Antibiotic Resistance and the Environment…

…What we Know and What we Need to Know!

Dr. Dearbháile Morris

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National University of Ireland Galway.

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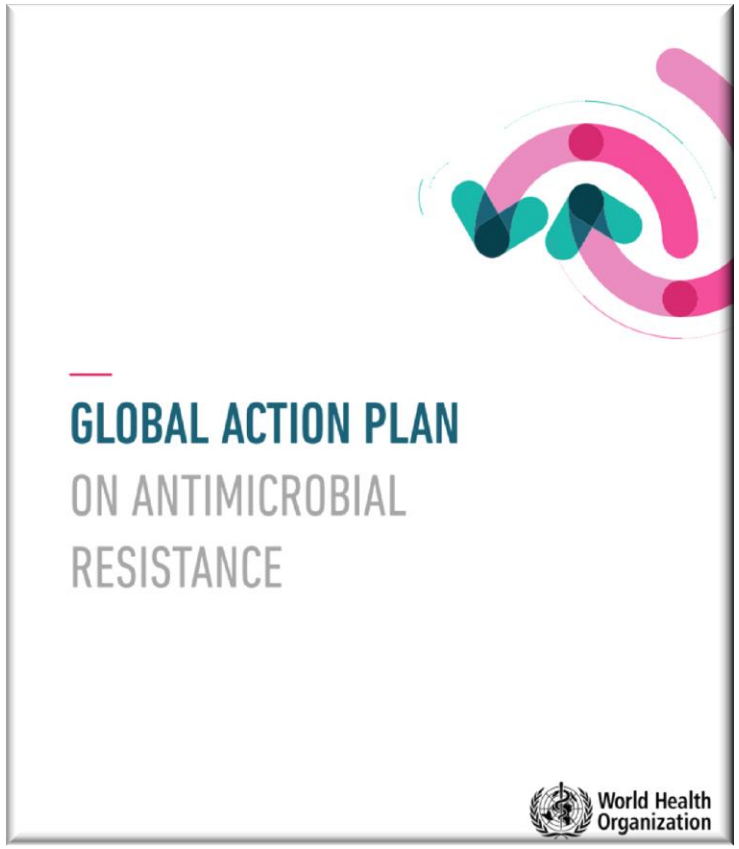
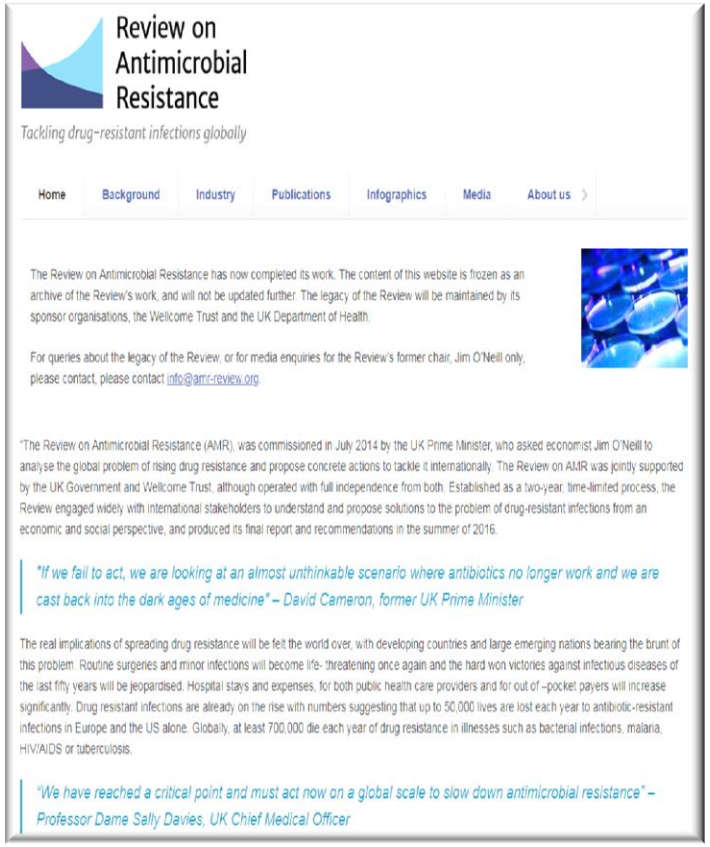
Antimicrobial Resistance and Microbial Ecology Group

Antimicrobial Resistance is a major public health problem





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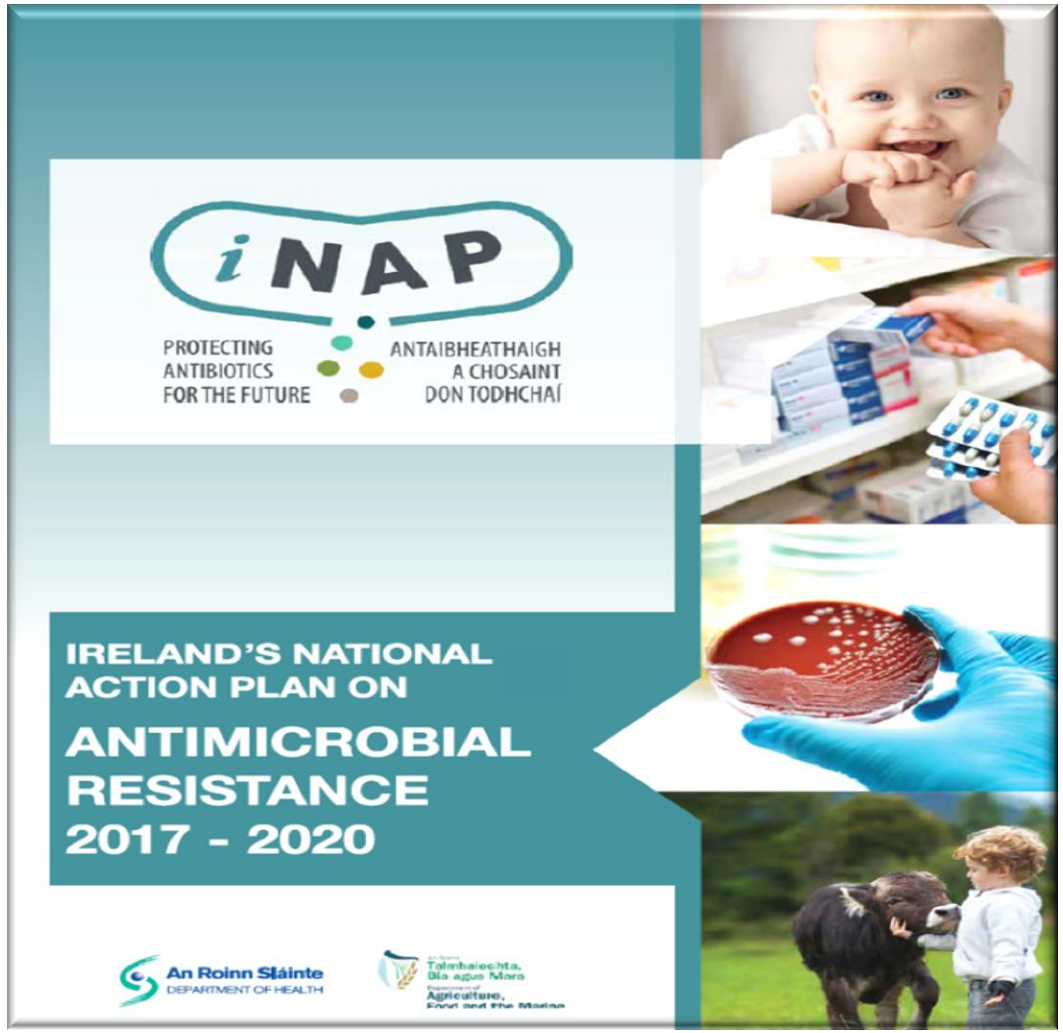

Strategic Objective 1: Improve awareness and knowledge of antimicrobial resistance

Strategic Objective 2: Enhance surveillance of antibiotic resistance and antibiotic use

Strategic Objective 3: Reduce the spread of infection and disease

Strategic Objective 4: Optimise the use of antibiotics in human and animal health

Strategic Objective 5: Promote research and sustainable investment in new medicines, diagnostic tools, vaccines and other interventions

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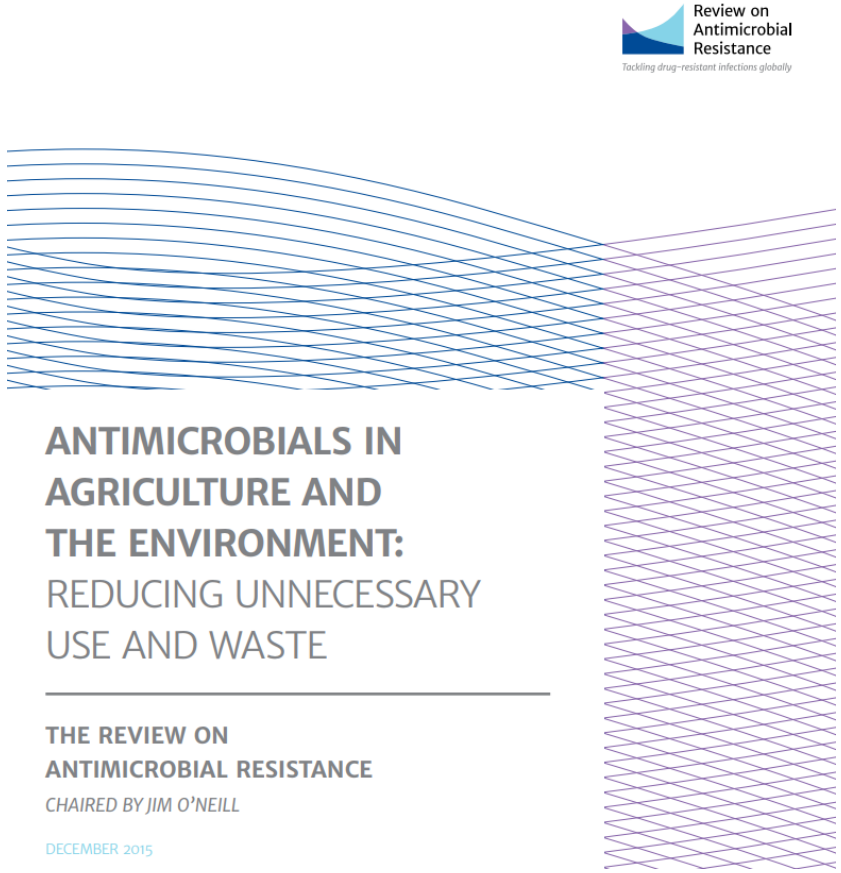

3.6 CLOSE KNOWLEDGE GAPS ON AMR IN THE ENVIRONMENT AND ON HOW TO PREVENT TRANSMISSION

AMR is a good example of a One Health matter in which human health is connected to that of animals and the environment. Only a multidisciplinary effort can provide an adequate response. There is a major lack of knowledge about the release and spread of resistant organisms in the environment and the threats and risks this poses to human and animal health. For example, the release of antimicrobials into the environment through human, animal and manufacturing waste streams should be assessed and new technologies developed to enable efficient and rapid degradation of antimicrobials in wastewater treatment plants, organic waste streams or the environment.

The feasibility and implementation of monitoring programmes need to be further studied, including the development of harmonised monitoring of antimicrobials and microorganisms resistant against antimicrobials in the environment. Using harmonised monitoring and research data, risk assessment methodologies should be developed to evaluate risks to human and animal health. In the agri-food sector, the links between farming practices, animal health and AMR development and spread need to be further investigated.

The Commission will:

- support research into knowledge gaps on the release of resistant microorganisms and antimicrobials into the environment and their spread;
- explore risk assessment methodologies, with the support of scientific agencies and bodies, and use them to evaluate the risks to human and animal health from the presence of antimicrobials in the environment;
- support research into and the development of new tools for monitoring antimicrobials and microorganisms resistant against antimicrobials in the environment;
- support the development of technologies that enable efficient and rapid degradation of antimicrobials in wastewater and the environment and reduce the spread of AMR.

2.4 BETTER ADDRESSING THE ROLE OF THE ENVIRONMENT

The environment is increasingly acknowledged as a contributor to the development and spread of AMR in humans and animals, in particular in high risk areas due to human, animal and manufacturing waste streams, but strong evidence is still required to better inform decision-making in this area. Specific actions to improve the knowledge base are considered in section 3. Once relevant monitoring and research data become available, risk assessment methodologies should be developed to evaluate the risks to human and animal health.

The Commission will:

- adopt an EU strategic approach to pharmaceuticals in the environment[51];
- maximise the use of data from existing monitoring, e.g. Watch List monitoring under the Water Framework Directive[52], to improve knowledge of the occurrence and spread of antimicrobials in the environment, including by using the Information Platform for Chemical Monitoring (IPCheM) to access relevant monitoring data[53];
- reinforce the role of the Scientific Committee on Health and Environmental Risks (SCHER) in providing the expertise on environment-related AMR issues.

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ARMe

Antimicrobial Resistance is a major public health problem

- Different types of antimicrobial resistant bacteria.
- Carbapenemase-producing *Enterobacteriaceae* (CPE) are resistant to almost all available antibiotics
- Treatment of infection with CPE very difficult.
- Different types of carbapenemase enzymes – most common in Ireland and the U.K. are KPC, OXA-48 and NDM.
- January 2017 - first report of death due to an untreatable infection caused by NDM-producing *Klebsiella pneumoniae*[1]

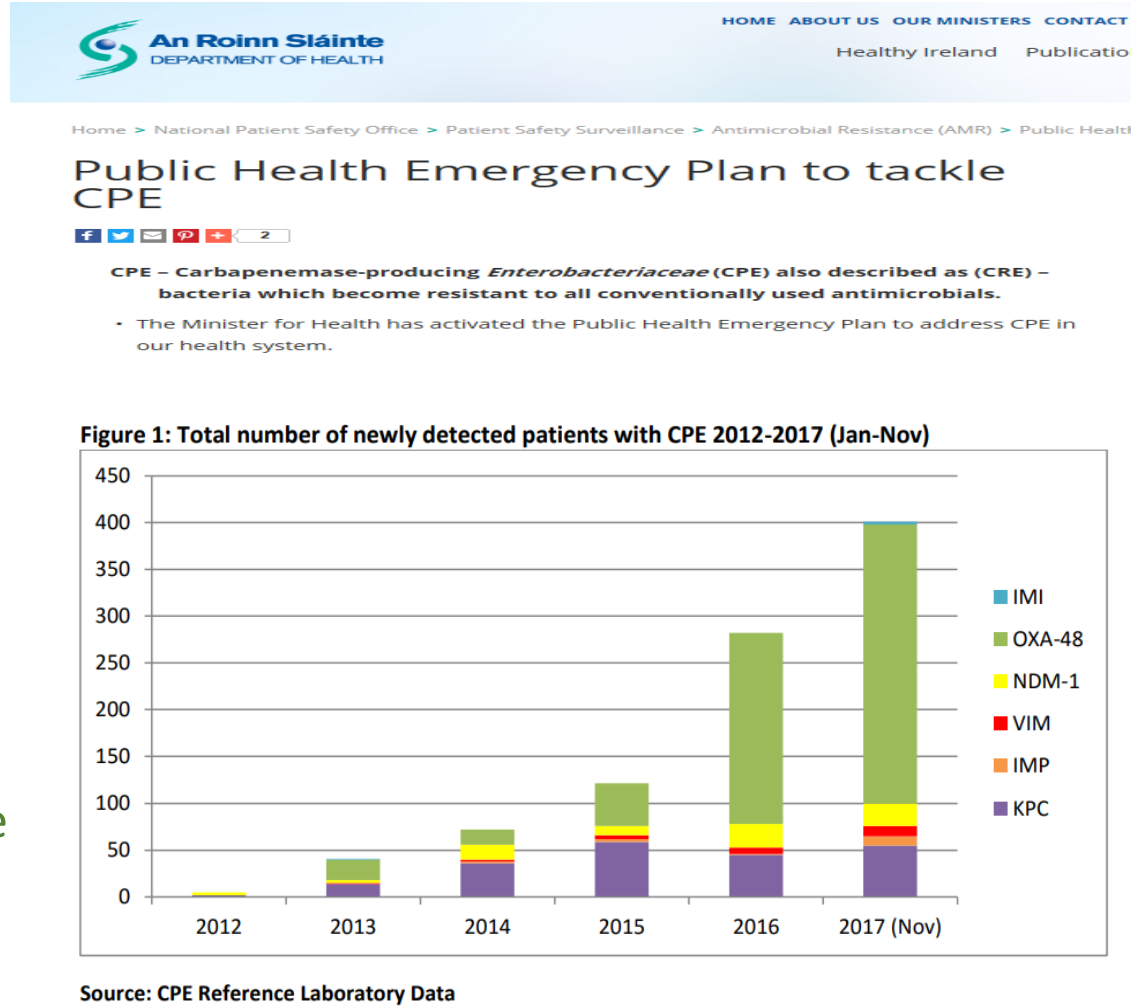

Figure 1: Total number of newly detected patients with CPE 2012-2017 (Jan-Nov)

Source: CPE Reference Laboratory Data

1. Chen L, Todd R, Kiehlbauch J, et al. Pan-resistant New Delhi metallo-beta-lactamase-producing Klebsiella pneumoniae — Washoe County, Nevada, 2016. *MMWR Morb Mortal Wkly Rep* 2017; 66: 33

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CAUSES OF ANTIBIOTIC RESISTANCE

HANDLE ANTIBIOTICS WITH CARE

Antibiotic resistance happens when bacteria change and become resistant to the antibiotics used to treat the infections they cause.

Over-prescribing of antibiotics

Patients not finishing their treatment

Over-use of antibiotics in livestock and fish farming

Poor infection control in hospitals and clinics

Lack of hygiene and poor sanitation

Lack of new antibiotics being developed

www.who.int/drugresistance

#AntibioticResistance

World Health Organization

Rialtas na hÉireann
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Ireland

One Health Report on Antimicrobial Use & Antimicrobial Resistance

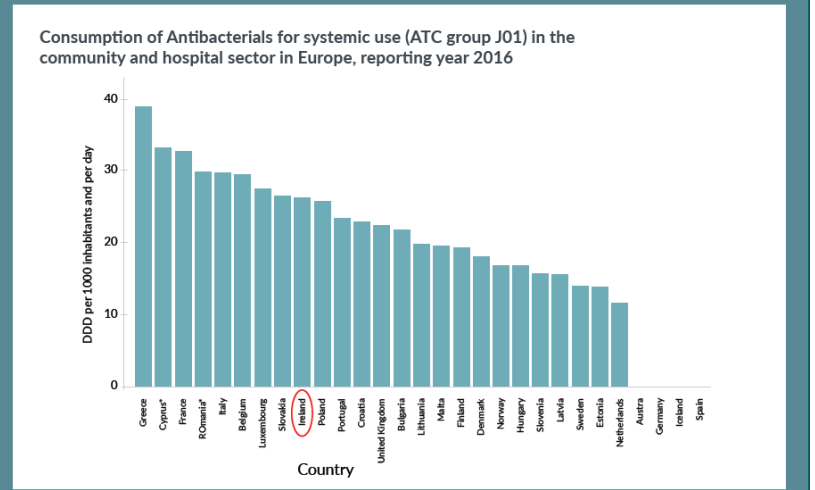
Ireland's first One Health Report on Antimicrobial Use and Antimicrobial Resistance 2016

January 2019

AMU in Humans

Ireland ranked 9th highest of 25 EU/ EEA Member States for antibacterial consumption in humans in 2016.

26.1 defined daily doses (DDD) per 1,000 inhabitants per day (DID).



Source: TESSy, The European Surveillance System on 2018-03-06

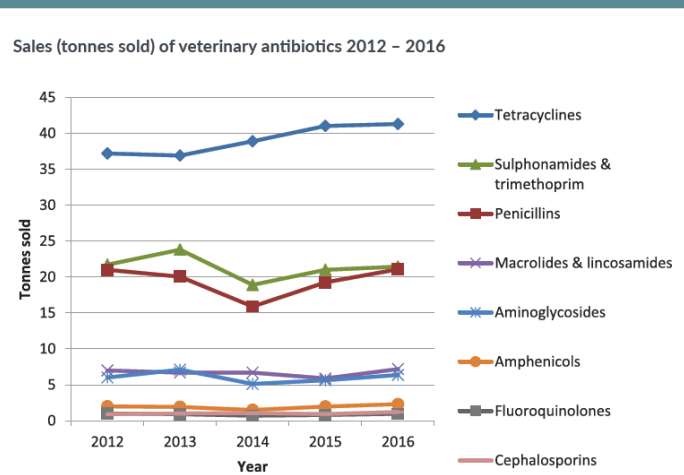
AMU in Animals

Ireland ranked 17th highest of 30 EU/ EEA member states for antimicrobial use in animals (mg/kg biomass) in 2016.

Based on sales data, most animal AMU in Ireland (66.6%) is formulated as premixes or oral remedies, presumed to be predominantly used as in-feed or in-water medication for the intensive pig and poultry sectors.

The antimicrobials most commonly sold for animal use in Ireland (by weight) are:

- Tetracyclines (39.9%)
- Sulphonamides & trimethoprim (20.7%)
- Penicillins (20.4%)



Source: HPRA

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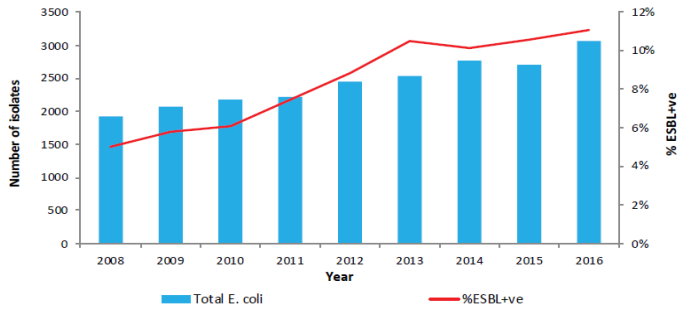
AMR in bacterial isolates from Humans

Extended spectrum beta lactamase (ESBL)-producing *E. coli*

E. coli is by far the most common causative pathogen of bloodstream infection (BSI) in Ireland, with around 3,000 cases per year. When *E. coli* acquire the capacity to produce ESBLs, this enables them to resist the activity of most beta lactam antimicrobials (e.g. penicillins, cephalosporins, monobactams). This increases dependence on carbapenems for effective treatment of infection.

In 2016, of those *E. coli* causing blood stream infection, 11% were ESBL-producing *E. coli*. This is the highest level since surveillance began. Concerns about increased risk of ESBL-producing *E. coli* may in turn drive increased carbapenem use for empiric treatment of invasive infection.

Annual total *E.coli* BSI: 2008-2016 (%ESBL producing = red line)



Source: HPSC

Indicator (non-pathogenic) Bacteria

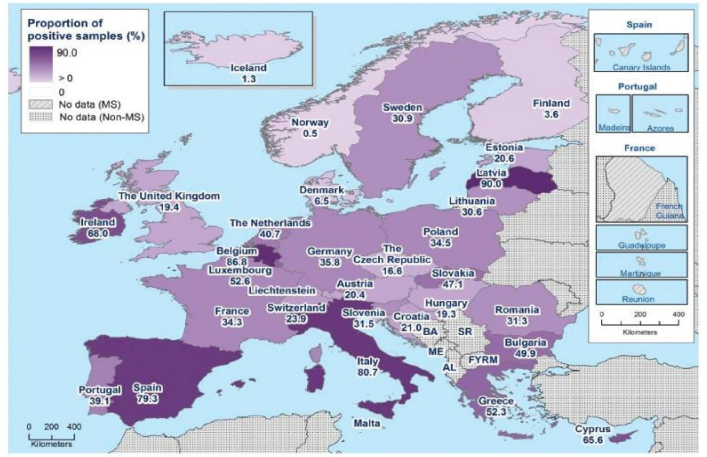
Indicator commensal *E. coli*

- More frequently resistant to antimicrobials commonly used in veterinary medicine.
- Proportion of MDR was higher in poultry compared to pig isolates.

ESBL-producing *E. coli*

- In 2016, the proportion of Irish poultry meat samples harbouring ESBL *E. coli* was above the EU average.

Presumptive ESBL *E. coli* from broilers, 2016 (specific monitoring)



Source: EFSA and ECDC, 2018. The European Union summary report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2016. EFSA Journal 2018;16(2):5182, 270 pp. https://doi.org/10.2903/j.efsa.2018.5182

Antimicrobial Resistance - Humans

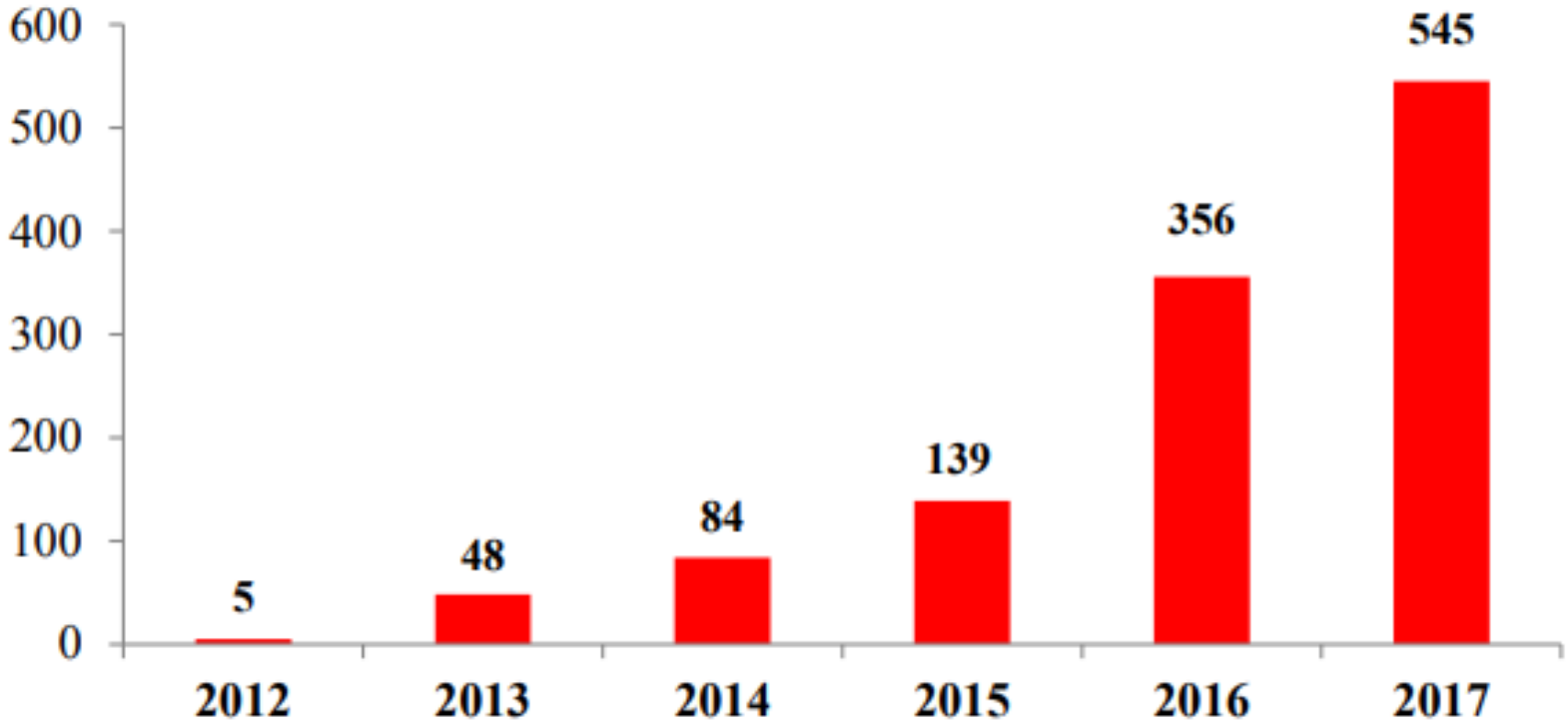


Figure 1: Carbapenemases detected in clinical isolates of Enterobacterales in Ireland Sept 2012 to Dec 2017.

Source: National Carbapenemase Producing Enterobacterales Reference Laboratory service Annual Report 2017.

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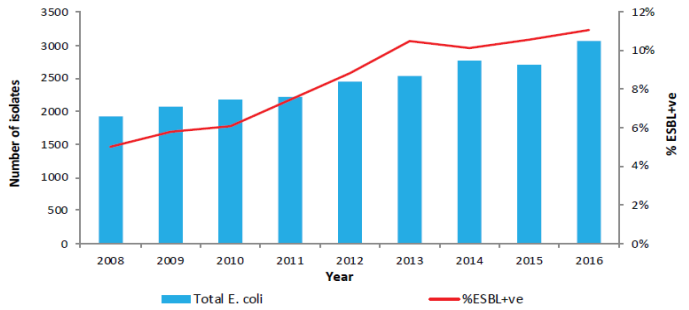

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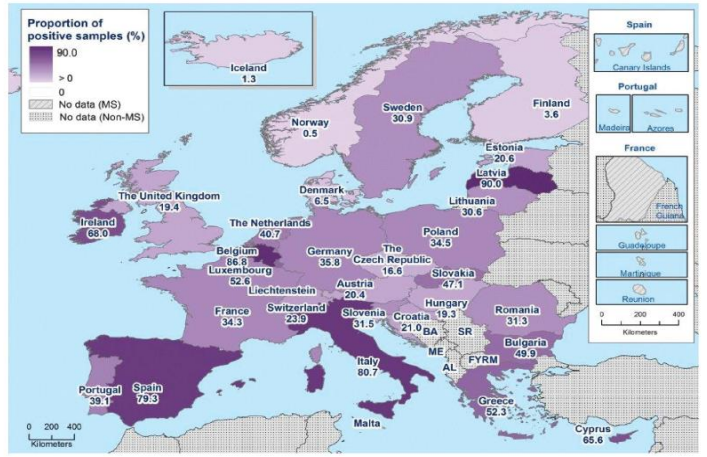

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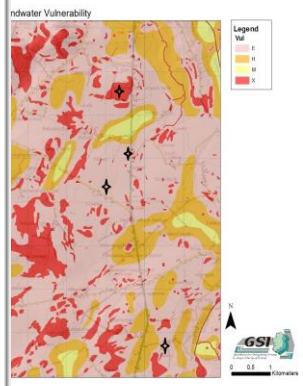
Where Antimicrobials and Antimicrobial Resistant Bacteria Go



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What we Know and What we Need to Know

- Dispensing raw sewage in the vicinity of recreational bathing areas is a major risk for transmission of antimicrobial resistant organisms.

Eurosurveillance 20 years 1996–2016
Europe's journal on infectious disease epidemiology, prevention and control

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Eurosurveillance, Volume 22, Issue 15, 13 April 2017

Rapid communication

INDISTINGUISHABLE NDM-PRODUCING *ESCHERICHIA COLI* ISOLATED FROM RECREATIONAL WATERS, SEWAGE, AND A CLINICAL SPECIMEN IN IRELAND, 2016 TO 2017

BM Mahon [1], C Brehony [1], E McGrath [2 3], J Killeen [1], M Cormican [1 2 3], P Hickey [4], S Keane [4], B Hanahoe [3], A Dolan [5], D Morris [1]

Source: EPA, Urban Waste Water Treatment in 2017

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- Do current drinking and bathing water quality regulations protect public health?

Source: EPA, Urban Waste Water Treatment in 2017

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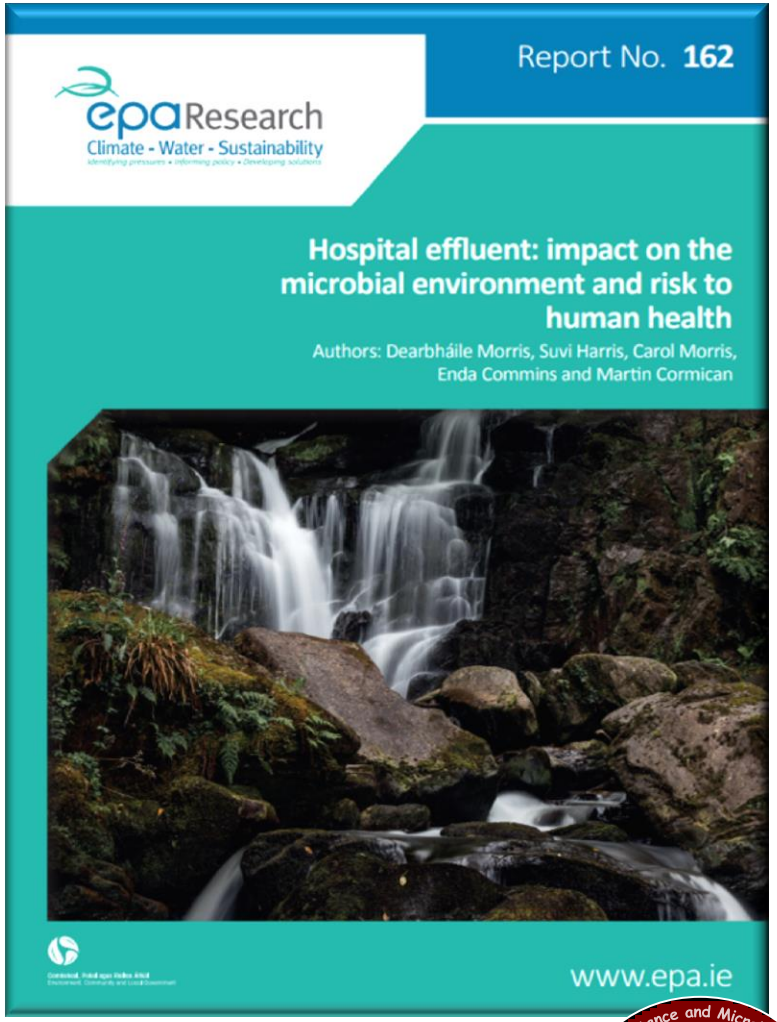
What we Know and What we Need to Know

- Current waste water treatment processes do not remove all antimicrobial resistant organisms (AROs)
- What level and type of waste water treatment is effective for the removal of AROs?
- Integrated constructed wetlands are a natural alternative to conventional wastewater treatment processes but are they effective at removing AROs?



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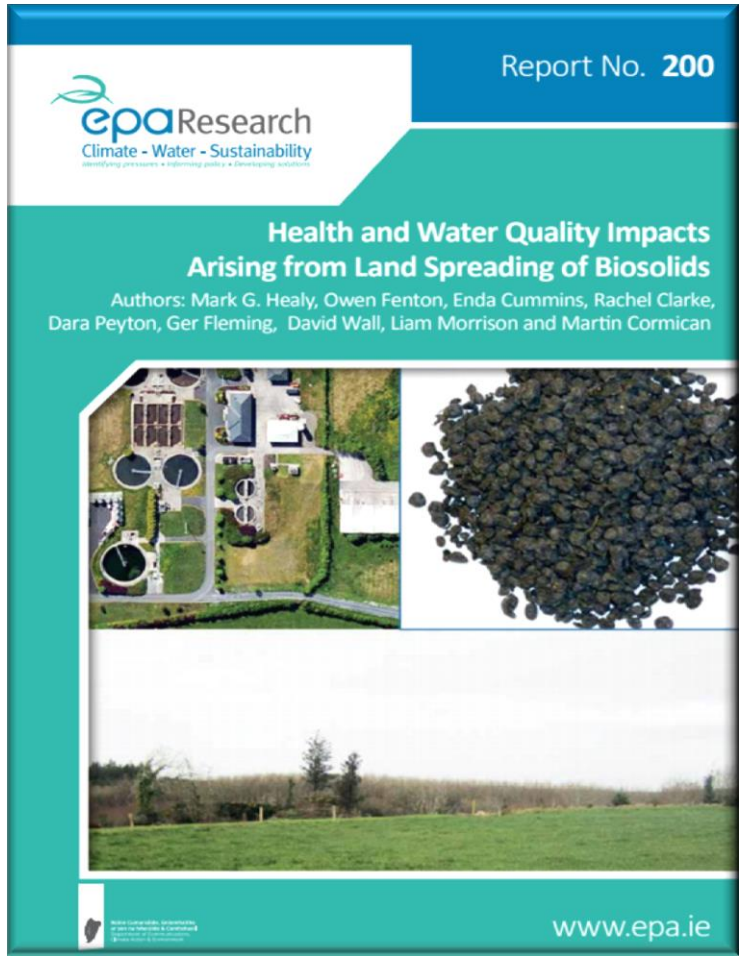
What we Know and What we Need to Know

- Land spreading of organic wastes (animal manure and sewage sludge) is an important part of the circular economy

- Studies have shown land spreading of manures increased the proliferation of ARO and abundance of antimicrobial resistance genes in soils[1,2].



1. Udikovic-Kolic, N., Wichmann, F., Broderick, N. A. & Handelsman, J. Bloom of resident antibiotic-resistant bacteria in soil following manure fertilization. *Proc. Natl. Acad. Sci.* **111,** 15202–15207 (2014).
2. Muurinen, J. *et al.* Influence of Manure Application on the Environmental Resistome Under Finnish Agricultural Practice with Restricted Antibiotic Use. *Environ. Sci. Technol.* acs.est.7b00551 (2017). doi:10.1021/acs.est.7b00551

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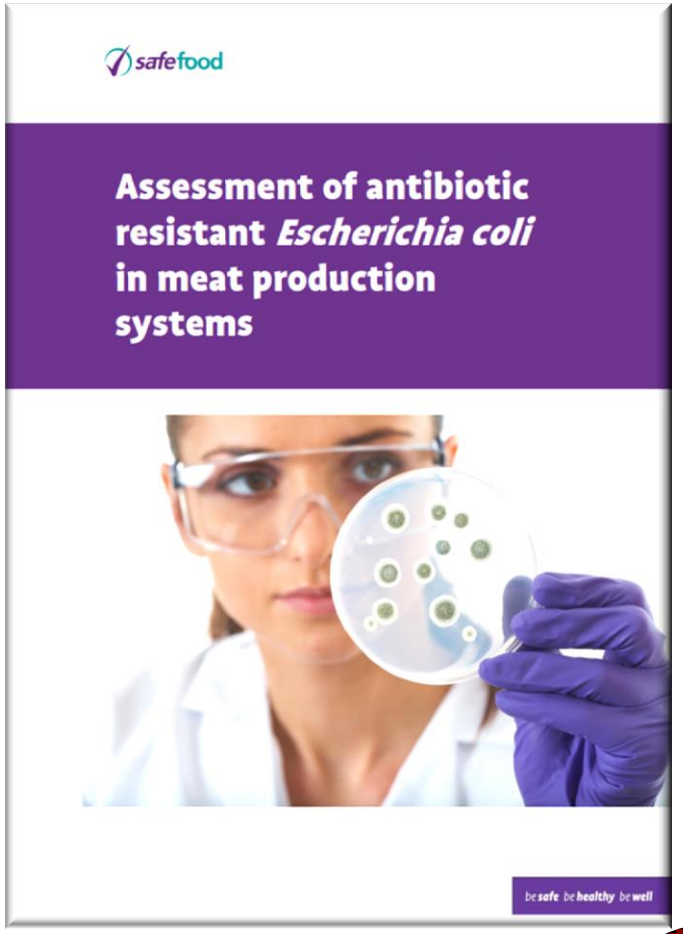
What we Know and What we Need to Know

- Retail meats: 99% of chicken meats, 33% of pork products and 14% of beef products contaminated with AROs[1]
- What is the level of AROs in manures from different sources?
- What treatment is effective at removing them?
- What impact does application have on soil?



[1]https://www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Research%20Reports/Assessment-of-antibiotic-resistant-Escherichia-coli-in-meat-production-systems_1.pdf

ONE HEALTH

AREST

epaResearch
Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

AREST: 2018-2021

Antimicrobial Resistance and the Environment –

Sources, persistence, Transmission and risk management (2017-HW-LS-1)

Web: http://www.nuigalway.ie/medicine-nursing-and-health-sciences/medicine/disciplines/bacteriology/research/arest/

@AREST_AMR

https://www.researchgate.net/project/AREST-Antimicrobial-Resistance-and-the-Environment-Sources-Persistence-Transmission-and-Risk-Management

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AREST: 2018-2021

Antimicrobial Resistance and the Environment – Sources, persistence, Transmission and risk management

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AREST: 2018-2021

Antimicrobial Resistance and the Environment – Sources, persistence, Transmission and risk management

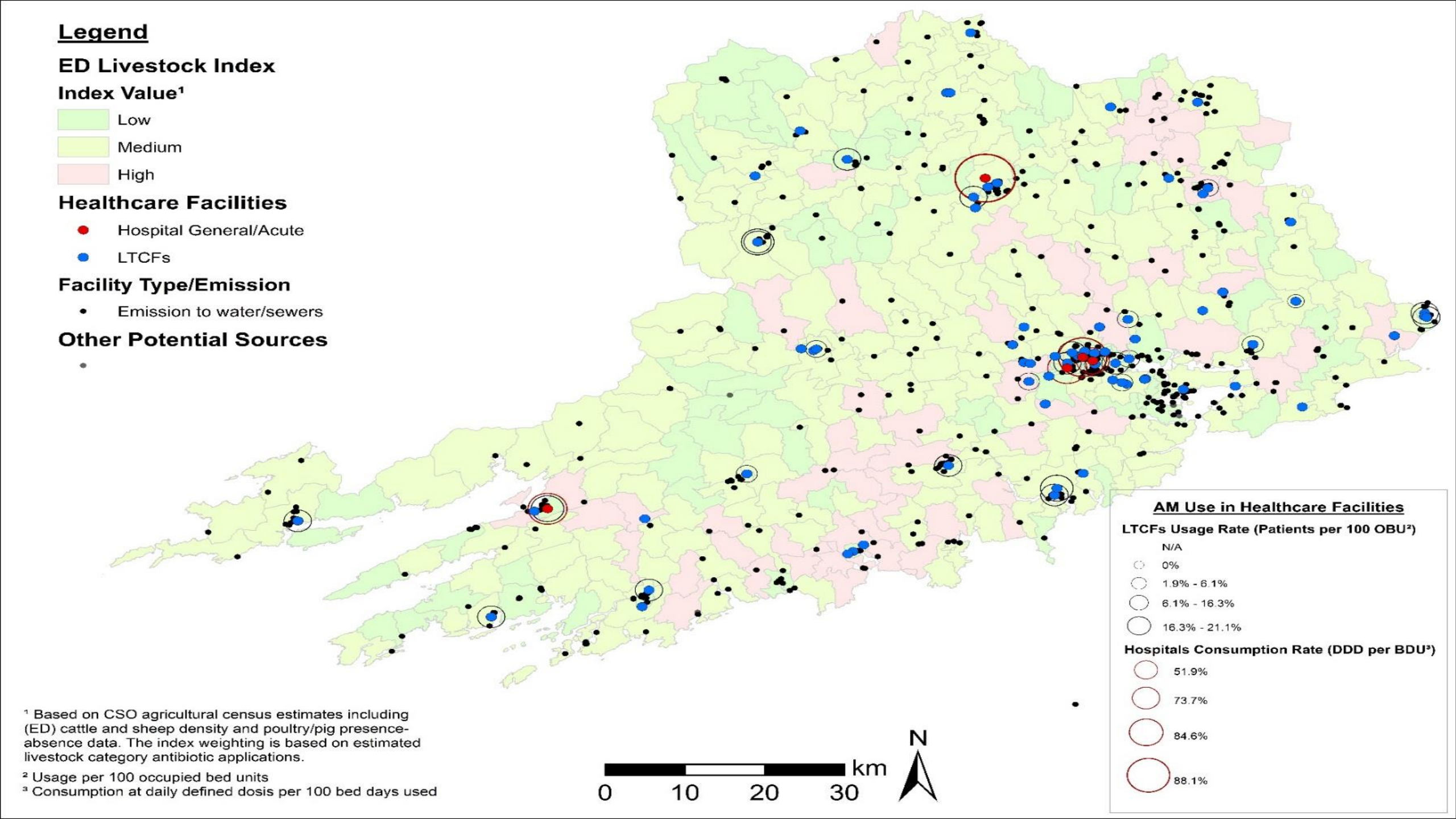
The AREST project will:

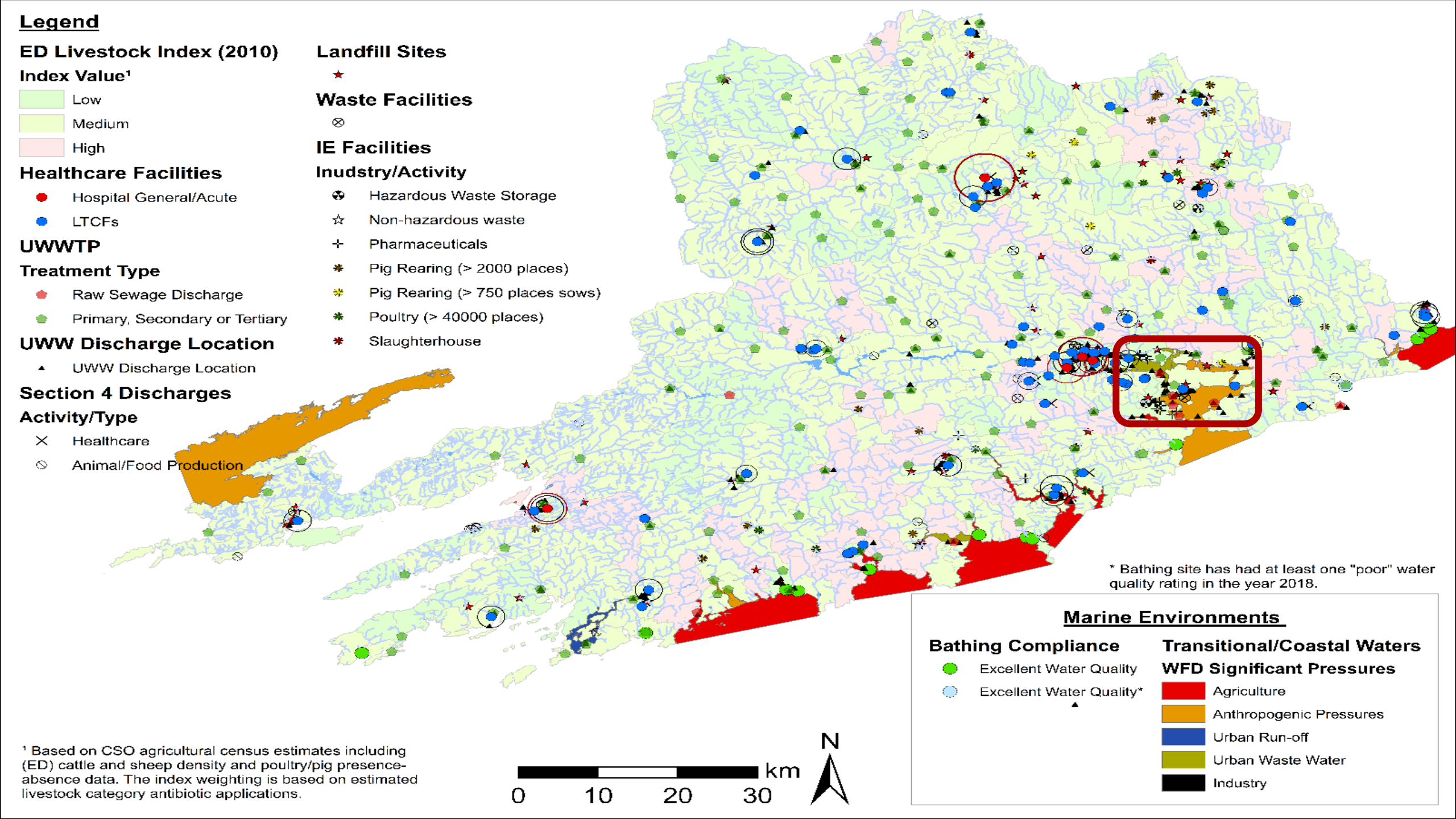
- Map hotspots of drivers of AMR in selected local authority areas:
  Galway City Council, Galway County Council, Fingal County Council and Cork County Council.
- Assess the relative contributions of various sectors (healthcare, agriculture) to ARO in the environment.
- Assess efficiencies of treatment processes for removal of ARO from drinking water, wastewater and manure.
- Develop a risk ranking protocol to assess the relative contribution of various sectors on the sources and levels of AROs in the environment.

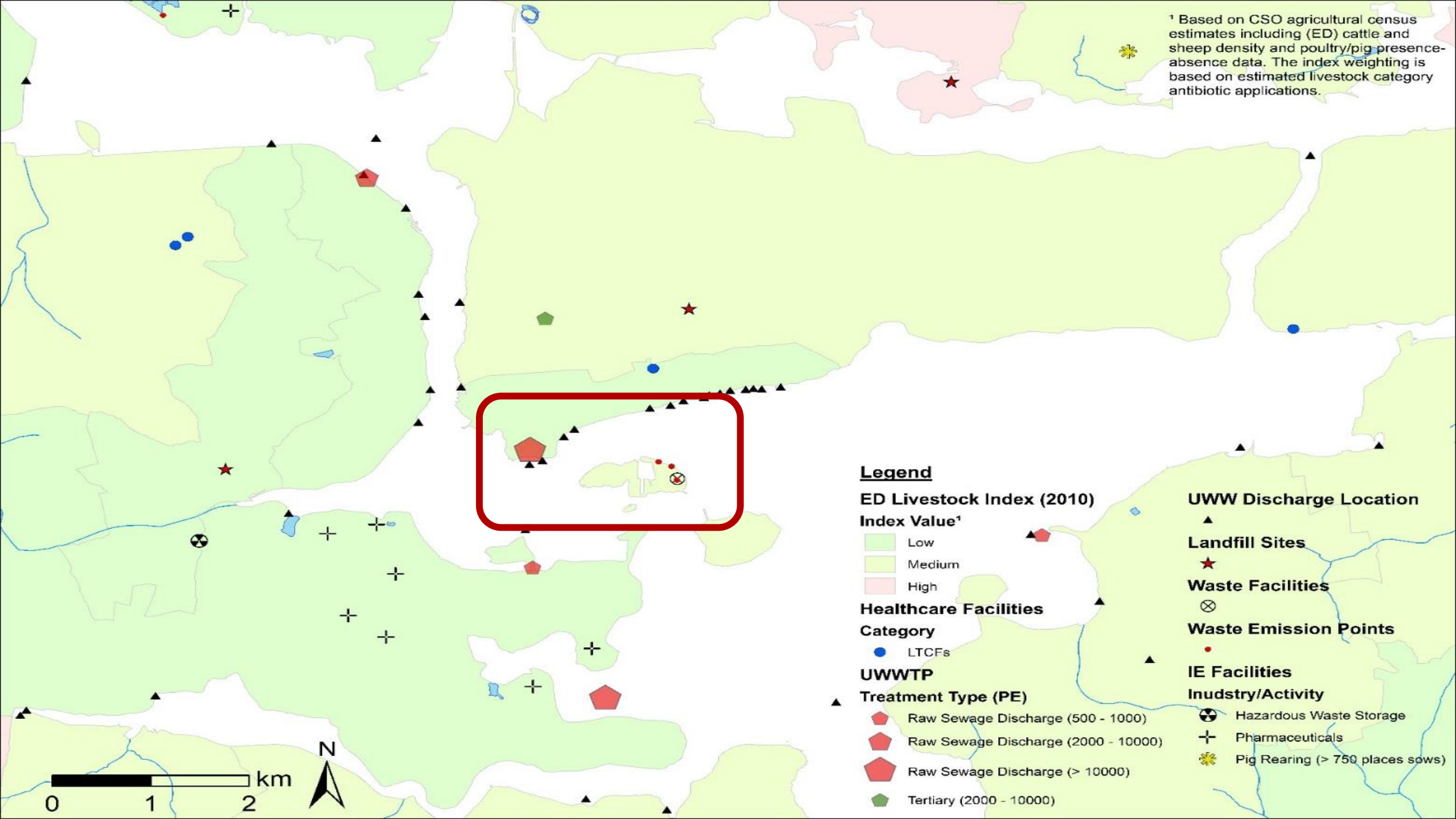
Galway City & County Council

Fingal County Council

Cork County Council


Legend
ED Livestock Index
Index Value[1]
Low
Medium
High
Healthcare Facilities
Hospital General/Acute
LTCFs
Facility Type/Emission
Emission to water/sewers
Other Potential Sources
AM Use in Healthcare Facilities
LTCFs Usage Rate (Patients per 100 OBU[2])
N/A
0%
1.9% - 6.1%
6.1% - 16.3%
16.3% - 21.1%
Hospitals Consumption Rate (DDD per BDU[3])
51.9%
73.7%
84.6%
88.1%
[1] Based on CSO agricultural census estimates including (ED) cattle and sheep density and poultry/pig presence-absence data. The index weighting is based on estimated livestock category antibiotic applications.
[2] Usage per 100 occupied bed units
[3] Consumption at daily defined dosis per 100 bed days used
0
10
20
30
km
N


Legend
ED Livestock Index (2010)
Index Value¹
Low
Medium
High
Healthcare Facilities
Hospital General/Acute
LTCFs
UWWTP
Treatment Type
Raw Sewage Discharge
Primary, Secondary or Tertiary
UWW Discharge Location
UWW Discharge Location
Section 4 Discharges
Activity/Type
Healthcare
Animal/Food Production
Landfill Sites
Waste Facilities
IE Facilities
Inudstry/Activity
Hazardous Waste Storage
Non-hazardous waste
Pharmaceuticals
Pig Rearing (> 2000 places)
Pig Rearing (> 750 places sows)
Poultry (> 40000 places)
Slaughterhouse
* Bathing site has had at least one "poor" water quality rating in the year 2018.
Marine Environments
Bathing Compliance
Excellent Water Quality
Excellent Water Quality*
Transitional/Coastal Waters
WFD Significant Pressures
Agriculture
Anthropogenic Pressures
Urban Run-off
Urban Waste Water
Industry
¹ Based on CSO agricultural census estimates including (ED) cattle and sheep density and poultry/pig presence-absence data. The index weighting is based on estimated livestock category antibiotic applications.
0
10
20
30
km
N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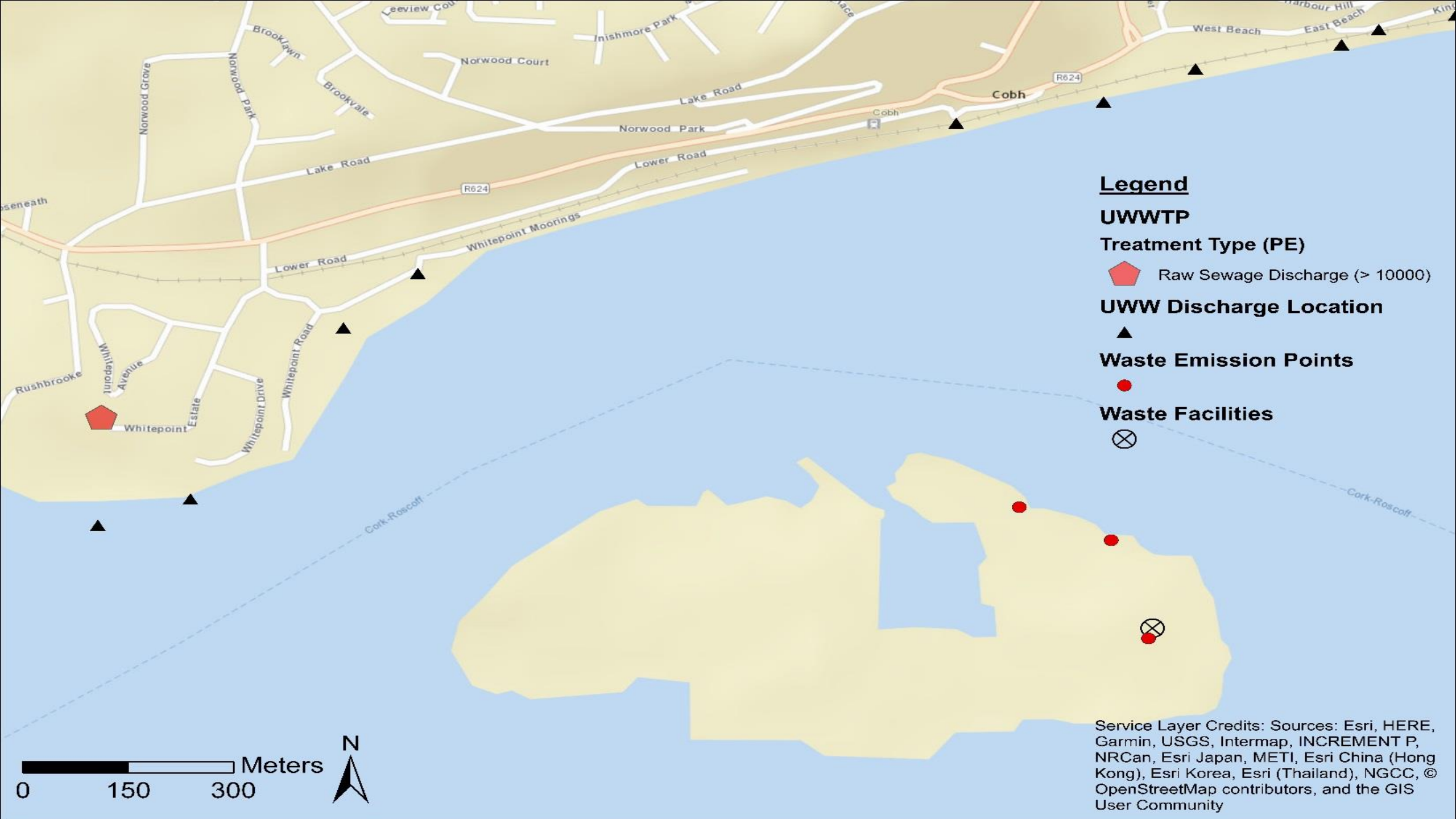
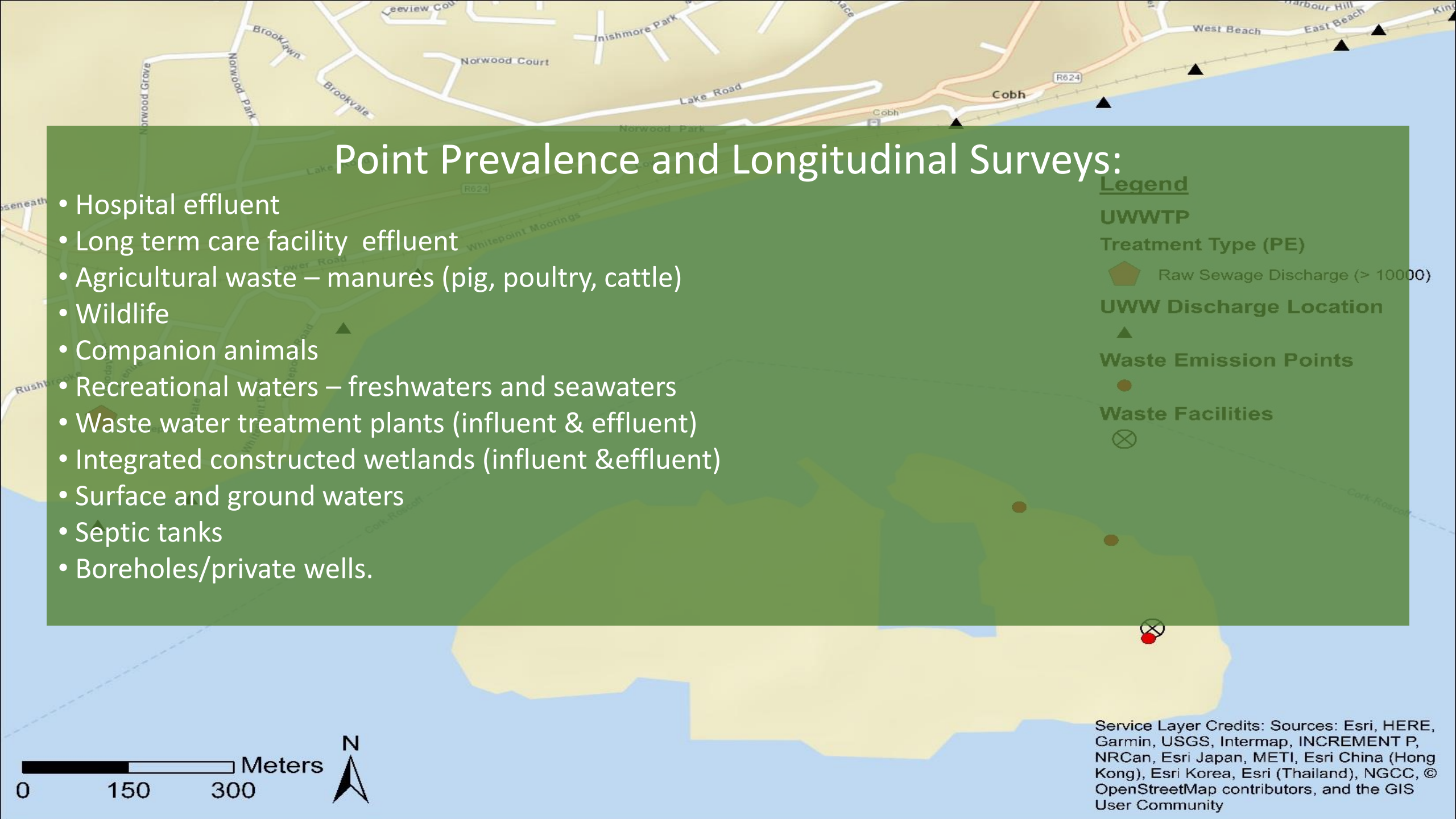
Legend
ED Livestock Index (2010)
Index Value¹
Low
Medium
High
Healthcare Facilities
Category
LTCFs
UWWTP
Treatment Type (PE)
Raw Sewage Discharge (500 - 1000)
Raw Sewage Discharge (2000 - 10000)
Raw Sewage Discharge (> 10000)
Tertiary (2000 - 10000)
UWW Discharge Location
Landfill Sites
Waste Facilities
Waste Emission Points
IE Facilities
Inudstry/Activity
Hazardous Waste Storage
Pharmaceuticals
Pig Rearing (> 750 places sows)
0
1
2
km
N


Legend
UWWTP
Treatment Type (PE)
Raw Sewage Discharge (> 10000)
UWW Discharge Location
Waste Emission Points
Waste Facilities
Lake Road
Lower Road
Norwood Park
Norwood Court
Norwood Grove
Brooklawn
Brookvale
Inishmore Park
Leeview Court
Cobh
R624
West Beach
East Beach
Harbour Hill
Whitepoint Moorings
Whitepoint Road
Whitepoint Drive
Whitepoint Avenue
Whitepoint Estate
Rushbrooke
Cork-Roscoff
Meters
0
150
300
N
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Point Prevalence and Longitudinal Surveys:

- Hospital effluent
- Long term care facility effluent
- Agricultural waste – manures (pig, poultry, cattle)
- Wildlife
- Companion animals
- Recreational waters – freshwaters and seawaters
- Waste water treatment plants (influent & effluent)
- Integrated constructed wetlands (influent &effluent)
- Surface and ground waters
- Septic tanks
- Boreholes/private wells.



AREST: 2018-2021

Antimicrobial Resistance and the Environment – Sources, persistence, Transmission and risk management

The AREST project will:

- Generate national level data on the key sources, hot spots and drivers of AMR in the environment from various sectors which will inform priority areas for action.
- Provide evidence of the extent of contamination of the environment with antimicrobial resistant organisms to support policy decisions and engage with health, agriculture and the local authority sectors on AMR.
- Produce engaging visual representations of data that will strongly support wider communication with the public and policy makers.
- Embed the “One Health” concept and build the capacity of Ireland’s research community to support Irelands National Action Plan on AMR.

epa Research
Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

PIER: 2019-2022

Public health Impact of Exposure to antimicrobial Resistance in coastal waters (2018-HW-LS-2)

Web: http://www.nuigalway.ie/medicine-nursing-and-health-sciences/medicine/disciplines/bacteriology/research/pier/

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University of Exeter
Ryan Institute
Centre for Health from Environment Ionad Sláinte ó Chomhshaol
Antimicrobial Resistance and Microbial Ecology Group

PIER: 2019-2022

Public health Impact of Exposure to antimicrobial Resistance in coastal waters (2018-HW-LS-2)

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PIER: 2019-2022

Public health Impact of Exposure to antimicrobial Resistance in coastal waters (2018-HW-LS-2)

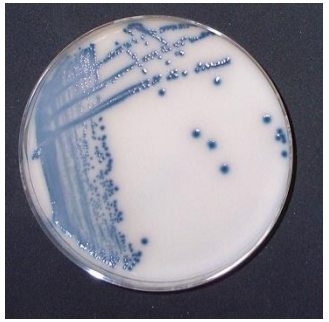
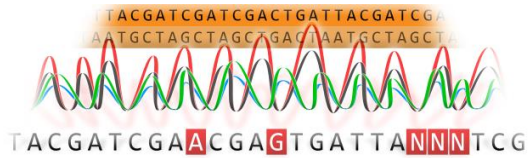


Photo by Guy Kawasaki on Unsplash



epa Research
Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

DESIGN: 2019-2020

Detection of Environmental Sources of Infectious diseases in Groundwater Networks

OÉ Gaillimh NUI Galway
UCC Coláiste na hOllscoile Corcaigh, Éire University College Cork, Ireland
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DESIGN: 2019-2020

Detection of Environmental Sources of Infectious diseases in Groundwater Networks

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DESIGN: 2019-2020

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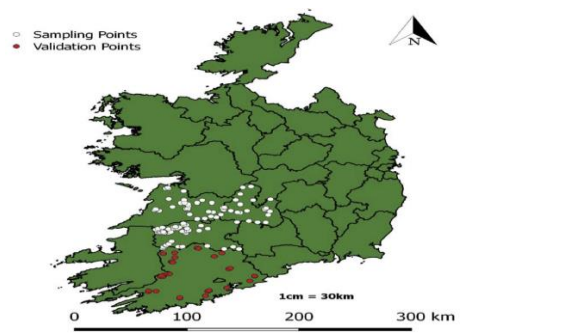

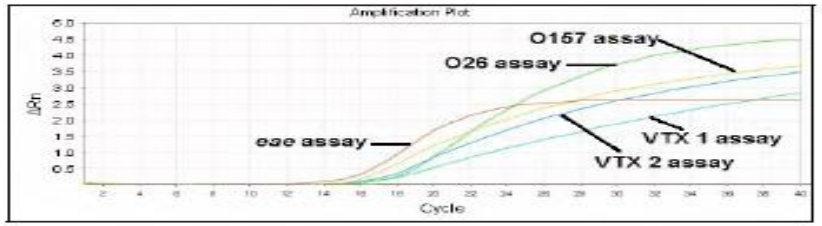

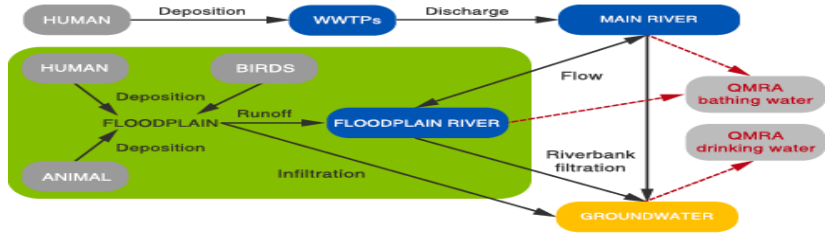

@ARME_galway

Acknowledgements

- Environmental Protection Agency

- Department of Public Health, HSE West:
  Dr. Diarmuid O'Donovan, Dr. Áine McNamara, Dr. Regina Kiernan

- Environmental Health Service, HSE West:
  Paul Hickey, Shane Keane, Seamus Mitchell

- The ARME Group:
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Web: http://www.nuigalway.ie/medicine-nursing-and-health-sciences/medicine/disciplines/bacteriology/research/

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Antimicrobial Resistance and Microbial Ecology Group
ARME

ONE HEALTH EJP ASM 2019

DUBLIN, MAY 22ND -24TH 2019

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