7	1
Clun River	14.3	1
Mawddach Estuary North	14.3	1
Wye H and W - Ithon to Hay	14.3	1
Conwy Upper	14	1
Mawddach	14	1
Wnion	13.3	1
Dysynni	13	1
Dee Upper above Alwen	12	1
Dyfi Upper	12	1
Severn Upper and Vrynwy River	12	1
Wye H and W u s Ithon	8.7	1

Table 10.2: AMR exposure map hazard scores. Hazard scores shown were summed from all attribute-specific hazard scores (unadjusted) and re-ranked into final hazard scores (adjusted).

Operational catchment	Unadjusted hazard score	Adjusted hazard score
Dwyfor	10	5
Dyfi Lower	10	5
Gwyrfai Seiont	10	5
Artro	6	4
Clwyd Lower	6	4
Coastal streams - Cardigan to Aberaeron	6	4
Coastal streams - Druidston to Fishguard Bay	6	4
Coastal streams and Nevern - Fishguard Bay to Cardigan	6	4
Coastal streams of North Milford Haven - Llangwm Pill to St Anne's Head	6	4
Coastal streams of South Pembs and South Milford Haven - Pendine to Landshipping	6	4
Conwy Lower	6	4
Crigyll Caradog	6	4
Dee Middle Ceiriog to Alwen	6	4
Dulas Ganol	6	4
Dwyryd	6	4
Dysynni	6	4
Erch	6	4
Glaslyn	6	4
Irfon	6	4
Llynfi	6	4
Mawddach	6	4
Mawddach Estuary South	6	4
Monnow	6	4
Neath	6	4

Operational catchment	Unadjusted hazard score	Adjusted hazard score
Rheidol and Clarach	6	4
Usk Brecon to Abergavenny	6	4
Usk Lower Abergavenny	6	4
Ystwth	6	4
Dee Upper above Alwen	5	4
Tywi	5	4
Usk Upper Brecon	5	4
Wye	5	4
Wye H and W - Ithon to Hay	5	4
Aeron	2	1
Afan	2	1
Alaw Goch	2	1
Alwen	2	1
Alyn	2	1
Arrow, Lugg and Frome	2	1
Arth and Wyre	2	1
Braint Cadnant Lleiniog	2	1
Cefni	2	1
Ceiriog	2	1
Clun River	2	1
Clwyd Upper	2	1
Clywedog - Dee	2	1
Coastal streams - North Gower	2	1
Coastal streams - South Gower	2	1
Conwy Upper	2	1
Cynon	2	1
Dee Estuary	2	1
Dee Lower Chester Weir to Ceiriog	2	1
Dyfi Upper	2	1
East Reens	2	1
Eastern Cleddau	2	1
Ebbw Sirhowy	2	1
Elwy	2	1
Ely	2	1
Gele	2	1
Gwendraeth Fach and Fawr	2	1
Ithon	2	1
Kenfig	2	1
Lligwy - Ynys Mon	2	1
Llwyd	2	1
Loughor	2	1
Lugg	2	1
Mawddach Estuary North	2	1
Morda and Severn North Shropshire	2	1
Ogmore	2	1
Ogwen Ddu	2	1

Operational catchment	Unadjusted hazard score	Adjusted hazard score
Perry Roden and Tern North Shropshire	2	1
Rea Brook	2	1
Reens West	2	1
Rhondda	2	1
Rhymney	2	1
Severn Up Trannon Clywedog	2	1
Severn Up Twrch and Banwy	2	1
Severn Upper and Cain River	2	1
Severn Upper and Rhiw River	2	1
Severn Upper and Tanat River	2	1
Severn Upper and Vrynwy River	2	1
Severn Upper Montfort East	2	1
Severn Upper Montfort North	2	1
Severn Upper Montfort South	2	1
Soch	2	1
Taf	2	1
Taff d s Cynon	2	1
Taff u s Cynon	2	1
Tawe	2	1
Teifi	2	1
Teme Upper	2	1
Thaw and Cadoxton	2	1
Trothy	2	1
Western Cleddau	2	1
Wnion	2	1
Worthenbury	2	1
Wye H and W d s Lugg	2	1
Wye H and W u s Ithon	2	1
Wygyr	2	1

11 APPENDIX-E: DATA REGISTER

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
1	1999 Environment Agency report on sewage sludge	http://www.environmentdata.org/download/file/ealit:4812/ealit:4812/1/0/OBJ/PDF/NA	Contains detailed data on average sludge production, treatments, quality (concentrations of pollutants), area of land used and application methods.	Biosolid landspreading can be a major mechanism for the dissemination of AMR in the environment and source of exposure to humans through rambling, food and aerosols.	1999 report	United Kingdom	PDF	N	Y
2	Airport	https://ourairports.com/data/	List of airport locations across the world.	Areas in which international travellers may bring in new AMR genes/organisms	Last Updated: January 2021	World	CSV	Y	N
3	Animal and Plant Health Agency (APHA) Livestock Demographic Data Group Enhanced Demographic reports (Cattle, Pigs)	Cattle: http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-dem-report-cattle2019.pdf Pig: http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-dem-report-pig2019.pdf	APHA reports only, focussed on additional information to help understand the movement of disease in animals, and discussing imports, exports, transportation.	Antimicrobials, resistant organisms from animal excreta can leach from land into waterbodies.	2019 (cattle), 2018 (pigs)	Great Britain	PDF	N	Y
4	Animal and Plant Health Agency (APHA) Livestock Demographic Data Group population density (Cattle, Sheep, Goat, Poultry)	Cattle: http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-pop-report-cattle2019.pdf Sheep: http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-pop-report-sheep2019.pdf Pig: http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-pop-report-pig2019.pdf Goat: http://apha.defra.gov.uk/docu	Datasets that include population density of cattle, poultry, goat and sheep across the UK (2019) at 1km scale (averaging over a radius of 15km) based on reporting from farms on each animal type.	Antimicrobials and resistant organisms from animal excreta can leach from land into waterbodies.	2019	Great Britain	Raster	Y	Y

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
		ments/surveillance/diseases/lddg-pop-report-goat2019.pdf Poultry: http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-pop-report-avian2019.pdf							
5	Aquaculture	https://www.seafish.org/document/?id=4382B7AA-FFCE-448B-850D-46A8F7959115	Distribution of aquaculture activity and estimated contribution to employment across Wales	Antimicrobials used in aquaculture can leach into downstream waterways and can select for antibiotic resistant bacteria and genes which can also spread into downstream water bodies. In addition, consumption of fish may result in exposure to antibiotic resistant bacteria and genes.	Published: September 2016	England, Wales and Northern Ireland	PDF	N	Y
6	Areas affecting bathing waters	http://lle.gov.wales/catalogue/item/AreasAffectingBathingWaters/?lang=en	This dataset comprises of polygons relating to each site identified under the Bathing Water Directive (76/160/EEC); however these polygons have no formal status under the Bathing Water Directive.	Areas that affect bathing water sites may result in input of anthropogenic pollution (including antimicrobials and AMR organisms) and could potentially expose bathers.	2022	Wales	SHP	Y	N
7	Bathing Water Quality at Designated Beaches	http://lle.gov.wales/catalogue/item/BathingWaterQualityAtDesignatedBeaches/?lang=en	Natural Resources Wales monitors bathing water sites identified under EC Bathing Waters Directive 2006/7/EC in Wales. Samples are taken throughout the bathing season from May to the end of September and analysed for two parameters: Escherichia coli and intestinal enterococci. A classification of bathing water quality, generally based on 4 years of sample results, is produced for each bathing water at the end of each season.	Low bathing water quality could result in higher human exposure events to AMR.	2016	Wales	XLSX	Y	N
8	Bio-solid use rates from British Survey Fertiliser Practices	https://www.gov.uk/government/statistical-data-sets/british-survey-of-fertiliser-practice-dataset	This dataset gives annual statistics on fertiliser use on the major crops and grass grown in mainland Britain. It is updated each year when the annual report on the British Survey of Fertiliser Practice is published.	Biosolid lanspreading can be a major mechanism for the dissemination of AMR in the environment and source of exposure to humans and wildlife through rambling, food and aerosols.	Updated annually (Data updated: 17/12/20)	Great Britain	ODS	N	N

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
9	CEH Land Cover plus Pesticides 2019	First national maps of pesticide and fertiliser use | UK Centre for Ecology & Hydrology (ceh.ac.uk)	CEH Land Cover plus: Pesticides maps annual average pesticide applications across England, Wales and Scotland. The product provides application estimates for 162 different active ingredients including herbicides, insecticides, molluscicides and fungicides.	Pesticide concentrations are co-selective for for AMR and therefore their presence in the environment may increase AMR there	2019	United Kingdom	Maps	N	Y
10	Coal authority	Interactive Map Viewer | Coal Authority (bgs.ac.uk)	Map showing the coal mining reporting areas in Great Britian	Mining run off can cause co-selection of AMR in the environment	No information	Great Britain	Online interactive map	Y	Unclear
11	Consented discharges to controlled waters with conditions	Lle - Consented Discharges to Controlled Waters with Conditions (gov.wales)	This dataset provide details of permit details as required under the Environmental Permit Regulations. Consented discharges include from WWTPs, aquaculture and shellfisheries, industrial discharges etc	Discharge of antimicrobials and resistant organisms into water environments.	2013	Wales	XLSX	Y	N
12	England and Wales - Shellfish Classification Zones of England and Wales	http://data.cefas.co.uk/#/View/79	Map of Bivalve mollusc (shellfish) classification zones in England and Wales.	Shellfish beds can be exposed to sewage and harbour antimicrobial resistance that can be passed on to humans through consumption of shellfish (raw or cooked).	Updated Quarterly Dataset reference date: 24/11/2020 (Revision)	England and Wales	ESRI Shapefile	Y	N
13	Environmental Permitting Regulations – Industrial Sites	Lle - Environmental Permitting Regulations - Industrial Sites (gov.wales)	The Environmental Permitting Regulations, amongst other things, implement the IPPC (Integrated Pollution Prevention and Control) Directive (EC/61/96) in England and Wales.	Industrial pollution can be a localised hotspot for AMR	2013	England and Wales	XLSX	Y	N
14	Environmental Permitting Regulations – Waste Sites	Lle - Environmental Permitting Regulations – Waste Sites (gov.wales)	Waste management licence is a legal document issued under the Environmental Protection Act 1990. A licence authorises the treatment, keeping or disposal of waste in or on the land. Once we have issued a licence, neither the activities nor the area of land may be changed unless the licence is modified.	Pollution, in general, can be a driver for AMR.	2022	Wales	XLSX	Y	N
15	Environmetnal pollution incidents	Lle - Environmental Pollution Incidents (gov.wales)	This dataset contains details pollution incidents reported to NRW. Only substantiated and closed environmental protection incidents are included.	Anthropogenic pollution can lead to antimicrobial and other co-selecting compounds entering the environment (& selecting for resistant in environmental and clinical organisms) and resistant bacteria and genes entering the environment.	04/2013-02/2016	Wales	XLSX	Y	Y

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
16	Estimates of manure volumes by livestock type and land use for England and Wales	https://catalogue.ceh.ac.uk/documents/517717f7-d044-42cf-a332-a257e0e80b5c	Estimates of annual volumes of manure produced by six broad farm livestock types for England and Wales at 10 km resolution, modelled with MANURES-GIS.	Antimicrobials and AMR found in manure can leach from land into rivers and groudwater and also impact wildlife and ramblers.	2010-01-01 to 2010-12-31	England and Wales	SHP	Y	Y
17	Event Duration Monitoring - Storm Overflows - 2021 (England and Wales)	Event Duration Monitoring - Storm Overflows - 2021 (England and Wales) | Event Duration Monitoring - Storm Overflows - 2021 (England and Wales) | Catchment Based Approach	The data shows how often and for how long monitored storm overflows discharged during 2021 for 10 water companies operating in England and Wales.	Discharge of untreated wastewater into dowstream waterbodies can increase the abundance of antimicrobial concentrations and resistant organisms	2021	England and Wales	SHP	Y	N
18	Hafren Dyfrdwy WWTP locations and population equivalents	N/A - data held internally at UKCEH	This dataset provide details of details of Hafren Dyfrdwy WWTP assets and discharge pipe locations, type of wastewater treatment, permit number and total population equivalents.	Discharge of antimicrobials and resistant organisms from treated wastewater into water environments.	~2012	Covers a portion of Wales. The rest of Wales is covered by Welsh Water (Dataset 53).	SHP	Y	Y
19	Historical Landfill	Lle - Historic Landfill Sites (gov.wales)	Historic Landfill Sites is a spatial dataset. These are landfill sites which have been taken off the Authorised Landfill Sites when the waste licence status changed.	Leaching of antimicrobials and AMR from landfill sites into waterways	2020	Wales	SHP	Y	N
20	Hospitals in Wales	Health in Wales | Hospitals	Directory of all hospitals in Wales Note: We have created a geospatial dataset with hospital location and bed number based on this data see appendix F	Hospital waste is an important source of antibiotics and AMR into the water environment.	No information	Wales	Website	N	Unclear
21	Important Bird Areas UK	https://opendata-rspb.opendata.arcgis.com/datasets/c38f60f68f094f269d90db26b1381837_0	Royal Society for the Protection of Birds - Important Bird Areas, updated Feb 2020 to resolve projection issue	Migrating birds can bring antimicrobial resistant organisms across long distances into and distribute within the UK	Data updated: Feb 2020	United Kingdom	SHP	Y	N
22	Inventory of closed mining facilities	Lle - Inventory of Closed Mining Waste Facilities (gov.wales)	The European Mining Waste Directive (2006/21/EC) requires Member States to create an inventory of closed or abandoned mine waste facilities causing serious environmental impacts, and to make this inventory available to the public.	Mining run off can cause co-selection of AMR in the environment	2015	Wales	SHP	Y	Y

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
23	June agricultural survey	https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june	Detailed annual statistics on the structure of the agricultural industry at 1 June in the UK.	Agricultural practices can result in antimicrobials, resistant organisms into water bodies.	1984 - 2020 (Annual Statistics)	United Kingdom	ODS	N	N
24	LAND COVER MAP 2020	UKCEH Land Cover Maps | UK Centre for Ecology & Hydrology	The UKCEH Land Cover Maps (LCMs) map UK Land Cover. They do this by describing the physical material on the surface of the United Kingdom providing an uninterrupted national dataset of land cover classes from grassland, woodland and fresh water to urban and suburban built-up areas.	The crop map will indicate the land use and crop grown on it which will lend inference to the kind of pesticides/herbicides that could be found locally and impact on AMR	2020	Great Britain	SHP	Y	N
25	Land Cover Map plus Crops 2015-2021	UKCEH Land Cover® plus: Crops | UK Centre for Ecology & Hydrology	UKCEH Land Cover® plus: Crop maps were the first detailed, interactive, digital maps of cropping in Great Britain.	The crop map will indicate the land use and crop grown on it which will lend inference to the kind of pesticides/herbicides that could be found locally and impact on AMR	2021	Great Britain		Y	N
26	Latest animal feed production statistics	https://www.gov.uk/government/statistics/animal-feed-production	Monthly statistics on raw material usage and production of compound animal feed by manufacturers in Great Britain.	Animal feed can contain antimicrobials and co-selecting chemicals making their production and use a source of AMR.	1990-2019	Great Britain	ODS	N	Y
27	LF2000-WQX (wastewater concentrations across England and Wales)	Low Flows software | UK Centre for Ecology & Hydrology (ceh.ac.uk)	The CEH Low Flows software is a decision support tool that estimates river flows at ungauged sites.	Wastewater concentrations will informtation to be gathered about exposure risk to those who come into contact with rivers based on how concentrated or diluted the wastewater is	No information	England and Wales	SHP	Y	Unclear
28	Materials Facilities Reporting (waste)	Lle - Materials Facilities Reporting (gov.wales)	Quarterly Operator reported, input and output sampling data that qualifying Materials Facilities are required to provide by the regulations.	Leaching of chemicals used in materials facillities may be able to co-select for AMR	2021	Wales	XLSX	Y	N
29	Minerals resource polygons Wales version 1	Mineral resource polygons Wales version 1 - data.gov.uk	Comprehensive, relevant and accessible information base to enhance the sustainability of mineral resources for Wales.	This mineral map includes data on metallic minerals which are able to co-select for AMR	2020	Wales	SHP	Y	N

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
30	Ofwat report appendix on "Sludge treatment, transport and disposal – supporting evidence and design options"	https://www.ofwat.gov.uk/wp-content/uploads/2015/12/pap_tec20151210water2020app1.pdf	Limited regional data on sewage sludge production rates, but with graphs of sludge treatment centre capacities, but overall focussed on economics.	Biosolid lanspreading can be a major mechanism for the dissemination of AMR in the environment and source of exposure to humans through rambling, food and aerosols.	2015 report	England and Wales	PDF	N	Y
31	OS Detailed Path Network	https://www.ordnancesurvey.co.uk/business-government/products/path-network	OS Detailed Path Network is a fully-connected, heighted path network covering Britain's National Parks.	Paths that intersect with farms that are amended with sludge or biosolids can be a mechanism of AMR transmission to rambling humans, companion animals and wildlife.	Possibility to order the most up to date version	Great Britain	GPKG	Y	N
32	OS MasterMap Water Network Layer	https://www.ordnancesurvey.co.uk/business-government/products/mastermap-water	OS MasterMap® Water Network Layer offers one of the world's most detailed, heighted water networks, showing the flow and precise course of every river, stream, lake and canal in Great Britain.	Water network map is an essential tool	Updated Quarterly - April, July, October, January	Great Britain	FGDB	Y	N
33	OS Open Rivers	OS Open Rivers - data.gov.uk	OS Open Rivers GIS data contains over 144,000 km of water bodies and watercourses map data. These include freshwater rivers, tidal estuaries and canals.	A river layer is a basic necessity for undertaking this type of work. This datalayer is more detailed than the WFD equivalent.	2021	Great Britain	SHP	Y	N
34	OS Vectormap district - roads	https://www.ordnancesurvey.co.uk/business-government/products/vectormap-district	Thematic layers, including settlements, named places, roads, woodland and administrative boundaries	Roads that intersect with water bodies may lead to road run off of heavy metals and could allow for the co-selection of AMR in the receiving waterbodies.	Updated twice a year, in May and November	Great Britain	SHP	Y	N
35	Permitted waste sites	Natural Resources Wales / Find details of permitted waste sites	Businesses in Wales that use, recycle, treat, store or dispose of waste need a permit from Natural Resources Wales to legally operate.	Leaching of antibiotics and AMR from landfill sites into waterways	2021	Wales	Interactive online map	Y	N
36	Pets UK	https://www.rvc.ac.uk/vetcompass/learn-zone/infographics/uk	Demographic information for pets in Scotland, Wales, Northern Ireland, Northern England, Midland England, South West England or South East England. Including disease prevalence data for UK pet cats and dogs.	Use of antimicrobials in companion animals is significant and could impact the spread of AMR. In addition, concerns about raw pet food diets in the spread and transmission of AMR to companion animals. Excretion by companion animals can lead to downstream pollution of the ennvironment	No information	United Kingdom	PDF	N	Unclear

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
37	Scientific journal paper: Summary of current knowledge of the size and spatial distribution of the horse population within Great Britain	https://bmcvetres.biomedcentral.com/articles/10.1186/1746-6148-8-43#Sec11	Detailed annual statistics on the structure of the agricultural industry at 1 June in England and the UK.	Animal manure can be a source of AMR through antimicrobial resistant organisms and chemical drivers	2012 article	Great Britain	PDF	N	Y
38	Sensitive Areas - Eutrophic Lakes	Lle - Sensitive Areas – Eutrophic (gov.wales)	This dataset consists of 3 shapefiles showing the extent of Urban Wastewater Treatment Directive (91/271/EEC) (UWWTD) sensitive areas (eutrophic). The UWWTD describes eutrophication as 'the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorous, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned'. The UWWTD regulates the collection and treatment of waste water from homes and from industry. In the UK, the Directive is implemented through the Urban Wastewater Treatment Regulations 1994. Under these Regulations, water bodies that are (or may soon become) eutrophic should be designated as sensitive areas by Defra. This applies to still fresh waters, rivers, estuaries and coastal waters.	Eutrophic lakes are an indication of pollution which can select for AMR.	2016	Wales	SHP	Y	Y
39	Septic tanks	Natural Resources Wales / Register your septic tank or small sewage (package) treatment plant	Online form for registration for septic tanks. Registration held by Natural Resources Wales. Note: Data held by Natural Resources Wales. This would need to be accessed to be used for mapping.	Untreated wastewater harbouring can leach from septic tanks into the surrounding environment.	No information	Wales	Website	N	Unclear

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
40	Shellfish Water Protected Areas	Natural Resources Wales / Shellfish Water Protected Areas	The Water Framework Directive requires specification of protected areas for those areas designated for the protection of economically significant species. This list are those protected areas previously designated under the repealed Shellfish Waters Directive which are now specified under the Water Framework Directive.	Shellfish beds can be exposed to sewage and harbour antimicrobial resistance that can be passed on to humans through consumption of shellfish (raw or cooked).	2016	Wales	PDF	N	Y
41	Sites of Special Scientific Interests	Lle - Sites of Special Scientific Interest (SSSI) (gov.wales)	This spatial dataset contains the boundaries of Sites of Special Scientific Interest (SSSIs) in Wales. SSSIs cover a wide range of habitats from small fens, bogs and riverside meadows to sand dunes, woodlands and vast tracks of uplands.	These are areas that are unlikely to be high in AMR and could offer potential controls sites for comparing AMR prevalence.	2022	Wales	SHP	Y	N
42	Soils metal data	Soil metals data 2007 [Countryside Survey] - EIDC (ceh.ac.uk)	This dataset consists of metal concentrations (aluminium, arsenic, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, titanium and zinc) measured from soils sampled across Great Britain in 2007.	Heavy metal concentrations are highly co-selective for for AMR and therefore their presence in the environment may increase AMR there	2007	Great Britain	CSV	N	Y
43	Traditional Orchards	Lle - Traditional Orchards (gov.wales)	This is a spatial dataset contain the location of Traditional Orchards sites around Wales.	Antimicrobials used in orchards may leach into the environment (and subsequent downstream water bodies) and select for resistant bacteria.	2013-2016	Wales	SHP	Y	Y
44	Urban Waste Water Treatment Directive	Natural Resources Wales / Urban waste water	The Urban Waste Water Treatment Directive (91/271/EEC) ('the Directive') is one of a number of European Union (EU) directives which are intended to protect the water environment for the animals and plants that live in and around water, as well as for recreational purposes and use as a resource for drinking water, sanitation, industry and commerce.	Discharge of treated effluent into dowstream waterbodies can increase the abundance of antimicrobial concentrations, antimicrobial resistant organisms and genes	No information	Wales	Website	N	Unclear
45	Veterinary Antimicrobial Resistance and Sales Surveillance 2020	UK Veterinary Antibiotic Resistance and Sales Surveillance Report UK-VARSS 2019 (publishing.service.gov.uk)	This report (UK VARSS) provides the details of UK veterinary antibiotic resistance and sales surveillance. Contains information on antimicrobial sales and use by animal types (including aquaculture and pets), and on surveillance of antimicrobial resistance.	Antimicrobial sales will have an environmental footprint on AMR	2020	United Kingdom	PDF	N	N

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
46	Wales Activity Mapping	Wales Activity Mapping - Wales Activity Mapping	The project is a study into the type, amount and distribution of activities carried out on the South West Wales Coastline which includes information on relevant infrastructure and management issues.	Areas that are heavily used may result in a greater risk of exposure to environmental AMR (e.g., sewage, wildlife faeces).	No information	Pembrokeshire only	Interactive online map	Y	Y
47	Waste Permit Returns Data Interrogator	Lle - Waste Permit Returns Data Interrogator (gov.wales)	All operators of regulated waste management facilities have to provide us with details of the quantities and types of waste they deal with i.e. waste received into site and waste sent on from site to other facilities or processes. This data is used to monitor compliance but has historically been used by the EC, DEFRA and local authorities to assist in planning for new waste facilities and for monitoring against statutory targets.	Incinerators and the pollution it generates could be important for local levels of AMR	2020	Wales	XLSX	Y	N
48	Water Framework Directive (WFD) Canal waterbodies Cycle 2	Lle - Water Framework Directive (WFD) Canal waterbodies Cycle 2 (gov.wales)	This dataset is a GIS layer identifying the canal waterbodies managed under the Water Framework Directive and any related programmes. This includes canals which are reported to Europe as artificial rivers.	Classifications can show potential exposure routes for humans to AMR in water bodies	2018	Wales	SHP	Y	Y
49	Water Framework Directive (WFD) Lake Waterbodies Cycle 2	Lle - Water Framework Directive (WFD) Lake Waterbodies Cycle 2 (gov.wales)	WFD Lake Waterbodies is a spatial dataset containing Water Framework Directive (WFD) attributes that have been collated as defined for the implementation of the Water Framework Directive. Article 2, clause 5 of the WFD defines them as '…a body of standing inland surface water'. There is data on the physical characteristics, risk, classification and proposed objectives that can be linked to waterbodies by their unique identifiers.	High quality habitats are likely to have low pollution with means it migh be a poor place to select for AMR	2018	Wales	SHP	Y	Y
50	Water Framework Directive (WFD) Operational Catchments Cycle 2	Lle - Water Framework Directive (WFD) Operational Catchments Cycle 2 (gov.wales)	Operational catchments are a way of grouping Water Framework Directive (WFD) waterbodies together for the purposes of economic appraisal. Every waterbody has been assigned to an Operational catchment. They are not always hydrologically correct catchments as the river waterbodies may have been grouped based on pressures and measures than hydrology. They may also include coastal waters for example.	River catchment map is an essential tool	2018	Wales	SHP	Y	Y

ID	Title	URL	Dataset description	Use in AMR surveillance	Temporal extent	Spatial extent	Data format	Geo-spatial	Need to update?
51	Water Framework Directive (WFD) River Waterbodies Cycle 2	Lle - Water Framework Directive (WFD) River Waterbodies Cycle 2 (gov.wales)	This is a spatial dataset identifying the river waterbodies managed under the Water Framework Directive and any related programs. 'WFD River Waterbodies Cycle 2' is a subset extracted from the NRWs Detailed River Network.	Classifications can show potential exposure routes for humans to AMR in water bodies	2018	Wales	SHP	Y	Y
52	Water Framework Directive (WFD) Surface Water Transfer waterbodies Cycle 2	Lle - Water Framework Directive (WFD) Surface Water Transfer waterbodies Cycle 2 (gov.wales)	This dataset is a GIS layer identifying the Surface Water Transfer (SWT) waterbodies managed under the Water Framework Directive and any related programmes. This includes SWT which are reported to Europe as artificial rivers. These waterbodies are represented by their centreline, and can be linked to other WFD data using the unique water body ID (WB_ID).	Classifications can show potential exposure routes for humans to AMR in water bodies	2018	Wales	SHP	Y	Y
53	Welsh Water WWTP locations and population equivalents	N/A - data provided via information request	This dataset provide details of details of Welsh Water WWTP assets and discharge pipe locations, type of wastewater treatment, permit number, total population equivalents and populations excluding non-resisdents.	Discharge of antimicrobials and resistant organisms from treated wastewater into water environments.	2022	Covers a portion of Wales. The rest of Wales is covered by Hafren Dyfrdwy (Dataset 18).	SHP	Y	N
54	Wild Swimming	http://www.wildswimming.co.uk/wales/?multi_region=wales	Locations of wild swimming sites in Wales. Note: We have created a geospatial dataset with wild swimming location based on this dataset. See appendix G	Wild swimming in sites that are not monitored for bathing water quality can put bathers at risk of exposure to environmental AMR.	No information	Wales	Online interactive map	Y	Unclear

12 APPENDIX-F: HOSPITALS DATA SET

Hospital name	Hospital type	Postcode	Grid Reference	X	Y	Latitude	Longitude	Bed number	Bed number reference
Bronglais General Hospital	Major acute	SY23 1ER	SN 59240 81842	259240	281842	52.41641	-4.07113	155	https://hduhb.nhs.wales/about-us/governance-arrangements/freedom-of-information/disclosure-log/disclosure-logs/hywel-dda-university-health-board/
Glan Clwyd Hospital	Major acute	LL18 5UJ	SJ 00232 75974	300232	375974	53.27133	-3.49748	466	Glan Clwyd Hospital - Wikipedia
Glangwili General Hospital	Major acute	SA31 2AF	SN 42827 21251	242827	221251	51.86763	-4.28422	403	https://hduhb.nhs.wales/about-us/governance-arrangements/freedom-of-information/disclosure-log/disclosure-logs/hywel-dda-university-health-board/
Morriston Hospital	Major acute	SA6 6NL	SN 66311 00206	266311	200206	51.68465	-3.93525	720	Morriston Hospital - Swansea Bay University Health Board (nhs.wales)
Prince Charles Hospital	Major acute	CF47 9DT	SO 04475 08105	304475	208105	51.76345	-3.38557	410	https://heiw.nhs.wales/files/foundation-programmes/prince-charles-royal-glamorgan-princess-of-wales-f2/
Princess of Wales Hospital	Major acute	CF31 1RQ	SS 91044 81050	291044	181050	51.51783	-3.57169	200	Princess of Wales Hospital - Wikipedia
Royal Glamorgan Hospital	Major acute	CF72 8XR	ST 03646 84215	303646	184215	51.54857	-3.39099	545	https://heiw.nhs.wales/files/foundation-programmes/prince-charles-royal-glamorgan-princess-of-wales-f2/
The Grange University Hospital	Major acute	NP44 8YN	ST 31120 94709	331120	194709	51.64694	-2.99691	560	The Grange University Hospital - Aneurin Bevan University Health Board (nhs.wales)
Withybush General Hospital	Major acute	SA61 2PZ	SM 95739 16887	195739	216887	51.81319	-4.96469	213	https://hduhb.nhs.wales/about-us/governance-arrangements/freedom-of-information/disclosure-log/disclosure-logs/hywel-dda-university-health-board/
Wrexham Maelor Hospital	Major acute	LL13 7TD	SJ 32521 50330	332521	350330	53.04596	-3.008	800	Wrexham Maelor Hospital - Wikipedia
Ysbyty Gwynedd	Major acute	LL57 2PW	SH 55857 70173	255857	370173	53.20902	-4.15983	463	Ysbyty Gwynedd - Wikipedia
Barry Hospital	Community	CF62 8YH	ST 10731 69096	310731	169096	51.41383	-3.28502	60	Cardiff and Vale University Health Board - Wikipedia
Brecon War Memorial Hospital	Community	LD3 7NS	SO 04921 28753	304921	228753	51.94912	-3.3848	No information	
Bryn Beryl Hospital	Community	LL53 6TT	SH 39057 37661	239057	337661	52.91221	-4.3949	24	180718brynberylen.pdf (hiw.org.uk)
Cardigan Integrated Care Centre	Community	SA43 1JX	SN 17676 46721	217676	246721	52.08873	-4.66266	0	Cardigan Integrated Care Centre (wales.nhs.uk)
Denbigh Community Hospital	Community	LL16 3ES	SJ 05870 66357	305870	366357	53.18595	-3.41013	40	Hospital%/20Inspection%/20Report%/20-%/20Mold%/20Community%/20Hospital%/20-%/20Betsi%/20Cadwaladr%/20University%/20Health%/20Board%/20-%/2024%/20and%/2025%/20November%/202015.pdf (hiw.org.uk)

Hospital name	Hospital type	Postcode	Grid Reference	X	Y	Latitude	Longitude	Bed number	Bed number reference
Dolgellau & Barmouth District Hospital	Community	LL40 1NT	SH 73058 17562	273058	317562	52.74074	-3.88177	20	180321dolygellautywynen.pdf (hiw.org.uk)
Holywell Community Hospital	Community	CH8 7TZ	SJ 18963 75413	318963	375413	53.26949	-3.21654	44	170227bcucommunityen.pdf (hiw.org.uk)
Llandovery Hospital	Community	SA20 0LA	SN 76747 34889	276747	234889	51.99872	-3.79674	16	200228llandoveryen.pdf (hiw.org.uk)
Llandrindod Wells County War Memorial Hospital	Community	LD1 5HF	SO 06091 61452	306091	261452	52.24321	-3.37681	10	Introduction (hiw.org.uk)
Llandudno General Hospital	Acute	LL30 1LB	SH 78317 80914	278317	380914	53.31114	-3.82782	150	Introduction (hiw.org.uk)
Mold Community Hospital	Community	CH7 1XG	SJ 23370 64244	323370	364244	53.16977	-3.1478	40	Hospital%20Inspection%20Report%20-%20Mold%20Community%20Hospital%20-%20Betsi%20Cadwaladr%20University%20Health%20Board%20-%2024%20and%2025%20November%202015.pdf (hiw.org.uk)
Neath Port Talbot Hospital	Acute	SA12 7BX	SS 75402 90466	275402	190466	51.59921	-3.80035	190	https://sbuhb.nhs.wales/files/freedom-of-information-disclosure-log-2020/march/20-c-029-hospital-beds/
Nevill Hall Hospital	Acute	NP7 7EG	SO 28824 14435	328824	214435	51.82398	-3.03412	213	Nevill Hall Hospital - Aneurin Bevan University Health Board (nhs.wales)
Prince Philip Hospital	Major acute	SA14 8QF	SN 52544 01397	252544	201397	51.6919	-4.13476	218	https://hduhb.nhs.wales/about-us/governance-arrangements/freedom-of-information/disclosure-log/disclosure-logs/hywel-dda-university-health-board/
Royal Gwent Hospital	Acute	NP20 2UB	ST 30895 87317	330895	187317	51.58046	-2.9987	371	Royal Gwent Hospital - Aneurin Bevan University Health Board (nhs.wales)
Tenby Walk-in Centre	Community	SA70 8AG	SN 13231 01101	213231	201101	51.67754	-4.70277	0	Not open overnight https://111.wales.nhs.uk/LocalServices/ViewLocalService.aspx?id=3189
Tywyn Memorial Hospital	Community	LL36 9HH	SH 59086 00513	259086	300513	52.58411	-4.0813	16	180321dolygellautywynen_0.pdf (hiw.org.uk)
Victoria Memorial Hospital	Community	SY21 7DU	SJ 22765 07783	322765	307783	52.66225	-3.1434	21	General Hospital - Victoria War Memorial (wales.nhs.uk)
Ysbyty Alltwen	Community	LL49 9AQ	SH 55655 40297	255655	340297	52.9406	-4.14943	18	Ysbyty Alltwen - Betsi Cadwaladr University Health Board (nhs.wales)
Ysbyyt Aneurin Bevan	Acute	NP23 6GL	SO 17026 09316	317026	209316	51.77634	-3.20405	107	Ysbyty Aneurin Bevan - Aneurin Bevan University Health Board (nhs.wales)
Ysbyty Cwm Cynon	Community	CF45 4BZ	ST 03818 99642	303818	199642	51.68727	-3.39275	No information	
Ysbyty Cwm Rhondda	Community	CF40 2LX	SS 99747 94069	299747	194069	51.63647	-3.45002	81	Introduction (hiw.org.uk)

Hospital name	Hospital type	Postcode	Grid Reference	X	Y	Latitude	Longitude	Bed number	Bed number reference
Ysbyty Penrhos Stanley	Community	LL65 2QA	SH 25796 81795	225796	381795	53.30437	-4.61585	33	170629penrhosen.pdf (hiw.org.uk)
Ysbyty Ystrad Fawr	Acute	CF82 7GP	ST 14646 93561	314646	193561	51.63436	-3.23467	164	Ysbyty Ystrad Fawr - Aneurin Bevan University Health Board (nhs.wales)
Ystradgynlais Community Hospital	Community	SA9 1AU	SN 78184 09051	278184	209051	51.76684	-3.76669	No information	
Pontypridd & District Cottage Hospital	Acute	CF37 4AL	ST 08267 90098	308267	190098	51.60222	-3.32591	6	Pontypridd Cottage Hospital (wales.nhs.uk)
St. Woolos Hospital	Acute	NP20 4SZ	ST 30586 87460	330586	187460	51.5817	-3.00318	0	Not open overnight https://111.wales.nhs.uk/LocalServices/ViewLocalService.aspx?id=3174
Aberaeron Integrated Care Centre	Community	SA46 0DY	SN 45911 62319	245911	262319	52.23744	-4.258	0	Not open overnight https://hduhb.nhs.wales/healthcare/hospitals-and-centres/centres-and-clinics/health-centres-ceredigion/aberaeron-integrated-care-centre/
Abergele Hospital	Community	LL22 8DP	SH 94704 75477	294704	375477	53.2658	-3.58017	No information	
Amethyst SARC	Community	LL29 8AB	SH 85814 78180	285814	378180	53.28825	-3.71438	No information	
Amman Valley Hospital	Community	SA18 2BQ	SN 67452 13970	267452	213970	51.8086	-3.924	28	Amman Valley Hospital (final report January 2018).pdf (wales.nhs.uk)
Bronllys Hospital	Community	LD3 0LY	SO 13677 35118	313677	235118	52.00776	-3.25904	0	Day beds only. Not open overnight. Bronllys Health Centre (wales.nhs.uk)
Cardiff Royal Infirmary	Community	CF24 0SZ	ST 19377 76916	319377	176916	51.48543	-3.16251	0	Not open overnight
Chepstow Community Hospital	Community	NP16 5YX	ST 52618 93611	352618	193611	51.6393	-2.68608	47	Chepstow Community Hospital - Aneurin Bevan University Health Board (nhs.wales)
Children's Hospital for Wales	Community	CF14 4XW	ST 17518 79364	317518	179364	51.50716	-3.18985	179	Noah's Ark Children's Hospital for Wales - Wikipedia
Chirk Community Hospital	Community	LL14 5LN	SJ 29397 38959	329397	338959	52.94336	-3.0521	31	Chirk Community Hospital - Wikipedia
Colwyn Bay Community Hospital	Community	LL29 8AY	SH 86100 78117	286100	378117	53.28774	-3.71007	42	Colwyn Bay Community Hospital (wales.nhs.uk)
County Hospital	Community	NP4 5YA	ST 29177 99589	329177	199589	51.69056	-3.02597	0	County Hospital (wales.nhs.uk)
Deeside Community Hospital	Community	CH5 1XS	SJ 30503 67758	330503	367758	53.20234	-3.04188	62	Deeside Community Hospital - Wikipedia
Dewi Sant Hospital	Community	CF37 1LB	ST 07043 89680	307043	189680	51.59827	-3.34347	0	Dewi Sant Hospital (wales.nhs.uk)
Eryri Hospital	Community	LL55 2YE	SH 48704 61606	248704	361606	53.13008	-4.26279	34	Introduction (hiw.org.uk)

Hospital name	Hospital type	Postcode	Grid Reference	X	Y	Latitude	Longitude	Bed number	Bed number reference
Glan Irfon Health and Social Care Centre (Builth Wells)	Community	LD2 3DG	SO 03333 51337	303333	251337	52.15182	-3.4143	12	Glan Irfon Health and Social Care Centre (wales.nhs.uk)
Gorseinon Hospital	Community	SA4 4UU	SS 58480 99033	258480	199033	51.67219	-4.04798	44	https://111.wales.nhs.uk/localservices/viewlocalservice.aspx?id=3118
Knighton Hospital	Community	LD7 1DF	SO 28595 72067	328595	272067	52.34201	-3.04954	7	Knighton Hospital - Wikipedia
Llanidloes War Memorial Hospital	Community	SY18 6HF	SN 95467 84959	295467	284959	52.45255	-3.53967	16	Llanidloes War Memorial Health Centre (wales.nhs.uk)
Machynlleth Community Hospital (Bro Ddyfi)	Community	SY20 8AD	SH 75065 00928	275065	300928	52.59175	-3.84575	14	Bro Dyfi Hospital (Machynlleth) - Powys Teaching Health Board (nhs.wales)
Maesteg Community Hospital	Community	CF34 9PW	SS 84494 91568	284494	191568	51.61106	-3.6695	20	Maesteg Hospital (Bridgend) (dewis.wales)
Monnow Vale Health & Social Care Facility	Community	NP25 5BL	SO 50102 12638	350102	212638	51.81014	-2.72516	19	170927monnowvaleen.pdf (hiw.org.uk)
Montgomery County Infirmary	Community	SY16 2DW	SO 10924 92279	310924	292279	52.52108	-3.31425	0	No inpatient facilities
Royal Alexandra Hospital	Community	LL18 3AS	SJ 01481 82102	301481	382102	53.32663	-3.48067	0	No inpatient facilities
Ruthin Community Hospital	Community	LL15 1PS	SJ 12878 58111	312878	358111	53.11304	-3.30304	No information	
South Pembrokeshire Hospital	Community	SA72 6SY	SM 95752 03509	195752	203509	51.69308	-4.95663	35	South Pembrokeshire Hospital - Wikipedia
St. Davids Hospital (Cardiff)	Community	CF11 9XB	ST 17187 76551	317187	176551	51.48183	-3.19395	100	St David's Hospital, Cardiff - Wikipedia
Tregaron Hospital	Community	SY25 6JP	SN 67799 59270	267799	259270	52.21574	-3.93649	20	20211210TregaronHospital-EN.pdf (hiw.org.uk)
Ysbyty George Thomas	Community	CF42 6YG	SS 96079 96257	296079	196257	51.65546	-3.50365	No information	
Singleton Hospital	Major acute	SA2 8QA	SS 62521 91967	262521	191967	51.6097	-3.98681	334	https://sbuhb.nhs.wales/files/freedom-of-information-disclosure-log-2020/march/20-c-029-hospital-beds/
University Hospital Llandough	Major acute	CF64 2XX	ST 16516 72765	316516	172765	51.4477	-3.20272	480	Cardiff and Vale University Health Board - Wikipedia
Ablett Unit	Psychiatric: Mental illness	LL18 5UT	SJ 00198 75506	300198	375506	53.26712	-3.49785	57	Direct Line: 02920 928852 (hiw.org.uk)

Hospital name	Hospital type	Postcode	Grid Reference	X	Y	Latitude	Longitude	Bed number	Bed number reference
Bodnant EMI Unit	Psychiatric: Mental illness	LL30 1QY	SH 78114 81140	278114	381140	53.31312	-3.83096	Closed?	
Bryn Hesketh Unit	Psychiatric: Mental illness	LL29 8AT	SH 86162 78051	286162	378051	53.28716	-3.70911	13	180212brynheskethen.pdf (hiw.org.uk)
Cefn Coed Hospital	Psychiatric: Mental illness	SA2 0GH	SS 62437 94015	262437	194015	51.62808	-3.98882	34	Introduction (hiw.org.uk)
Garngoch Hospital	Psychiatric: Mental illness	SA4 4LH	SS 60988 97462	260988	197462	51.6587	-4.01111	No information	
Glanrhyd Hospital	Psychiatric: Mental illness	CF31 4LN	SS 90075 81977	290075	181977	51.52597	-3.58594	No information	Lots of information about different wards but no overall information about number of wards
Maindiff Court Hospital	Psychiatric: Mental illness	NP7 8NF	SO 31486 15426	331486	215426	51.83322	-2.99571	15	Introduction (hiw.org.uk)
St. Cadocs Hospital	Psychiatric: Mental illness	NP18 3XQ	ST 33289 91000	333289	191000	51.61386	-2.96486	54	Introduction (hiw.org.uk)
Tonna Hospital	Psychiatric: Mental illness	SA11 3LX	SS 78035 99396	278035	199396	51.68004	-3.76547	14	https://sbuhb.nhs.wales/about-us/key-documents-folder/board-papers/february-2020-board-papers/3-1-appendix-2-pdf/
Ysbyty'r Tri Chwm	Psychiatric: Mental illness	NP23 6GT	SO 16121 10778	316121	210778	51.78935	-3.21751	13	180301ysbytyrtychwmen.pdf (hiw.org.uk)
Bryn y Neuadd Hospital	Psychiatric: Mental illness	LL33 0HH	SH 67654 74601	267654	374601	53.25187	-3.98514	No information	
Cwm Seren, Tudor house & Ty Bryn	Psychiatric: Mental illness	SA31 3HB	SN 39399 20127	239399	220127	51.85656	-4.33344	No information	
Rookwood Hospital	Specialist acute	CF5 2YN	ST 15047 77987	315047	177987	51.49442	-3.22511	48	Rookwood Hospital | Healthcare Inspectorate Wales (hiw.org.uk)
University Dental Hospital	Specialist acute	CF14 4XW	ST 17551 79319	317551	179319	51.50676	-3.18936	0	Not open overnight https://111.wales.nhs.uk/LocalServices/ViewLocalService.aspx?id=3132

NOTES:

- Hospitals gathered from: http://www.wales.nhs.uk/ourservices/directory/hospitals
- CHC local committee excluded (care homes)
- Clinics excluded as they have no beds
- Day hospital excluded as no beds
- Community hospital: Elderly Mental Infirm excluded as these are care homes
- Psychiatric learning disability excluded as more care home
- Bed number data was collected from available data on the internet. NHS website, freedom of information requests or data from Health Inspectorate Wales were prioritised. As a last resort, Wikipedia was used.
- Hospitals with no informations on beds were not taken into account in the analysis

13 APPENDIX-G: WILD SWIMMING LOCATIONS DATA SET

Name	Longitude	Latitude	Type	X	Y
Blue Lagoon, Moel-y-Faen	53.02125	-3.21651	Wild swimming	318497	347798
Blue Pool, Golwern Quarry	52.68882	-4.04163	Wild swimming	262103	312082
Bugle Bridge, Llanthony	51.93971	-3.03366	Wild swimming	329039	227306
Crickhowell, Usk	51.85645	-3.14155	Wild swimming	321477	218157
Cwm Pennant	53.02335	-4.1658	Wild swimming	254833	349534
Dorothea Quarry lake & ruins	53.0551	-4.2396	Wild swimming	249994	353217
Fairy Glen	53.07178	-3.79304	Wild swimming	279967	354231
Hafod	52.33879	-3.84097	Wild swimming	274671	272785
Horseshoe Falls	51.77176	-3.59506	Wild swimming	290039	209324
Island Picnic Site Usk	51.70576	-2.9079	Wild swimming	337360	201171
Little Canyon	51.76724	-3.59734	Wild swimming	289871	208825
Llyn Cau, Cadair Idris	52.69492	-3.89913	Wild swimming	271752	312497
Llyn Cwm Llwch	51.8879	-3.45172	Wild swimming	300186	222035
Llyn Dinas	53.02517	-4.06422	Wild swimming	261651	349536
Llyn Du'r Arddu	53.08073	-4.09011	Wild swimming	260096	355765
Llyn Eiddew Bach	52.8911	-4.0145	Wild swimming	264567	334528
Llyn Gwynant	52.04823	-4.02167	Wild swimming	261460	240800
Llyn Moel y Llyn	52.50689	-3.89946	Wild swimming	271179	291584
Llyn Padarn	53.12486	-4.12549	Wild swimming	257871	360744
Llyn Tegid	52.88847	-3.62697	Wild swimming	290630	333574
Llyn y Fan Fach	51.88143	-3.742	Wild swimming	280193	221753
Llyn-y-parc	53.11463	-3.8072	Wild swimming	279139	359021
Lynnau Diffwys	53.0006	-4.00012	Wild swimming	265874	346681
Pen-doll Rocks	52.15938	-3.41749	Wild swimming	303131	252181
Pen-y-Fan, Nant Sere	51.89772	-3.41639	Wild swimming	302639	223079
Porthdafarch	53.28411	-4.63939	Coasteering	224144	379599
Rhaeadr Du	52.93076	-3.98489	Wild swimming	266681	338885
Rhaedr Mawddach	52.83007	-3.87797	Wild swimming	273574	327491
Rheidol Vale	52.38704	-3.87297	Wild swimming	272630	278208
Sgwd Gwladys/Lady Falls	51.77217	-3.60121	Wild swimming	289616	209379
The Rectory Pool	52.03889	-3.26663	Wild swimming	313216	238590
The Warren	52.07708	-3.13837	Wild swimming	322080	242691
Wash Pool, Irfon	52.13629	-3.66799	Wild swimming	285937	249978
Watkins path Waterfall or Gorge	53.04401	-4.05478	Wild swimming	262345	351612
Wolf's Leap, Irfon	52.17989	-3.69618	Wild swimming	284121	254871
Ystradffin	52.1047	-3.78615	Wild swimming	277764	246657

Wild swimming locations and one coasteering location were obtained from:
http://www.wildswimming.co.uk/wales/?multi_region=wales

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