Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

S1-S7

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

5.1

5.17

CONTENTS

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1	INTRODUCTION	1
1.1	STRUCTURE OF THIS REPORT	1
1.2	PROJECT TEAM	2
1.3	BACKGROUND	3
1.3.1	The Experience of Setting PSZs in the Netherlands and the United Kingdom	4
2	DEFINING AND CALCULATING PUBLIC SAFETY ZONES	6
2.1	IDENTIFYING AN APPROPRIATE METHODOLOGY	6
2.2	IDENTIFYING APPROPRIATE GUIDANCE (RISK CRITERIA AND POLICY)	7
2.3	CALCULATING RISKS	8
3	PUBLIC SAFETY ZONES: CORK AIRPORT	10
3.1	MAIN RUNWAY 17/35	10
3.1.1	Towards the North – End 17	10
3.1.2	Towards the South – End 35	10
3.2	CROSS-RUNWAY 7/25	10
3.2.1	Towards the West – End 7	10
3.2.2	Towards the East – End 25	11
4	PUBLIC SAFETY ZONES: DUBLIN AIRPORT	17
4.1	MAIN (EXISTING) RUNWAY 10R/28L	17
4.1.1	Towards the West – End 10R	17
4.1.2	Towards the East – End 28L	17
4.2	PROPOSED RUNWAY 10L/28R	17
4.2.1	Towards the West – End 10L	17
4.2.2	Towards the East – End 28R	18
4.3	CROSS-RUNWAY 16/34	18
4.3.1	Towards the North-west – End 16	18
4.3.2	Towards the South-east – End 34	18
4.4	RUNWAY 11/29	19
4.4.1	Towards the West – End 11	19
4.4.2	Towards the East – End 29	19
5	PUBLIC SAFETY ZONES: SHANNON AIRPORT	30
5.1	MAIN RUNWAY 6/24	30
5.1.1	Towards the West -End 6	30
5.1.2	Towards the East – End 24	30
5.2	CROSS-RUNWAY 13/31	30
5.2.1	Towards the North-west – End 13	30
5.2.2	Towards the South-east – End 31	31
6	RECOMMENDATIONS AND CONCLUSIONS	37

6.1	*RECOMMENDATIONS FOR PUBLIC SAFETY ZONES*	*37*
6.2	*GUIDANCE ON PERMITTED DEVELOPMENTS WITHIN THE PROPOSED PUBLIC SAFETY ZONES (TABLE 6.1)*	*37*
6.2.1	*What Types of Developments Need to be Assessed Against the Guidance?*	*38*
6.2.2	*Exceptions to Permitted Developments in the Inner PSZ*	*38*
6.2.3	*Exceptions to Permitted Developments in the Outer PSZ*	*38*
6.3	*CONCLUSIONS*	*41*

1 INTRODUCTION

This report is a detailed account of an investigation into Public Safety Zones (PSZs) at Ireland's three principal airports; Cork, Dublin and Shannon.

The investigation was performed by ERM Environmental Resources Management Ireland Ltd on behalf of the Department of Transport (DT) and the Department of Environment, Heritage and Local Government (DoEHLG) between December 2000 and June 2003 (1) (2).

A technical report was issued for public comment on 23rd June 2003, and three 'public information' days were held in July 2003 at Cork, Dublin and Shannon airports.

Over 130 people attended the information days, and a total of 42 written submissions were received up until 28th August 2003.

In response to the public comments this revised technical report was issued on 30th September 2003.

1.1 STRUCTURE OF THIS REPORT

This report is set out as follows:

- this section, *Section 1*, provides a synopsis of the project team who performed the work and undertook the public consultation, and it also provides background to Public Safety Zones (PSZs);
- *Section 2* outlines the processes undertaken in defining and calculating the PSZs proposed for Cork, Dublin and Shannon airports;
- *Sections 3, 4* and *5* illustrate the calculated PSZs for Cork Airport, Dublin Airport and Shannon Airport, respectively;
- *Section 6* provides ERM's recommendations and conclusions for PSZs at Cork, Dublin and Shannon airports;
- *Annex A* provides a detailed and mathematical explanation of the calculation method;

(1) Environmental Resources Management. Contact: 22 Earlsfort Terrace, Dublin 2.

(2) Department of Transport (formerly the Department of Public Enterprise) and Department of the Environment and Local Government (2000). Terms of Reference for the preparation of Recommendations for Public Safety Zones in the Vicinity of Dublin Airport. Letter of 29th November 2000, from Martina Walsh, Secretary to the Public Safety Zones Working Group, Aviation Regulations & International Relations Branch.

- *Annex B* provides an overview of risk and land-use planning, expert opinions, and the development of criteria and policy for Cork, Dublin and Shannon airports;

- *Annexes C, D* and *E* detail the assumed aircraft movement data and provide an example risk calculation for Cork Airport, Dublin Airport and Shannon Airport, respectively;

- *Annex F* details ERM's response to the public comments received following issue of the technical report on 23rd June 2003 and the information days held in July 2003 at Cork, Dublin and Shannon airports.

1.2 PROJECT TEAM

Davies, Paul. Dr Paul Davies is a Partner of ERM. He has an honours degree in Mechanical Engineering, a doctorate in Quantitative Risk Assessment, and over 15 years experience in the field. This experience has covered fire, explosion, toxic, and crash hazards in process operations, storage facilities, road, rail, air and pipeline transport, quarrying, offshore platforms, ports and power generation.

With regards to airports and aircraft, Paul has been the project director, manager and/or principal analyst for numerous studies. These include: the investigation of risks to persons 'on-the-ground' from potential aircraft crashes at Manchester Airport (this work was presented as evidence for Queens Council at the Public Inquiry into the Proposed Second Runway at Manchester Airport); a peer review of the assessment of risk to major hazard installations due to runway re-alignment at Liverpool Airport; the assessment of risks presented to aircraft from the blasting of rock during the development of Hong Kong's Chek Lap Kok Airport; methodology development for the investigation of third party risk (land-use planning issues) for the proposed location of a second Sydney Airport; and an assessment of the risks to persons 'on-the-ground' in the vicinity of Farnborough Aerodrome.

O'Riordáin, Seán. Sean is the Managing Director of ERM's Dublin office. He joined ERM from the Institute of Public Administration, Dublin (IPA) in 2000. He continues to contribute to the planning and regional development elements of the IPAs MA Local Government programme. He is also a visiting lecturer in Planning at the University of Dublin, Trinity College.

Sean has widespread experience in liaising with public agencies, including the EU, and has been involved with research into public management issues in Ireland and the European Union generally. This includes undertaking evaluation and assessment of regional policy initiatives in Ireland and elsewhere in the European Union and Central and Eastern Europe. Since joining ERM he has been involved in work addressing the National Spatial Strategy and local and regional planning.

Quinn, Daniel. Daniel is a Senior Consultant with ERM. His principal areas of work include hazard identification, scenario quantification, risk evaluation and mathematical modelling of fire, gas and crash impacts. Projects include the risk assessment of gas compression stations, power stations, underground gas storage facilities, sulphur trioxide/oleum transport, petroleum transport, management factors in the prevention and cause of accidents associated with the transport of hazardous materials by road, rail and inland waterway; and risks profiling of flammable gas storage and delivery systems.

With regards to airports and aircraft, Daniel was the principal analyst for the assessment of risks to persons 'on-the-ground' from potential aircraft crashes in the vicinity of Farnborough Aerodrome.

Williams, Kirsten. Kirsten is a Social Scientist/Social Planner with considerable experience in environmental impact assessment, social impact assessment and strategic planning components of large multi-disciplinary infrastructure projects. Ms Williams also designs, manages and conducts consultation and evaluation processes, is experienced in strategy and policy development, and is a highly experienced Project Manager.

Projects undertaken have covered a wide range of industries including transportation (roads, rail, ports and airports), construction, mining, housing, education, tourism, recreation, public utilities, water resources, forestry, agriculture, pipelines, and foreign aid. In addition to her extensive European and Australian experience, Ms Williams has been responsible for undertaking social and environmental resource assignments in China and Indonesia for a major international donor agency, and more recently for BP in Turkey. Areas of focus have included environmental and social impact assessment, poverty alleviation, community and stakeholder consultation, natural resource management, infrastructure development and institutional strengthening. More recently, Kirsten has been involved in the development Ireland's National Spatial Strategy, revision of Irelands Nuclear Emergency Plan, and a Strategic review of Ireland's rail network.

1.3 *BACKGROUND*

The risks to persons 'on the ground' from aircraft crashes have been appreciated for some time. As such, Ireland, as do many other countries, operates 'protection zones' at the end of runways where the risk is greatest.

In Ireland, these zones are currently referred to as 'red zones' and serve to aid safe navigation of aircraft and to protect the public on the ground (1). This is done by limiting the type and allowable height of buildings and structures within the zones.

(1) In Ireland, a number of terms have been used when referring to the 'red zones', for example safety zones, and even public safety zones. The reason for this, most probably, relates to the (existing) dual purpose of the 'red zones' (i.e. to aid safe navigation of aircraft, by providing an obstacle clearance surface, and to protect persons on the ground by controlling land-use (within the zones)). In this report, the existing zones are referred to as 'red zones' and those zones proposed to protect people 'on the ground' as public safety zones or PSZs.

Advances in modelling techniques have made it possible to quantify the risks to the public (on the ground) from aircraft crashes. These techniques have shown that the risk pattern 'on the ground' bears little relation to the extent and shape of the red zones. Therefore, a set of protection zones, termed Public Safety Zones (PSZs), have been recommended for Cork, Dublin and Shannon airports. If adopted, these PSZs will help protect the public, whilst the red zones will continue to aid safe navigation of aircraft.

Two 'individual risk values' have been assessed in determining appropriate PSZs at Cork, Dublin and Shannon airports. They are 1 in 100,000 per year and 1 in one million per year [1]. An inner and an outer PSZ, corresponding to these risk values, have been set for each runway.

These 'individual risk values' were selected because they are established in the setting of protection zones at airports, for example in the Netherlands and the UK (as discussed in *Section 1.3.1*); and because they are comparable with those used in setting protection zones around chemical installations in Ireland and internationally. Further details are provided in *Annex B*.

Furthermore, in calculating and setting the PSZs for Cork, Dublin and Shannon airports it was recognised that they may impact upon existing and proposed land-use in the vicinity of the airports. As such, the study scope was broadened to investigate the potential land-use implications of the proposed PSZs. It was found that there would be no changes to existing land-use around Cork, Dublin and Shannon airports, and only minor alterations to proposed development plans (i.e. either a reduction in housing density or a variation to a proposed location). Further details are provided in *Annex B*.

In summary, this study has led ERM to propose a two-zone PSZ system for Cork, Dublin and Shannon airports, i.e. an inner and an outer PSZ. The calculation and setting of these zones, and the proposed criteria/policy to apply in operating these zones are outlined in the following sections.

1.3.1 *The Experience of Setting PSZs in the Netherlands and the United Kingdom*

Studies performed in the Netherlands and the UK have drawn similar conclusions to the investigation of PSZs in Ireland. This has resulted in the setting of new/revised PSZs at the end of runways at Schiphol Airport and at all major UK airports [2] [3].

The extent of the Dutch and UK PSZs has been based on the individual risk of fatality. The Dutch government has adopted both an inner and outer PSZ set at an individual risk of 1 in 100,000 per year and 1 in one million per year,

(1) Individual risk of 1 in 100,000 per year; i.e. 10^{-5} or a 0.00001 chance of death per year for an individual exposed 24 hours per day, 365 days per year. Individual risk of 1 in one million per year; i.e. 10^{-6} or a 0.000001 chance of death per year for an individual exposed 24 hours per day, 365 days per year.

(2) Ale, B.J.M. and Piers, M. (2000). The Assessment and Management of Third Party Risk Around a Major Airport. Journal of Hazardous Materials, 71, 1-3, pp 1-16.

(3) UK Department of the Environment, Transport and the Regions (DETR). (1997). Third Party Risk Near Airports and Public Safety Zone Policy. R&D Report 9636. National Air Traffic Services, London.

respectively [1]. By comparison, the UK government has adopted only a single PSZ set at 1 in 100,000 per year.

Within the PSZs that are set at an individual risk of 1 in 100,000 per year, both the Dutch and UK governments prevent any further building. In addition, the Dutch government plan to remove all existing housing within this zone. This compares with the UK government's decision to allow all existing developments to remain within this zone.

In addition, within the Dutch government's outer PSZ (i.e. set at a risk of 1 in one million per year), no future development of housing, hospitals and/or schools is permitted. However, all existing development is permitted to remain. This compares with the UK's approach of allowing unrestricted development outside the 1 in 100,000 PSZ (in respect of the risk from aircraft).

Annex B provides further details on the zones, criteria and policy adopted in the Netherlands and the UK.

(1) Individual risk of 1 in 100,000 per year; i.e. 10^{-5} or a 0.00001 chance of death per year for an individual exposed 24 hours per day, 365 days per year. Individual risk of 1 in one million per year; i.e. 10^{-6} or a 0.000001 chance of death per year for an individual exposed 24 hours per day, 365 days per year.

2 DEFINING AND CALCULATING PUBLIC SAFETY ZONES

2.1 IDENTIFYING AN APPROPRIATE METHODOLOGY

In determining the most appropriate method to use in calculating Public Safety Zones (PSZs) for Cork, Dublin and Shannon airports, a review was undertaken of the methodologies used by the Dutch and UK governments in setting PSZs at their airports [1] [2].

Both governments' methods have been translated into computer models, with the results used to develop policy and set the size, shape and extent of PSZs in these countries [3] [4]. The approaches used have drawn upon the work of others during this period, and an overview of some of these methods is given in the UK government's report on third party risk around airports and in a recent paper on the approach adopted in the Netherlands [5] [6].

The principal difference between the two approaches is the adoption of different crash location models. In the Netherlands, the probability of crash location is related to individual flight paths (known as a curve-linear approach). By comparison, the UK method relates potential crash location to a runway's extended centreline.

Intuitively, a potential crash location is related to an aircraft's flight path, and so the Dutch approach appears to offer improved modelling accuracy. However, in many accident reports no details of an aircraft's intended route are given and hence, compared with the UK approach, fewer accidents are available to form the basis of the Dutch model. Considering the already 'small' set of accidents upon which the UK model is based, it can be argued that the Dutch approach has less statistical basis.

Further support for the UK approach is given by the fact that landing aircraft (half of all movements) tend to align with the extended runway centreline at considerable distances from the runway (e.g. 10 km or more) and that the crash rate for landings is approximately 2½ times that of departures. Hence, landing crashes (which are likely to be distributed about the extended runway centreline) have a greater influence on the overall distribution of crash locations.

With regards to accident consequences, both approaches use the extent of potential crash area to estimate fatal injuries, and relate this area to Maximum

(1) Ale, B.J.M. and Piers, M. (2000). The Assessment and Management of Third Party Risk Around a Major Airport. Journal of Hazardous Materials, 71, 1-3, pp 1-16.
(2) Cowell, P.G., et al. (2000). A Methodology for Calculating Individual Risk Due to Aircraft Accidents Near Airports. R&D Report 0007. National Air Traffic Services, London.
(3) Ministerie van Verkeer en Waterstaat, Den Haag. (19-Dec-99). The Future of the National Airport [Schiphol].
(4) UK Department for Transport. (10-Jul-02). Control of Development in Airport Public Safety Zones. Circular 1/2002.
(5) UK Department of the Environment, Transport and the Regions (DETR). (1997). Third Party Risk Near Airports and Public Safety Zone Policy. R&D Report 9636. National Air Traffic Services, London.
(6) Refer to footnote 1, page 6.

Aircraft Weights (MAW) [1]. Similarly, crash rates are based on established accident databases, and modified to reflect so called 'first-world' operations (i.e. eliminating accidents specific to countries where aircraft types and aircraft/airport operations are not comparable to Western Europe and the United States).

With the above in-mind, the model used to calculate PSZs for Cork, Dublin and Shannon airports is based upon the method employed on behalf of the UK government. The method is detailed in *Annex A*.

2.2 *IDENTIFYING APPROPRIATE GUIDANCE (RISK CRITERIA AND POLICY)*

As stated in *Section 1.3* a two-zone Public Safety Zone (PSZ) system is proposed for Cork, Dublin and Shannon airports; an inner PSZ representing an individual risk of 1 in 100,000 per year, and an outer PSZ representing 1 in one million per year [2].

Within the PSZs the following land-use policy is proposed:

- prevent further development within inner PSZs, but allow existing developments to remain; and
- allow existing developments to remain within outer PSZs, but prevent high density housing development, and the building of schools, hospitals and facilities attracting large numbers of people (for further detail refer to *Section 6*).

These 'individual risk values' (i.e. criteria) and the associated policy on land-use within the PSZs are based upon:

- a review of the established risk criteria used to protect the public from industrial hazards both in Ireland and internationally;
- a comparison of these 'industrial' criteria with those recently implemented at airports in the Netherlands and the UK; and
- a consideration of expert opinions.

The review, comparison and expert opinions are detailed in *Annex B*.

(1) The Dutch and UK approaches refer to Maximum Take-off Weight (MTOW) and Maximum Take-off Weight Authorised (MTWA), respectively. These terms are synonymous with the term used here, Maximum Aircraft Weight (i.e. the maximum weight allowed, to include full load and fuel).

(2) Individual risk of 1 in 100,000 per year; i.e. 10^{-5} or a 0.00001 chance of death per year for an individual exposed 24 hours per day, 365 days per year. Individual risk of 1 in one million per year; i.e. 10^{-6} or a 0.000001 chance of death per year for an individual exposed 24 hours per day, 365 days per year.

2.3 *CALCULATING RISKS*

The calculation of risks upon which to determine Public Safety Zones (PSZs) in Ireland involved the following stages:

1. identifying the number of annual movements (i.e. landings and take-offs) with respects to aircraft types/classes (1);

2. calculating an 'all classes' movement-weighted average crash rate (crashes per million movements). This is done by using crash rates for each aircraft class (crashes per million movements) and multiplying it by the proportion of movements for that class, and summing the individual products;

3. calculating average crash areas (within which persons 'on the ground' are assumed to be fatally injured) for 'large' aircraft and 'light' aircraft. These are calculated by determining the average Maximum Aircraft Weight (MAW) for each class, multiplying the average crash area by the proportion of annual crashes for that class, and summing the individual products;

4. calculating the probability that crashing aircraft impact a specified location. For 'large' aircraft, this is performed by integrating probability density functions over the calculated average crash area. A similar calculation is performed for 'light' aircraft;

5. calculating the annual frequency that crashing aircraft impact a specified location (i.e. the individual risk). This is performed by multiplying the annual probability of a crash for the specified location by the appropriate average crash rate and associated number of movements (landings and take-offs) for each runway end;

6. using the individual risk results to determine 'best fit' zones representing specified annual individual risks (e.g. 1 in 100,000 per year and 1 in one million per year for the proposed inner and outer PSZs). The shape of each contour (extending away from the runway end) is very similar to that of a triangle. Therefore, to provide a simple geometric area that can be readily defined and easily reproduced on maps and plans, the risk contours are represented by zones alongside and parallel to the runway and triangular zones extending away from the runway ends.

The principal purpose of the outer PSZ is to minimise the possibility of a multiple fatality accident. For example, to limit the possibility of an aircraft crashing into a school, hospital or other development where large numbers of people can be expected. In relation to the 'size', 'speed' and weight of aircraft,

(1) The extent of PSZs is related to the number of aircraft movements and aircraft types. To minimise the need to periodically revise zone extents the Steering Group agreed that the number of aircraft movements for each runway should be set as either (a) the runway's movement capacity, or (b) the expected maximum number of movements. Similarly, aircraft types have been categorised as either 'large' or 'light', and the proportion of both set to provide a good representation of the expected split.

it is judged that 'light' aircraft have a far lower likelihood of causing a multiple fatality accident than 'large' aircraft [1]. Therefore, the extent of the outer PSZs is based upon large aircraft crashes only.

A detailed explanation of the calculation procedure and input data is given in *Annex A*, *Annex C* (Cork Airport), *Annex D* (Dublin Airport) and *Annex E* (Shannon Airport).

(1) Light aircraft <4 tonnes MTWA, compared with a movement weighted average MTWA of 33 tonnes, 95 tonnes and 54 tonnes for Cork, Dublin and Shannon Airports, respectively. Maximum Take-off Weight Authorised (MTWA).

3 PUBLIC SAFETY ZONES: CORK AIRPORT

The dimensions of the Public Safety Zones (PSZs) proposed for the two runways at Cork Airport are described below and illustrated in *Figures 3.1* to *3.5*. The inner and outer PSZs relate to an individual risk of fatality of 1 in 100,000 per year and 1 in one million per year, respectively. Where calculated, the individual risk of fatality of 1 in 10,000 per year is also shown.

3.1 MAIN RUNWAY 17/35

3.1.1 *Towards the North - End 17*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3065 m, and a maximum width at the end of the runway of 260 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 11290 m, and a maximum width at the end of the runway of 962 m.

3.1.2 *Towards the South - End 35*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3055 m, and a maximum width at the end of the runway of 278 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 11015 m, and a maximum width at the end of the runway of 1056 m.

3.2 CROSS-RUNWAY 7/25

3.2.1 *Towards the West - End 7*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 625 m, and a maximum width at the end of the runway of 96 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 2615 m, and a maximum width at the end of the runway of 224 m.

3.2.2 *Towards the East - End 25*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 625 m, and a maximum width at the end of the runway of 96 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 2300 m, and a maximum width at the end of the runway of 170 m.

Figure 3.1 *Cork Airport – Proposed Public Safety Zones*

Figure 3.2 *Cork Airport – Proposed Public Safety Zones, Main Runway 17/35 (North End 17)*

Figure 3.3 *Cork Airport – Proposed Public Safety Zones, Main Runway 17/35 (South End 35)*

Figure 3.4 *Cork Airport – Proposed Public Safety Zones, Cross Runway 7/25 (West End 7)*

Figure 3.5 ***Cork Airport – Proposed Public Safety Zones, Cross Runway 7/25 (East End 25)***

4 PUBLIC SAFETY ZONES: DUBLIN AIRPORT

The dimensions of the Public Safety Zones (PSZs) proposed for the three existing runways and the additional proposed runway at Dublin Airport are described below and illustrated in *Figures 4.1* to *4.11*. The inner and outer PSZs relate to an individual risk of fatality of 1 in 100,000 per year and 1 in one million per year, respectively. Where calculated, the individual risk of fatality of 1 in 10,000 per year is also shown.

4.1 MAIN (EXISTING) RUNWAY 10R/28L

4.1.1 *Towards the West - End 10R*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3155 m, and a maximum width at the end of the runway of 370 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 11455 m, and a maximum width at the end of the runway of 1448 m.

4.1.2 *Towards the East - End 28L*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 4375 m, and a maximum width at the end of the runway of 352 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 15430 m, and a maximum width at the end of the runway of 1394 m.

4.2 PROPOSED RUNWAY 10L/28R

4.2.1 *Towards the West - End 10L*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3050 m, and a maximum width at the end of the runway of 378 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 11330 m, and a maximum width at the end of the runway of 1462 m.

4.2.2 *Towards the East - End 28R*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3970 m, and a maximum width at the end of the runway of 344 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 15010 m, and a maximum width at the end of the runway of 1383 m.

4.3 *CROSS-RUNWAY 16/34*

4.3.1 *Towards the North-west - End 16*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 1240 m, and a maximum width at the end of the runway of 138 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 5645 m, and a maximum width at the end of the runway of 462 m.

4.3.2 *Towards the South-east - End 34*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 1290 m, and a maximum width at the end of the runway of 146 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 4370 m, and a maximum width at the end of the runway of 454 m.

4.4 *RUNWAY 11/29*

4.4.1 *Towards the West - End 11*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 1655 m, and a maximum width at the end of the runway of 144 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3970 m, and a maximum width at the end of the runway of 438 m.

4.4.2 *Towards the East - End 29*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 1230 m, and a maximum width at the end of the runway of 118 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 5215 m, and a maximum width at the end of the runway of 432 m.

Figure 4.1 *Dublin Airport - Public Safety Zones, Existing Runways*

Figure 4.2 *Dublin Airport - Public Safety Zones, Including Proposed Runway 10L/28R*

Figure 4.3 *Dublin Airport - Public Safety Zones, Main Existing Runway 10R/28L (West End 10R)*

Figure 4.4 *Dublin Airport - Public Safety Zones, Main Existing Runway 10R/28L (East End 28L)*

Figure 4.5 ***Dublin Airport - Public Safety Zones, Proposed Runway 10L/28R (West End 10L)***

Figure 4.6 *Dublin Airport - Public Safety Zones, Proposed Runway 10L/28R (East End 28R)*

Figure 4.7 *Dublin Airport - Public Safety Zones, Cross-Runway 16/34 (North-west End 16)*

Figure 4.8 *Dublin Airport - Public Safety Zones, Cross-Runway 16/34 (South-east End 34)*

Figure 4.9 *Dublin Airport - Public Safety Zones, Runway 11/29 (West End 11)*

Figure 4.10 *Dublin Airport - Public Safety Zones, Runway 11/29 (East End 29)*

5 PUBLIC SAFETY ZONES: SHANNON AIRPORT

The dimensions of the Public Safety Zones (PSZs) proposed for the two runways at Shannon Airport are described below and illustrated in *Figures 5.1* to *5.5*. The inner and outer PSZs relate to an individual risk of fatality of 1 in 100,000 per year and 1 in one million per year, respectively. Where calculated, the individual risk of fatality of 1 in 10,000 per year is also shown.

5.1 MAIN RUNWAY 6/24

5.1.1 *Towards the West -End 6*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 2505 m, and a maximum width at the end of the runway of 307 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 9805 m, and a maximum width at the end of the runway of 1161 m.

5.1.2 *Towards the East - End 24*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 3770 m, and a maximum width at the end of the runway of 295 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 13970 m, and a maximum width at the end of the runway of 1,149 m.

5.2 CROSS-RUNWAY 13/31

5.2.1 *Towards the North-west - End 13*

Inner PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 600 m, and a maximum width at the end of the runway of 72 m.

Outer PSZ
An area with a maximum extent from the end of the runway, along the extended runway centreline, of 2315 m, and a maximum width at the end of the runway of 225 m.

5.2.2 *Towards the South-east – End 31*

Inner PSZ

An area with a maximum extent from the end of the runway, along the extended runway centreline, of 665 m, and a maximum width at the end of the runway of 91 m.

Outer PSZ

An area with a maximum extent from the end of the runway, along the extended runway centreline, of 2285 m, and a maximum width at the end of the runway of 199 m.

Figure 5.1 *Shannon Airport - Public Safety Zones*

Figure 5.2 *Shannon Airport - Public Safety Zones, Main Runway 6/24 (West End 6)*

Figure 5.3 *Shannon Airport - Public Safety Zones, Main Runway 6/24 (East End 24)*

Figure 5.4 *Shannon Airport - Public Safety Zones, Cross Runway 13/31 (North-west End 13)*

Figure 5.5 *Shannon Airport - Public Safety Zones, Cross Runway 13/31 (South-east End 31)*

6 RECOMMENDATIONS AND CONCLUSIONS

6.1 RECOMMENDATIONS FOR PUBLIC SAFETY ZONES

ERM Environmental Resources Management Ireland Ltd, proposes the following Public Safety Zones (PSZs) for Cork, Dublin and Shannon airports:

- *Inner PSZ (extent set at an individual risk of 1 in 100,000 per year)*
  - prevent further development within inner PSZs, but allow existing developments to remain; and

- *Outer PSZ (extent set at an individual risk of 1 in one million per year)*
  - allow existing developments to remain within the outer PSZs, but prevent high density housing development, and the building of schools, hospitals and facilities attracting large numbers of people.

The permitted developments proposed for these zones are detailed in *Table 6.1* and summarised in *Table 6.2* and *Table 6.3*. Further guidance is given in *Section 6.2* and *Annex B*.

It is important to note that the guidance given in *Table 6.1* is not recommended for retrospective use. This is because the risks to existing developments (within the PSZs) are not so high as to be judged intolerable. The sole purpose of the guidance is to ensure that the risks do not become intolerable/unacceptable by controlling future land-use within the PSZs.

The size, shape and extent of the PSZs for each airport and runway are detailed in *Sections 3, 4* and *5*.

6.2 GUIDANCE ON PERMITTED DEVELOPMENTS WITHIN THE PROPOSED PUBLIC SAFETY ZONES (TABLE 6.1)

Table 6.1 is for guidance, and only applicable to 'safety risks' from aircraft. It should be used in conjunction with appropriate legislative and regulatory controls and guidance, and other guidance, official development plans and objectives.

In some cases, permitted developments are restricted to a maximum density of persons. This density is expressed as the number of persons per half hectare. A half hectare was chosen as this approximates the average maximum aircraft crash area. The maximum density should be applied to any single half hectare within which the proposed development is located.

The guidance for the inner PSZ and outer PSZ applies only to those parts of a development located within the respective zone. The guidance does not apply to parts of a development outside the PSZs.

6.2.1 *What Types of Developments Need to be Assessed Against the Guidance?*

It is not practical to list all development types that may or may not be permitted in the PSZs. However, in general terms, a development should be assessed where people can be expected to be present for all or part of the day.

It follows that developments that need not be considered are those where persons are not normally expected to be present (e.g. normally unoccupied buildings, such as a tool store) (1).

6.2.2 *Exceptions to Permitted Developments in the Inner PSZ*

The only exceptions for permitted developments in the inner PSZ are:

- developments where persons are not expected to be present;
- long stay car parks (i.e. greater than 24 hours), provided that persons are normally expected to park their car and then immediately leave the car park development. Buildings associated with car parks are subjected to the guidance given in *Table 6.1*; and
- roads and railways where vehicles and passenger trains/trams are not expected to be stationary. For example, road vehicles can be expected to be stationary at major road intersections, junctions and traffic lights. Therefore, major road intersections, junctions, traffic lights and similar should not be permitted in the inner PSZ.

6.2.3 *Exceptions to Permitted Developments in the Outer PSZ*

In most cases, the guidance given in *Table 6.1* will be sufficient to identify whether a proposed development should be permitted in the outer PSZ. However, there may be cases, in exceptional circumstances, where it is judged that a development's socio-economic benefits (etc.) outweigh the 'safety risk', and that it is impractical for such a development to be located elsewhere. An Airport Terminal, as described below, is a good example of such a development.

Airport Terminals

To ensure risks to people are as low as reasonably practicable, it is desirable to locate airport terminals outside PSZs. However, this may not be practicable and there are precedents to accept a greater, but tolerable risk, where persons gain a direct benefit from the activity presenting the risk.

In the case of an airport terminal, all those working and using the terminal would be receiving a direct benefit (i.e. related to employment or travel) and

(1) For chemical sites, it is understood that the UK Health & Safety Executive has judged a building to be unoccupied where the presence of people does not amount to more than 2 hours in one day. Gakhar, S.J. (2000). Assessing Risks to Occupants of Existing Buildings on Chemical Plants due to Hazards of Fire and Explosion. Hazards XV, The Process, its Safety, and the Environment, Getting it Right, pp 433-449. Manchester, 4-6 April.

therefore an annual individual risk greater than 1 in one million (i.e. corresponding to the extent of the outer PSZ) but less than 1 in 100,000 (i.e. corresponding to the extent of the inner PSZ) is considered tolerable. Hence, location of an airport terminal in the outer PSZ is judged tolerable.

Extensions to Existing Developments

Extensions to existing developments are permitted. This is provided the development is of a permitted development type, and the proposed extended development (i.e. original development plus extension) does not result in the density figures listed in *Table 6.1* being exceeded (i.e. the number of persons per half hectare should not be exceeded).

For example, a proposed extension to a house which would increase the occupancy to five would be appropriate, provided no half hectare (i.e. 5,000 m^2 or approximately 1.24 acres) encompassing the extended development exceeded 60 persons.

Roads and Railways

Roads and railways are permitted in the outer PSZs, including major road and rail intersections, junctions and traffic lights.

Bus and Rail Terminals

Bus and rail terminals are permitted in the outer PSZs provided the density does not exceed 110 persons per half hectare.

Car Parks

Car parks are permitted in the outer PSZs. This is provided that persons are normally expected to park their car and then leave the car park development. Buildings associated with car parks are subjected to the guidance given in *Table 6.1*.

Table 6.1 ***Permitted Developments (applicable to new applications for development)***

Permitted Developments	Public Safety Zone (PSZ)	
	Inner PSZ	**Outer PSZ**
All developments	No further development (existing developments remain)	see below (existing developments remain)

	Outer PSZ
1. Housing	≤ 60 persons/half hectare
2. Holiday Accommodation	≤ 100 beds per development
3. Retail/Leisure Facilities	≤ 85 persons/half hectare
4. Working Premises	≤ 110 persons/half hectare
5. Institutional Accommodation	No further development
6. Sports Stadia	No further development
7. Limited Use	≤ 220 persons/half hectare

No restrictions on development beyond Outer PSZ

Notes
1. Housing – i.e. residential accommodation, persons at home.
2. Holiday Accommodation – i.e. hotels, caravan parks.
3. Retail/Leisure Facilities – i.e. shopping centres, sports halls, sports grounds, swimming pools, bowling alleys, golf clubs.
4. Working Premises – i.e. factories, offices and facilities where persons are expected to congregate, such as railway stations.
5. Institutional Accommodation – i.e. hospitals, schools, nurseries, care homes, prisons.
6. Sports Stadia – i.e. football/rugby stadia.
7. Limited Use – use not exceeding (approximately) a maximum of 12 hours in one week. i.e. Sunday markets, car boot sales, day fairs.

Table 6.2 ***Proposed Developments – Summary*** *of Permitted Developments (applicable to new applications for development)*

	Inner PSZ			Outer PSZ[1]		
	Industry[2]	**Housing**	**Vulnerable[3]**	**Industry[2]**	**Housing**	**Vulnerable[3]**
Ireland	NO	NO	NO	YES	YES	NO
Netherlands	NO	NO	NO	YES	NO	NO
UK	NO	NO	NO	YES	YES	YES

NO – development not permitted YES – development permitted
1. For the UK, the Outer PSZ refers to land beyond the single PSZ.
2. Industry – includes offices.
3. Vulnerable – hospitals, schools and sports stadia, etc.

Table 6.3 ***Existing Developments – Summary of Permitted Developments*** *(applicable to existing development)*

	Inner PSZ			Outer PSZ[1]		
	Industry[2]	**Housing**	**Vulnerable[3]**	**Industry[2]**	**Housing**	**Vulnerable[3]**
Ireland	Remain	Remain	Remain	Remain	Remain	Remain
Netherlands	Remain	Remove	Remove	Remain	Remain	Remain
UK	Remain	Remain	Remain	Remain	Remain	Remain

Remove – developments to be removed Remain – developments to remain and current use can continue
1. For the UK, the Outer PSZ refers to land beyond the single PSZ.
2. Industry – includes offices.
3. Vulnerable – hospitals, schools and sports stadia, etc.

6.3 CONCLUSIONS

It is the Consultant's view that the proposed inner and outer PSZs provide appropriate consistency with established risk criteria and zoning practice around airports, and around chemical installations in Ireland (set by the Health and Safety Authority), whilst recognising the differences between hazards presented by chemical installations and aircraft approaching and departing airports.

Acknowledging that the proposed PSZs might impact upon existing and proposed land-use, the implications of the zones calculated for Cork, Dublin and Shannon airports have been investigated. It is concluded that adoption of the PSZs would not require any changes to existing land-use around the airports, and would only require minimal changes to proposed development plans.

CONTENTS

1	INTRODUCTION	1
1.1	STRUCTURE OF THIS REPORT	1
1.2	PROJECT TEAM	2
1.3	BACKGROUND	3
1.3.1	The Experience of Setting PSZs in the Netherlands and the United Kingdom	4
2	DEFINING AND CALCULATING PUBLIC SAFETY ZONES	6
2.1	IDENTIFYING AN APPROPRIATE METHODOLOGY	6
2.2	IDENTIFYING APPROPRIATE GUIDANCE (RISK CRITERIA AND POLICY)	7
2.3	CALCULATING RISKS	8
3	PUBLIC SAFETY ZONES: CORK AIRPORT	10
3.1	MAIN RUNWAY 17/35	10
3.1.1	Towards the North – End 17	10
3.1.2	Towards the South – End 35	10
3.2	CROSS-RUNWAY 7/25	10
3.2.1	Towards the West – End 7	10
3.2.2	Towards the East – End 25	11
4	PUBLIC SAFETY ZONES: DUBLIN AIRPORT	17
4.1	MAIN (EXISTING) RUNWAY 10R/28L	17
4.1.1	Towards the West – End 10R	17
4.1.2	Towards the East – End 28L	17
4.2	PROPOSED RUNWAY 10L/28R	17
4.2.1	Towards the West – End 10L	17
4.2.2	Towards the East – End 28R	18
4.3	CROSS-RUNWAY 16/34	18
4.3.1	Towards the North-west – End 16	18
4.3.2	Towards the South-east – End 34	18
4.4	RUNWAY 11/29	19
4.4.1	Towards the West – End 11	19
4.4.2	Towards the East – End 29	19
5	PUBLIC SAFETY ZONES: SHANNON AIRPORT	30
5.1	MAIN RUNWAY 6/24	30
5.1.1	Towards the West –End 6	30
5.1.2	Towards the East – End 24	30
5.2	CROSS-RUNWAY 13/31	30

5.2.1	*Towards the North-west – End 13*	*30*
5.2.2	*Towards the South-east – End 31*	*31*
6	*RECOMMENDATIONS AND CONCLUSIONS*	*37*
6.1	*RECOMMENDATIONS FOR PUBLIC SAFETY ZONES*	*37*
6.2	*GUIDANCE ON PERMITTED DEVELOPMENTS WITHIN THE PROPOSED PUBLIC SAFETY ZONES (TABLE 6.1)*	*37*
6.2.1	*What Types of Developments Need to be Assessed Against the Guidance?*	*38*
6.2.2	*Exceptions to Permitted Developments in the Inner PSZ*	*38*
6.2.3	*Exceptions to Permitted Developments in the Outer PSZ*	*38*
6.3	*CONCLUSIONS*	*41*

ANNEX A *CALCULATION OF THIRD PARTY INDIVIDUAL RISK: DETERMINING PUBLIC SAFETY ZONES FOR AIRPORTS*

ANNEX B *PUBLIC SAFETY ZONES: CRITERIA AND POLICY, RISK ASSESSMENT AND EXPERT OPINIONS*

ANNEX C *MAXIMUM AIRCRAFT MOVEMENT DATA AND THE CALCULATION OF RISK AND PSZS: CORK AIRPORT*

ANNEX D *MAXIMUM AIRCRAFT MOVEMENT DATA AND THE CALCULATION OF RISK AND PSZS: DUBLIN AIRPORT*

ANNEX E *MAXIMUM AIRCRAFT MOVEMENT DATA AND THE CALCULATION OF RISK AND PSZS: SHANNON AIRPORT*

ANNEX F *PUBLIC CONSULTATION: ERM'S RESPONSE TO PUBLIC SUBMISSIONS*

Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

5.8

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

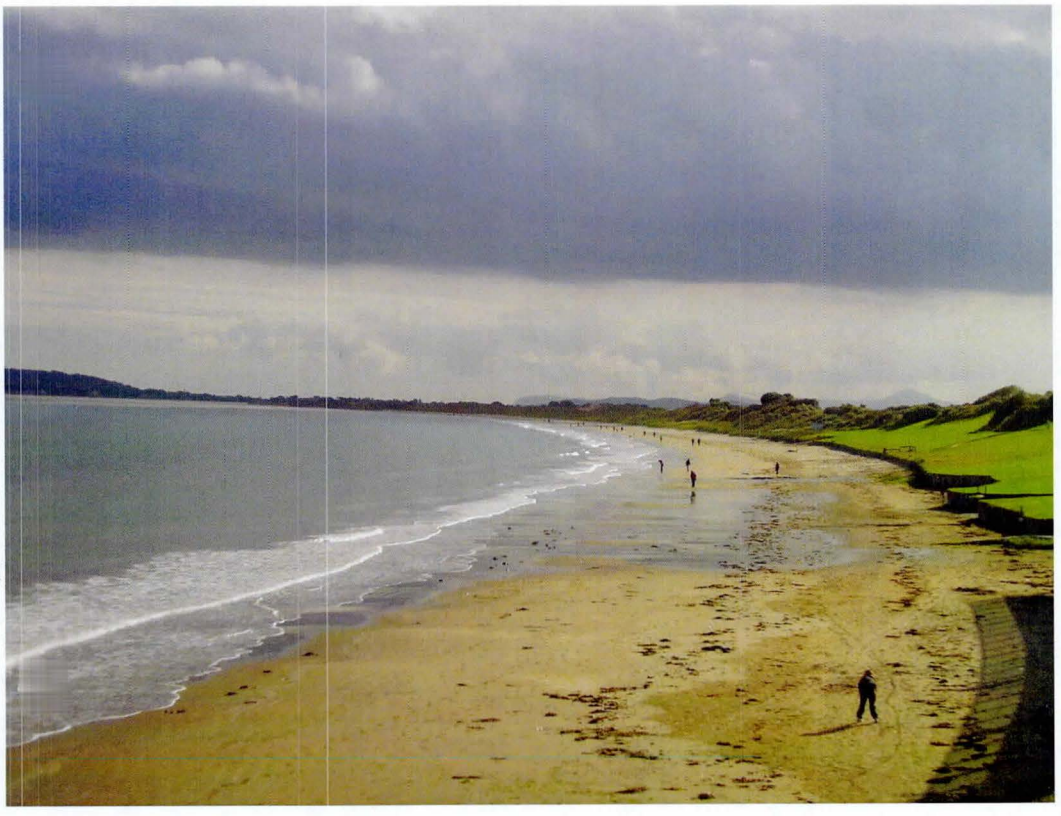
Bathing Water Profile - Portmarnock, Velvet Strand Beach (2023)

Bathing Water:	Portmarnock, Velvet Strand Beach
Bathing Water Code:	IEEABWC070_0000_0200
Local Authority:	Fingal County Council
River Basin District:	Eastern
Monitoring Point:	324873E, 244142N

1. Profile Details:

Profile Id:	BWPR00725
Year Of Profile:	2023
Year Of Identification	1992
Version Number:	1

Figure 1: Bathing Water



Amenities

Beach activity zones	No
Beach Information board	Yes
Beach Wheelchair	Yes
Car free zone	No
Cars allowed on beach	No
Cars not allowed on beach	Yes
Disability Access	Yes
Dogs allowed on lead	Yes
Dogs not allowed	No
First Aid	Yes
Lifebuoy at beach	Yes
Lifeguarded zone	Yes
Litter Bin	Yes
Natural Sensitive Area	No
Near Public Transport	Yes
Parking	Yes
Recycling facilities	Yes
Toilets	Yes

2. Bathing Water Details:

Map 1: Bathing Water Location & Extent



Bathing Water location and extent:	Portmarnock Velvet Strand is located approximately 14km north of Dublin City Centre, in Fingal, North County Dublin. The beach is approximately 1.5km from the town centre. The designated area is approximately 3.3km long and the beach extends beyond the designated area approximately 3.0 km long.
Main features of the Bathing Water:	**Location and Extent**: Portmarnock Velvet Strand is located approximately 14km north of Dublin City Centre, in Fingal, North County Dublin. The beach is approximately 1.5km from the town centre. The designated area is approximately 3.3km long and the beach extends beyond the designated area approximately 3.0 km long. **Main Features**: **Beach Description**:Portmarnock Velvet Strand Beach is a long, open, gently sloping beach facing east. It is backed by an extensive dune system which consists of embryonic, marram and grey dunes. The beach stretches south to the Baldoyle Estuary and adjoins Malahide Beach to the north over 2km to the north. There is a view of the Dublin Mountains and Howth Harbour, Lambay Island and Ireland's Eye. ***Flora/Fauna/Riparian Zone:*** PortmarnockVelvetStrand is part of Baldoyle Estuary and the Portmarnock dune system. Baldoyle Estuary is very important for wildlife. The large expanse of mudflats and open water provide feeding grounds for many wading birds, ducks and geese. Thousands of migratory birds such as the Brent Goose, Blacktailed Godwits, Redshanks and Golden Plover spend the autumn and winter here, to feed and to rest, before returning to their breeding grounds in northern Europe andCanada. Portmarnock beach is backed by an extensive dune system. Despite the presence of two golf courses, the dunes support a huge variety of plant species and have attracted botanists for over 100 years. Colourful plants such as Wild Pansys, Kidney Vetch, Yellow Worth, and Burnet Rose arein abundant. The dunes also support a large number of rare plant species such as Hairy Violet, Marsh Helleborines, Green-flowered Helleborines and Hound's Tongue. 15 Bee species such as the Snail-shell Nesting Bee and the Sand Mining Bee and 7 species of Butterfly can be found here. More information about wildlife in Portmarnock is available on the website:www.fingalbiodiversity.ie ***Water Depth/Tidal Range***: Estimated depth of the designated bathing water is approximately 2m however, this fluctuates with tidal movement.

	Land use: The land use in the area immediately surrounding the beach is discontinuous urban fabric, which is typical for towns. ***Approximately number of visitors***: The beach is popular and at peak time there can be up to 2,500 visitors.
Activities available at the Bathing Water:	Swimming – Canoeing, Fishing and Walking
Contributing catchment details:	***Location and Extent:*** Portmarnock Velvet Strand Beach is located in Mayne-Santry-Coastal/Coastal (Portmarnock) catchment area. However, the contributing catchment is limited to the north and north-east Portmarnock. ***Water Bodies Draining to Bathing Area***: There is no river or stream discharging directly to the beach. However, there is surface water discharges to the beach from surrounding urban run-off. ***Topography***: The contributing catchment area is mainly flatland, with occasional hills, gently rolling to the east. ***Land Use:*** The contribution catchment area is discontinuous urban fabric which is typical for town areas. ***Soil, Subsoil, Bedrock***: Limestone till (Carboniferous) is a predominant soil type in the contributing catchment area. It is a well drained material derived from mainly calcareous parent materials. However, the small part of the catchment, including the area immediately surrounding the beach is marked as a made/built ground. The bathing water area is classified as blown sand dunes. Dinantian Lower Impure Limestones to the north and Dinantian Upper Impure Limestones to the south underlie the catchment area. In terms of groundwater, the catchment area is marked as low vulnerability. The Portmarnock area is designated a high vulnerability area. ***Formal Designated Area:*** Baldoyle Estuary andIreland's Eye located near by the Portmarnock beach are designated a Special Protection Area (SPA) and Special Area of Conservation(SAC). ***Population Centres***: In the contributing catchment area, Portmarnock with a population of 8,110 is the main population centre. ***Rainfall:*** There is no synoptic station or rain gauge in the catchment area. The closest rain gauge is located in Malahide Castle (Grid Ref. 322200E 245400N) approx 3km to the west of the designated beach. The closest synoptic station is located in Dublin Airport (Grid Ref. 316900E 243400N) and it is approximately 8km to the west of the designated water area. Fingal have a rain gauge at Dungriffin Resevoir, approx 6.9km to the south east and another at Malahide WWTP, approx 3.4km to the north west. Both stations are on telemetry. According to the data from the synoptic station from the period 1960-1991 mean annual rainfall was 732.8mm. The month with the highest mean precipitation during that period was December with mean 75.8mm, while July had the lowest mean precipitation at 50mm. However, rainfall data for last 4 years (2007 - 2010) indicates that the amount of rainfall can periodically significantly increase to more than twice the mean expected rainfall. Additionally, the hourly rainfall exceeded the rainfall return figures for 1:3 year and/or 1:5 year probabilities. In addition, it should be noted that rainfall is localised and due to the distance between the synoptic station and the designated area the rainfall data may not be wholly accurate
Monitoring point details:	The grid reference for the nominated bathing water monitoring point is: 324873.1055E 244141.6905N
Reason for selection of the monitoring point:	The location of the monitoring point is the location where the most bathers are expected to use the bathing water. However, the location of monitoring point may vary due to tidal and weather influence. In spite of this, the monitoring point is located always on the monitoring axis located perpendicularly from the Life Guard Station into the bathing area. .
Water quality assessment:	Bathing water quality monitoring has been carried out at Portmarnock since 1996. The water quality results indicate that the water quality has achieved good water quality status 2008-2013 but since 2014-2022 has achieved excellent water quality status and complied with the EU Guide and

Mandatory values as set out in the Quality of Bathing Water Regulations, 1992 (S.I. 155 of 1992 – repealed in 2014) & Bathing Water Regulations, 2008 (S.I. 75 of 2008 and the EU Directive concerning the quality of Bathing Waters (2006/7/EC). Portmarnock beach has been a recipient of the Blue Flag Beach Award from 2009-2022.

The detailed water quality results are available on the website:http://www.beaches.ie

3. Identified Pressures:

Map 2: Bathing Water Catchment



3.1 Potential pressures in the catchment assessed as posing no risk:

No pressures identified

3.2 Potential pressures in the catchment assessed as posing risk:

Description:	There are a number of surface water pipes discharging to the beach from the surrounding residential area.
Source:	MISCONNECTIONS TO THE SURFACE WATER SYSTEM
Type:	Other
Short Term Pressure:	Yes
Nature:	Moderate Risk
Frequency:	on-going
Duration:	< 72 hours
Risk Assessment Methodology:	Fingal lies within the Eastern River Basin District (ERBD). The designated bathing water forms part of the Santry/Mayne/Sluice Water Management Unit (WMU), established for water quality management purposes under the Water Framework Directive (60/EC/2000). A Programme of Measures (POM's) designed to maintain and improve water quality in the catchment was formulated within the ERBD, River Basin Management Plan (RBMP). The surface water discharges to Velvet Strand do not form part of the statutory WFD Operational Monitoring Programme so there is currently no water quality data available for this site. There maybe misconnections to the surface water system in the vicinity of Portmarnock which may impact on the bathing water quality.
Risk Assessment Results:	Risk from misconnections to the surface water system and overflows within the foul network to the surface water system are ongoing.
Details:	risk is greatest following intense rainfall events
agement Measures:	In FCC, the Inspectorate Division is liaising with Drainage Operations Section on this matter. Monitoring of the surface water discharges to Velvet Strand is conducted simultaneously with bathing water throughout the bathing season.

Description:	There is one pump station in close proximity to Portmarnock Velvet Strand at Portmarnock Strand. In the event of mechanical or electrical breakdown, or heavy rainfall, the pump station overflows to the surface water system which discharges directly to the Irish Sea immediately north of the designated bathing area.
Source:	pumping station
Type:	Other
Short Term Pressure:	Yes
Nature:	Moderate Risk
Frequency:	occasional
Duration:	< 24 hours
Risk Assessment odology:	The MPP has been assessed as HIGH in accordance with the Microbial Pollution Potential (MPP) Grades for sewage outfalls adapted from WHO 2003 - detailed in the EPA Guidance document 'Guidance for Development of Bathing Water Profiles for Bathing Water Quality Regulations 2008 (July 2010).
Risk Assessment Results:	Microbial Pollution Potential (MPP) = HIGH Discharge is immediately adjacent to the designated area. Water Quality Impact (WQI) = B The 95 percentiles monitoring results from the last 4 years is estimated at WQI grade B with a value between 41-200 intestinal enterococci (cfu/100ml) Microbial Pollution Risk (MPR) = HIGH * The MPR is estimated as 'HIGH based on EPA guidelines and may only apply in the event of an overflow.
Details:	The risk is highest during heavy rainfall events.
Management Measures:	Upgrading of Portmarnock Strand Pump Station is included in the Water Services Investment Programme as part of the Portmarnock Sewerage Scheme. The scheme is in the early stages of design. The Pump Station is on telemetry and so in the event of overflows, Fingal staff respond promptly. In the event of bathing water not achieving sufficient quality bathers shall be notified of a potential risk to the water quality by Fingal County Council and advised not to use the designated bathing area. The information is provided via notice board at the beach, by Lifeguards on duty and via the Fingal website www.fingal.ie – this warning system is currently operational during the bathing season

3.3 Other Risks:

Assessment of the potential for proliferation of cyanobacteria:	Monitoring on the beach has been carried out since 1996. There is no indication of significant potential for proliferation of cyanobacteria on this beach. Not a risk.
Proposed management measures for cyanobacteria:	N/A
Assessment of the potential for proliferation of macroalgae:	Monitoring on the beach has been carried out since 1996. There is no indication of significant potential for proliferation of Macroalgae on this beach. Not a risk.
Proposed management measures for macroalgae:	N/A
Assessment of the potential for proliferation of marine phytoplankton:	Monitoring on the beach has been carried out since 1996. There is no indication of significant potential for proliferation of Marine Phytoplankton on this beach. Not a risk.
Proposed management measures for marine phytoplankton:	N/A
Additional Information:	N/A

4 Bathing Water Status From Previous Sampling Years:

	2019	2020	2021	2022
Portmarnock, Velvet Strand Beach	Excellent Quality	Excellent Quality	Excellent Quality	Excellent Quality

5 Contact Details:

Contact:	Fingal County Council
Email:	bathingwaters@fingalcoco.ie
Address:	Fingal County Council, Environment, Climate Action & Active Travel Dept., County Hall, Dublin
Phone:	01 8905000

Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

6.1

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

6.1

EMFF Operational Programme 2014-2020

Marine Biodiversity

Assessment of species catch composition in fisheries posing a risk to biodiversity

Supply of Vertebrate Necropsy and Sample Recovery Services

Merged Final Reports

EMFF 2014-2020

Marine Institute Report Series

Citation/Authors: Stephanie Levesque, Jim O'Donovan, Mags Daly, Sinéad Murphy, Mick O'Connell, Paul Jepson, Rob Deaville, James Barnett, and Simon Berrow.

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Foras na Mara
Marine Institute

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Operational Programme	European Maritime and Fisheries Fund (EMFF) Operational Programme 2014-2020
Priority	Union Priority 1 Sustainable Development of Fisheries Union Priority 6 Fostering the implementation of the Integrated Maritime Policy
Thematic Objective	TO 6 - Preserving and protecting the environment and promoting resource efficiency
Specific Objective	UP1 SO1 - Reduction of the impact of fisheries and aquaculture on the marine environment, including the avoidance and reduction, as far as possible, of unwanted catch. UP1 SO2 - Protection and restoration of aquatic biodiversity and ecosystems. UP6 SO1 - Development and implementation of the Integrated Maritime Policy
Measure	Marine Biodiversity Scheme
Project Reference	Assessment of species catch composition in fisheries posing a risk to biodiversity MB/2017/04 & MB/2019/04
EMFF Certifying Body	Finance Division, Department of Agriculture, Food and the Marine
Managing Authority	Marine Agencies & Programmes Division, Department of Agriculture, Food and Marine
Specified Public Beneficiary Body	Marine Institute
Grant Rate	100%
EU Co-Financing Rate	50%
Legal Basis	Article 29, 40 & 80 EMFF

This project or operation is part supported by the Irish government and the European Maritime & Fisheries Fund as part of the EMFF Operational Programme for 2014-2020

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020 Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara Department of Agriculture, Food and the Marine

EUROPEAN UNION This measure is part-financed by the European Maritime and Fisheries Fund

Foras na Mara Marine Institute

Background

In Ireland, monitoring of bycatch interactions of endangered and protected species with fisheries is carried out through an enhanced bycatch programme focusing on high-risk fisheries, which was launched to supplement the standard at sea catch-sampling programme that is conducted as part of The Data Collection Framework (DCF) programme. As part of this project, a Necropsy pilot study was conducted on stranded cetaceans to evaluate mortality through fisheries' bycatch. The project also aimed to provide resources not readily available through the standard sampling schemes, in the form of animal tissue samples, to facilitate the future investigation of areas of concern for marine mammals in Irish waters.

The Necropsy pilot study was established in 2017, and was conducted in two phases; the first phase ran from October 2017 until December 2018 (Tender: ITT17-024, ITT18-005), the second phase from January to November 2019 (Tender: ITT18-050). The work was contracted to the Irish Whale and Dolphin Group (IWDG) and Galway Mayo Institute of Technology (GMIT), with support from the Regional Veterinary Laboratory (RVI) in Cork and in consultation with the Institute of Zoology (IoZ) in London. The study focused on three marine mammal species of potential bycatch concern, common dolphins (*Delphinus delphis*), striped dolphins (*Stenella coeruleoalba*), and harbour porpoises (*Phocoena phocoena*), and over the course of the programme a total of 118 specimens were recovered for necropsy, the majority of which were common dolphins (71%). In addition to determining the *cause of death* (COD), tissue samples from all specimens were collected and are being used as part of ongoing contaminant, diet, aging, and stress studies. Overall, confirmed bycatch was considered to represent between approximately 10 and 20% of all CODs. The proportion of CODs attributed to bycatch varied between the two phases of the study, attributed to a number of factors including increased sampling effort and the better condition of specimens in the peak winter season of 2019.

Results of this study can assist the design of future monitoring programmes to support Ireland's reporting obligations under MSFD, OSPAR, Natura and the CFP. In addition, the sample repository collected as part of the study has the potential to further contribute to broadening our understanding of cetacean ecology and life history, to other MSFD Descriptors and to OSPAR contaminant ecosystem indicators, through independent studies carried out in both Irish universities and the Marine Institute.

Reports from IWDG from both phases of the pilot study are presented in the following sections. The Marine Biodiversity Scheme is established under Union Priority 1 (Sustainable Fisheries) and Union Priority 6 (Integrated Maritime Policy) of Ireland's Operational Programme (OP) under the EMFF and is co-funded by the Irish Government and the EU.

Contents

Supply of Vertebrate Necropsy and Sample Recovery Services 2017-2018 Final Report 6
Executive Summary 7
Introduction 7
Methods 8
Results 11
Discussion 38
Acknowledgements 39
References 40
Appendices 42
Supply of Vertebrate Necropsy and Sample Recovery Services Extension - 2019 Final Report 63
Executive Summary 64
Introduction 64
Methods 65
Results 68
Discussion 84
Acknowledgements 87
References 88
Appendices 90

Supply of Vertebrate Necropsy and Sample Recovery Services 2017-2018 Final Report

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Reference Number: ITT17-024, ITT18-005

Clients: Marine Institute with support of the National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht

February 2022

Executive Summary

The Marine Institute (MI) issued a tender for the *Supply of Vertebrate Necropsy and Sample Recovery Services* Tender to cover the period of June 2017 to December 2017 (ITT17-024). They then requested an extension of this contract to continue throughout the period of January to March 2018. Following this extension, a second contract was issued to cover the period April to December 2018 (ITT18-005). The results of these two contracts have been merged for the purposes of this report.

These tenders required i) the recovery and standardised necropsy of three cetacean species with associated case history reporting, ii) the provision of sampling kits to be used for the recovery of tissue samples collected from bycaught animals (birds, seals and cetaceans) by observers on commercial inshore and offshore fishing vessels in Irish waters in order to provide additional data to the MI's existing catch sampling programme and iii) the storage and subsequent delivery of all samples and associated databases to the client.

Recovery of 24 animals from two geographical lots was the target for the initial contract (2017) and was achieved. The contract extension (early 2018) required the collection and necropsy of a further 16 animals, which was exceeded as 19 animals were collected. A target of 30 animals to be recovered was required in the second contract (2018) and was also successfully reached. These 73 animals comprised 53 common dolphins (*Delphinus delphis*), ten striped dolphins (*Stenella coeruleoalba*) and ten harbour porpoises (*Phocoena phocoena*). Forty-one of the 73 (56%) individuals were recovered from Lot 1 from counties Clare to Donegal, while 32 (44%) individuals were recovered from Lot 2 from counties Wexford to Kerry.

Thirty-five sampling kits were assembled and delivered to the Marine Institute, and additional kits were prepared and available upon request for distribution to their panel of fishery observers. Between 24 July and 14 December 2017, two adult male grey seals wereincidentally captured in tangle nets and reported to the Project Coordinator.Results from these tenders will inform the development of a long-term strategy for necropsy of stranded cetaceans and recovery of tissue samples for further biological studies.

Samples requiring long-term storage at -20°C, including those for virology, were transported in a portable refrigerator to the IWDG office in Kilrush, Co. Clare and stored at facilities on site. Formalin fixed tissues, such as reproductive organs and adrenal glands, were stored at the RVL in Cork. All samples have been delivered to the Marine Institute in Oranmore, Co. Galway along with a detailed database of samples collected.

Introduction

The Marine Institute (MI) published two tenders for the provision of vertebrate necropsy services for cetaceans stranded on the Irish coast and for the provision of sampling kits for observers involved in Data Collection Framework (DCF) surveys. These contracts were delivered by the Irish Whale and Dolphin Group (IWDG) as the main contractor with two sub-contractors - the Regional Veterinary Laboratories (RVL) of the

Department of Agriculture, Food and the Marine (DAFM) and the Galway-Mayo Institute of Technology (GMIT).

The first task of the contract required the recovery and standardised necropsy of a targeted sample of three species of stranded cetaceans, with associated case history reporting. The second task consisted of the provision of sampling kits to be used for the recovery of tissue samples collected from bycaught animals (birds, seals and cetaceans) by Data Collection Framework (DCF) observers out on commercial fishing vessels in Irish waters. The existing catch sampling at sea programme is led by the MI for the DAFM in order to enhance and verify the accuracy of catch data as well as support the wider assessment of commercial fish/shellfish and to assess fish catches under the DCF programme (Marine Institute, 2017).

The aim of these contracts was to conduct standardized laboratory necropsies of a targeted number of common and striped dolphins, as well as harbour porpoises. Stranded cetaceans were sourced and retrieved via the IWDG Cetacean Stranding Scheme, which was established in 1991 and co-ordinates a network of trained recorders throughout Ireland.

Methods

NECROPSIES

Three species were targeted for collection for necropsy; common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*) and harbour porpoise (*Phocoena phocoena*). The area of coverage for the contract extended from County Donegal to County Wexford, which was divided into two lots. Lot 1 included coastal areas of counties Donegal to County Clare inclusive, and Lot 2 consisted of coastal areas of counties Kerry to south County Wexford inclusive. A target of 24 animals was set for the first contract, followed by 16 during the contract extension, and 30for the subsequent contract issued by the MI and the National Parks and Wildlife Service (NPWS)to be split evenly between each lot where possible. This report covers the period from June 2017 to December 2018.

Locating carcasses and assessing suitability for necropsy

The IWDG has been co-ordinating an All-Ireland Cetacean Stranding Scheme since 1991 and has a network of recorders who visit and photograph stranded animals and record basic parameters, with over 90% of records accompanied by photographs. This network was used to locate and assess the suitability of stranded target species for necropsy.

Suitability of carcasses for post-mortem was assessed by examining available photographs and utilising descriptions of body condition as defined by the UK Cetacean Strandings Investigation Programme (CSIP) (2016). Carcasses were recovered within decomposition codes: **2a** (extremely fresh), **2b** (slight decomposition), **3** (moderate decomposition) and **4** (advanced decomposition) – see Figure 1. If no photos were available, the animal was deemed unsuitable for collection.

Decomposition code 2a. Extremely fresh



Photo 1. A female common dolphin which live stranded at Ballylongford, Co. Kerry with a calf (Photo. Joanne O'Brien)

Decomposition code 2b. Slight decomposition



Photo 2. A female striped dolphin was found dead on Derrymore Strand, Co. Kerry (Photo. Annette Enright)

Decomposition code 3. Moderate decomposition



Photo 3. A male common dolphin in moderate condition from Ballinacourty, Co. Galway (Photo. Stephanie Levesque)

Decomposition code 4. Advanced decomposition



Photo 4. A female common dolphin found in Castletownbere, Co. Cork (Photo IWDG/RVL)

Figure 1. Examples of the four categories (extremely fresh, slight decomposition, moderate decomposition, advanced decomposition) used to determine whether a stranded cetacean was suitable for necropsy.

Post-mortem protocol

Each animal was assigned an IWDG Stranding Code Reference Number in addition to a Regional Veterinary Laboratory Post-mortem Number for tracking purposes. Necropsies were undertaken in accordance with the CSIP's *Guidelines for the Post-mortem Examination and Tissue Sampling of Cetaceans during Stranding Events* (Appendix II) and templates of the CSIP data collection sheets (Appendix III) and cetacean post-mortem report (Appendix IV) were utilised within the current project. Samples were collected as per the agreed sampling protocol outlined by the NPWS and the MI (Appendix V).

The tender team attended a two-day necropsy workshop hosted by CSIP at the Institute of Zoology (IoZ) in London in June 2017, which provided the team with expert training and technical guidance. The IoZ team made a number of presentations describing their experiences in cetacean recovery and necropsy, offering valuable knowledge on their findings and advice such as which techniques and equipment to employ when recovering an animal and carrying out a post-mortem examination. The workshop continued in the post-mortem lab where CSIP scientists led the tender team in the necropsy of a common dolphin. Methods of recording, photographing, assessing organs/overall animal health, and cause of death were covered.

Afterward, the tender team had the opportunity to lead the examinations of several cetaceans in order to attempt to determine cause of death with guidance from the CSIP scientists. Suspected causes of death included ship strike, bycatch, and seal attack.

Necropsies for this contract were carried out by a trained veterinarian from the RVL in Cork, with the assistance of biologists from the IWDG and GMIT. Detailed case history reports for each animal documenting the animal's initial gross examination, as well as the results of bacteriology and histopathology assessments (if available) and any other significant findings, were prepared. The IoZ was contracted to review the individual Case History Reports to provide guidance on standardised reporting with external schemes and to validate cause of death. Biological samples were collected, labelled and stored for future studies. Samples for bacteriology and general histopathology assessments were processed by the RVL through their existing lab facilities at the Cork RVL and in Back Weston, Co. Kildare. All samples requiring long-term storage at -20°C, including those for virology, were transported in a portable refrigerator to the IWDG office in Kilrush, Co. Clare and stored at facilities on site. Formalin fixed tissues, such as reproductive organs and adrenal glands, were stored at the RVL in Cork. A database was created detailing all samples collected, their storage requirement and location.

Case history reporting
For each completed necropsy on an individual animal, a comprehensive digital Case History was produced in accordance with the post-mortem examination reporting protocol. The individual Case History file included a presentation of factual evidence as observed and documented during the post-mortem examination, as well as photographic evidence and charts of external lesions. The full detailed Case History Report was completed by the Project Lead Scientist carrying out the necropsy, and reviewed by a second project Lead Scientist. Following internal sign off by the Principal Investigator, 2017 and 2018 Case History files were submitted electronically to a panel of veterinary experts led by the IoZ for independent validation of the necropsy results. Case History files were then submitted to the Project Steering Group upon completion.

DATA COLLECTION FRAMEWORK

The contract also included the provision of bycatch sampling kits to the Irish Data Collection framework (DCF) programme, and the retrieval of samples collected at sea from DCF observers. Bycatch sampling kits were assembled and delivered to the DCF Observer Programme Co-ordinatorat the MI for distribution to the at-sea observers when required. Kits included a bycatch sampling protocol leaflet (see Appendix VI). Contents of the bycatch sampling kits are presented in Appendix VII. If a bycatch incident was to occur and animals sampled, observers were to notify the DCF Programme Co-ordinator who would then liaise with the Necropsy Project Co-ordinator. Samples were then to be retrieved and stored at the IWDG office.

Results

NECROPSIES

Cetacean Collection and Reporting

A total of 73 animals were collected between 21 June 2017 and 31 December 2018 comprising 53 common dolphins, ten striped dolphins and ten harbour porpoises (Figure2).

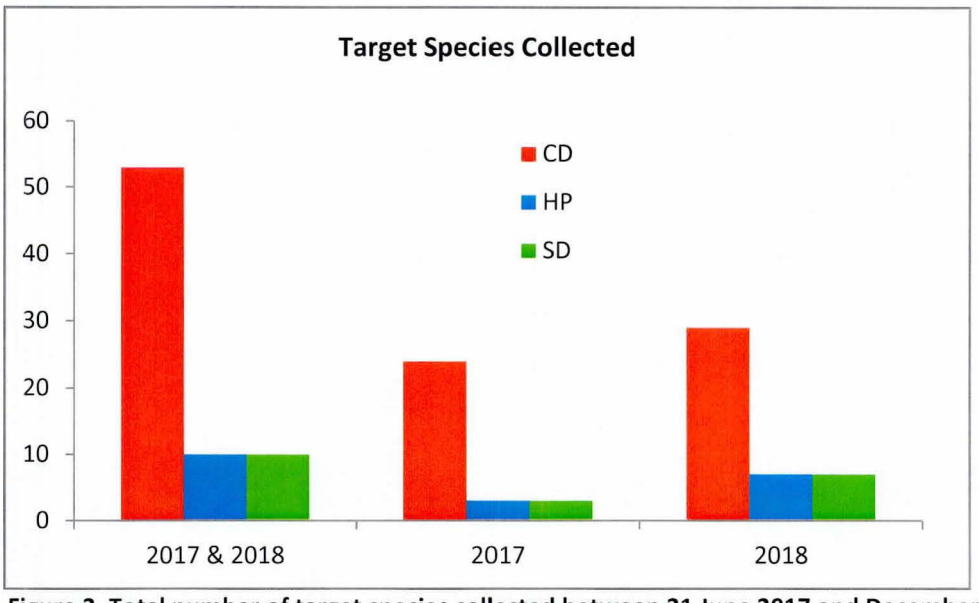


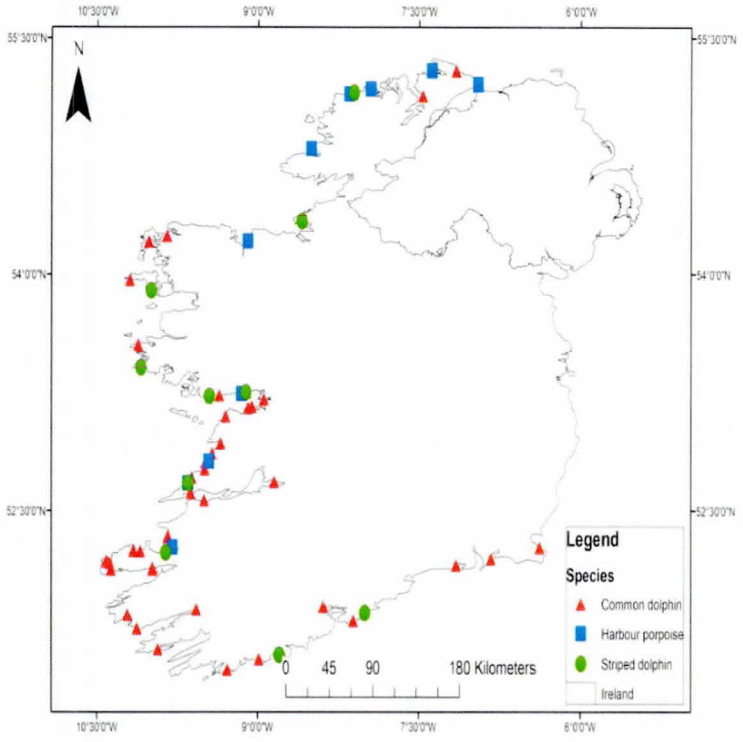
Figure 2. Total number of target species collected between 21 June 2017 and December 2018. Four animals were collected before the start of the first tender during the months of March, May and early June 2017 – they are included in this chart.

Overall, 56% (41/73) of animals were recovered from Lot 1 and 44% (32/73) from Lot 2. Lots 1 and 2 can be distinguished in Figure 3a. Out of the nine counties from which animals were collected, most (30%) were from county Kerry, followed by counties Clare (22%), Donegal and Galway (each with 14%), Cork (10%), Mayo (4%), Sligo and Wexford (3%) and Waterford (1%) (Figure 3a). Of the animals necropsied during this contract, the majority were common dolphins (72.6%, n=53) followed by harbour porpoises (13.6%, n=10) and striped dolphins (13.6%, n=10).

In order to explore the proportion of strandings reported to the IWDG and recovered for post-mortem we accessed all strandings data available from the IWDG. The three target species were recorded from 16 counties throughout the whole of Ireland during 2017 and 2018 (Figure 3b). Again, most strandings (23%), were reported from Co. Kerry.

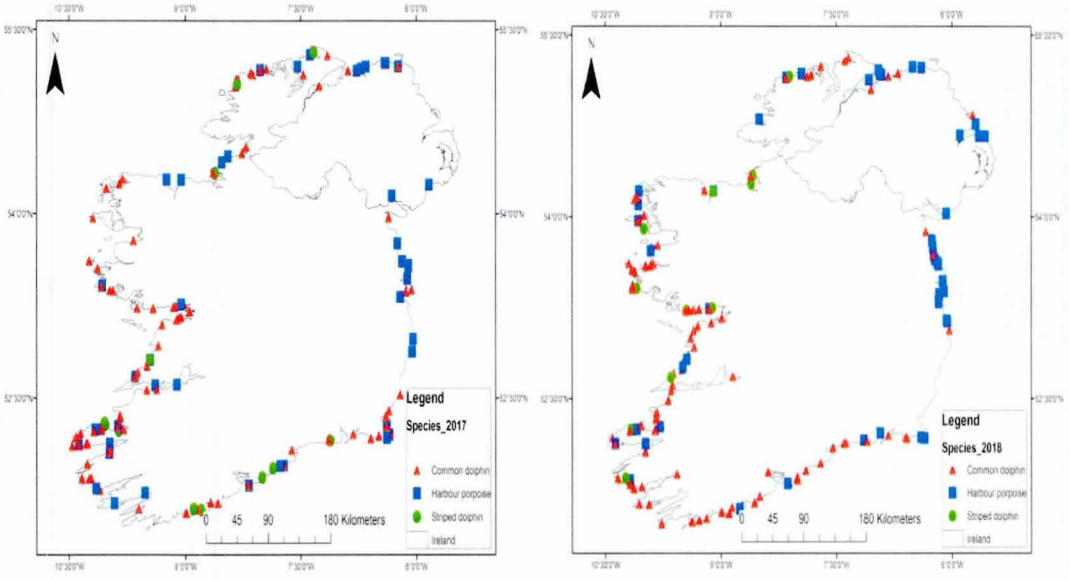
Of those individuals collected for post-mortem whose sex was known, 46% (33/72) were female and 54% (39/72) were male. The sex of one common dolphin was unknown due to extensive scavenger damage.

Of the animals recovered 79% (58/73) were found dead, while 21% (15/73) were reported as live strandings. Four mass stranding events resulted in the collected of five animals, all involving common dolphins. A mass stranding is defined as *"two or more cetaceans (excluding cow/calf pairs) stranding at the same time and place"* (NOAA Fisheries).



Collected for PM	
Counties	Proportion of Strandings
Clare	0.22
Cork	0.10
Donegal	0.14
Galway	0.14
Kerry	0.30
Mayo	0.04
Sligo	0.03
Waterford	0.01
Wexford	0.03

Figure 3. (a) Map of all animals collected for post-mortem examination from 21 June 2017 to 31 December 2018 accompanied by a table representing the percentage of strandings reported per county.



Strandings All of Ireland	
Counties	Proportion of Strandings
Antrim	0.03
Clare	0.10
Cork	0.10
Derry	0.03
Donegal	0.09
Down	0.02
Dublin	0.05
Galway	0.12
Kerry	0.23
Louth	0.02
Mayo	0.08
Meath	0.01
Sligo	0.03
Waterford	0.03
Wexford	0.04
Wicklow	0.02

Figure 3. (b)Location of stranded animals within the whole of Ireland from 1 January to 31 December 2017 on the left, map representing location of stranded animals from 1 January to 31 December 2018 on the right, accompanied by a table representing percentage of strandings per county.

Of the single live strandings, nine were common dolphins, of which one was a mother and calf pair, and one was a striped dolphin. Details of animals recovered for post-mortem examination are presented in Table 1.

Table 1. Details of animals recovered for post-mortem examination.

Lot	IWDG code	Species	Location	Stranding type when found
1	IWDG 2017_067	CD	Flaggy Shore, Co. Clare	Single, Dead
1	IWDG 2017_112	CD	Silver Strand, Co. Galway	Single, Dead
1	IWDG 2017_121	CD	Doughmore, Co. Clare	Single, Live
1	IWDG 2017_128	HP	Quilty, Co. Clare	Single, Dead
2	IWDG 2017_145	SD	Donaghmore, Eastern Beach, Co. Cork	Single, Dead
2	IWDG 2017_146	SD	Derrymore Strand, Co. Kerry	Single, Dead
2	IWDG 2017_156	CD	Cloghane, Cappah Beach, Co. Kerry	Single, Live
1	IWDG 2017_158	CD	Bellmullet, Co. Mayo	Mass, Live (2 adults)
1	IWDG 2017_161	CD	Ballinacourty, Co. Galway	Single, Dead
2	IWDG 2017_162	CD	Cloghane, Cappah Beach, Co. Kerry	Single, Dead
2	IWDG 2017_163	CD	Ballylongford, Co. Kerry	Single, Live (2: mother/calf)
2	IWDG 2017_163a	CD	Ballylongford, Co. Kerry	Single, Live (2: mother/calf)
2	IWDG 2017_168	CD	Derrymore Strand, Co. Kerry	Single, Dead
1	IWDG 2017_182	CD	Culdaff Beach, Inishowen, Co. Donegal	Single, Dead
2	IWDG 2017_189	CD	Rosslare, Co. Wexford	Single, Live
1	IWDG 2017_191	HP	Kilkee, Co. Clare	Single, Dead
1	IWDG 2017_194	CD	Buncrana Beach, Inishowen, Co. Donegal	Single, Dead
2	IWDG 2017_198	CD	Ventry Beach, Co. Kerry	Single,Live
1	IWDG 2017_205	HP	Pollan Beach, Ballyliffin, Co. Donegal	Single, Dead
1	IWDG 2017_207	CD	Salthill, Co. Galway	Single, Dead
1	IWDG 2017_208	CD	Keem, Achill Island, Co. Mayo	Mass, Live (4 adults, 1 calf)
2	IWDG 2017_209	CD	Smerwick Harbour, Co. Kerry	Single, Dead
1	IWDG 2017_210	CD	Aughinish, Co. Clare	Mass, Live (2 adults)
2	IWDG 2017_215	CD	Reenroe, Ballinaskelligs, Co. Kerry	Single, Live
2	IWDG 2017_216	CD	Banna Beach, Co. Kerry	Single, Dead
2	IWDG 2017_217	CD	Smerwick Harbour, Co. Kerry	Single, Dead
1	IWDG 2017_224	CD	Kilkee, Co. Clare	Single, Dead
1	IWDG 2017_225	CD	Doughmore, Co. Clare	Single, Dead
1	IWDG 2017_226	CD	Killahoey, Co. Donegal	Single, Dead
2	IWDG 2017_230	SD	Garryvoe, Ballycotton Bay, Co. Cork	Single, Dead
2	IWDG 2017_233	CD	Smerwick Harbour, Co. Kerry	Single, Dead
2	IWDG 2018_005	CD	Tramore, Co. Waterford	Single, Dead
1	IWDG 2018_006	CD	Fanore, Co. Clare	Single, Dead
2	IWDG 2018_014	HP	Ballygarron, Tralee, Co. Kerry	Single, Dead
1	IWDG 2018_023	CD	Falcarragh, Co. Donegal	Single, Live
1	IWDG 2018_024	CD	Inverin, Co. Galway	Single, Dead
2	IWDG 2018_027	CD	Smerwick Harbour, Co. Kerry	Mass, Live (2)
2	IWDG 2018_027a	CD	Smerwick Harbour, Co. Kerry	Mass, Live (2)
1	IWDG 2018_029	CD	Cleggan Bay, Co. Galway	Single, Dead
2	IWDG 2018_030	CD	Inch, Dingle Bay, Co. Kerry	Single, Dead
2	IWDG 2018_039	CD	Cloghane, Cappah Beach, Co. Kerry	Single, Dead
1	IWDG 2018_042	CD	Saints Island, Shannon, Co. Clare	Single, Dead

1	IWDG 2018_043	CD	Farrihy Bay, Co. Clare	Single, Dead
2	IWDG 2018_053	CD	Derrynane Bay, Co. Kerry	Single, Dead
2	IWDG 2018_066	CD	Kenmare, Co. Kerry	Single, Dead
2	IWDG 2018_068	CD	Castletownbere, Co. Cork	Single, Dead
1	IWDG 2018_097	CD	Doughmore, Co. Clare	Single, Dead
1	IWDG 2018_108	HP	Rosbeg, Co. Donegal	Single, Dead
2	IWDG 2018_111	CD	Brandon Bay, Co. Kerry	Single, Dead
2	IWDG 2018_112	CD	TragumnaBay, Co. Cork	Single, Dead
1	IWDG 2018_116	HP	Greencastle, Co. Donegal	Single, Dead
1	IWDG 2018_122	HP	Freeport, Barna, Co. Galway	Single, Dead
1	IWDG 2018_131	SD	Rusheen Bay, Barna, Co. Galway	Single, Live
1	IWDG 2018_150	SD	Lisadell, Co. Sligo	Single, Dead
1	IWDG 2018_154	CD	Barna, Co. Galway	Single, Dead
1	IWDG 2018_161	SD	Bunowen, Co. Galway	Single, Dead
1	IWDG 2018_168	CD	Spanish Point, Co. Clare	Single, Dead
1	IWDG 2018_181	CD	Lahinch, Co. Clare	Single, Dead
1	IWDG 2018_194	HP	Enniscrone, Co. Sligo	Single, Dead
2	IWDG 2018_195	CD	Banna Strand, Co. Kerry	Single, Dead
2	IWDG 2018_199	CD	Cork City, Co. Cork	Single, Live
1	IWDG 2018_206	CD	Querrin, Co. Clare	Single, Dead
1	IWDG 2018_207	CD	Seafield, Co. Clare	Single, Dead
1	IWDG 2018_216	HP	Magheroarty Beach, Co. Donegal	Single, Dead
2	IWDG 2018_217	CD	Inch Beach, Co. Kerry	Single, Dead
1	IWDG 2018_221	SD	Falcaragh Beach, Co. Donegal	Single, Dead
1	IWDG 2018_229	SD	An TraMhor, Co. Galway	Single, Dead
2	IWDG 2018_232	CD	Fethard, Co. Wexford	Single, Dead
1	IWDG 2018_237	HP	Killahoey, Co. Donegal	Single, Dead
1	IWDG 2018_243	SD	Kilkee, Co. Clare	Single, Dead
2	IWDG 2018_244	CD	Ballycroneen Beach, Co. Cork	Single, Dead
2	IWDG 2018_247	CD	Owenahincha Beach, Co. Cork	Single, Dead
1	IWDG 2018_231	SD	Achill Island, Co. Mayo	Single, Dead

The combined sampling period covered June 2017 to December 2018. The month with the highest number of strandings in a single year was January 2018 (n=9) (Figure 4) which is consistent with the peak stranding period for common dolphins.

In order to determine whether stranding patterns during the tender periods were consistent with previous years, the IWDG Stranding Database was interrogated using data collected over the period from 2016 to 2018 for the relevant species (see Figures 5 and 6). Stranding numbers for common dolphins appear to be on the rise year on year (Figure 5a).

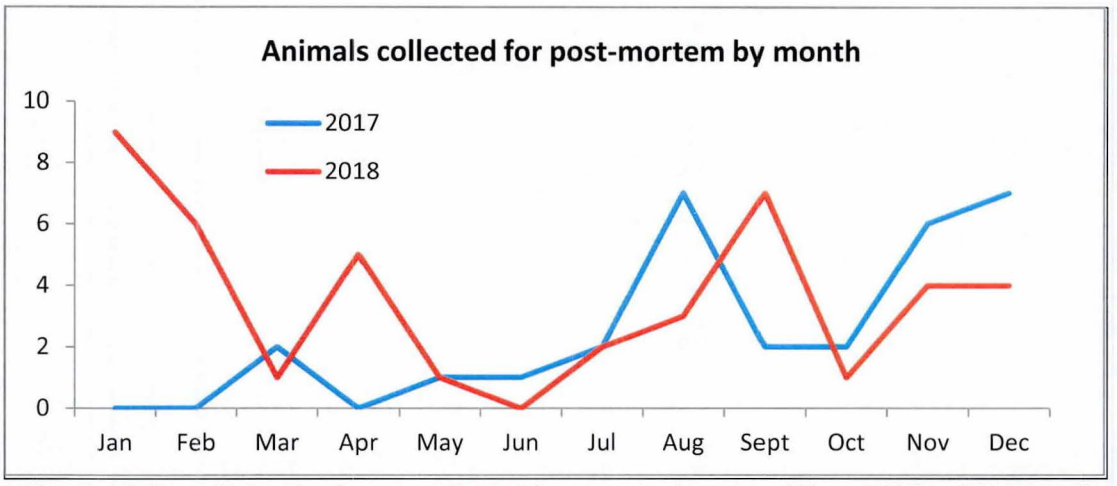


Figure 4. Months during which animals were collected for necropsy between 21June 2017 and 31 December 2018. Four animals were collected prior to June 2017 and were kept in frozen storage to be necropsied upon the start of the contract in June.

The common dolphin was the most frequently reported species stranded on Irish coastlines during the sampling period in all three years, while striped dolphins were the least frequently reported of the three target species (Figure 5a). We also compared the suitability of stranded cetaceans for post-mortem over the three years by examining body condition from stranding record photos using the CSIP body condition categories. Using records from the whole of Ireland (Figure 5b), and those from Lots 1 and 2 only (Figure 6a), there was an overall increase in the number of common dolphins suitable for necropsy over the period 2016 to 2018, but a drop in numbers of harbour porpoises in 2017 compared to 2016 and 2018.Within the tender area, when compared to 2016 and 2018, there was a peak in common dolphin strandings suitable for post-mortem and a consistent decrease in harbour porpoise numbers during 2017.

We also compared the number of each species reported during the tender periods to the number of animals suitable for post-mortem from the whole of Ireland and the tender area, and the number of each species collected for post-mortem (Figure 6b).

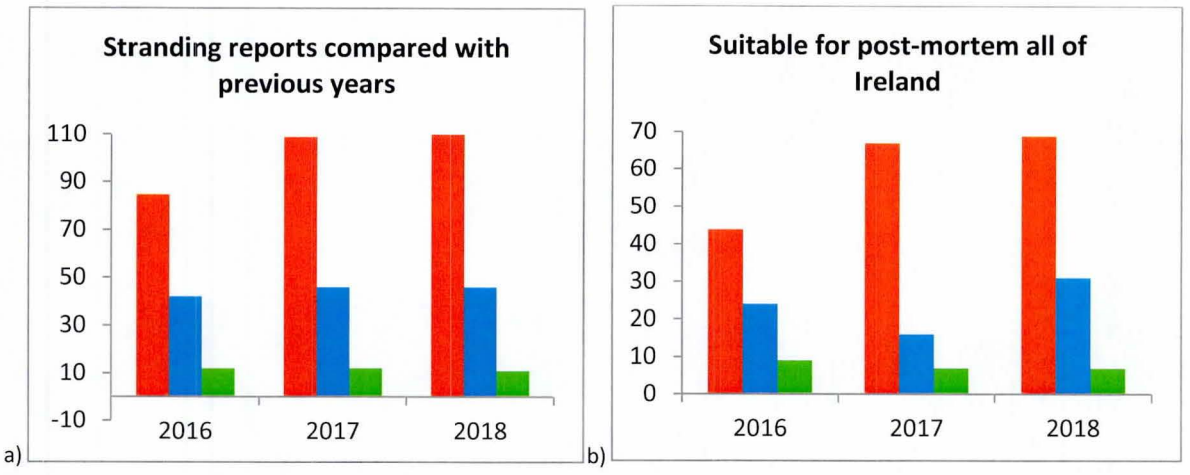


Figure 5. (a) Strandings reported for the three target species compared between 1 January and 31December 2016, 2017 and 2018. (b) Total suitable for post-mortem examination in whole of Ireland between the dates of 1 January and 31December 2016, 2017 and 2018. Common dolphin = red, harbour porpoise = blue, striped dolphin = green.

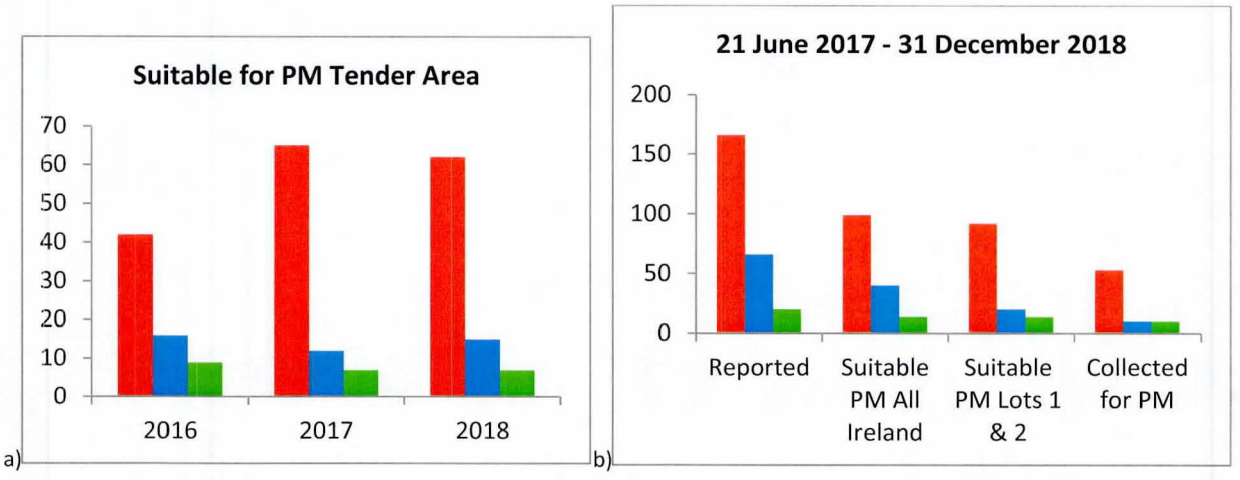


Figure 6. (a) Total suitable for post-mortem examination from Tender Lots 1 and 2 between January and December 2016, 2017 and 2018.(b) Comparisons for animals reported between June and December 2018. Common dolphin = red, harbour porpoise = blue, striped dolphin = green.

Animals suitable for post-mortem but which were not collected was mainly due to animals being reported at a later date, being washed away, or due to severe deterioration of carcasses over a short period of time due to scavenging and extreme weather conditions experienced during the summer of 2018. All animals necropsied were within decomposition codes 1 to 4 and thus were suitable for inclusion within the contract. On average, animals were collected within a day of being reported and necropsied within five days from delivery to RVL Cork.

Post-Mortem Results

Full necropsies were undertaken at RVL Cork. Although outside the requirements of the tender, routine bacteriological analysis of samples was undertaken at RVL Cork. If bacteria of significance were observed, the isolate was referred to the National Reference Laboratory in Back Weston for confirmation. General histopathological assessment of tissues was also undertaken by one of the lead scientists (JO'D).

A probable cause of death (COD) was described wherever possible based on collective findings from post-mortem and other diagnostic investigations undertaken. Criteria used to establish selected COD were based on those defined by the CSIP (2016) (see Appendix VIII). As per the first contract (Levesque *et al.* 2017), in the case of live strandings this COD was attributed to those animals known or suspected (from post-mortem examination) to have live-stranded in '*apparent good health and nutritional status and excluded severely diseased or emaciated animals that stranded alive*'. Where applicable, COD of starvation is attributed to animals that were '*severely emaciated and, following post-mortem examination, ascertained to have no other significant disease processes that could explain the poor nutritional status'*. Whereas bycatch was ascribed as a COD '*using established pathological criteria for by-catch diagnosis'* (Kuiken *et al.* 1994; Kuiken 1996).

Case History Reporting

Case History reports for all 73 animals from the first contract have been reviewed by the IoZ to provide independent oversight on each case, and submitted to the Project Steering Group. Results from the two contracts can be seen below in Table 2.

Table 2. Summary of Cause of Death of necropsied cetaceans.

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_067	CD	Male	177	Juvenile	Infectious disease	*Brucella ceti*infection Heavy gastric parasitism	Chronic granulomatous bronchointerstitial pneumonia with intralesional nematode profiles	Yes	Infectious disease
IWDG 2017_112	CD	Male	147	Juvenile	Not established	Moderate-to-poor nutritional state	Mild gastric parasitism Light pulmonary parasitism Multifocal lesions in blubber	**Yes**	Starvation/hypothermia (pending histology)
IWDG 2017_121	CD	Male	162.5	Juvenile	Infectious disease	Live stranding &Euthanasia Non-suppurative meningitis	Pulmonary parasitism Gastric parasitism 'Pox-like' epidermal lesions	Yes	Infectious disease
IWDG 2017_128	HP	Female	102.5	Juvenile	Not established	NA	Acute pulmonary oedema chronic parasitic pneumonia	Yes	Not established
IWDG 2017_145	SD	Male	198	sub-adult	Starvation	Suspected live stranding	NA	Yes	Starvation/hypothermia (pending histology)
IWDG 2017_146	SD	Female	184	sub-adult	Not established	Lung abnormality	NA	Yes Possible pneumonia or bronchopneumonia (pending histopathology)	Infectious disease (pending histopathology)

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_156	CD	Male	210	Adult	Starvation	Live stranding	Very light pulmonary and gastric parasitism. Three small foci of suppurative pneumonia. Focal pyonecrotic hepatitis	Yes	Starvation/hypothermia
IWDG 2017_158	CD	Male	230	Adult	Live stranding	Moderate-to-poor nutritional condition	Gastric and pulmonary parasitism.	Yes Starvation/hypothermia dolphin live stranded and died *in extremis* (as a terminal event	Starvation/hypothermia
IWDG 2017_161	CD	Male	211	sub-adult/adult	Other?	Suspected intussussception in intestine Suspect lesions that may be attributed to bycatch Multifocal gastric ulceration &haemorrhage in the cardiac stomach	NA	Yes	Not established
IWDG 2017_162	CD	Female	171.5	Juvenile	Infectious disease	*Brucella ceti* meningitis (pending full confirmation on)	Gastric parasitism & ulceration	Yes	Infectious disease

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_163	CD	Female	200	Adult	Live stranding or infectious disease	Live stranding Poor body condition associated with gastric parasitism and ulceration	Mild pulmonary parasitism	Yes Ulcerative and verminous gastritis, moderate-heavy	Infectious disease
IWDG 2017_163a	CD	Female	104	Calf	Live stranding	Unweaned calf	NA	Yes	Live stranding (with lactating mother)
IWDG 2017_168	CD	Female	205	Adult	Infectious disease	Very poor body condition associated with a. heavy gastric parasitism with gastric ulceration; b. moderate pulmonary parasitism c. very thin blubber layer, increasing susceptibility of hypothermia	*Phyllobothrium* sp. parasitism of the blubber	Yes Very severe gastric parasitism with associated ulceration	Infectious disease
IWDG 2017_182	CD	Female	202	Sub-adult/Adult	Not established	Not determined	Pulmonary parasitism/pneumonia. Enlarged adrenal glands and spleen (with capsular haemorrhage) dental loss	Yes	Not established

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary CODcategories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_189	CD	Female	117.5	Calf	Starvation	Live stranding Calf	NA	Yes	Starvation/hypothermia (neonate)
IWDG 2017_191	HP	Male	100	Juvenile	Infectious disease	Erysipelas	NA	Yes Generalised bacterial infection (*Erysipelothrixrhusiopathiae*	Infectious disease
IWDG 2017_194	CD	Male	122	Calf	Starvation?	Moderate to poor body condition Abscess on tail stock	NA	Yes Abscess	Infectious disease

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_198	CD	Male	226	Adult	NA	Live stranding Very poor body condition Severe pediculosis (ulcerative dermatitis) Arthritis/DJD of the atlantooccipital joint Heavy gastric parasitism and ulceration	Light pulmonary parasitism	Yes Ulcerative dermatitis and heavy gastric parasitism with associated ulceration	Infectious disease
IWDG 2017_205	HP	Male	149	Adult	Other	Suspected testicular infraction Suspect "atypical Salmonella" isolate Moderate-to-poor nutritional condition	Pulmonary and gastric parasitism Missing teeth	Yes Testicular enlargement	Gas embolism and infectious disease
IWDG 2017_207	CD	Male	215	sub-adult/adult	Suspected bycatch	NA	Moderate-to-poor nutritional condition 'Pox-like' epidermal lesions	Yes	Bycatch
IWDG 2017_208	CD	Female	182	sub-adult	Live stranding	Mass live stranding event	NA	Yes	Live stranding

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_209	CD	Male	215	adult	NA	Hepatophy	Gastric & pulmonary parasitism Wear/loss of teeth	Yes Subacute-chronic hepatic gas embolism/ chronic form of cetacean decompression sickness	Gas embolism
IWDG 2017_210	CD	UNK	212	sub-adult/adult	Live stranding	Live stranding	Gastric parasitism	Yes	Live stranding
IWDG 2017_215	CD	Male	175	juvenile	NA	Live stranding Pulmonary hypostatic congestion and oedema	Gastrooesophogeal parasitism - moderate. Pulmonary parasitism – mild	Yes Gastric impaction	Other

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_216	CD	M	161	Juvenile	Infectious disease	Brucella ceti isolated from multiple organs Emaciation Verminous bronchitis and pneumonia Verminous gastritis and ulceration		Infectious disease	Infectious disease
IWDG 2017_217	CD	M	228	Adult	Infectious Disease	Extensive verminous gastritis with gastric ulceration Emaciation	*Streptococcus equi* subsp. *equi*isolated from organs, significant unknown Verminous bronchitis and pneumonia Missing and/or broken dentition	Infectious disease	Infectious disease
IWDG 2017_224	CD	F	152	Juvenile	Other	Gastric impaction in cardiac stomach Emaciation Verminous gastritis	Verminous pneumonia and bronchitis (mild to moderate)	Other (Gastric Impaction)	Other (Gastric impaction)
IWDG 2017_225	CD	F	147	Juvenile	Starvation	Emaciation/hypothermia Verminous gastritis with ulceration		Starvation/hypothermia (pending histology)	Starvation/hypothermia (pending histology)
IWDG 2017_230	SD	F	163	Juvenile	Starvation	Suspected live stranded Emaciation	Mild verminous gastritis Mild chronic verminous pneumonia	Not established (Suspected live stranding)	Not established (Suspected live stranding)

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_233	CD	F	205	Adult	Infectious disease	Cellullitis lesion – right mandible Heavy Anisakis sp. burden (verminous gastritis)	Macerated foetal skeletal remnant in the uterus. Minor haemorrhaging around head and thorax	Infectious disease (suspected live stranded)	Infectious disease
IWDG 2018_005	CD	F	203	Adult	Starvation/ hypothermia	Emaciation	Vaginal calculus Verminous gastritis and ulceration Verminous pneumonia and bronchitis	Starvation/ hypothermia	Starvation/ hypothermia
IWDG 2018_006	CD	M	171	Juvenile	Infectious disease (Suspected bycatch)	Emaciation Verminous gastritis Verminous bronchitis and pneumonia Extensive haemorrhaging around head and thorax Clean, straight cuts to tail flukes	Rostrum fractured – query caused by post mortem storm damage to carcase or bycatch	Infectious disease (Verminous gastritis)	Infectious disease (Verminous gastritis)

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2017_226	CD	M	222	Adult	Infectious disease	Severe arthrodesis of the atlanto-occipital and atlantoaxial joints (associated with suspected Brucella sp. infection of these joints, kidney and liver). Starvation Gastric ulceration and verminous gastritis	Verminous bronchitis	Infectious disease	Infectious disease
IWDG 2018_014	HP	M	162	Adult	Infectious disease	Verminous pneumonia	Parasitic gastritis and gastric ulceration.Dental loss – only one tooth present Parasitic hepatitis – trematode burden. Well circumscribed tumour in the liver	Not established (missing photos for confirmation)	Infectious disease
IWDG 2018_023	CD	M	201	Adult	Live stranding	Live stranded	Proctitis and constipation Very minor burden of parasites in the lungs, cardiac stomach, blubber and abdominal musculature	Live stranding	Live stranding
IWDG 2018_024	CD	F	194.5	Adult	Suspected bycatch	Sudden death, possible by-catch or oesophageal impaction following feeding	Severe ulcerative verminous gastritis Mild verminous pneumonia Heavy Monorygma sp. Burden	Not Established	Not Established

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_027	CD	F	199	Adult	Infectious disease	Hepatitis with abscessation and emphysema – due to, tentatively, *Brucella sp.* infection. Confirmation awaited from reference laboratory Live stranded Emaciated	Chronic-active pericarditis associated with *Enterococcus avium* infection Moderate verminous gastritis and ulceration	Possible infectious disease pending further assessment	Infectious disease (suspect Brucella)
IWDG 2018_027 a	CD	F	224	Adult	Live stranding	Live stranded	Verminous gastritis with ulceration Dental loss	Live stranding	Live stranding
IWDG 2018_029	CD	M	230	Adult	Infectious disease	Emaciation/hypothermia Severe verminous gastritis	None	Infectious disease (Verminous ulcerative gastritis)	Infectious disease (Verminous ulcerative gastritis)
IWDG 2018_030	CD	F	166.5	Juvenile	Infectious disease	Emaciation Severe verminous gastritis	Verminous bronchitis and pneumonia	Infectious disease (Verminous gastritis)	Infectious disease (Verminous gastritis)
IWDG 2018_039	CD	M	205	Adult	Possible live stranding	Possible live stranding Hypostatic congestion of lungs	Verminous gastritis Multifocal pulmonary granulomas	Not available	Not established (Suspected live stranding)

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_042	CD	M	205	Adult	Not Established	None	None	Not available	Not established
IWDG 2018_043	CD	M	211	Adult	Not Established	Not Established	Mild verminous gastritis of cardiac stomach with mucosal ulceration	Not Established	Not Established
IWDG 2018_053	CD	F	169	Juvenile	Starvation/ hypothermia	Starvation/ hypothermia	Gastric ulcer (cardiac stomach) Mild verminous bronchitis	Starvation/ hypothermia	Starvation/ hypothermia
IWDG 2018_066	CD	M	207	Sub-adult/Adult	Infectious disease (possible live stranding)	Severe verminous ulcerative gastritis Hepatomegaly – type of enlargement to be determined by histopathology. Possibly live stranded - marked pulmonary congestion and oedema of the right lung	None	Infectious disease (Verminous ulcerative gastritis)	Infectious disease (Verminous ulcerative gastritis)
IWDG 2018_068	CD	F	163	Juvenile	Infectious disease	Verminous ulcerative gastritis Verminous bronchitis and pneumonia (moderately severe)	Emaciation/hypothermia	Not established (missing photos for confirmation)	Infectious disease

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_097	CD	M	211	Adult	Not Established	None	None	Not available	Not Established
IWDG 2018_108	HP	M	163	Adult	Not Established Suspected infectious disease	Not established - Verminous bronchitis and pneumonia may have been a contributing factor	Verminous gastritis	Not Established	Not established – Suspected infectious disease
IWDG 2018_111	CD	M	175	Sub-adult	Infectious disease	Severe, diffuse verminous bronchitis and pneumonia	Verminous gastritis	Infectious disease Possible live stranding	Infectious disease
IWDG 2018_112	CD	F	156	Sub-adult	Other - Gastric impaction	Poor body condition associated with gastric impaction.	Verminous bronchitis and pneumonitis Verminous gastritis.	Other – Gastric impaction	Other – Gastric impaction
IWDG 2018_116	HP	F	179	Adult	Infectious disease	Ill thrift associated with severe trematodal gastritis Verminous pneumonia with abscessation	Mild chronic liver fluke infection	Infectious disease	Infectious disease
IWDG 2018_122	HP	F	107	Juvenile	Infectious disease	Verminous gastritis –severe. Verminous bronchitis – heavy burden in trachea. Poor body condition	None	Infectious disease	Infectious disease

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_131	SD	F	185	Juvenile	Live stranding	Live stranding Poor body condition Emphysema of perirenal connective tissue/renal capsule	Verminous ulcerative gastritis Trematodal gastritis	Live stranding	Live stranding
IWDG 2018_150	SD	F	215	Adult	Not established	None	Verminous gastritis. Pregnancy Fair body condition	Not established Possible dystocia	Not established
IWDG 2018_154	CD	F	205	Adult	Bycatch	Impression marks around head, haematoma over thorax Good body condition with evidence of recent feeding.	Gastric ulceration with scarring	Bycatch	Bycatch
IWDG 2018_161	SD	M	160	Juvenile	Not established Possible bycatch	None	Verminous gastritis with ulceration	Possible bycatch	Possible bycatch
IWDG 2018_168	CD	F	190	Adult	Bycatch	Fluke amputation	None	Bycatch	Bycatch

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_181	CD	F	159	Juvenile	Infectious disease	Septic pleurisy and pneumonia Verminous bronchopenumonitis Poor body condition	Verminous gastritis Multifocal ulcerative dermatitis	Infectious disease	Infectious disease
IWDG 2018_194	HP	M	131	Adult	Infectious disease	Very poor body condition Trematodal gastritis focally extensive Verminous bronchitis and pneumonia.	None	Infectious disease	Infectious disease
IWDG 2018_195	CD	M	214	Adult	Gas embolism	Emphysematous change in the liver and other tissues. Very poor body condition (parasitism will have contributed to this, particularly verminous gastritis)	Verminous gastritis. Verminous pneumonia.	Possible gas embolism	Gas embolism

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_199	CD	F	213	Adult	Infectious disease	Extremely thin Severe verminous gastritis Chronic verminous pneumonia Palatine ulceration	Cystic anomaly of left kidney	Infectious disease	Infectious disease
IWDG 2018_206	CD	F	204	Adult	Physical trauma (boat/ship strike) and Possible bycatch	Severe trauma to skull resulting in comminuted fractures of calvarium and occipital condyles & intracranial haematoma formation Amputation of tip of tail fluke appears to have been done by a sharp tool	Gastric ulceration. Verminous bronchopneumonmonitis	Physical trauma (unknown origin)	Physical trauma (boat/ship strike) and Possible bycatch
IWDG 2018_207	CD	M	227	Adult	Infectious disease	Peritonitis and perihepatitis secondary to perforated ulcer in fundic stomach Ulcer associated with attached parasites Very poor body condition	Verminous gastritis of cardiac stomach & multifocal ulceration. Mild verminous bronchitis/pneumonia Moderate degenerative joint disease of atlantooccipital joint	Infectious disease Other (degenerative joint disease)	Infectious disease

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_216	HP	F	152.5	Adult	Infectious disease	Bronchopneumonia (with consolidated lung tissue) Very poor nutritional state	Verminous bronchopneumonitis Bile duct fibrosis	Infectious disease	Infectious disease
IWDG 2018_217	CD	M	214	Adult	Not established	Trauma – fractured rostrum; Possibly ante-mortem	Mild verminous gastritis	Not established	Not established
IWDG 2018_221	SD	M	193	Juvenile	Not established	Very poor nutritional condition No evidence of recent feeding	Mild verminous bronchopneumonitis Light *Monorygma sp.* and *Phyllobothrium sp.* burdens.	Not established	Not established
IWDG 2018_229	SD	M	161	Juvenile	Physical Trauma (possible bycatch)	Suspect beak fracture was antemortem	Severe osteoarthritis of atlantooccipital joint with fusion and restricted motion of joint Moderate gastric parasitism Mild verminous bronchopneumonitis.	Physical trauma (possible boat strike)	Physical trauma (possible bycatch)

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_231	SD	M	185	Juvenile	Bycatch	Suspect beak fracture was antemortem	Thin nutritional condition Mild pulmonary nematode parasite burden Mild gastric nematode and trematode parasite burdens	Bycatch	Bycatch
IWDG 2018_232	CD	M	215	Adult	Bycatch	Found entangled in net	Catarrhal bronchitis, verminous bronchitis/pneumonia Resolved peritonitis	Bycatch	Bycatch
IWDG 2018_237	HP	M	119	Juvenile	Bycatch	Impression marks and lacerations on head and tail fluke	None	Bycatch	Bycatch
IWDG 2018_243	SD	F	177	Sub-adult	Bycatch	Trauma - spinal and skull fractures	Very mild verminous pneumonia and gastritis	Bycatch	Bycatch
IWDG 2018_244	CD	F	193	Adult	Infectious disease	Severe verminous gastritis Chronic verminous pneumonia Poor body condition	*Monorygma*spp. and *Phyllobothrium*spp infections. Pregnancy	Infectious disease	Infectious disease

IWDG code	Species	Sex	Length (cm)	Tentative age/maturity category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2018_247	CD	M	218	Adult	Not established	None	Verminous bronchitis & pneumonia (moderately severe)	Not established Possible infectious disease	Not established

Common dolphin

Of the 53 common dolphins collected for necropsy, the sex of one animal could not be determined due to extensive scavenger damage. For the remaining 52 animals, 46% (24/52) were female and 54% (28/52) male. Lengths for females and males ranged from 103to 224 cm and 122 to 230 cm, respectively.

Common dolphins were collected from four separate mass strandings events. Three of these events involved two animals. IWDG 2017-158 and IWDG 2017-210 were each collected from two separate stranding events, while IWDG 2018-027 and IWDG 2018-027 who live-stranded together and were both collected for post-mortem. The next event involved four adults, of which one was collected for post-mortem (IWDG 2017-208).

One individual swam into the River Lee in Cork City and was found floating in the river the following day (IWDG 2018-199). There were nine other cases of single live strandings collected for post-mortem.

The most common cause of death for common dolphins was found to be **infectious disease** representing 42% of the sample. This was followed by **not established** (15%), **starvation/hypothermia** (11%), and **bycatch** (7%). An adult male in county Wexford was found entangled in fishing gear (IWDG 2018-232) (Photo. 1). There were two cases of **gas embolism**, and three cases of **gastric impaction**. All remaining cause of death categories can be found in Table 3 below.



Photo 1. Adult male common dolphin entangled in fishing gear in Co. Wexford. Photo. Dierdre Slevin.

Striped dolphin

Five male and five female striped dolphins were collected for necropsy. One female live-stranded in Rusheen Bay, Barna, Co. Galway (IWDG 2018-131). Another female was pregnant and found dead in Lisadell, Co. Sligo (IWDG 2018-150). Male and female lengths ranged from 160 to 198 cm and 163 to 215 cm, respectively.

The two most common cause of death categories for striped dolphins were **bycatch** and **not established**, both representing 20% of the sample. All remaining cause of death categories can be found in Table 3 below.

Harbour porpoise

Six male and four female harbour porpoises were collected for necropsy. Male and female lengths ranged from 100 to 190 cm and 102.5 to 169 cm, respectively. The most common cause of death among harbour porpoises was infectious disease, representing 60% of the sample. There was one case of confirmed **bycatch**, and one case of **gas embolism**. All remaining cause of death categories can be found in Table 3 below.

Table 3. Cause of death categories for all necropsied animals.

COD Categories	Species			Total
	CD	SD	HP	
Bycatch	4	2	1	**7**
Physical Trauma (boat/ship strike) and Possible bycatch	1	0	0	**1**
Physical Trauma (possible bycatch)	0	1	0	**1**
Possible bycatch	0	1	0	**1**
Gas embolism	2	0	0	**2**
Infectious disease	22	1	6	**29**
Live stranding	4	1	0	**5**
Live stranding (with lactating mother)	1	0	0	**1**
Starvation/hypothermia	6	1	0	**7**
Starvation/hypothermia (neonate)	1	0	0	**1**
Gas embolism & Infectious disease	0	0	1	**1**
Other (Gastric impaction)	3	0	0	**3**
Not established	8	2	1	**11**
Not established - suspected live stranding	1	1	0	**2**
Not established - suspected infectious disease	0	0	1	**1**
Total	**53**	**10**	**10**	**73**

DATA COLLECTION FRAMEWORK

Between 24 July and 14 December 2017 two animals were sampled at sea by DCF observers; both adult male grey seals (total body lengths of 140 cm and 110 cm) incidentally captured in tangle nets (Table 4).

Table 4. Samples recovered from DCF observers

Date	Species	Sex	Total Body Length/ Standard Body Length	Samples	Type of net	Lat/Long
24/07/2017	Grey seal	Male	140cm/130cm	2 biopsies (skin and blubber)	Tangle net	52.1615, -10.4562
14/12/2017	Grey seal	Male	110cm/105cm	2 biopsies (skin and blubber)	Tangle net	52.2385, -10.5803

Discussion

Seventy-three stranded dolphins and porpoise were recovered and necropsied under two contracts during 2017 and 2018. The majority of the animals collected for necropsy were recovered from County Kerry most likely due to the high number of strandings reported to the IWDG Cetacean Strandings network from this county.

Common dolphins represented 73% of the animals recovered. Prior to 2011, numbers of common dolphin strandings were similar to those of harbour porpoises, being either the first or second most frequently reported species each year (McGovern *et al.* 2016). During the last seven years, however, recorded strandings for common dolphins have increased out of proportion with other species. Between 2006 and 2010 the IWDG received 134 records of common dolphins; an average of 27 animals per year. However, during the years 2013 to 2018, 503 common dolphin strandings were recorded. One-hundred and eighteen were reported from 2018 alone representing a large increase on previous years (O'Connell and Berrow 2019). The reason for this remains unclear, although interactions with pelagic trawl fisheries have been identified (Anon 2013). Although this could in part be due to increased observer effort over the years, if this were the only explanation, we would expect a similar increase to be reported for other dolphin species. Common dolphin strandings occur mainly on the west and south coasts and peak in the winter months of January to March and December (McGovern *et al.* 2016).

Harbour porpoise are consistently the second most frequently stranded cetacean species in Ireland, having only recently been surpassed by the common dolphins. They have been recorded stranded on all coasts, although higher rates along the south and east coasts with peaks from December to March, (McGovern *et al.* 2016); the latter region was outside the scope of the current study. Stranding records have been consistent with around 30 reported per year in Ireland (O'Connell and Berrow 2018; 2019).

Striped dolphins are less frequently stranded relative to other cetacean species, accounting for around 5% of all strandings in a typical year (McGovern *et al.* 2016). In the ten years up to and including 2018, 121 striped dolphin stranding records were received; an annual average of slightly more than 12 animals. This varied from a low of eight records in 2012 to a peak of 18 in 2014. Small numbers of strandings were recorded throughout the year, mainly from the south and west coasts (McGovern *et al.* 2016).

The proportion of each species recovered for post-mortem was therefore consistent with the relative number of individuals stranded during the study period.

Bacteriological and histopathological analyses undertaken by the RVL are ongoing and case histories will be updated with results from these assessments when available. Samples collected during the necropsies were stored at the IWDG office in Kilrush, Co. Clare and the RVL in Cork during the contract and then transferred to the MI with their associated databases where they may later be used to facilitate a variety of future investigations into marine mammal ecology.

This scheme has demonstrated that it is possible to recover a sample of stranded dolphins and porpoises and transport to a regional veterinary lab in a timely manner for post-mortem examination. In addition, it has demonstrated an effective collaboration between a state agency, third level institute and a non-government organisation. This can support a continuation of necropsies of stranded

cetaceans to provide a greater sample size, especially of species other than common dolphin, and provide robust data with which to inform management. Consideration should be given to extend this programme to include **bottlenose dolphins** (*Tursiops truncatus*), an Annex II species requiring special conservation measures, and other species which, although strand infrequently, would be of ecological interest (e.g. **Atlantic white-sided dolphin** (*Lagenorhynchus acutus)*, **white-beaked dolphin** (*Lagenorhynchus albirostris)*). It would also be advisable to include the east coast in the sampling area as this is where many harbour porpoises tend to strand.

Further recommendations for future work would include the provision of additional resources in order to continue providing bacteriology and histopathology assessment services, as one of the most common causes of death reported here was **infectious disease**. For several cases, this was generously carried out by the RVL, and was instrumental in determining causes of death for those animals.

A delay with reporting arose due to constrained resources at the Regional Veterinary Laboratory in Cork, specifically available personnel. As the involvement of the RVL was voluntary and in addition to their ongoing obligations, this put significant pressure on one pathologist to carry out and report on all of the post-mortem examinations. If the post mortem scheme was to continue, IWDG recommends there be multiple pathologists formally dedicated to the scheme to ensure reports are returned in an appropriate timeframe, and that a contract be negotiated to provide these pathological services.

Acknowledgements

The Marine Biodiversity Scheme is established under Union Priority 1 (Sustainable Fisheries) and Union Priority 6 (Integrated Maritime Policy) of Ireland's Operational Programme (OP) under the EMFF and is co-funded by the Irish Government and the EU. We would like to thank the Contracting Management and Steering Group, especially Drs. Leonie O'Dowd, Helen McCormick and Oliver Tully of the Marine Institute and Drs Oliver Ó Cadhla, Ferdia Marnell and David Tierney of the NPWS. We would like to thank Barry Keane and Sean O'Callaghan for providing indispensable assistance to the project coordinator in recovering animals, as well as Mark Reader, Graham Cooper, Don Cotton, Gary Kett, Nick Massett, Louise Overy, Tony Murray, Gareth Doherty, Patrick Molloy, Sorsha Kennedy, Brian O'Callaghan, Irene O'Brien and Frances Bermingham for assistance on the beach.

We would like to thank the IWDG stranding network members whose records made this contract possible, and the DCHG for funding the IWDG Stranding Scheme. Finally, we would like to thank the support of Michéal Casey and the RVL staff at RVL Cork for providing additional support during necropsy examinations.

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Appendices

Appendix I:

IWDG Necropsy Case History Cover Page

Case History Report

IWDG Stranding Code: _____ **Species**: _____

Date of Necropsy: _____ **Pathologist(s)**: _____

Case History (Provide brief summary of where/how the animal was initially found and necropsy results):

Cover photo:

Approved by SB: _____ **Date:**_____
Approved by IoZ: _____ **Date**: _____

Appendix II:

CSIP Guidelines for the Postmortem Examination and Tissue Sampling of Cetaceans during Stranding Events

CONTENTS

a) Introduction
b) Basic measurements
c) External examination
d) Examination of abdominal organs (except G.I. tract, pancreas, and spleen)
e) Examination of organs of head, neck and thorax
f) Examination of the G.I. tract, pancreas and spleen

a) Introduction

These guidelines are meant primarily as an aid to veterinary surgeons carrying out post-mortem examinations on stranded cetaceans involved in the UK. Post-mortem examinations are carried out under the aegis of the UK Cetacean Strandings Investigation Programme, which is jointly funded by Defra and the Devolved Administrations. This protocol is based partly on guidelines written by Dr John Baker and Dr Thijs Kuiken and partly on the protocol produced at the European Cetacean Society workshop on cetacean pathology, held in Leiden, The Netherlands, in September 1991[1].

All structures must be examined visually and by palpation, making incisions into the organs. A full post-mortem record must be kept, preferably on the standard "Cetacean Post-mortem Report" form for recording animals involved in a stranding.

Lesions in any organs should be described, photographed and sampled. The description should include the size, location, colour, texture, shape, and the nature of the transition from normal to abnormal tissue. Photographs should include a ruler, scale bar or similar object to indicate the size of the lesion. According to the suspected aetiology of the lesion, samples should be collected for bacteriological examination (especially if the lesion is of a purulent nature) or for virological examination. In all cases, a sample of the lesion should be preserved for histopathological examination.

The post-mortem examination need not take place in the order described below. However, samples for bacteriological and virological examination need to be taken as early as possible. Also, examination of the G.I. tract should be left until last to prevent cross-contamination with enteric micro-organisms.

Paul Jepson and Rob Deaville
London, January 2010

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[1]Kuiken, T. and Garcia Hartmann, M. (eds.) (1991) Proceedings of the first European Cetacean Society workshop on cetacean pathology: dissection techniques and tissue sampling. ECS newsletter 17, Special issue: 39pp

b) Basic measurements

photographs

Photographs should be taken of the lateral views of the whole body, from both sides. Particularly in bottle-nosed dolphins, photographs should be taken of the dorsal fin, also from both sides. In baleen whales, the ventral side of the tail flukes should be photographed. Photographs should also be taken of any lesions of interest found during the post-mortem, including the use of a scalebar.

body condition

Estimate the body condition- that is the state of decomposition of the carcass, using the categories of the condition code[2]. Where possible, note the presence and extent of rigor mortis.

body weight

If recording the body weight is impossible, collect the heart weight so that the body weight can be estimated[3].

body length

Measure the body length by placing the carcass on its belly, holding a measuring tape or ruler next to the carcass in a straight line parallel to the longitudinal body axis and measuring the distance between the notch in the tail flukes and the tip of the upper jaw. Measure the body girth at the level of the anterior insertion of the dorsal fin. If it is impossible to move the carcass, a half circumference measurement may be taken and doubled.

body girth

c) External examination

nutritional state

Indicate the nutritional state of the carcass, using one of the following three categories:
-good: the aspect of the upper flanks on either side of the dorsal fin is rounded;
-moderate: the aspect of the upper flanks on either side of the dorsal fin is sloping;
-poor: the aspect of the upper flanks on either side of the dorsal fin is hollow (in these animals, one can make out the transverse processes of the lumbar vertebrae, and there is an indentation dorsally just behind the head).

body orifices

---

[2]The body condition, or state of decomposition of a carcass, can be described using the following condition code:

1) **live** *(becomes code 2 at death)*
2a) **extremely fresh** *(as if just died, no bloating, meat is considered by most to be edible)*
2b) **slight decomposition** *(slight bloating, blood imbibition visible)*
3) **moderate decomposition** *(bloating, skin peeling, penis may be extended in males, organs still intact, excluding postmortem damage)*
4) **advanced decomposition** *(major bloating, skin peeling, penis extended in males, organs beyond recognition, bones exposed due to decomposition)*
5) **indeterminate** *(mummified carcass or skeletal remains, no organs present)*

[3] The body weight can be estimated from the heart weight using the formula log W = (log H + 2.2) / 0.984, with H = heart weight and W = body weight, both in kg.

Examine the body orifices (mouth, eyes, ear openings, blow-hole, anus, genital slit and mammary slits) for lesions and any discharge. Collect and preserve left and right eyes separately in 10% formalin if lesions are noted.

epidermis

Examine the animal for external lesions, including evidence of physical trauma and/or fresh contra- or con-specific rakemarks and photograph and sample these accordingly. Examine the skin carefully for any ectoparasites. These are most likely to be found in or near the body orifices and next to the fins and flukes. Take a 4 cm^2 piece of epidermis down to the blubber for DNA-studies, and freeze.

milk

blubber

Massage the skin in the area cranial to the mammary slits in a caudal direction to express any fluid present in the mammary glands. Note the volume, colour, and consistency of the fluid.

Cut a transverse strip of blubber about 2 cm wide from the anterior insertion of the dorsal fin, from the mid-dorsal to the mid-ventral region. Make sure to cut at right-angles to the surface of the skin. Measure the thickness of the blubber strip with a ruler 2cm lateral to the dorsal mid-line, mid-laterally, and 2cm lateral to the ventral mid-line. (Using this method, the tension of the blubber tissue is relieved before measuring.)

muscle

Cut a strip of blubber a few cm wide and a few cm long at the level of the caudal insertion of the dorsal fin. Make sure to cut at right-angles to the surface of the skin. From this blubber strip, take 2x20 g cross-sectional samples of blubber for organochlorine analysis. It is important to take samples of the whole layer, from the skin to the muscle. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes.

Take 2x20 g muscle samples for toxicological analysis, at the same location as and directly below the blubber sample, at the level of the caudal insertion of the dorsal fin. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes. Take a 1 cm^3 sample of both the longissimus dorsi and abdominal muscle in 10% formalin (for histopathology).

mammary gland

With the animal on its right side (if possible) make a mid-line ventral incision from the symphysis of the mandible to a short distance posterior of the anus, circumventing the genital slit and anus. From the posterior end of the ventral incision make a second one almost to the dorsal mid-line. Reflect the skin and blubber off the uppermost side. Any parasites in the blubber should be noted. They may occur as white cysts less than 1 cm in diameter, often in the ano-genital region or the dorsal aspect of the chest wall.

subcutaneous tissue

In females, examine the mammary gland for pathological changes and parasites. Collect a cross-sectional slice of about 1 cm thick from halfway along the length of the left mammary gland for histopathological examination, and place in 10% formalin.

scapula

Examine the subcutaneous tissue for the presence of bruises and parasites.

Remove the left scapula.

d) Examination of abdominal organs (except G.I. tract, pancreas, and spleen)

virology samples

Remove the left abdominal wall, freeing the testis or ovary and uterus. Any parasites in the abdominal wall (for instance cysts under the peritoneum) should be noted. Remove the left thoracic wall, for example with bone shears.

bacteriology samples

Before handling the internal organs, take a 1 cm^3 sample of lung tissue from the cranio-ventral part of the left lung and a 1cm^3 sample of kidney tissue from the left kidney for virological examination. Also take a sample of lung tissue from the cranio-ventral part of the left lung, a sample of kidney tissue from the left kidney and a sample of liver tissue from the left lobe of the liver for bacteriological examination.

gas bubbles in the mesentery

Examine the gastrointestinal tract for any abnormalities including gas bubbles in the mesenteric and intestinal veins. If any are present, take photos with a scalebar and sample tissue for histological examination.

pericardial fluid/ serum

Sever the intestine close to the anus and the oesophagus close to the diaphragm. Working forward along the dorsal aspect of the abdominal cavity, remove the stomach, intestines, pancreas, spleen and mesenteric lymph node, attached to each other, from the carcass. Leave the examination of the G.I. tract to the end of the postmortem examination to prevent cross-contamination of other tissues with enteric micro-organisms.

urinary bladder

Collect sample of pericardial fluid after incising the pericardial sac. Collect any blood present in the heart lumen, to obtain serum for serological examination. Even if it is haemolytic, it is still of value.

female reproductive tract

Open and examine the bladder in situ, noting the contents, if any. Preserve a 1cm^3 sample of the bladder in 10% formalin (for histopathology).

foetus

In females remove the entire reproductive tract, open the vagina and uterus, note any corpora lutea, corpora albicantia or follicles on each ovary and then place the ovaries separately in 10% formalin for reproduction studies. Preserve a 1cm^3 sample of the uterus in 10% formalin (for histopathology). Describe the state of sexual maturity.

male reproductive tract

If a foetus is present, record the weight, length, sex and the state of decomposition. The whole foetus and its placenta can be wrapped in hexane-washed aluminium foil and stored frozen for organochlorine analysis.

adrenal glands

In males remove the testes and weigh them separately after removing the epididymis. After incision and examination, place the testes in 10% formalin for reproductive studies. Place a cross-sectional slice about 1 cm thick from mid-way along the length in 10% formalin. Examine the penis and preputium. Describe the state of sexual maturity where possible, final confirmation may be dependent on histological examination.

kidneys

Remove and examine the adrenal glands, and place a cross-sectional slice about 1 cm thick from the middle of the left adrenal gland in 10% formalin.

Examine the peri-renal vasculature for any gas bubbles. Describe and photograph if present and take samples of any associated lesions for histological examination.

liver

Remove the kidneys from the body cavity and weigh them. Incise both kidneys longitudinally, and if possible, strip the capsule. Then, take 2x20 g samples for toxicological analysis from halfway the length of the left kidney. These samples should be cross-sectional and include both medullary and cortical tissue. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes. Preserve 1 cm^3 from a kidney in 10% formalin for histopathological examination.

thyroid

Examine the liver for any evidence of gas cavities beneath the capsule. Describe and photograph if present. Remove and weigh the liver. Examine both surfaces and make multiple incisions into the substance. Examine the parenchyma for the presence of any gas cavities. Describe and photograph if present and take samples of any associated lesions for histological examination. Examine the bile ducts for parasites. Then, take 2x20 g for trace metal analysis. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes. Place 1 cm^3 of liver tissue in 10% formalin for histopathological examination.

e) Examination of organs of head, neck and thorax

Carefully remove the superficial muscles overlying the trachea and larynx to expose the thyroid gland. Examine this tissue and preserve 1 cm^3 of tissue in 10% formalin for histopathological examination.

tongue

Incise along the internal aspects of both mandibles and free the tongue. Once the tongue is free reflect it backwards and cut the hyoid bones close to the skull.

oesophagus

respiratory tract

Free the larynx from the sphincter muscle holding it in place and pulling the tongue backwards incise along the neck to free the trachea and oesophagus. Then, incising dorsally and ventrally in the thoracic cavity, free the heart and lungs. Note any attachments of the lungs to the thoracic walls. This procedure should give you the tongue, larynx, trachea, oesophagus, thymus, heart and lungs all still fastened together.

Examine the surface of the tongue.

Open the oesophagus longitudinally and check for lesions or parasites.

thymus

heart

Look for evidence of pulmonary hypostasis and photograph if present. Open the larynx, trachea and major bronchi longitudinally. Look for evidence of aspiration of seawater, mud or beach material. Photograph if present. Make multiple incisions into the substance of both lungs. Any parasites may be collected. Two pieces of lung (about 1 cm^3) from the hilus and periphery of the left lung, and the same from the right lung, should be collected in 10% formalin for histopathological examination. The samples should include part of the major bronchial tree. Open all major branches of the pulmonary veins and examine for the presence of parasites. Examine the bronchial and so-called "pulmonary associated" lymph nodes. The latter can be found about halfway along the ventral edges of each lung. Cut a 1 cm thick cross-sectional slice from the middle of the left pulmonary associated lymph node, and place it in 10% formalin for histopathological examination.

acoustic fat and tympanic bullae

Examine the thymus, if present (noting the presence of any macroscopic cysts). Place 1 cm^3 of thymus in 10% formalin for histopathological examination.

Separate the heart from the lungs by cutting through the major blood vessels where they enter the heart. Open the left and right ventricles and atria for examination and to take out any blood clots present. Any parasites should be noted. Weigh the heart. Cut a 1 cm thick slice of heart tissue, to include a piece of the wall of the left ventricle and of the atrioventricular septum, and place it in 10% formalin for histopathological examination.

teeth (baleen plates)

Examine acoustic fats and note and photograph any haemorrhages. Take a 1 cm^3 section and place in 10% formalin. Examine the tympanic bullae if possible (which in cetaceans are not part of the skull but lie free just behind the mandibles). Carefully dissect each tympanic bulla (and associated cochlea) free of their connective tissue attachments to the skull. Examine the internal cavity of each bulla and note the presence of any nematodes or abnormalities. Preserve the left tympanic bulla/cochlea and right tympanic bulla/cochlea separately in 10% formalin if the carcass is in a suitable condition.

spinal cord

skull

If possible, remove two sets of (at least) 4 teeth from the middle of the lower jaw for ageing, and store frozen (separately). (In baleen whales, cut off 2 baleen plates as near as possible to their basis and store frozen.)

brain

Remove the head at the atlanto-occipital joint; collect a sample of cervical spinal cord and fix in 10% formalin.

If possible, open the skull, and examine the brain. The skull can be opened by making a vertical cut parallel and about 2 cm posterior to the transverse dorsal ridge which is clearly visible and palpable on top of the skull. The second cut should be made in the horizontal plane, through the occipital condyles, making sure to leave the posterior portion of the condyles on the skull, so that the condylo-basal length can still be measured. Both cuts should be extended until they meet each other. The separated piece of skull can then be pried loose using a chisel or flat-bladed screwdriver, and the brain can be removed.

Examine for the presence of bubbles within the vasculature in areas of the brain not damaged during skull excision. Describe and photograph any suspected bubbles/lesions. Take a 1 cm^3 sample of brain for virological examination and bacteriology and morbillivirus samples as described previously. Where possible, place the rest of the brain in 10% formalin for at least a week. To allow faster fixation, a longitudinal incision can be made in the cerebrum to expose the lateral ventricles. When it is fixed, make multiple slices into the tissue to look for pathological lesions, including the presence of parasites. Take 1 cm^3 samples of the cortex, cerebellum, and medulla for histopathological examination. Where possible, dissect the pituitary gland from the pituitary fossa (located in the cranial floor) and preserve in 10% formalin.

spleen

pancreas

mesenteric lymph node

Skulls may be stored frozen for morphometrics studies or museum archive. However, examination of the brain and spinal cord takes precedence.

stomach

f) Examination of the G.I. tract, pancreas and spleen

Examine and weigh the spleen and put a piece (about 1 cm^3), including a section of capsule, in 10% formalin for histopathological examination. One often finds smaller accessory spleens near to the main spleen.

Examine the pancreas. Look for parasites, particularly in the pancreatic ducts. Place a 1 cm^3 piece of pancreas tissue in 10% formalin for histopathological examination.

intestine

Examine the mesenteric lymph node and put a 1 cm thick cross-sectional slice from halfway its length in 10% formalin for histopathological examination.

Open the cardiac section of the stomach. Note and photograph if watery fluid or ingested beach material is present in the lumen. Collect any fish bones, otoliths and other food remains and preserve in 70% ethanol or freeze for prey studies. Any parasites should be noted and the approximate burden described. Describe any lesions, including the distribution and size of any ulcers. Open the fundic and pyloric sections of the stomach. Any food material should be preserved for prey studies as for the cardiac section. Any nodules in the walls of the fundic and pyloric sections should be noted and, if they are found, attempts should be made to express the contents. Any parasites found in the contents should be noted.

Open the intestinal tract at several points along its length. Make note of any contents and/or lesions and any parasites that are found.

Appendix III:

CSIP PM Data collection sheets

CETACEAN POSTMORTEM REPORT

When this report has been completed, please send a copy to: UK Cetacean Strandings Investigation Programme, The Wellcome Building, Institute of Zoology, Regent's Park, London, NW1 4RY, UK. Tel: 020 7449 6672 or 6691 Fax: 020 7483 2237
email: rob.deaville@ioz.ac.uk or paul.jepson@ioz.ac.uk

SW NO. : ..... PM NO. : .....
SPECIES : .... SEX : ....
LOCATION FOUND :..... ....
DATE FOUND : .. ..FOUND BY : ....
....
PATHOLOGIST :. ....DATE OF PM :.... ....

FROZEN?: Y / N

1. BASIC MEASUREMENTS

BODY CONDITION USING CONDITION CODE :

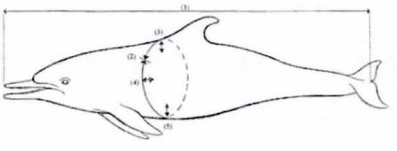
Condition code:

1) **live** (becomes code 2 at death)
2a) **extremely fresh** (as if just died, no bloating, meat is considered by most to be edible)
2b) **slight decomposition** (slight bloating, blood imbibition visible)
3) **moderate decomposition** (moderate bloating, skin peeling, penis may be extended in males, organs still intact, excluding postmortem damage)
4) **advanced decomposition** (major bloating, skin peeling, penis extended in males, organs beyond recognition, bones exposed due to decomposition)
5) **indeterminate** (mummified carcass or skeletal remains, no organs present)

PHOTOGRAPHS TAKEN
-lateral views whole body, both sides: Y/N
-lateral views dorsal fin, both sides: Y/N
-baleen whales: ventral view tail flukes: Y/N
-other photographs (list):
- -
- -

BODY WEIGHT (kg):. . . . . .

LENGTH, GIRTH AND BLUBBER THICKNESS (see diagram below):
-tip upper jaw to tail notch (cm) (1):. . . . .
-girth in front of dorsal fin (cm) (2):. . . . .
-blubber thickness in front of dorsal fin:
-dorsal mid-line (mm) (3):. . . . .
-lateral (mm) (4):. . . . .
-ventral mid-line (mm) (5):. . . . .



2. GROSS PATHOLOGICAL EXAMINATION

Encircle the appropriate category:

NE = not examined
NAD = nothing abnormal detected
A = abnormal (describe fully in section 5)

EXTERNAL EXAMINATION

NE NAD A -body orifices
NE NAD A -fins and flukes
nutritional state: good / moderate / poor

INTEGUMENT

NE NAD A -epidermis
NE NAD A -blubber
NE NAD A -subcutaneous tissue
NE NAD A -mammary glands

MUSCULOSKELETAL SYSTEM

NE NAD A -skull
NE NAD A -other bones
NE NAD A -back muscle mass
NE NAD A -other muscles

NERVOUS SYSTEM

NE NAD A -brain
NE NAD A -spinal cord
NE NAD A -peripheral nerves

CARDIOVASCULAR SYSTEM

NE NAD A -pericardial sac
NE NAD A -myocardium
NE NAD A -valves
NE NAD A -arteries, veins

RESPIRATORY SYSTEM

NE NAD A -nasal cavity
NE NAD A -sinuses
NE NAD A -trachea, bronchi
NE NAD A -lungs
NE NAD A -pleura/pleural cavity

ALIMENTARY SYSTEM

NE NAD A -mouth
NE NAD A -oesophagus
NE NAD A -cardiac section stomach
NE NAD A -fundic section stomach
NE NAD A -pyloric section stomach
NE NAD A -intestine
NE NAD A -anus
NE NAD A -liver
NE NAD A -pancreas
NE NAD A -peritoneum/peritoneal cavity

UROGENITAL SYSTEM

NE NAD A -kidneys
NE NAD A -ureters
NE NAD A -urinary bladder
NE NAD A -urethra
NE NAD A -ovaries/testes
NE NAD A -uterus
NE NAD A -vagina/penis
NE NAD A -vulva/preputium

LYMPHATIC AND ENDOCRINE SYSTEMS

NE NAD A -adrenal glands
NE NAD A -thyroid gland
NE NAD A -spleen
NE NAD A -thymus
NE NAD A -lymph nodes

3. CHECKLIST OF STANDARD SAMPLES

In each square, enter: ☑ *= sample taken*
Blank = sample not taken or not present
Record any extra samples taken in section 4.

Weights (optional)
left testis (g):. . . . . .
right testis (g):. . . . . .
heart (g): . . . . . .
cardiac section stomach (g): . . . . . .

S/C's and Parasites

☐ food remains		Frozen	☐ lung	1 cm^3
Ethanol				
from:	☐	☐		
. . . . .	☐	☐		
. . . . .	☐	☐		
. . . . .				

☐ parasites from: (pref. all- stored in ethanol)
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

Freeze at -20°C

☐ epidermis	4 cm^2
☐ blubber	2 x 20g
☐ liver	2 x 20g
☐ muscle	2 x 20g
☐ serum or PCF	up to 20 ml
☐ teeth	>4 (2 sets)
☐ baleen plates	>4 plates
☐ urine	up to 10 ml
☐ faecal material	up to 50 ml
☐ brain (RNAlater)	0.5 cm^3
☐ spleen (RNAlater)	0.5 cm^3
☐ lung (RNAlater)	0.5 cm^3

Virology (freeze at -80°C)

☐ brain	1 cm^3
☐ spleen	1 cm^3

10% Formalin

☐ adrenal glands both
☐ bladder 1 cm^3
☐ cerebrum 1 cm slice
☐ cerebellum 1 cm slice
☐ heart 1 cm^3
☐ kidney 1 cm^3
☐ liver 1 cm^3
☐ lung 1 cm^3 x
☐ mammary gland 1 cm slice
☐ mesenteric ln. 1 cm slice
☐ pancreas 1 cm^3
☐ pulm. ass. ln. 1 cm slice
☐ skin and blubber 1 cm^3
☐ spinal cord 1 cm^3
☐ spleen 1 cm^3
☐ testes both/slices
☐ thymus 1 cm^3
☐ thyroid 1 cm^3
☐ uterus 1 cm^3
☐ brain whole (in 15% formol saline)
☐ ovaries both (separately if immature)

Bacteriology

☐ brain swab/block
☐ kidney swab/block
☐ liver swab/block
☐ lung swab/block
☐ spleen swab/block
☐ CSF swab/fluid

4. LIST OF EXTRA SAMPLES

Extra samples of lesions taken for histological examination (list):	Extra samples of lesions taken for bacteriological examination (list):	Other extra samples taken (list):
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
	-	

Optional (if time and storage allows)

Freeze at -20°C

☐ foetus/placenta	whole
☐ scapula	whole
☐ skull	whole
☐ milk	up to 20 ml
☐ eyes	both

Virology (freeze at -80°C) or RNAlater (freeze at -20°C)

☐ pituitary	section
☐ cranial nerve	section

Fixed tissue)

☐ pituitary	whole
☐ tympanic bullae/cochlea	both (only in 2a cases)
☐ *longissimus dorsii* muscle	slice (held under tension)
☐ *rectus abdominus* muscle	slice (held under tension)

5. DESCRIPTION OF ABNORMALITIES ON GROSS PATHOLOGICAL EXAMINATION
(add extra pages if necessary)

PRELIMINARY DIAGNOSIS OF GROSS PATHOLOGICAL EXAMINATION (in order of importance):

a.

b.

c.

d.

e.

6. RESULTS OF HISTOLOGICAL EXAMINATION (add extra pages if necessary)

7. RESULTS OF BACTERIOLOGICAL EXAMINATION

Heart blood: .....

Lung: .....

Liver: .....

Kidney: .....

Other: .....

.....

8. MISCELLANEOUS RESULTS

9. FINAL DIAGNOSIS (in order of importance):

a.

b.

c.

d.

Appendix IV:
Final Cetacean Post-Mortem Report

REFERENCE NUMBER: SW2017/
POST-MORTEM NUMBER:
HISTOLOGY NUMBER:
SPECIES:
SEX:
DATE FOUND:
LOCATION FOUND:
NATIONAL GRID NUMBER:
DATE OF POSTMORTEM:
PATHOLOGIST: Rob Deaville

1. BASIC MEASUREMENTS

FROZEN:
CARCASS CONDITION:
BODY WEIGHT: kg
LENGTH, GIRTH AND BLUBBER THICKNESS:

-tip upper jaw to tail notch: cm
-girth in front of dorsal fin: cm

-blubber thickness in front of dorsal fin:

-dorsal mid-line: mm
-lateral: mm
-ventral mid-line: mm

2. GROSS POSTMORTEM

External examination

Nutritional state:
Body orifices:
Ectoparasites:
Fins and flukes:

Integument

Epidermis:
Blubber:
Subcutaneous tissue:
Mammary glands:

Musculoskeletal system

Skull:
Other bones:
Back muscle mass:
Other muscles:

Nervous system

Brain:
Spinal cord:
Peripheral nerves:

Cardiovascular system

Pericardial sac:
Myocardium:
Valves:
Arteries, veins:

Respiratory system

Nasal cavity:
Sinuses:
Trachea, bronchi:
Lungs:
Pleura/pleural cavity:

Alimentary system

Mouth:
Oesophagus:
Cardiac section stomach:
Fundic section stomach:
Pyloric section stomach:
Duodenum/small intestine:
Large intestine:
Anus:
Liver:
Pancreas:
Peritoneum/peritoneal cavity:

Urogenital system

Ovaria/testes:
Uterus:
Vagina/penis:
Kidneys:
Ureters:
Urinary bladder:
Urethra:

Lymphatic and endocrine systems

Adrenals:
Thyroid:
Spleen:
Thymus:
Lymph nodes:

3. HISTOLOGY

4. BACTERIOLOGY

5. MISCELLANEOUS

DIAGNOSIS

I *Significant diseases or conditions* thought to contribute to the death of the animal

II *Incidental diseases or conditions* not thought to contribute to the death or condition causing it

Comments:

6. INSTIUTE OF ZOOLOGY REVIEW PANEL

Comments:

Appendix V:

IWDG-RVL-GMIT Sample Collection Form

MI-NPWS PRIORITY SAMPLE CHECK-LIST

ANIMAL ID: _____

Storage notes:
PARASITES: Whole (70% ethanol)
LESIONS: Histology ($1cm^3$) – x1 10% Formalin, Bacteriology (swab/block) – x1 Fridge
TOXICOLOGY: Wrapped in aluminum dull side up

SKIN ($4cm^2$):

- x1 Frozen -20°C ☐

BLUBBER:

- Toxicology (20g) – x2 Frozen -20°C ☐

MUSCLE:

- Toxicology (20g) – x2 Frozen -20°C ☐

KIDNEY:

- Toxicology (20g) – x2 Frozen -20°C ☐
- Histology ($1cm^3$) – x1 10% Formalin ☐
- Virology ($1cm^3$) – x1 Frozen -80°C ☐
- Bacteriology (swab/block) – x1 Fridge ☐

LIVER:

- Toxicology (20g) – x2 Frozen -20°C ☐
- Histology ($1cm^3$) – x1 10% Formalin ☐
- Bacteriology (swab/block) – x1 Fridge ☐

LUNG:

- Histology (4 x $1cm^3$) – 10% Formalin ☐
- Bacteriology (swab/block) – x1 Fridge ☐
- Virology ($1cm^3$) – 1x Frozen -80°C ☐

MAIN SPLEEN:

- Virology ($1cm^3$) – x1 Frozen -80°C ☐
- Bacteriology (swab/block) – x1 Fridge ☐

SERUM OR PCF (Up to 20ml):

- PCF ☐**OR** Serum ☐

URINE (Up to 20ml):

- Toxicology – x1 Freeze -20°C ☐

STOMACH:

- Whole (Frozen -20°C) ☐

TEETH (5-10):

- Frozen -20°C ☐

REPRODUCTIVE SYSTEMS:

- R+L testes + epi (5 cm^2 from mid-testes and epi and store in separate labelled pots) Formalin 10% ☐

OR R+L ovaries (whole in separate labelled pots or note differences in external appearance) - Formalin 10% ☐

BRAIN:

- Virology ($1cm^3$) – x1 Frozen -80°C ☐

REQUESTED ADDITIONAL SAMPLES/INFORMATION

SPLEEN

- Histology ($1cm^3$) – x1 10% Formalin ☐

GLANDS – HISTOLOGY (10% Formalin):

- Prescapular lymph node ($1cm^3$)☐
- Thymus ($1cm^3$)☐
- Thyroid ($1cm^3$)☐
- Pulmonary associated lymph node L+R (nick L) ($1\ cm^3$) ☐
- Adrenal R+L (nick L) (Whole) ☐
- Mammary R+L (nick L) ($1cm^3$)☐

INTESTINE

- Last 10 cm (Frozen -20°C) ☐

FEMALE REPRODUCTIVE TRACT (excl. ovaries)

- Whole (Formalin 10%) ☐

MILK (Up to 20ml):

- Toxicology – x1 Freeze -20°C ☐

BRAIN

- Bacteriology (swab/block) – 1x Fridge ☐
- Histology ($1cm^3$) – x4 10% Formalin ☐

ADDITIONAL INFORMATION:

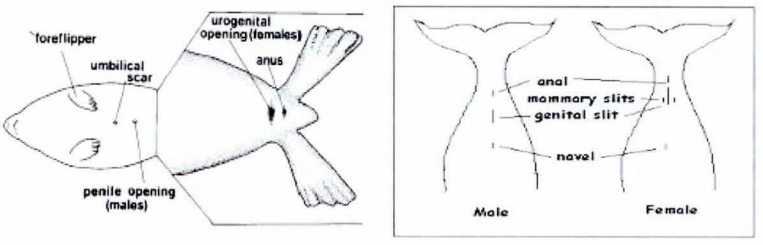
POST-ANAL HUMP: Photograph + Blubber thickness (mm) _____Muscle thickness (mm) _____(measurements from where hump is thickest)

ADDITIONAL SAMPLES:

SAMPLE	STORAGE (frozen, ethanol etc.)	PURPOSE (B,H,V,T,O)	NO. OF SAMPLES/SIZE	LOCATION (if parasites/lesions)

Appendix VI:
Bycatch Sample Collection Protocol

1. Wear clean non-powdered vinyl gloves provided. To avoid cross-contamination, clean gloves should be used for each carcass.
2. **For birds**: Birds are to be double bagged using the black plastic bags. Fill out one of the labels for the birds and place it on the outside bag. Record details on the bycatch record form.
3. Ask crew where it can be stored (in ice or in freezer (preferable)).
4. **For cetaceans**: Measure the length (in cm) by placing it on its belly and holding the tape measure down parallel to the carcass in a straight line. Measure the distance between the notch in the tail fluke and the tip of the upper jaw - record on the bycatch record form.
5. **For seals**: Place animal on belly and measuring tape parallel to carcass in a straight line. Measure (in cm) from the tip of the snout to the tip of the tail – record on the bycatch record form.
6. **For cetaceans and seals:** For species and sex verification, if possible, take photos of the animal's genital area as well as full side views of cetaceans and head profile pictures for seals. Determine the sex and record on the bycatch record form.



7. Complete labels on the zip-lock sample bags (as below) using a permanent pen.
8. Take a sample using the biopsy punch tool immediately in front of dorsal fin for cetaceans, or from the sternal region on the seals. Push it in far enough so the entire metal end of the tool is full of blubber when removed – when pulling the tool out of the animal hold it at an angle and twist it so the entire sample comes out within the tool. Discard and repeat if the tool is not full - a full cross section of the blubber layer must be obtained with skin attached to the outer layer, and muscle attached to the inner blubber layer. The tools are sterile before use so must be handled carefully when sampling in order to avoid cross-contamination.
9. Remove the blubber/skin sample with forceps from the biopsy punch tool, place and wrap in the tin foil (dull side up) square provided and place into the zip-lock bag you have labelled. Repeat steps - you should have two biopsy samples per animal. Two aluminum squares each containing one sample will go into the same plastic bag for the one animal.
10. Disinfect the biopsy tool and forceps between samples in tube of ethanol.
11. Ask crew where it can be stored (in ice or in freezer (preferable)).
12. When leaving the vessel, place all cetacean and bird samples into your box of iced fish/nephrops samples coming ashore. Inform the Catch Sampling Manager that you have samples and they will arrange to have them collected along with your normal samples.
13. If you require any more sampling equipment, please contact the Catch Sampling Manager.

Label on cetacean sample bag:
Animal ID:
Date:
Species:
Length:
Sex:
Sample: Skin+ Blubber

Label on bird bag:
Animal ID:
Date:
Species:

Appendix VII:

Bycatch sampling kit contents

Twenty-five bycatch sampling kits were assembled for the at sea observers which contained the following items:

1. Sample protocol sheet (see below)
2. Eight pairs of disposable gloves
3. One permanent waterproof pen
4. Five disposable biopsy punch tools for skin/blubber sample collection
5. Ten squared of aluminium foil for samples to be wrapped in
6. One pair of forceps for sample extraction from biopsy tool
7. One tube of ethanol for disinfection of biopsy tool and forceps
8. Five pre-labelled zip-lock bags for samples to be kept in
9. One measuring tape for marine mammal length measurements
10. Six large black bags for seabird collection
11. Three pre-written labels for seabird bags
12. One bottle of hand sanitizer.

Appendix VIII:
Criteria used to establish selected causes of death are described below (CSIP, 2016).

- **By-catch (entanglement in fishing gear)** was ascribed as a cause of death in cetacean carcasses using established pathological criteria for by-catch diagnosis
- **Infectious Disease**- a broad category consisting of a number of causes of death of infectious origin
- **Live Stranding**- attributed as the cause of death in cetaceans that were known or suspected (from post-mortem examination) to have live-stranded in apparent good health and nutritional status. This category excluded severely diseased or emaciated animals that stranded alive
- **Starvation**- given as the cause of death in animals that were severely emaciated and, following post-mortem examination, ascertained to have no other significant disease processes that could explain the poor nutritional status
- **Starvation (neonate)**- given as the cause of death in neonates that were severely emaciated and, following post-mortem examination, ascertained to have no other significant disease processes that could explain the poor nutritional status. Some of these animals may have become maternally separated
- **Fatal attack from one or more bottlenose dolphins**- ascribed as a cause of death in cetacean carcasses using established pathological criteria
- **Grey seal attack**- ascribed as a cause of death in individuals presenting with pathology potentially consistent with grey seal attack, as recently described
- **Physical trauma (boat/ship strike)**- physical trauma consistent with impact from a boat or ship. Includes blunt trauma to dorsal/lateral aspect of body wall and/or injuries consistent with propeller strike
- **Dystocia & Stillborn**- attributed as the cause of death in animals which have died during the act or process of giving birth (mothers or calves)
- **Physical trauma (unknown origin)**- where evidence of physical trauma is found at post-mortem, but no obvious origin or other significant underlying factors. This category is likely to include some undiagnosed cases of boat/ship strike, by-catch or bottlenose dolphin attack.
- **Gas embolism**- intravascular gas bubble formation that obstructs circulation and causes associated tissue injury
- **Entanglement**- a cause of death category largely confined to minke whales. Denotes evidence of entanglement in rope (creel etc.) or discarded fishing gear/marine litter
- **Cold stunned**- a cause of death category specific to hard shelled species of marine turtle, resulting from exposure to cold water around the UK coast, leading to immobility, hypothermia and eventual starvation
- **Neoplasia**- where the cause of death is due to the formation of a tumour
- **Others-** a broad category covering causes of death that cannot be categorised using existing criteria

Supply of Vertebrate Necropsy and Sample Recovery Services Extension - 2019 Final Report

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Reference Number: ITT18-050

Clients: Marine Institute with support of the National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht

December 2019

Executive Summary

The Marine Institute (MI) contract *Supply of Vertebrate Necropsy and Sample Recovery Services* required i) the recovery and standardised necropsy of three cetacean species with associated case history reporting; ii) the provision of sampling kits to be used for the recovery of tissue samples collected from bycaught animals (birds, seals and cetaceans) by observers on commercial inshore and offshore fishing vessels in Irish waters in order to provide additional data to the MI's existing catch sampling programme; and iii) the storage and subsequent delivery of all samples and associated databases to the client.

During this contract, a total of 45 individual cetaceans were recovered for necropsy from two geographical lots between 1 January and 12 November 2019, exceeding the target goal of 44 specified in the contract. These 45 animals comprised31common dolphins (*Delphinus delphis*), five striped dolphins (*Stenella coeruleoalba*) and nine harbour porpoises (*Phocoena phocoena*). Twenty-two of the 45 (49%) individuals were recovered from Lot 1 from counties Clare to Donegal, and 23 (51%) individuals were recovered from Lot 2 from counties Wexford to Kerry (Figure 1).

Seven sampling kits were assembled and delivered to the MI as well as 50 biopsy punches for distribution to their panel of fishery observers. No bycaught animals were reported by the DCF programme to the Project Coordinator.

Results from this contract will inform the development of a long-term strategy for necropsy of stranded cetaceans and recovery of tissue samples for further biological studies.

Samples requiring long-term storage at -20°C, including those for virology, were transported in a portable refrigerator to the IWDG office in Kilrush, Co. Clare and stored at facilities on site. Formalin fixed tissues, such as reproductive organs and adrenal glands were stored at the RVL in Cork. All samples were delivered to the Marine Institute in Oranmore, Co. Galway, along with a detailed database of samples collected.

Introduction

The Marine Institute published a tender for the provision of vertebrate necropsy services for cetaceans stranded on the Irish coast and for the provision of sampling kits for observers involved in Data Collection Framework (DCF) surveys. The first task required the recovery and standardised necropsy of a targeted sample of three species of stranded cetaceans with associated case history reporting. The second task consisted of the provision of sampling kits to be used for the recovery of tissue samples collected from bycaught animals (birds, seals and cetaceans) by DCF observers out on commercial fishing vessels in Irish waters. The existing catch sampling at sea programme is led by the MI for the Department of Agriculture, Food and the Marine (DAFM) in order to enhance and verify the accuracy of catch data as well as support the wider assessment of commercial fish/shellfish and to assess fish catches under the DCF programme (Marine Institute, 2017).

The aim of this contract was to conduct standardized laboratory necropsies of a targeted number of common and striped dolphins, as well as harbour porpoises. The Irish Whale and Dolphin Group (IWDG) were the main contractor with two sub-contractors, the Regional Veterinary Laboratories (RVL) of the DAFM and the Galway-Mayo Institute of Technology (GMIT). Stranded cetaceans were sourced and retrieved via the IWDG Cetacean Stranding Scheme, which was established in 1991 and co-ordinates a network of trained recorders.

Methods

NECROPSIES

Three species were targeted for collection for necropsy; common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*) and harbour porpoise (*Phocoena phocoena*). The area of coverage for the contract extended from County Donegal to County Wexford, which was divided into two lots. Lot 1 included coastal areas of counties Donegal to County Clare inclusive, and Lot 2 consisted of coastal areas of counties Kerry to south County Wexford inclusive. A target of 44 animals was set by the MI and the National Parks and Wildlife Service (NPWS) consisting of 22animals from each lot. For the purposes of this report, the time period of animal collection was set from 1 January to 1 December 2019.

Locating carcasses and assessing suitability for necropsy

The IWDG has been co-ordinating an All-Ireland Cetacean Stranding Scheme since 1991 and has a network of recorders who visit and photograph stranded animals and record basic parameters, with over 90% of records accompanied by photographs. This network was used to locate and assess the suitability of stranded target species for necropsy.

Suitability of carcasses for post-mortem was assessed by examining available photographs and utilising descriptions of body condition as defined by the UK Cetacean Strandings Investigation Programme (CSIP) (2016). Carcasses were recovered within decomposition codes: **2a** (extremely fresh), **2b** (slight decomposition), **3** (moderate decomposition) and **4** (advanced decomposition) – see Figure 1. If no photos were available, the animal was deemed unsuitable for collection.



Photo 1. Decomposition code 2a. Extremely fresh. A female common dolphin which live stranded at Ballylongford, Co. Kerry with a calf (Photo. Joanne O'Brien).



Photo 2. Decomposition code 2b. Slight decomposition. A female striped dolphin was found dead on Derrymore Strand, Co. Kerry (Photo. Annette Enright).



Photo 3. Decomposition code 3. Moderate decomposition. A male common dolphin in moderate condition from Ballinacourty, Co. Galway (Photo. Stephanie Levesque)



Photo 4. Decomposition code 4. Advanced decomposition. A female common dolphin found in Castletownbere, Co. Cork (Photo IWDG/RVL)

Figure 1. Examples of the four categories (extremely fresh, slight decomposition, moderate decomposition, advanced decomposition) used to determine whether a stranded cetacean was suitable for necropsy.

Post-mortem protocol

Each animal was assigned an IWDG stranding code reference number in addition to a Regional Veterinary Laboratory post-mortem number. Necropsies were undertaken in accordance with the CSIP's *Guidelines for the Post-mortem Examination and Tissue Sampling of Cetaceans during Stranding Events* (Appendix II). Templates of the CSIP data collection sheets (Appendix III) and cetacean post-mortem report (Appendix IV) were utilised within the current project. Samples were collected as per the agreed sampling protocol outlined by the NPWS and the MI (Appendix V).

The tender team attended a two-day necropsy workshop hosted by CSIP at the Institute of Zoology (IoZ) in London in June 2017, which provided the team with expert training and technical guidance. The IoZ team made a number of presentations describing their experiences in cetacean recovery and necropsy, offering valuable knowledge on their findings and advice such as which techniques and equipment to employ when recovering an animal and carrying out a post-mortem examination. The workshop continued in the post-mortem lab where CSIP scientists led the tender team in the necropsy

of a common dolphin. Methods of recording, photographing, assessing organs/overall animal health and cause of death were covered. Afterward, the tender team had the opportunity to lead the examinations of several cetaceans in order to attempt to determine cause of death with guidance from the CSIP scientists. Suspected causes of death included ship strike, bycatch, and seal attack.

Necropsies for this contract were carried out by a trained veterinarian from the RVL in Cork with the assistance of biologists from GMIT and IWDG. Detailed case history reports for each animal documenting the animal's initial gross examination, as well as the results of bacteriology and histopathology assessments (if available) and any other significant findings, were prepared. The IoZ was contracted to review the individual Case History reports to provide guidance on standardised reporting with external schemes and validation of causes of death. Biological samples were collected, labelled and stored for future studies. Samples for bacteriology and general histopathology assessments were processed by the RVL through their existing lab facilities at Cork RVL and Back Weston, Co. Kildare. All samples requiring long-term storage at -20°C, including those for virology, were transported in a portable refrigerator to the IWDG office in Kilrush, Co. Clare and stored at facilities on site. Formalin fixed tissues, such as reproductive organs and adrenal glands, were stored at the RVL in Cork. A database was created detailing all samples collected, their storage requirement and location.

Case history reporting

For each completed necropsy on an individual animal, a comprehensive digital Case History was produced in accordance with the post-mortem examination reporting protocol. The individual Case History file includes a presentation of factual evidence as observed and documented during the post-mortem examination, as well as photographic evidence and charts of external lesions. The full detailed Case History report was completed by the project Lead Scientist leading the necropsy, and reviewed by a second project Lead Scientist. Following internal sign off by the Principal Investigator, Case History files were submitted electronically to a panel of veterinary experts led by the IoZ for independent validation of the necropsy results. Case History files were then submitted to the project Steering Group.

DATA COLLECTION FRAMEWORK

The contract also included the provision of bycatch sampling kits to the Irish DCF programme, and the retrieval of samples collected at sea from DCF observers. Seven bycatch sampling kits were assembled for the at-sea observers, which included a bycatch sampling protocol leaflet (see Appendix VI). All sampling kits, along with 50 additional biopsy punches, were delivered to the DCF Observer Programme Co-ordinator for distribution. Contents of the bycatch sampling kits may be found in Appendix VII. If a bycatch incident occurred and animals were sampled, observers were to notify the DCF Programme Co-ordinator, who then liaised with the Necropsy Project Co-ordinator. Samples were then to be retrieved and stored at the IWDG office.

Results

NECROPSIES

Cetacean Collection and Reporting

A total of 45 animals were collected for this contract comprising 31 common dolphins, five striped dolphins and nine harbour porpoises (Figure2).

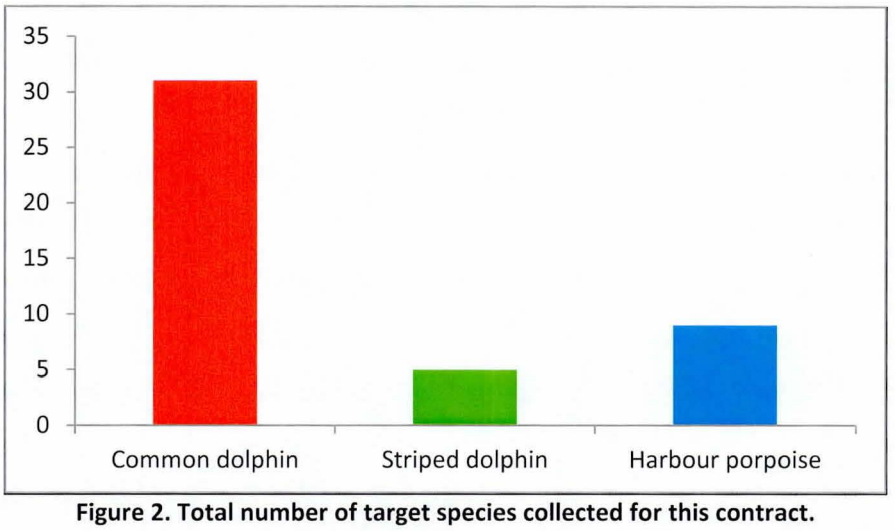


Figure 2. Total number of target species collected for this contract.

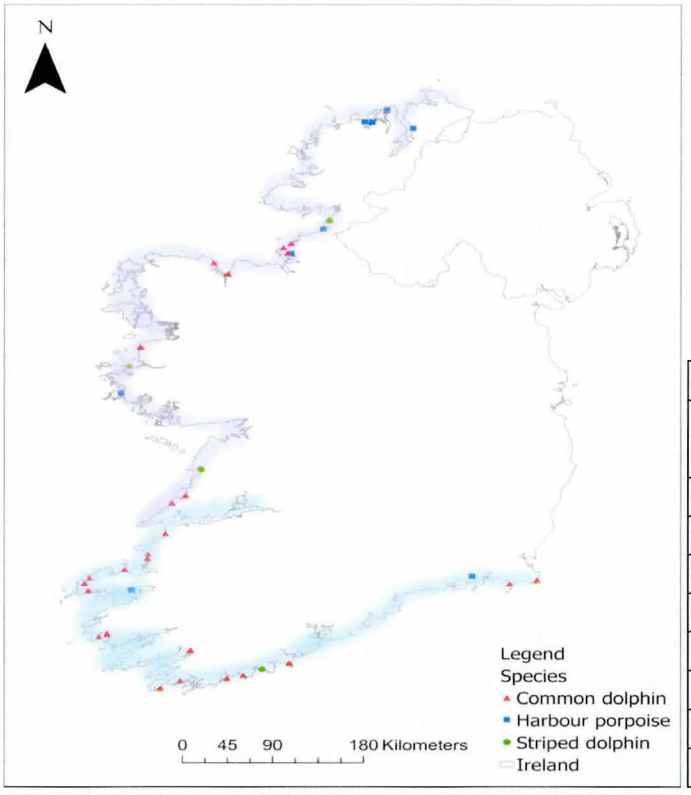
Overall, 49% (22/45) of animals were recovered from Lot 1 and 51% (23/45) from Lot 2(Figure 3a). Out of the eight counties from which animals were collected, most (29%) were collected from County Kerry, followed by Donegal (20%), Cork (16%), Mayo (11%), Clare (9%), Sligo (7%), Galway (4%) and Wexford (4%) (Figure 3a).

On review of all available strandings data, these three species were recorded stranded in a total of 16 counties throughout the whole of Ireland over the 2019 tender period (Figure 3b). Again, most strandings (17%)were reported from Co. Kerry (Figure 3b).

Of the animals necropsied during this contract, the majority were common dolphins (69%) followed by harbour porpoises (20%) and striped dolphins (11%). All animals necropsied were within decomposition codes 1 to 4 and thus suitable for inclusion within the contract.

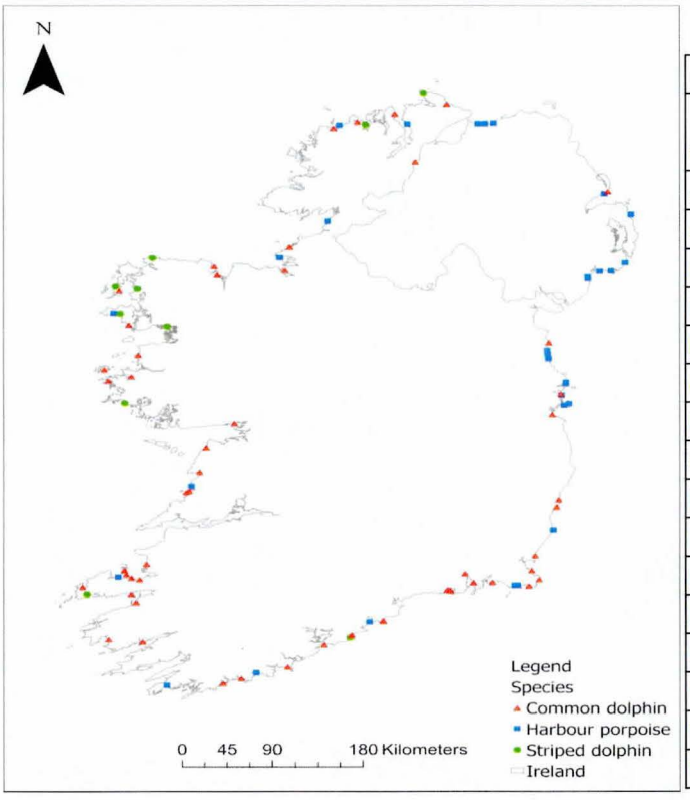
Of the 44 animals collected whose sex could be determined, 57% (25/45) were male and 43% (19/45) were female. The sex for one individual was undetermined due to extensive scavenger damage.

a)



Collected for PM	
County	**Proportion of Strandings**
Clare	0.09
Cork	0.16
Donegal	0.20
Galway	0.04
Kerry	0.29
Mayo	0.07
Sligo	0.11
Wexford	0.04

b)



All of Ireland	
County	**Proportion of Strandings**
Antrim	0.01
Clare	0.07
Cork	0.11
Derry	0.03
Donegal	0.12
Down	0.04
Dublin	0.05
Galway	0.05
Kerry	0.17
Louth	0.02
Mayo	0.10
Meath	0.01
Sligo	0.05
Waterford	0.06
Wexford	0.09
Wicklow	0.01

Figure 3. (a) Location of stranded animals collected for necropsy. Shaded region in purple represents Lot 1 covering the coastal areas of counties Donegal to County Clare inclusive, and shaded region in blue represents Lot 2 covering the coastal areas of counties Kerry to south County Wexford inclusive, accompanied by table representing percentage of strandings reported per county
(b) Location of stranded animals within the whole of Ireland over the tender period accompanied by table representing percentage of strandings reported by county.

Of the animals recovered during this tender, 98% (44/45) were found dead, while only one (2%) was reported as a live stranding. This was an adult male striped dolphin in Country Clare. Details of all animals recovered for post-mortem examination can be found in Table 1.

Table 1. Details of animals recovered for post-mortem examination.

Lot	Code	Species	Sex	Stranding Location
1	IWDG 2019_002	CD	Female	Rossnowlagh Beach, Co. Donegal
1	IWDG 2019_003	SD	Male	Rossnowlagh Beach, Co. Donegal
2	IWDG 2019_004	CD	Female	Banna Strand, Co. Kerry
1	IWDG 2019_007	CD	Female	Carrowinsky Beach, Co. Mayo
2	IWDG 2019_009	CD	Female	Kilmore Quay, Co. Wexford
2	IWDG 2019_010	CD	Female	Wine Strand, Smerwick Harbour, Co. Kerry
2	IWDG 2019_011	HP	Female	Inch Beach, Co. Kerry
1	IWDG 2019_012	CD	Male	Carrowinsky Beach, Co. Mayo
1	IWDG 2019_014	SD	Male	Renvyle, Co. Galway
1	IWDG 2019_015	HP	Female	Bunowen Beg, Ballyconneely, Co. Galway
2	IWDG 2019_018	CD	Female	Waterville, Co. Kerry
2	IWDG 2019_021	CD	Female	Ballybunnion, Co. Kerry
1	IWDG 2019_022	HP	Male	Buncrana Beach, Lough Swilly , Co. Donegal
2	IWDG 2019_023	CD	Male	Carne, Co. Wexford
2	IWDG 2019_039	CD	Female	Waterville, Co. Kerry
2	IWDG 2019_040	CD	Female	Bantry Bay, Snave Beach, Co. Cork
2	IWDG 2019_044	SD	Male	Lahinch, Co. Clare
2	IWDG 2019_045	CD	Male	Schull, Co. Cork
2	IWDG 2019_046	SD	Female	Ballinglanna Bay, Seven Heads - Co. Cork
2	IWDG 2019_047	CD	Male	Union Hall, Carrigillihy, Co. Cork
2	IWDG 2019_049	CD	Male	Ventry Beach, Co. Kerry
2	IWDG 2019_050	CD	Male	Ballinaskelligs, Co. Kerry
2	IWDG 2019_051	CD	Male	Waterville, Co. Kerry
1	IWDG 2019_058	CD	Male	Fanad Head, Co. Donegal
1	IWDG 2019_059	CD	Male	Farrihy Bay, Co. Clare
1	IWDG 2019_061	CD	Female	Streedagh Beach, Co. Sligo
1	IWDG 2019_063	HP	Female	Tullan Strand, Bandoran, Co. Donegal
1	IWDG 2019_065	HP	Male	Ballyhiernan Bay, Fanad - Co. Donegal
1	IWDG 2019_078	HP	Male	Lisadell, Co. Sligo
2	IWDG 2019_088	CD	Female	Ballyheigue, Co. Kerry
2	IWDG 2019_092	CD	Male	Feoghanagh, Co. Kerry
2	IWDG 2019_093	CD	Male	Smerwick Harbour, Co. Kerry
1	IWDG 2019_104	CD	Male	Lislary, Co. Sligo
1	IWDG 2019_120	CD	Female	Doughmore, Co. Clare
1	IWDG 2019_127	SD	Male	Lahinch, Co. Clare
1	IWDG 2019_146	CD	UNK	Enniscrone, Kilalla Bay, Co. Sligo
2	IWDG 2019_147	CD	Male	Garrylucas Beach, Co. Cork
1	IWDG 2019_151	CD	Male	Lackan Bay, Nr. Kilcummin, Co. Mayo
1	IWDG 2019_158	HP	Female	Marble Hill Beach, Dunfanaghy, Co. Donegal
1	IWDG 2019_159	CD	Male	Lisdell, Co. Sligo
2	IWDG 2019_176	CD	Female	Crookhaven, Co. Cork
2	IWDG 2019_177	CD	Male	Long Strand, Castlefreke, Co. Cork
1	IWDG 2019_180	HP	Male	Sheephaven Bay, Co. Donegal
2	IWDG 2019_181	CD	Male	Brandon Bay, Co. Kerry
1	IWDG 2019_184	HP	Female	Shroove, Inishowen Head

The sampling period for this contract was set from 1 January to 1 December 2019. The majority of animals were collected during the month of January (Figure4).

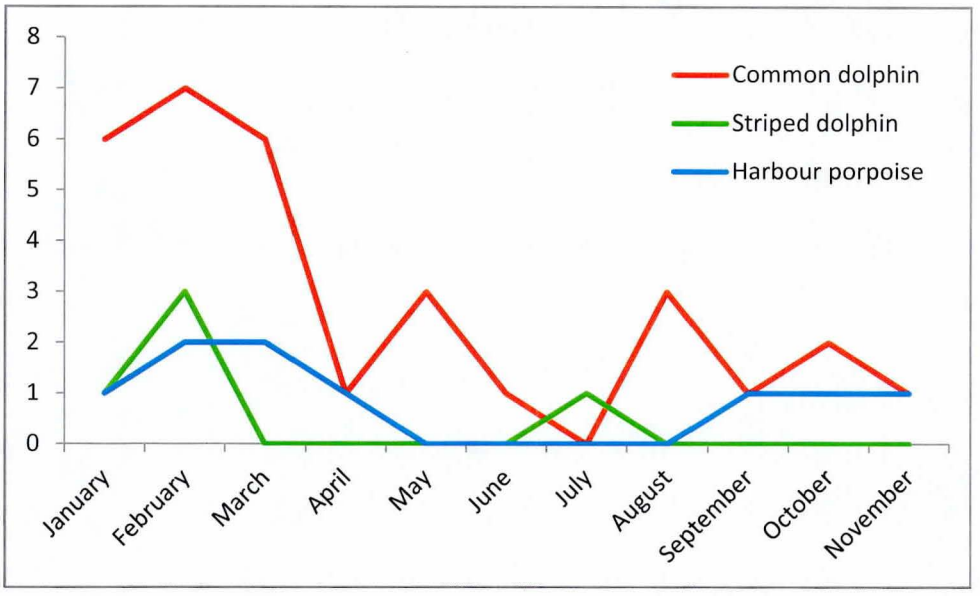


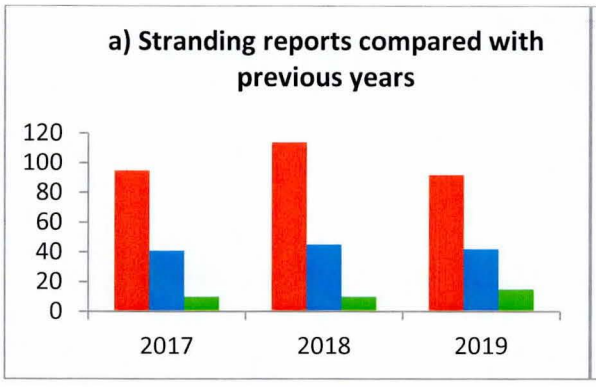
Figure 4. Months during which animals were collected for necropsy. A peak occurred in February. Collection numbers for November could have been higher as collection ceased mid-November when the final animal was recovered. This is also why December was not included in this chart.

In order to determine whether stranding patterns during this contract were consistent with previous years, the IWDG Stranding Database was interrogated to examine stranding patterns over the last three years for the relevant species (see Figures 5 and 6). Strandings during the 2019 sampling period were similar to those in 2017 for common dolphins and harbour porpoises – both species had lower stranding numbers compared to 2018, more so for common dolphins. There appears to have been a slight increase in striped dolphin strandings in 2019 compared to the previous two years (Figure 5a).

Common dolphins were the most frequently reported species during the sampling period in all three years, while striped dolphins were the least frequently stranded species reported of the three target species (Figure 5a). We also compared the suitability of stranded cetaceans for post-mortem over the previous two years by examining body condition from stranding record photos using CSIP body condition categories mentioned previously. Using records from the whole of Ireland (Figure 5b), and those from Lots 1 and 2 only (Figure 6a), once again, we see the peak in 2018 common dolphin strandings and a slight rise in the number of striped dolphins. Harbour porpoise numbers appear to have remained somewhat relatively consistent.

Figure 6b presents the total number of the three species reported with the total number suitable for post-mortem from the whole of Ireland, the two tender lots, and total number of each species collected in the current contract.

On average, animals were collected within a day of being reported and necropsied within five days from delivery to RVL Cork.



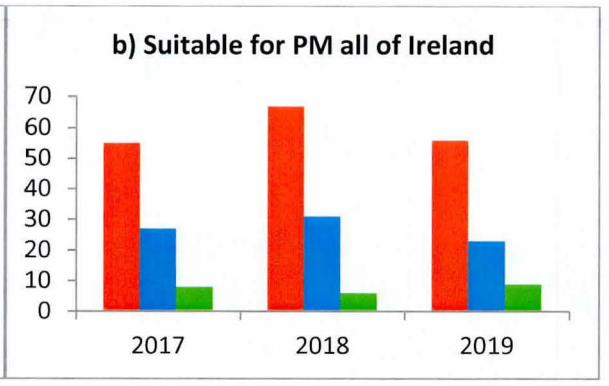
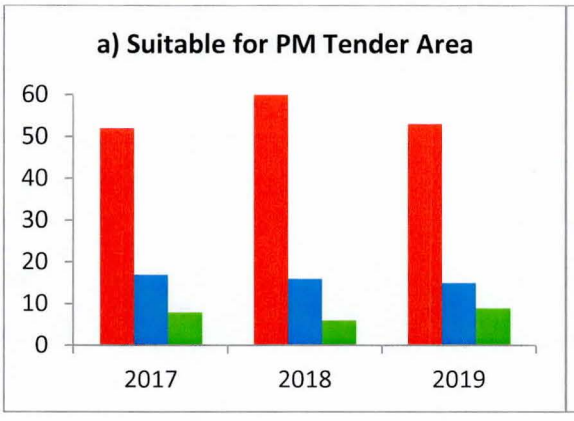


Figure 5. (a) Strandings reported for the three target species compared between 1 January and 1 December 2017, 2018 and 2019.

(b) Total suitable for post-mortem examination in whole of Ireland between the dates of 1 January and 1December 2017, 2018 and 2019. Common dolphin = red, harbour porpoise = blue, striped dolphin = green.



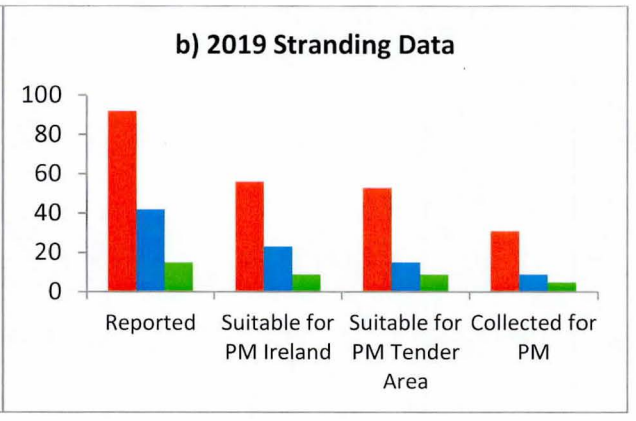


Figure 6. (a) Total suitable for post-mortem examination from Tender Lots 1 and 2 between the dates of 1 January and 1December 2017, 2018 and 2019.

(b) Comparisons for animals reported between the dates of 1 January and 1December 2019.Common dolphin = red, harbour porpoise = blue, striped dolphin = green.

Post-Mortem Results

Full necropsies were undertaken at RVL in Cork. Although outside the requirements of the tender, routine bacteriological analysis of samples is ongoing and undertaken by RVL staff in Cork City. If bacteria of significance were observed, the isolate was referred to the National Reference Laboratory for confirmation. General histopathological assessment of tissues is also ongoing and being undertaken by one of the lead scientists (JO'D).

A probable cause of death (COD) was described wherever possible based on collective findings from post-mortem and other diagnostic investigations. Criteria used to establish COD were based on those defined by the CSIP (2016) (see Appendix VIII). As per the previous contract, in the case of live strandings, this COD was attributed to those animals known or suspected (from post-mortem

examination) to have live-stranded in '*apparent good health and nutritional status and excluded severely diseased or emaciated animals that stranded alive*'. Where applicable, COD of starvation is attributed to animals that were '*severely emaciated and, following post-mortem examination, ascertained to have no other significant disease processes that could explain the poor nutritional status'*. Whereas bycatch was ascribed as a COD '*using established pathological criteria for by-catch diagnosis'* (Kuiken*et al.* 1994; Kuiken 1996).

A table of representing a summary of significant and incidental diseases from the necropsied animals for this are presented in Table 2 below. As adult common dolphin collected from county Sligo (IWDG 2019_146) was too decomposed at time of necropsy, and therefore has been excluded from the table and post-mortem results analyses.

Table 2. Summary of Cause of Death of necropsied cetaceans.

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_002	CD	Female	157	Juvenile	Malnutrition / Hypothermia	Poor body condition /hypothermia Possible brucellosis –isolate ID pending	Moderate verminous bronchopneumonia	Malnutrition / Hypothermia. Potentially due to Verminous bronchopneumonia and suspected Brucella infection	Starvation
IWDG 2019_003	SD	Male	167	Juvenile	Not established	Not apparent	Verminous gastritis Marked granulomatous mural gastritis	Not established – possible live stranding. Histopathology required	Not established– Suspected live stranding
IWDG 2019_004	CD	Female	194	Adult	Bycatch	Bycatch- PUE Severe cavitation/gas bubble lesions in liver and retroperitoneum	Poor body condition Severe gastric parasitism with ulceration. Mild verminous bronchitis	Suspected Gas embolism Live stranding	Bycatch
IWDG 2019_007	CD	Female	154.5	Sub-adult	Illthriftand endoparasitism	Very poor body condition. Severe verminous gastritis with ulceration and verminous bronchitis and pneumonia	None	Infectious disease - Endoparasitism.	Infectious Disease
IWDG 2019_009	CD	Female	207	Adult	Not established Suspected Infectious Disease	Suspected*Morganellamorganii*septicaemia	Verminous gastritis with ulceration	Suspected infectious disease - Histopathology required	Not established - Suspected Infectious Disease
IWDG 2019_010	CD	Female	179	Adult	Probable bycatch	Fractured rostrum, shallow lacerations / impression marks	Verminous bronchitis. Verminous gastritis with mucosal ulceration	Probable bycatch	Not established - Suspected Bycatch

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_011	HP	Female	135	Adult	Infectious disease	Severe, diffuse, chronic-active, verminous pneumonia Poor body condition likely due to endoparasitic lesions.	Severe, parasitic granulomatous gastritis. Nematodes in fundic stomach and trematodes in pyloric stomach. Focal dermatitis.	Infectious disease - Parasitic bronchopneumonia	Infectious disease
IWDG 2019_012	CD	Male	219	Adult	Bycatch	Marked congestion of the liver and dorsal lungs. Intraocular haemorrhage, erythema of sclera and haemorrhage in thoracic rete miriable Indentation mark on tail stock Recently ingested prey	Focal gastritis Verminous pneumonia	Probable bycatch	Bycatch
IWDG 2019_014	SD	Male	172	Juvenile	Probable live stranding	Hypostatic pulmonary congestion Presence of seaweed in airways	Verminous gastritis with ulceration. Parasitic mural gastritis (*Pholeter*sp.)	Probable live stranding. Histopathology and Brucella culture required to confirm cause of live stranding	Not Established – Suspected live Stranding
IWDG 2019_015	HP	Female	134	Sub-adult	Trauma/bycatch	Multiple bilateral rib fractures, bilateral haemothorax, laceration of the parietal pulmonary pleura Intraocular haemorrhages Rope/net indentation marks around the body (cranial to the pectoral fins)	Verminous pneumonia and bronchitis Verminous gastritis with ulceration	Bycatch	Bycatch

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_018	CD	Female	196	Adult	Physical trauma (unknown origin)	Pulmonary haemorrhage Pleural rupture	Verminous gastritis with ulceration	Physical trauma - Possible bottlenose dolphin attack - Pulmonary haemorrhage/ Pleural rupture	Physical trauma – Suspected bottlenose dolphin attack
IWDG 2019_021	CD	Female	176	Sub-adult	Infectious disease	Verminous bronchitis and pneumonia Poor nutritional state/hypothermia	Verminous gastritis	Infectious disease - Verminous bronchitis and pneumonia Possible terminal livestranding	Infectious disease
IWDG 2019_022	HP	Male	131	Juvenile	Infectious disease	Verminous bronchitis Pneumonia Obstruction of airways by clotted blood and nematode worms	Moderate verminous gastritis and ulceration Chronic trematodal gastritis with mural fibrosis Termatodalcholangiohepatitis with bile duct fibrosis.	Infectious disease - Verminous bronchitis and pneumonia	Infectious disease
IWDG 2019_023	CD	Male	138	Juvenile	Not established	Not determined	Verminous pneumonia Trematodal gastritis	Not established – Histopathology required	Not established
IWDG 2019_039	CD	Female	198	Adult	Infectious disease	Multifocal abscessation (*Photobacterium damselae)* Septic peritonitis Verminous gastritis, gastric ulceration	Verminous pneumonia	Infectious disease	Infectious disease

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_040	CD	Female	138.5	Juvenile	Starvation Probable live stranding	Moderate/poor nutritional state Ill thrift with no evidence of recent feeding Hypostatic congestion of lung	None	Starvation Probable terminal live stranding	Starvation
IWDG 2019_044	SD	Male	151	Sub-adult	Not established	Poor body condition	Verminous bronchitis Verminous gastritis	Not established due to level of decomposition and scavenger damage	Not established
IWDG 2019_045	CD	Male	196	Adult	Not established	Evidence of chronic thoracic/pulmonary pathology Haemorrhage over one scapula, loss of mandible, evidence of recent feeding	Verminous bronchitis/pneumonia Verminous gastritis	Not established due to level of decomposition and post mortem damage to the skin Possible bycatch	Not Established – Suspected Bycatch
IWDG 2019-046	SD	Female	152.5	Sub-adult	Probable live stranding	Poor body condition	None	Probable live stranding. Histopathology required to confirm	Not Established – Suspected Live Stranding Starvation
IWDG 2019_047	CD	Male	205.5	Adult	Live stranding	Ingestion of sand, stones Hypostatic pattern of congestion in lungs. *Photobacterium damselae* isolated from lungs	Verminous gastritis Verminous bronchitis/pneumonia	Live stranding	Live stranding
IWDG 2019_049	CD	Male	c160	Juvenile	Bycatch	Amputated tail stock	Verminous gastritis Verminous pneumonia	Bycatch	Bycatch

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_050	CD	Male	191	Sub-adult	Bycatch	Net marks on fins Recently ingested prey / chyle	Verminous gastritis with ulceration.Verminous bronchitis/pneumonia	Bycatch	Bycatch
IWDG 2019_051	CD	Male	220	Adult	Live stranding Infectious disease	Live stranding (hypostatic congestion of lungs). Septic ureteritis Verminous bronchitis and pneumonia	Verminous gastritis Other parasitic infections	Infectious disease Possible live stranding	Infectious disease
IWDG 2019_058	CD	Male	134	Juvenile	Infectious disease Starvation	Verminous bronchitis and pneumonia Poor body condition Lack of recent feeding	Mild trematodal(*Pholeter* sp.) gastritis	Infectious disease - pneumonia Poor body condition	Infectious disease
IWDG 2019_059	CD	Male	155	Juvenile	Not established	Not apparent	Verminous gastritis Verminous bronchitis	Not established - histopathology required	Not established
IWDG 2019_061	CD	Female	150	Sub-adult	Live stranding	Hypostatic congestion of lungs Ventral erythema	Trematodal gastritis Verminous bronchopneumonia	Live stranding	Live stranding
IWDG 2019_063	HP	Female	107.5	Juvenile	Starvation	Poor body condition	Endoparasitism	Starvation - histopathology required to establish cause	Starvation

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_065	HP	Male	147	Adult	Not established	Not apparent	Verminous gastritis withulceration. Chronic trematodal mural gastritis Chronic trematodal hepatitis with bile duct fibrosis. Dental wear/decay	Not established – High level of scavenging and relatively autolysed	Not established
IWDG 2019_078	HP	Male	111	Juvenile	Starvation	Poor nutritional condition	*Pholetergastrophila* gastritis	Starvation - histopathology required to establish cause	Starvation
IWDG 2019_088	CD	Female	174	Juvenile	Not Established - Suspected Bycatch	Intravascular gas bubble formation	Verminous bronchitis and pneumonia Parasitic gastritis	Not established Possible bycatch	Not Established - Suspected Bycatch
IWDG_2019_092	CD	Male	200	Sub-adult	Bycatch	Laceration to tail stock/tail fluke	Verminous gastritis Verminous bronchitis and pneumonia	Bycatch – Multifilament net (trawler)	Bycatch
IWDG 2019_093	CD	Male	198	Sub-adult	Bycatch	Linear lacerations on rostrum / pectoral fins.	Verminous gastritis	Bycatch – Multifilament net (trawler)	Bycatch
IWDG 2019_104	CD	Male	133	Juvenile	Starvation	Poor body condition	Verminous bronchitis	Starvation - histopathology required to establish cause	Starvation

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_120	CD	Female	189	Adult	Bycatch	Lacerations and partial amputation of dorsal fin Gas bubbles present throughout	Verminous gastritis with ulceration Verminous bronchitis and pneumonitis	Bycatch	Bycatch
IWDG 2019_127	SD	Male	215	Adult	Probable live stranding	None	None	Live stranding	Live stranding
IWDG 2019_147	CD	Male	93	Neonate	Maternal separation	Separation from the dam and consequent starvation/hypoglycaemia	*Acinetobacter lwoffii* isolate significance unknown without histopathology	Maternal separation. Histopathology required to confirm significance of *Acinetobacter lwoffii* isolate	Starvation (neonate)
IWDG 2019_151	CD	Male	238	Adult	Poor body condition	Very poor body condition Verminous gastritis Arthritis – atlanto-occipital joint	Verminous bronchitis	Infectious disease Degenerative joint disease Poor body condition	Infectious disease
IWDG 2019-158	HP	Female	111	Juvenile	Bycatch	Found entangled in fishing nets	None – marked decomposition	Bycatch - entanglement	Bycatch
IWDG 2019_159	CD	Male	96	Calf	Live stranding Maternal separation	Erythema/bruising to ventral surface	None	Maternal separation Possible terminal live stranding – histopathology required to confirm	Maternal separation

IWDG code	Species	Sex	Length	Tentative age/maturity Category	Preliminary COD categories	Significant disease or conditions	Incidental diseases or conditions	Validated COD	Finalised COD categories
IWDG 2019_176	CD	Female	199	Adult	Infectious disease Possible live stranding	Stenosis of pyloric stomach Asymmetrical congestion of lungs indicative of possible live stranding Moderate-poor body condition	Verminous gastritis Verminous pneumonia and bronchitis *Phyllobothrium*sp. burden *Monorygma* sp. burden	Stenosis presumably associated with parasitic burden of stomach wall. Extensive ulceration of cardiac stomach & parasitic gastritis likely contributors to poor body condition	Infectious disease
IWDG 2019_177	CD	Male	Adult	229	Possible live stranding	Erythema/bruising on ventral surface, asymmetrical congestion of lungs Moderate-poor body condition	Verminous gastritis with ulceration Focal suppurative pneumonia *Aeromonas bestiarum* isolated from purulent matter	Possible live stranding	Live stranding
IWDG 2019_180	HP	Male	123	Sub-adult	Physical trauma (possible bycatch)	Severe trauma resulting in multiple/extensive fracturing of ribs, lacerations on dorsal fin,redsclera,retroperitoneal gas bubbles	Verminous pneumonia and bronchitis	Physical trauma	Physical Trauma – Suspected Bycatch
IWDG 2019-181	CD	Male	198	Adult	Hepatic gas bubble disease	Severe hepatic gas bubble lesions Mild and more acute retroperitoneal gas bubbles	Verminous bronchitis and gastritis *Phyllobothrium*sp. and *Monorygma*sp infections	Hepatic gas lesions	Other - Hepatic gas bubble disease
IWDG 2019_184	HP	Female	153	Adult	Physical trauma (bottlenose dolphin attack)	Multiple fractures, haemothorax, pneumothorax, rake marks consistent with bottlenose dolphin	Verminous bronchitis, gastritis, and hepatitis	Physical trauma (bottlenose dolphin attack)	Physical trauma - Bottlenose Dolphin Attack

Case history reporting

Case history reports from the 44 individuals and their associated material were submitted to the IoZ to provide independent oversight on each case. One common dolphin was found to be in an advanced state of decomposition at time of necropsy and was therefore excluded from post-mortem analyses.

Common dolphin

Of the 30common dolphins collected for necropsy, 57% (17/30) were sexed as male and 43% (13/30) as female. Males and females ranged in total body length from 93-238 cm and 107.5-207 cm, respectively.

One of the two most common causes of death for common dolphins was '**infectious disease**", representing 23% of the sample size. The other most common cause of death was "**bycatch**", also 23%. There were three additional cases of "**not established (suspected bycatch)**".

There was one case of "**physical trauma (suspected bottlenose dolphin attack)"** which was quite interesting, as IWDG have recently documented several cases of bottlenose dolphins interacting in a seemingly aggressive manner with common dolphins. This was historically reported occurring in Irish waters (Murphy et al. 2005)

"**Hepatic gas bubble disease**" was found to be the cause of death for one adult male. For all cause of death categories, see Table 3.



Figure 7. Adult common dolphin with tail cut off. Photo Nick Massett.

Striped dolphin

Five striped dolphins were retrieved for post-mortem examination comprising four males and one female. Of the five individuals, one adult male was a known live stranding (IWDG 2019-127).

The length of the female was 152 cm, and the lengths of the males ranged from 151 – 215 cm.

Cause of death for two of these animals was found to be "**suspected live stranding**", with another case found to be **"suspected live stranding due to starvation"** as the animal was in very poor nutritional

condition. One additional case was a confirmed live stranding. The fifth animals' cause of death was not established.

Harbour porpoise

Nine harbour porpoises were retrieved for post-mortem examination during the sampling period. One female was found entangled in a monofilament net (IWDG 2019-158) (Figure 8). Lengths for males and females ranged from 111 – 147 cm, and 108 – 153 cm respectively.

The top three cause of death categories for harbour porpoises were "**bycatch**" (n=2), "**infectious disease**" (n=2), and "**starvation**" (n=2), followed by "**physical trauma (suspected bottlenose dolphin attack)"** (n=1), **physical trauma (suspected bycatch)** (n=1), and one case was **not established**.



Figure 8. Harbour porpoise in monofilament netting. Photo. James Kenny.

Table 3. Cause of death categories for all necropsied animals.

COD Categories	Species			Total
	CD	SD	HP	
Bycatch	7	0	2	**9**
Live Stranding	3	1	0	**4**
Infectious Disease	7	0	2	**9**
Starvation	3	0	2	**5**
Starvation – Neonate	1	0	0	**1**
Maternal Separation	1	0	0	**1**
Physical Trauma - Suspected Bottlenose attack	1	0	1	**2**
Physical Trauma - Suspected Bycatch	0	0	1	**1**
Other - Hepatic Gas Bubble Disease	1	0	0	**1**
Not Established - Suspected Infectious Disease	1	0	0	**1**
Not Established - Suspected Live Stranding	0	2	0	**2**
Not Established - Suspected Bycatch	3	0	0	**3**
Not Established – Suspected live Stranding due to Starvation	0	1	0	**1**
Not Established	2	1	1	**4**
Total	**30**	**5**	**9**	**44**

DATA COLLECTION FRAMEWORK

No bycaught animals were reported by the DCF observers to the Project Coordinator during from 1 January to 1 December 2019.

Discussion

We successfully recovered and necropsied the target of 44 animals, as well as the supplied seven biopsy kits and 50 biopsy punches to DCF observers. The case history reports of all 44 animals were sent to the Institute of Zoology, London for review and returned with associated comments.

One of the two most frequent cause of death (CoD) categories for all animals was **infectious disease**, representing 20% of all cases. In the future, if this project is to continue, it would be advisable to carry out further analyses of those with this CoD to examine these cases in more depth, such as undertaking histopathological assessment. This would allow researchers to gain insight into any pathological trends of concern.

The other most frequent CoD was **bycatch**, also representing 20% of those sampled. The majority involved common dolphins (n=7). In addition, there were three cases of **suspected bycatch** and one case of **physical trauma (suspected bycatch)**, bringing the total of both **confirmed and suspected bycatch** cases to 30% for the whole sample.

The majority of the animals collected for necropsy were recovered from County Kerry, most likely due to the well-established network of IWDG members reporting from that area and the high number of strandings in this county.

Common dolphins represented 69% of the animals recovered. Prior to 2011, numbers of common dolphin strandings were similar to those of harbour porpoises, being either the first or second most frequently reported species each year (McGovern *et al.* 2016). Since 2011, recorded strandings for this species have increased out of proportion with other cetaceans. Between 2006 and 2010, the IWDG received 134 records for this species; an average of 27 animals per year. However, in the years 2013 to 2019, 595 common dolphin strandings were recorded averaging 85 per year (IWDG Stranding Network). The reason for this remains unclear, although interactions with pelagic trawl fisheries have been identified (Anon 2013). Common dolphin strandings occur mainly on the west and south coasts and peak in the months of January, February, March and December (McGovern *et al.* 2016). Although this could in part be due to increased observer effort over the years, if this were the only explanation, we would expect a similar increase to be reported for other dolphin species. There is recent evidence of an increase in common dolphin abundance in inshore waters to the south of Ireland in the Bay of Biscay (Astarloa et al. 2021), which has been associated with changes in climate indices and prey biomass. If a similar increase has occurred further north off Ireland, this may in some part explain increased stranding rates as strandings would increase with increased abundance. In recent years, a large scale increase in the abundance of common dolphins was reported in the North-east Atlantic, with more than 467,673 common dolphins observed throughout the North-east Atlantic in July 2016 during the SCANS-III survey, in addition to 13,632 dolphins in Irish waters, as part of the ObSERVE project; compared to 56,221 common dolphins reported for shelf waters for the year 2005, and 116,709 common dolphins for offshore waters for the year 2007. This may be due to a large-scale re-

distribution in the region, include latitudinal or offshore–inshore movements, or a mixture of the two (Murphy et al. 2019).

Harbour porpoises are consistently the second most frequently stranded cetacean species in Ireland, only recently been surpassed by the common dolphins. They have been recorded stranded on all coasts, although higher rates along the south and east coasts have been reported with peaks in strandings from December to March (McGovern *et al.* 2016). The east coast was not sampled during this project as it was excluded from the tender area. Stranding records have shown a consistent trend with around 30 reported per year in Ireland (IWDG, 2017).

Striped dolphin strandings are less frequent relative to other cetacean species, accounting for around 5% of all strandings in a typical year. Since 2010, 118 stranding records were received for this species; an annual average of slightly more than 11 animals. This varied from a low of 8 records in 2012 to a peak of 18 in 2014. Small numbers of strandings are recorded throughout the year, mainly from the south and west coasts (IWDG Stranding Network).

Table 4. Summary of animals collected from 2017 to 2019.

	2017	EXTENTION	2018	2019	TOTAL
Lot 1	13	7	21	22	63
Lot 2	11	12	9	23	55
Male	14	8	17	25	64
Female	9	11	13	19	52
CD	19	17	17	31	84
SD	2	1	7	5	15
HP	3	1	6	9	19
Found dead	14	16	28	44	102
Found alive	10	3	2	1	16

A rise in the number of confirmed and suspected bycatch cases in 2019 is apparent when comparing results from 2017 and 2018. In 2017/2018 we reported 13.7% of CoD as bycatch, compared to 29.5% in 2019. There are several possible explanations for this, the first one being that more animals were sampled in 2019 at the height of the winter peak from January to March (n=28) compared to the previous year (n=19) and over half of all bycatch cases in 2019 were collected during this peak stranding period. In addition, the animals collected during the winter peak in 2019 were overall in better condition compared to those in 2017/2018. This was most likely due to the fact that there was far less pressure to collect a target number of animals in a much shorter period of time as was the case during 2017 and 2018. Carcass condition can significantly affect the pathologist's ability to identify bycatch, as the evidence can be quite subtle, and become increasingly difficult to observe and diagnose as decomposition progresses. The pressure to reach a target number of animals in a shorter period of time during 2017/2018 also led to the use of frozen animals which were collected outside of the tender period, as well as the collection of more live stranded individuals; 15 known cases compared to just one in 2019. It is generally assumed that live stranded animals are far less likely to have stranded due to interaction with fishing gear.

This scheme has demonstrated that it is possible to recover a sample of stranded dolphins and porpoises and transport to a Regional Veterinary Lab in a timely manner for post-mortem examination. It has also demonstrated an effective collaboration between a state agency, third level institute and a non-government organisation. This reflects well for a continuation of necropsies of stranded cetaceans to provide a longer time series including inter-annual and seasonal coverage and a significant sample size.

Consideration should be given to extend this programme to include **bottlenose dolphins** (*Tursiops truncatus*), an Annex II species requiring special conservation measures, and other species which, although strand infrequently, would be of ecological interest (e.g. **Atlantic white-sided dolphin** (*Lagenorhynchus acutus)*, **white-beaked dolphin** (*Lagenorhynchus albirostris)*).

In addition, the geographic scope of sampling should be extended to include the east coast, in order to increase the number of harbour porpoises obtained for necropsy. Two porpoises management units/assessment units have been proposed for Irish waters, west Scotland/Ireland and Celtic and Irish Seas (NAMMCO & IMR, 2019). Thus, sampling of the east coast would be required for a full assessment of the Celtic and Irish Seas management unit/assessment unit.

Further recommendations for future work would include the provision of additional resources in order to continue providing bacteriology and histopathology assessment services, as one of the most common causes of death for this contract was **infectious disease**. For several cases, this was generously carried out by the RVL, and was instrumental in determining causes of death for those animals.

The number of animals presenting with signs of bycatch was quite high and worthy of further investigation. We recommend the establishment of a long term post-mortem scheme in order to examine the trend in causes of death, including the contribution from fisheries bycatch, by gathering the necessary evidence to advise government on potential mitigation efforts. It is advisable to monitor and examine a certain percentage of stranded cetacean species in order to monitor the general health of Irelands' cetaceans, and identify, as this project has done, any trends which need to be addressed.

A delay with reporting arose due to constrained resources at the Regional Veterinary Laboratory in Cork, specifically available personnel. As the involvement of the RVL was voluntary and in addition to their ongoing obligations, this put significant pressure on one pathologist to carry out and report on all of the post-mortem examinations. If the post mortem scheme was to continue, we recommend there be multiple pathologists formally dedicated to the scheme to ensure reports are returned in an appropriate timeframe, and that a contract be negotiated to provide these pathological services.

Acknowledgements

The Marine Biodiversity Scheme is established under Union Priority 1 (Sustainable Fisheries) and Union Priority 6 (Integrated Maritime Policy) of Ireland's Operational Programme (OP) under the EMFF and is co-funded by the Irish Government and the EU. We would like to thank the Contracting Management and Steering Group, especially Drs Leonie O'Dowd, Helen McCormick and Oliver Tully of the Marine Institute and Drs Oliver Ó Cadhla, Ferdia Marnell and David Tierney of the NPWS.

We would like to thank Barry Keane, Mark Reader, Gary Kett, Meadhbh Quinn, Nick Massett, Louise Overy, Tony Murray and Frances Bermingham for providing assistance in recovering animals. We would like to thank the IWDG stranding network members whose records made this contract possible, and the DCHG for funding the IWDG Stranding Scheme. Finally, we would like to acknowledge the support of Michéal Casey and the RVL staff at RVL Cork, Cosme Sanchez and Aideen Kennedy, for providing additional support during necropsy examinations.

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Appendices

Appendix I: IWDG Case History Cover Page














Case History Report

IWDG Stranding Code: _____ **Species**: _____

Date of Necropsy: _____ **Pathologist(s)**: _____

Case History (Provide brief summary of where/how the animal was initially found and necropsy results):

Cover photo:

Approved by PI: _____**Date:**_____
Approved by IoZ: _____ **Date**: _____

Appendix II:
CSIP Guidelines for the Postmortem Examination and Tissue Sampling of Cetaceans during Stranding Events

CONTENTS

a) Introduction
b) Basic measurements
c) External examination
d) Examination of abdominal organs (except G.I. tract, pancreas, and spleen)
e) Examination of organs of head, neck and thorax
f) Examination of the G.I. tract, pancreas and spleen

a) Introduction

These guidelines are meant primarily as an aid to veterinary surgeons carrying out post-mortem examinations on stranded cetaceans involved in the UK. Post-mortem examinations are carried out under the aegis of the UK Cetacean Strandings Investigation Programme, which is jointly funded by Defra and the Devolved Administrations. This protocol is based partly on guidelines written by Dr John Baker and Dr Thijs Kuiken and partly on the protocol produced at the European Cetacean Society workshop on cetacean pathology, held in Leiden, The Netherlands, in September 1991[4].

All structures must be examined visually and by palpation, making incisions into the organs. A full post-mortem record must be kept, preferably on the standard "Cetacean Post-mortem Report" form for recording animals involved in a stranding.

Lesions in any organs should be described, photographed and sampled. The description should include the size, location, colour, texture, shape, and the nature of the transition from normal to abnormal tissue. Photographs should include a ruler, scale bar or similar object to indicate the size of the lesion. According to the suspected aetiology of the lesion, samples should be collected for bacteriological examination (especially if the lesion is of a purulent nature) or for virological examination. In all cases, a sample of the lesion should be preserved for histopathological examination.

The post-mortem examination need not take place in the order described below. However, samples for bacteriological and virological examination need to be taken as early as possible. Also, examination of the G.I. tract should be left until last to prevent cross-contamination with enteric micro-organisms.

Paul Jepson and Rob Deaville
London, January 2010

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[4]Kuiken, T. and Garcia Hartmann, M. (eds.) (1991) Proceedings of the first European Cetacean Society workshop on cetacean pathology: dissection techniques and tissue sampling. ECS newsletter 17, Special issue: 39pp

b) Basic measurements

photographs

Photographs should be taken of the lateral views of the whole body, from both sides. Particularly in bottle-nosed dolphins, photographs should be taken of the dorsal fin, also from both sides. In baleen whales, the ventral side of the tail flukes should be photographed. Photographs should also be taken of any lesions of interest found during the post-mortem, including the use of a scalebar.

body condition

Estimate the body condition- that is the state of decomposition of the carcass, using the categories of the condition code[5]. Where possible, note the presence and extent of rigor mortis.

body weight

If recording the body weight is impossible, collect the heart weight so that the body weight can be estimated[6].

body length

Measure the body length by placing the carcass on its belly, holding a measuring tape or ruler next to the carcass in a straight line parallel to the longitudinal body axis and measuring the distance between the notch in the tail flukes and the tip of the upper jaw.

body girth

Measure the body girth at the level of the anterior insertion of the dorsal fin. If it is impossible to move the carcass, a half circumference measurement may be taken and doubled.

c) External examination

nutritional state

Indicate the nutritional state of the carcass, using one of the following three categories:
-good: the aspect of the upper flanks on either side of the dorsal fin is rounded;
-moderate: the aspect of the upper flanks on either side of the dorsal fin is sloping;
-poor: the aspect of the upper flanks on either side of the dorsal fin is hollow (in these animals, one can make out the transverse processes of the lumbar vertebrae, and there is an indentation dorsally just behind the head).

---

[5]The body condition, or state of decomposition of a carcass, can be described using the following condition code:

1) **live** *(becomes code 2 at death)*
2a) **extremely fresh** *(as if just died, no bloating, meat is considered by most to be edible)*
2b) **slight decomposition** *(slight bloating, blood imbibition visible)*
3) **moderate decomposition** *(bloating, skin peeling, penis may be extended in males, organs still intact, excluding postmortem damage)*
4) **advanced decomposition** *(major bloating, skin peeling, penis extended in males, organs beyond recognition, bones exposed due to decomposition)*
5) **indeterminate** *(mummified carcass or skeletal remains, no organs present)*

[6] The body weight can be estimated from the heart weight using the formula $\log W = (\log H + 2.2) / 0.984$, with H = heart weight and W = body weight, both in kg.

body orifices

Examine the body orifices (mouth, eyes, ear openings, blow-hole, anus, genital slit and mammary slits) for lesions and any discharge. Collect and preserve left and right eyes separately in 10% formalin if lesions are noted.

epidermis

Examine the animal for external lesions, including evidence of physical trauma and/or fresh contra- or con-specific rakemarks and photograph and sample these accordingly. Examine the skin carefully for any ectoparasites. These are most likely to be found in or near the body orifices and next to the fins and flukes. Take a 4 cm^2 piece of epidermis down to the blubber for DNA-studies, and freeze.

milk

Massage the skin in the area cranial to the mammary slits in a caudal direction to express any fluid present in the mammary glands. Note the volume, colour, and consistency of the fluid.

blubber

Cut a transverse strip of blubber about 2 cm wide from the anterior insertion of the dorsal fin, from the mid-dorsal to the mid-ventral region. Make sure to cut at right-angles to the surface of the skin. Measure the thickness of the blubber strip with a ruler 2cm lateral to the dorsal mid-line, mid-laterally, and 2cm lateral to the ventral mid-line. (Using this method, the tension of the blubber tissue is relieved before measuring.)

Cut a strip of blubber a few cm wide and a few cm long at the level of the caudal insertion of the dorsal fin. Make sure to cut at right-angles to the surface of the skin. From this blubber strip, take 2x20 g cross-sectional samples of blubber for organochlorine analysis. It is important to take samples of the whole layer, from the skin to the muscle. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes.

muscle

Take 2x20 g muscle samples for toxicological analysis, at the same location as and directly below the blubber sample, at the level of the caudal insertion of the dorsal fin. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes. Take a 1 cm^3 sample of both the longissimus dorsi and abdominal muscle in 10% formalin (for histopathology).

With the animal on its right side (if possible) make a mid-line ventral incision from the symphysis of the mandible to a short distance posterior of the anus, circumventing the genital slit and anus. From the posterior end of the ventral incision make a second one almost to the dorsal mid-line. Reflect the skin and blubber off the uppermost side. Any parasites in the blubber should be noted. They may occur as white cysts less than 1 cm in diameter, often in the ano-genital region or the dorsal aspect of the chest wall.

mammary gland

In females, examine the mammary gland for pathological changes and parasites. Collect a cross-sectional slice of about 1 cm thick from halfway along the length of the left mammary gland for histopathological examination, and place in 10% formalin.

subcutaneous tissue

Examine the subcutaneous tissue for the presence of bruises and parasites.

scapula

Remove the left scapula.

d) Examination of abdominal organs (except G.I. tract, pancreas, and spleen)

Remove the left abdominal wall, freeing the testis or ovary and uterus. Any parasites in the abdominal wall (for instance cysts under the peritoneum) should be noted. Remove the left thoracic wall, for example with bone shears.

virology samples

Before handling the internal organs, take a 1 cm^3 sample of lung tissue from the cranio-ventral part of the left lung and a $1cm^3$ sample of kidney tissue from the left kidney for virologicalexamination. Also take a sample of lung tissue from the cranio-ventral part of the left lung, a sample of kidney tissue from the left kidney and a sample of liver tissue from the left lobe of the liver for bacteriological examination.

bacteriology samples

gas bubbles in the mesentery

Examine the gastrointestinal tract for any abnormalities including gas bubbles in the mesenteric and intestinal veins. If any are present, take photos with a scalebar and sample tissue for histological examination.

Sever the intestine close to the anus and the oesophagus close to the diaphragm. Working forward along the dorsal aspect of the abdominal cavity, remove the stomach, intestines, pancreas, spleen and mesenteric lymph node, attached to each other, from the carcass. Leave the examination of the G.I. tract to the end of the post-mortem examination to prevent cross-contamination of other tissues with enteric micro-organisms.

pericardial fluid/ serum

Collect sample of pericardial fluid after incising the pericardial sac. Collect any blood present in the heart lumen, to obtain serum for serological examination. Even if it is haemolytic, it is still of value.

urinary bladder

Open and examine the bladder in situ, noting the contents, if any. Preserve a $1cm^3$ sample of the bladder in 10% formalin (for histopathology).

female reproductive tract

In females remove the entire reproductive tract, open the vagina and uterus, note any corpora lutea, corpora albicantia or follicles on each ovary and then place the ovaries separately in 10% formalin for reproduction studies. Preserve a $1cm^3$ sample of the uterus in 10% formalin (for histopathology). Describe the state of sexual maturity.

foetus

If a foetus is present, record the weight, length, sex and the state of decomposition. The whole foetus and its placenta can be wrapped in hexane-washed aluminium foil and stored frozen for organochlorine analysis.

male reproductive tract

In males remove the testes and weigh them separately after removing the epididymis. After incision and examination, place the testes in 10% formalin for reproductive studies. Place a cross-sectional slice about 1 cm thick from mid-way along the length in 10% formalin. Examine the penis and preputium. Describe the state of sexual maturity where possible, final confirmation may be dependent on histological examination.

adrenal glands

Remove and examine the adrenal glands, and place a cross-sectional slice about 1 cm thick from the middle of the left adrenal gland in 10% formalin.

kidneys

Examine the peri-renal vasculature for any gas bubbles. Describe and photograph if present and take samples of any associated lesions for histological examination. Remove the kidneys from the body cavity and weigh them. Incise both kidneys longitudinally, and if possible, strip the capsule. Then, take 2x20 g samples for toxicological analysis

from halfway the length of the left kidney. These samples should be cross-sectional and include both medullary and cortical tissue. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes. Preserve 1 cm^3 from a kidney in 10% formalin for histopathological examination.

liver

Examine the liver for any evidence of gas cavities beneath the capsule. Describe and photograph if present. Remove and weigh the liver. Examine both surfaces and make multiple incisions into the substance. Examine the parenchyma for the presence of any gas cavities. Describe and photograph if present and take samples of any associated lesions for histological examination. Examine the bile ducts for parasites. Then, take 2x20 g for trace metal analysis. Wrap them in hexane-washed aluminium foil and freeze. Alternatively, they can be placed in Sovirel glass tubes. Place 1 cm^3 of liver tissue in 10% formalin for histopathological examination.

thyroid

e) Examination of organs of head, neck and thorax

Carefully remove the superficial muscles overlying the trachea and larynx to expose the thyroid gland. Examine this tissue and preserve 1 cm^3 of tissue in 10% formalin for histopathological examination.

Incise along the internal aspects of both mandibles and free the tongue. Once the tongue is free reflect it backwards and cut the hyoid bones close to the skull.

Free the larynx from the sphincter muscle holding it in place and pulling the tongue backwards incise along the neck to free the trachea and oesophagus. Then, incising

tongue

dorsally and ventrally in the thoracic cavity, free the heart and lungs. Note any attachments of the lungs to the thoracic walls. This procedure should give you the

oesophagus

tongue, larynx, trachea, oesophagus, thymus, heart and lungs all still fastened together.

respiratory tract

Examine the surface of the tongue.

Open the oesophagus longitudinally and check for lesions or parasites.

Look for evidence of pulmonary hypostasis and photograph if present. Open the larynx, trachea and major bronchi longitudinally. Look for evidence of aspiration of seawater, mud or beach material. Photograph if present. Make multiple incisions into the substance of both lungs. Any parasites may be collected. Two pieces of lung (about 1 cm^3) from the hilus and periphery of the left lung, and the same from the right lung, should be collected in 10% formalin for histopathological examination. The samples should include part of the major bronchial tree. Open all major branches of the pulmonary veins and examine for the presence of parasites. Examine the bronchial and

thymus

so-called "pulmonary associated" lymph nodes. The latter can be found about halfway along the ventral edges of each lung. Cut a 1 cm thick cross-sectional slice from the middle of the left pulmonary associated lymph node, and place it in 10% formalin for histopathological examination.

heart

Examine the thymus, if present (noting the presence of any macroscopic cysts). Place 1 cm^3 of thymus in 10% formalin for histopathological examination.

Separate the heart from the lungs by cutting through the major blood vessels where they enter the heart. Open the left and right ventricles and atria for examination and to take out any blood clots present. Any parasites should be noted. Weigh the heart. Cut a 1 cm thick slice of heart tissue, to include a piece of the wall of the left ventricle and of the atrioventricular septum, and place it in 10% formalin for histopathological examination.

acoustic fat and tympanic bullae

Examine acoustic fats and note and photograph any haemorrhages. Take a 1 cm^3 section and place in 10% formalin. Examine the tympanic bullae if possible (which in cetaceans are not part of the skull but lie free just behind the mandibles). Carefully dissect each tympanic bulla (and associated cochlea) free of their connective tissue attachments to the skull. Examine the internal cavity of each bulla and note the presence of any nematodes or abnormalities. Preserve the left tympanic bulla/cochlea and right tympanic bulla/cochlea separately in 10% formalin if the carcass is in a suitable condition.

teeth (baleen plates)

If possible, remove two sets of (at least) 4 teeth from the middle of the lower jaw for ageing, and store frozen (separately). (In baleen whales, cut off 2 baleen plates as near as possible to their basis and store frozen.)

spinal cord

Remove the head at the atlanto-occipital joint; collect a sample of cervical spinal cord and fix in 10% formalin.

skull

If possible, open the skull, and examine the brain. The skull can be opened by making a vertical cut parallel and about 2 cm posterior to the transverse dorsal ridge which is clearly visible and palpable on top of the skull. The second cut should be made in the horizontal plane, through the occipital condyles, making sure to leave the posterior portion of the condyles on the skull, so that the condylo-basal length can still be measured. Both cuts should be extended until they meet each other. The separated piece of skull can then be pried loose using a chisel or flat-bladed screwdriver, and the brain can be removed.

brain

Examine for the presence of bubbles within the vasculature in areas of the brain not damaged during skull excision. Describe and photograph any suspected bubbles/lesions. Take a 1 cm^3 sample of brain for virological examination and bacteriology and morbillivirus samples as described previously. Where possible, place the rest of the brain in 10% formalin for at least a week. To allow faster fixation, a longitudinal incision can be made in the cerebrum to expose the lateral ventricles. When it is fixed, make multiple slices into the tissue to look for pathological lesions, including the presence of parasites. Take 1 cm^3 samples of the cortex, cerebellum, and medulla for histopathological examination. Where possible, dissect the pituitary gland from the pituitary fossa (located in the cranial floor) and preserve in 10% formalin.

spleen

Skulls may be stored frozen for morphometrics studies or museum archive. However, examination of the brain and spinal cord takes precedence.

pancreas

f) Examination of the G.I. tract, pancreas and spleen

mesenteric lymph node

Examine and weigh the spleen and put a piece (about 1 cm^3), including a section of capsule, in 10% formalin for histopathological examination. One often finds smaller accessory spleens near to the main spleen.

stomach

Examine the pancreas. Look for parasites, particularly in the pancreatic ducts. Place a 1 cm^3 piece of pancreas tissue in 10% formalin for histopathological examination.

Examine the mesenteric lymph node and put a 1 cm thick cross-sectional slice from halfway its length in 10% formalin for histopathological examination.

intestine

Open the cardiac section of the stomach. Note and photograph if watery fluid or ingested beach material is present in the lumen. Collect any fish bones, otoliths and other food remains and preserve in 70% ethanol or freeze for prey studies. Any parasites should be noted and the approximate burden described. Describe any lesions, including the distribution and size of any ulcers. Open the fundic and pyloric sections of the stomach. Any food material should be preserved for prey studies as for the cardiac section. Any nodules in the walls of the fundic and pyloric sections should be noted and, if they are found, attempts should be made to express the contents. Any parasites found in the contents should be noted.

Open the intestinal tract at several points along its length. Make note of any contents and/or lesions and any parasites that are found.

Appendix III:
CSIP PM Data collection sheets

CETACEAN POSTMORTEM REPORT

When this report has been completed, please send a copy to: UK Cetacean Strandings Investigation Programme, The Wellcome Building, Institute of Zoology, Regent's Park, London, NW1 4RY, UK. Tel: 020 7449 6672 or 6691 Fax: 020 7483 2237 email: rob.deaville@ioz.ac.uk or paul.jepson@ioz.ac.uk

SW NO. : ..... PM NO. : .....
SPECIES : .... SEX : ....
LOCATION FOUND : ....
DATE FOUND : .. ..FOUND BY : ....
....
PATHOLOGIST : .. ..DATE OF PM : ....

FROZEN?: Y / N

1. BASIC MEASUREMENTS

BODY CONDITION USING CONDITION CODE :

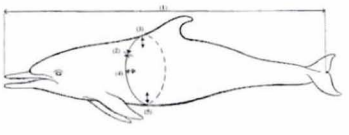
Condition code:

1) **live** (becomes code 2 at death)
2a) **extremely fresh** (as if just died, no bloating, meat is considered by most to be edible)
2b) **slight decomposition** (slight bloating, blood imbibition visible)
3) **moderate decomposition** (moderate bloating, skin peeling, penis may be extended in males, organs still intact, excluding postmortem damage)
4) **advanced decomposition** (major bloating, skin peeling, penis extended in males, organs beyond recognition, bones exposed due to decomposition)
5) **indeterminate** (mummified carcass or skeletal remains, no organs present)

PHOTOGRAPHS TAKEN
-lateral views whole body, both sides: Y/N
-lateral views dorsal fin, both sides: Y/N
-baleen whales: ventral view tail flukes: Y/N
-other photographs (list):
- -
- -

BODY WEIGHT (kg):. . . . .

LENGTH, GIRTH AND BLUBBER THICKNESS (see diagram below):
-tip upper jaw to tail notch (cm) (1):. . . . .
-girth in front of dorsal fin (cm) (2):. . . . .
-blubber thickness in front of dorsal fin:
-dorsal mid-line (mm) (3):. . . . .
-lateral (mm) (4):. . . . .
-ventral mid-line (mm) (5):. . . . .



2. GROSS PATHOLOGICAL EXAMINATION

Encircle the appropriate category:

NE = not examined
NAD = nothing abnormal detected
A = abnormal (describe fully in section 5)

EXTERNAL EXAMINATION

NE NAD A -body orifices
NE NAD A -fins and flukes
nutritional state: good / moderate / poor

INTEGUMENT

NE NAD A -epidermis
NE NAD A -blubber
NE NAD A -subcutaneous tissue
NE NAD A -mammary glands

MUSCULOSKELETAL SYSTEM

NE NAD A -skull
NE NAD A -other bones
NE NAD A -back muscle mass
NE NAD A -other muscles

NERVOUS SYSTEM

NE NAD A -brain
NE NAD A -spinalcord
NE NAD A -peripheralnerves

CARDIOVASCULAR SYSTEM

NE NAD A -pericardialsac
NE NAD A -myocardium
NE NAD A -valves
NE NAD A -arteries, veins

RESPIRATORY SYSTEM

NE NAD A -nasalcavity
NE NAD A -sinuses
NE NAD A -trachea, bronchi
NE NAD A -lungs
NE NAD A -pleura/pleuralcavity

ALIMENTARY SYSTEM

NE NAD A -mouth
NE NAD A -oesophagus
NE NAD A -cardiacsectionstomach
NE NAD A -fundic section stomach
NE NAD A -pyloric section stomach
NE NAD A -intestine
NE NAD A -anus
NE NAD A -liver
NE NAD A -pancreas
NE NAD A -peritoneum/peritonealcavity

UROGENITAL SYSTEM

NE NAD A -kidneys
NE NAD A -ureters
NE NAD A -urinarybladder
NE NAD A -urethra
NE NAD A -ovaries/testes
NE NAD A -uterus
NE NAD A -vagina/penis
NE NAD A -vulva/preputium

LYMPHATIC AND ENDOCRINE SYSTEMS

NE NAD A -adrenal glands
NE NAD A -thyroid gland
NE NAD A -spleen
NE NAD A -thymus
NE NAD A -lymph nodes

3. CHECKLIST OF STANDARD SAMPLES

In each square, enter: ☑ *= sample taken*
Blank = sample not taken or not present
Record any extra samples taken in section 4.

Weights (optional)
left testis (g):. . . . . .
right testis (g):. . . . . .
heart (g): . . . . . .
cardiac section stomach (g): . . . . . .

S/C's and Parasites

☐ food remains

	Ethanol	Frozen
from:	☐	☐
. . . . .	☐	☐
. . . . .	☐	☐
. . . . .		

☐ parasites from: (pref. all- stored in ethanol)
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

☐ lung	1 cm^3

Freeze at -20°C

☐ epidermis	4 cm^2
☐ blubber	2 x 20g
☐ liver	2 x 20g
☐ muscle	2 x 20g
☐ serum or PCF	up to 20 ml
☐ teeth	>4 (2 sets)
☐ baleen plates	>4 plates
☐ urine	up to 10 ml
☐ faecal material	up to 50 ml
☐ brain (RNAlater)	0.5 cm^3
☐ spleen (RNAlater)	0.5 cm^3
☐ lung (RNAlater)	0.5 cm^3

Virology (freeze at -80°C)

☐ brain	1 cm^3
☐ spleen	1 cm^3

10% Formalin

- ☐ adrenal glands — both
- ☐ bladder — 1 cm^3
- ☐ cerebrum — 1 cm slice
- ☐ cerebellum — 1 cm slice
- ☐ heart — 1 cm^3
- ☐ kidney — 1 cm^3
- ☐ liver — 1 cm^3
- ☐ lung — 1 cm^3 x
- ☐ mammary gland — 1 cm slice
- ☐ mesenteric ln. — 1 cm slice
- ☐ pancreas — 1 cm^3
- ☐ pulm. ass. ln. — 1 cm slice
- ☐ skin and blubber — 1 cm^3
- ☐ spinal cord — 1 cm^3
- ☐ spleen — 1 cm^3
- ☐ testes — both/slices
- ☐ thymus — 1 cm^3
- ☐ thyroid — 1 cm^3
- ☐ uterus — 1 cm^3
- ☐ brain — whole (in 15% formol saline)
- ☐ ovaries — both (separately if immature)

Bacteriology

- ☐ brain — swab/block
- ☐ kidney — swab/block
- ☐ liver — swab/block
- ☐ lung — swab/block
- ☐ spleen — swab/block
- ☐ CSF — swab/fluid

4. LIST OF EXTRA SAMPLES

Extra samples of lesions taken for histological examination (list):	Extra samples of lesions taken for bacteriological examination (list):	Other extra samples taken (list):
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
	-	

Optional (if time and storage allows)

Freeze at -20°C

☐ foetus/placenta	whole
☐ scapula	whole
☐ skull	whole
☐ milk	up to 20 ml
☐ eyes	both

Virology (freeze at -80°C) or RNA later (freeze at -20°C)

☐ pituitary	section
☐ cranial nerve	section

Fixed tissue)

☐ pituitary	whole
☐ tympanic bullae/cochlea	both (only in 2a cases)
☐ *longissimus dorsii* muscle	slice (held under tension)
☐ *rectus abdominus* muscle	slice (held under tension)

5. DESCRIPTION OF ABNORMALITIES ON GROSS PATHOLOGICAL EXAMINATION
(add extra pages if necessary)

PRELIMINARY DIAGNOSIS OF GROSS PATHOLOGICAL EXAMINATION (in order of importance):

a.

b.

c.

d.

e.

6. RESULTS OF HISTOLOGICAL EXAMINATION (add extra pages if necessary)

7. RESULTS OF BACTERIOLOGICAL EXAMINATION

Heart blood: .....

Lung: .....

Liver: .....

Kidney: .....

Other: .....

.....

8. MISCELLANEOUS RESULTS

9. FINAL DIAGNOSIS (in order of importance):

a.

b.

c.

d.

Appendix IV:
Final Cetacean Post-Mortem Report

REFERENCE NUMBER: SW2017/
POST-MORTEM NUMBER:
HISTOLOGY NUMBER:
SPECIES:
SEX:
DATE FOUND:
LOCATION FOUND:
NATIONAL GRID NUMBER:
DATE OF POSTMORTEM:
PATHOLOGIST: Rob Deaville

1. BASIC MEASUREMENTS

FROZEN:
CARCASS CONDITION:
BODY WEIGHT: kg
LENGTH, GIRTH AND BLUBBER THICKNESS:

-tip upper jaw to tail notch: cm
-girth in front of dorsal fin: cm

-blubber thickness in front of dorsal fin:

-dorsal mid-line: mm
-lateral: mm
-ventral mid-line: mm

2. GROSS POSTMORTEM

External examination

Nutritional state:
Body orifices:
Ectoparasites:
Fins and flukes:

Integument

Epidermis:
Blubber:
Subcutaneous tissue:
Mammary glands:

Musculoskeletal system

Skull:
Other bones:
Back muscle mass:
Other muscles:

Nervous system

Brain:
Spinal cord:
Peripheral nerves:

Cardiovascular system

Pericardial sac:
Myocardium:
Valves:
Arteries, veins:

Respiratory system

Nasal cavity:
Sinuses:
Trachea, bronchi:
Lungs:
Pleura/pleural cavity:

Alimentary system

Mouth:
Oesophagus:
Cardiac section stomach:
Fundic section stomach:
Pyloric section stomach:
Duodenum/small intestine:
Large intestine:
Anus:
Liver:
Pancreas:
Peritoneum/peritonealcavity:

Urogenital system

Ovaria/testes:
Uterus:
Vagina/penis:
Kidneys:
Ureters:
Urinary bladder:
Urethra:

Lymphatic and endocrine systems

Adrenals:
Thyroid:
Spleen:
Thymus:
Lymph nodes:

3. HISTOLOGY

4. BACTERIOLOGY

5. MISCELLANEOUS

DIAGNOSIS

I *Significant diseases or conditions* thought to contribute to the death of the animal

II *Incidental diseases or conditions* not thought to contribute to the death or condition causing it

Comments:

6. INSTIUTE OF ZOOLOGY REVIEW PANEL

Comments:

Appendix V:
IWDG-RVL-GMIT Sample Collection Form

MI-NPWS PRIORITY SAMPLE CHECK-LIST

ANIMAL ID: _____

Storage notes:
PARASITES: Whole (70% ethanol)
LESIONS: Histology (1cm^3) – x1 10% Formalin, Bacteriology (swab/block) – x1 Fridge
TOXICOLOGY: Wrapped in aluminum dull side up

SKIN (4cm^2):

- x1 Frozen -20°C ☐

BLUBBER:

- Toxicology (20g) – x2 Frozen -20°C ☐

MUSCLE:

- Toxicology (20g) – x2 Frozen -20°C ☐

KIDNEY:

- Toxicology (20g) – x2 Frozen -20°C ☐
- Histology (1cm^3) – x1 10% Formalin ☐
- Virology (1cm^3) – x1 Frozen -80°C ☐
- Bacteriology (swab/block) – x1 Fridge ☐

LIVER:

- Toxicology (20g) – x2 Frozen -20°C ☐
- Histology (1cm^3) – x1 10% Formalin ☐
- Bacteriology (swab/block) – x1 Fridge ☐

LUNG:

- Histology (4 x 1cm^3) – 10% Formalin ☐
- Bacteriology (swab/block) – x1 Fridge ☐
- Virology (1cm^3) – 1x Frozen -80°C ☐

MAIN SPLEEN:

- Virology (1cm^3) – x1 Frozen -80°C ☐
- Bacteriology (swab/block) – x1 Fridge ☐

SERUM OR PCF (Up to 20ml):

- PCF ☐**OR** Serum ☐

URINE (Up to 20ml):

- Toxicology – x1 Freeze -20°C ☐

STOMACH:

- Whole (Frozen -20°C) ☐

TEETH (5-10):

- Frozen -20°C ☐

REPRODUCTIVE SYSTEMS:

- R+L testes + epi (5 cm^2 from mid-testes and epi and store in separate labelled pots) Formalin 10% ☐

OR R+L ovaries (whole in separate labelled pots or note differences in external appearance) - Formalin 10% ☐

BRAIN:

- Virology (1cm^3) – x1 Frozen -80°C ☐

REQUESTED ADDITIONAL SAMPLES/INFORMATION

SPLEEN

- Histology ($1cm^3$) – x1 10% Formalin ☐

GLANDS – HISTOLOGY (10% Formalin):

- Prescapular lymph node ($1cm^3$)☐
- Thymus ($1cm^3$)☐
- Thyroid ($1cm^3$)☐
- Pulmonary associated lymph node L+R (nick L) ($1\ cm^3$) ☐
- Adrenal R+L (nick L) (Whole) ☐
- Mammary R+L (nick L) ($1cm^3$)☐

INTESTINE

- Last 10 cm (Frozen -20°C) ☐

FEMALE REPRODUCTIVE TRACT (excl. ovaries)

- Whole (Formalin 10%) ☐

MILK (Up to 20ml):

- Toxicology – x1 Freeze -20°C ☐

BRAIN

- Bacteriology (swab/block) – 1x Fridge ☐
- Histology ($1cm^3$) – x4 10% Formalin ☐

ADDITIONAL INFORMATION:

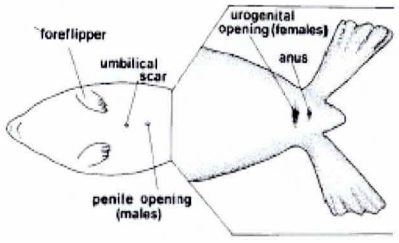
POST-ANAL HUMP: Photograph + Blubber thickness (mm) _____Muscle thickness (mm) _____
(measurements from where hump is thickest)

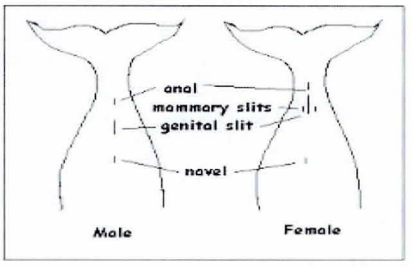
ADDITIONAL SAMPLES:

SAMPLE	STORAGE (frozen, ethanol etc.)	PURPOSE (B, H, V,T,O)	NO. OF SAMPLES/SIZE	LOCATION (if parasites/lesions)

Appendix VI:
Bycatch Sample Collection Protocol

14. Wear clean non-powdered vinyl gloves provided. To avoid cross-contamination, clean gloves should be used for each carcass.
15. **For birds**: Birds are to be double bagged using the black plastic bags. Fill out one of the labels for the birds and place it on the outside bag. Record details on the bycatch record form.
16. Ask crew where it can be stored (in ice or in freezer (preferable)).
17. **For cetaceans**: Measure the length (in cm) by placing it on its belly and holding the tape measure down parallel to the carcass in a straight line. Measure the distance between the notch in the tail fluke and the tip of the upper jaw - record on the bycatch record form.
18. **For seals**: Place animal on belly and measuring tape parallel to carcass in a straight line. Measure (in cm) from the tip of the snout to the tip of the tail – record on the bycatch record form.
19. **For cetaceans and seals:** For species and sex verification, if possible, take photos of the animals genital area as well as full side views of cetaceans and head profile pictures for seals. Determine the sex and record on the bycatch record form.





20. Complete labels on the zip-lock sample bags (as below) using a permanent pen.
21. Take a sample using the biopsy punch tool immediately in front of dorsal fin for cetaceans, or from the sternal region on the seals. Push it in far enough so the entire metal end of the tool is full of blubber when removed – when pulling the tool out of the animal hold it at an angle and twist it so the entire sample comes out within the tool. Discard and repeat if the tool is not full - a full cross section of the blubber layer must be obtained with skin attached to the outer layer, and muscle attached to the inner blubber layer. The tools are sterile before use so must be handled carefully when sampling in order to avoid cross-contamination.
22. Remove the blubber/skin sample with forceps from the biopsy punch tool, place and wrap in the tin foil (dull side up) square provided and place into the zip-lock bag you have labelled. Repeat steps - you should have two biopsy samples per animal. Two aluminum squares each containing one sample will go into the same plastic bag for the one animal.
23. Disinfect the biopsy tool and forceps between samples in tube of ethanol.
24. Ask crew where it can be stored (in ice or in freezer (preferable)).
25. When leaving the vessel, place all cetacean and bird samples into your box of iced fish/nephrops samples coming ashore. Inform the Catch Sampling Manager that you have samples and they will arrange to have them collected along with your normal samples.
26. If you require any more sampling equipment, please contact the Catch Sampling Manager.

Label on cetacean sample bag:
Animal ID:
Date:
Species:
Length:
Sex:
Sample: Skin+ Blubber

Label on bird bag:
Animal ID:
Date:
Species:

Appendix VII:
Bycatch sampling kit contents

Twenty-five bycatch sampling kits were assembled for the at sea observers which contained the following items:

13. Sample protocol sheet (see below)
14. Eight pairs of disposable gloves
15. One permanent waterproof pen
16. Five disposable biopsy punch tools for skin/blubber sample collection
17. Ten squared of aluminium foil for samples to be wrapped in
18. One pair of forceps for sample extraction from biopsy tool
19. One tube of ethanol for disinfection of biopsy tool and forceps
20. Five pre-labelled zip-lock bags for samples to be kept in
21. One measuring tape for marine mammal length measurements
22. Six large black bags for seabird collection
23. Three pre-written labels for seabird bags
24. One bottle of hand sanitizer.

Appendix VIII:

Criteria used to establish selected causes of death are described below (CSIP, 2016).

- **By-catch (entanglement in fishing gear)** was ascribed as a cause of death in cetacean carcasses using established pathological criteria for by-catch diagnosis
- **Infectious Disease**- a broad category consisting of a number of causes of death of infectious origin
- **Live Stranding**- attributed as the cause of death in cetaceans that were known or suspected (from post-mortem examination) to have live-stranded in apparent good health and nutritional status. This category excluded severely diseased or emaciated animals that stranded alive
- **Starvation**- given as the cause of death in animals that were severely emaciated and, following post-mortem examination, ascertained to have no other significant disease processes that could explain the poor nutritional status
- **Starvation (neonate)**- given as the cause of death in neonates that were severely emaciated and, following post-mortem examination, ascertained to have no other significant disease processes that could explain the poor nutritional status. Some of these animals may have become maternally separated
- **Fatal attack from one or more bottlenose dolphins**- ascribed as a cause of death in cetacean carcasses using established pathological criteria
- **Grey seal attack**- ascribed as a cause of death in individuals presenting with pathology potentially consistent with grey seal attack, as recently described
- **Physical trauma (boat/ship strike)**- physical trauma consistent with impact from a boat or ship. Includes blunt trauma to dorsal/lateral aspect of body wall and/or injuries consistent with propeller strike
- **Dystocia & Stillborn**- attributed as the cause of death in animals which have died during the act or process of giving birth (mothers or calves)
- **Physical trauma (unknown origin)**- where evidence of physical trauma is found at post-mortem, but no obvious origin or other significant underlying factors. This category is likely to include some undiagnosed cases of boat/ship strike, by-catch or bottlenose dolphin attack.
- **Gas embolism**- intravascular gas bubble formation that obstructs circulation and causes associated tissue injury
- **Entanglement**- a cause of death category largely confined to minke whales. Denotes evidence of entanglement in rope (creel etc.) or discarded fishing gear/marine litter
- **Cold stunned**- a cause of death category specific to hard shelled species of marine turtle, resulting from exposure to cold water around the UK coast, leading to immobility, hypothermia and eventual starvation
- **Neoplasia**- where the cause of death is due to the formation of a tumour
- **Others-** a broad category covering causes of death that cannot be categorised using existing criteria

Further details available on www.emff.marine.ie

Managing Authority EMFF 2014-2020	Specified Public Beneficiary Body
Department of Agriculture Food & the Marine Clogheen, Clonakilty, Co. Cork. P85 TX47 Tel: (+)353 (0)23 885 9500 www.agriculture.gov.ie/emff	Marine Institute Rinville, Oranmore, Co. Galway, H91 R673 Phone: (+)353 (0)91 38 7200 www.marine.ie

Greater Dublin Drainage Project

SID Application

ABP Case file 312131

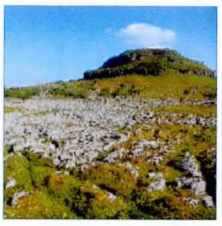
Appendix Reference:

6.2

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

NATIONAL PARKS AND WILDLIFE SERVICE



HARBOUR PORPOISE SURVEYS IN ROCKABILL TO DALKEY ISLAND SAC, 2021



Simon Berrow, Fiona Cummins, Gráinne Kane, Hannah Keogh and Dave Wall

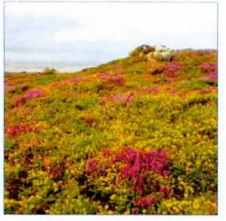


















An Roinn Cultúir, Oidhreachta agus Gaeltachta
Department of Culture, Heritage and the Gaeltacht

IRISH WILDLIFE MANUALS 1XX

National Parks and Wildlife Service (NPWS) commissions a range of reports from external contractors to provide scientific evidence and advice to assist it in its duties. The Irish Wildlife Manuals series serves as a record of work carried out or commissioned by NPWS, and is one means by which it disseminates scientific information. Others include scientific publications in peer reviewed journals. The views and recommendations presented in this report are not necessarily those of NPWS and should, therefore, not be attributed to NPWS.

Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Harbour porpoise *Phocoena phocoena* Randal Counihan/IWDG

HARBOUR PORPOISE SURVEYS IN ROCKABILL TO DALKEY ISLAND SAC, 2021

Simon Berrow, Fiona Cummins, Gráinne Kane, Hannah Keogh and Dave Wall

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Keywords: Harbour Porpoise, *Phocoena phocoena*, SAC, density estimates, abundance

Citation: e.g. Berrow, S.D., Cummins, F., Kane, G., Keogh, H. and Wall, D (2021). Harbour porpoise surveys in Rockabill to Dalkey Island SAC, 2020. *Irish Wildlife Manuals*, No. XXX. National Parks and Wildlife Service, Department Housing, Local Government & Heritage, Ireland.

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This IWM was edited by INSERT NAMES HERE

ISSN 1393 – 6670

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National Parks and Wildlife Service 2021

An Roinn Cultúir, Oidhreachta agus Gaeltachta, 90 Sráid an Rí Thuaidh, Margadh na Feirme, Baile Átha Cliath 7, D07N7CV
Department Housing, Local Government & Heritage (DHLGH), 90 North King Street, Smithfield, Dublin 7, D07 N7CV

Contents

Executive Summary i

Acknowledgements ii

1 Introduction 1

2 Methods 3

2.1 Survey site and Platform 3

2.2 Survey methodology 4

2.3 Density and abundance estimation 5

2.4 Mapping cetacean survey and encounter data 5

3 Results 6

3.1 Density and abundance estimation 10

3.2 Density and abundance estimation in different sea-states 14

3.3 Proportion of juveniles and calves 16

3.4 Additional marine mammal and megafauna sightings 16

4 Discussion 18

4.1 Harbour porpoise density estimates in Rockabill to Dalkey Island SAC 18

4.2 Proportion of juveniles and calves 20

4.3 Trends in harbour porpoise density estimates in Rockabill to Dalkey Island SAC 21

4.4 Recommendations 22

5 Bibliography & Relevant Literature 23

Executive Summary

A visual survey of harbour porpoises (*Phocoena phocoena*) was carried out in Rockabill to Dalkey Island SAC in order to derive local density and abundance estimates. Single platform line-transect surveys were carried out according to a standardised design across six days between July and August 2021. Distance sampling was used to produce a detection function based on the observed distribution of harbour porpoise sightings. Abundance estimates were calculated using the survey day as the sample and sightings as the observation for 1) each survey day, 2) stratified by sea state and 3) for all surveys combined

The survey effort in Rockabill to Dalkey Island SAC ranged from 116-124 km per survey and was 728 km overall. Sea-state was ≤2 for the whole of four surveys and 97% of survey 1. Sea-state 0 and sea-state 1 dominated for two surveys each. Only on one survey was sea-state 2 recorded for >50% of survey effort.

The number of porpoise sightings per survey ranged from 12 to 29 and from 12 to 42 individuals per survey with a total of 137 sightings of 181 individual porpoises overall. Clusters of sightings were evident and this survey highlights the importance of the areas between Howth Head and Lambay Island for harbor porpoises.

Sightings were made throughout the survey area. Density estimates ranged from 0.50 porpoises per km^2 to 0.98 porpoises per km^2 with an overall density estimate of 0.83±.014 porpoises per km^2. The coefficients of variation around the estimates were low ≤0.24 and was 0.17 overall. The effect of sea-state on density estimates was investigated by running models on data derived from sea-state 0, sea-state 0+1 and sea-state 0+1+2. The highest density estimate was collected in sea-state 0+1+2 (all survey data) (0.83 porpoises per km^2) and was 0.51 using data collected in sea-state 0 and 0.40 using data collected in sea-state 0 +1. Both these latter estimates had higher CVs, hence the best estimate was considered as that using data from all sea-states combined. Mean group size varied between 1.00 and 1.58 porpoises over the survey duration with no obvious trend over the study period. The overall pooled density estimate from all survey days combined gave an abundance estimate of 227±39 with 95% Confidence Intervals of 163-321. The proportion of young porpoises (juveniles and calves combined) recorded on survey days ranged from 6.3% to 9.5% and was 5.5% overall.

The density estimate recorded during the current survey was lower than previous estimates from Rockabill to Dalkey Island SAC in 2008, 2013 and 2016 where densities of 1.30, 1.47 and 1.62 porpoises per km^2 were calculated. The density estimate in 2021 represent a 46% decline on that reported in 2016 and a 42% decline on that reported in 2013. The number of sightings per survey were similar in 2013 and 2015, but down by 17% on the mean of the previous surveys. Surveys during 2021 were carried out in very favourable sea conditions and we are confident that the density estimates reported here are robust. The decrease in density reported in 2021 is the first significant decline reported since monitoring started, but whether this reflects a real change in population or more likely a change in the local distribution of porpoises, adjacent to the SAC, is not clear. Small changes in local distribution, driven by the distribution of their preferred prey can have profound effects on density estimates within a relatively small SAC compared to individual's home range.

We recommend these surveys are continued using the same methodology but on a more frequent (annual) basis to provide a more robust data time series within the site. Given the variability in density estimates per survey, consideration should also be given to given establishing fixed acoustic monitoring stations to derive acoustic indices from which to monitor population status. The most likely driver is the availability of preferred prey which may fluctuate locally over short periods. We recommend a study of the diet of harbour porpoises off the east coast of Ireland be considered including seasonal components.

Acknowledgements

We would like to thank skippers Jeff Brownlee, Peter Beamish and Vincent Duke for their commitment to get these harbour porpoise surveys completed in the best possible sea conditions and to Kevin Heapes for assisting with data delivery. This survey was funded by the Department Housing, Local Government & Heritage (DHLGH) and we thank Loraine Fay for her support throughout.

1 Introduction

The harbour porpoise (*Phocoena phocoena*) is the most widespread and abundant cetacean species in Irish waters (Rogan *et al.*, 2018). It has been recorded off all Irish coasts, including over the continental shelf but is thought to be most abundant off the southwest and east coasts (Wall *et al.*, 2013; Rogan *et al.*, 2018). It is also consistently one of the most frequently recorded species stranded on the Irish coast (O'Connell & Berrow, 2019; 2020).

There have been a number of dedicated surveys which have estimated absolute abundances of harbour porpoises in Irish waters. In July 1994, an abundance estimate of 36,280 harbour porpoises was calculated for the Celtic Sea as part of an international project called SCANS (Small Cetacean Abundance in the North Sea) (Hammond *et al.*, 2002). This survey was repeated in July 2005 (SCANS-II) when it covered all waters overlying the continental shelf, including the Irish Sea (Hammond *et al.*, 2013). Ship-based double platform line-transect surveys were carried out in the Celtic Sea and in offshore Ireland, while aircraft were used for coastal Ireland and in the Irish Sea. Harbour porpoise abundance estimates were generated for three areas; the Celtic Sea (80,613, CV=0.50), Irish Sea (15,230, CV=0.35) and Atlantic coastal Ireland (10,716, CV=0.37). The offshore Ireland survey area included Scotland and an estimate of 10,002 porpoises (CV=1.24) was generated for both areas combined. Hammond *et al.* (2013) reported a doubling of harbour porpoise density in the Celtic Sea between the SCANS and SCANS II survey years. Rogan *et al.* (2018) recorded a total of 296 harbour porpoise sightings during aerial surveys in 2015 and 2016. Across the total survey area, abundance across both years was higher in the summer than in the winter, with consistently highest summer densities/abundance recorded in the Celtic and Irish Seas. Densities along the south coast in summer 2016 were 0.29 porpoises per km^2 (CV=0.63) and 0.060 porpoises per km^2 (CV=0.73) during winter 2016-17. The predicted distribution of harbour porpoises for both summers highlights the importance of the south west part of the Celtic Sea (over the North Celtic Sea Basin), which had high numbers of sightings and was predicted as an area of high abundance. Recently Nielsen et al. (2021) reported harbour porpoise densities of 0.070 porpoises per km^2 in the Celtic Sea, 0.044 in the North Sea and 0.006 in the English Channel using data from platforms of opportunity.

Single platform line-transect surveys using distance sampling and acoustic monitoring were carried out at a further six regional sites around Ireland between 2010 and 2012. These sites were between 6-12 nm offshore and the surveys recorded all cetacean species encountered. Harbour porpoises were recorded at all sites but densities were highest in the Irish Sea with 1.58 ± 0.22 porpoises per km^2 recorded and with an associated CV of 0.14 (Berrow *et al.*, 2011).

EU Member States are required to designate Special Areas of Conservation (SACs) for species listed under Annex II of the EU Habitats Directive, one of which is the harbour porpoise. The Blasket Islands SAC and Rockabill to Dalkey Island SAC were designated as candidate SACs for the species in 2000. Designation of the Rockabill to Dalkey site as an SAC, with harbour porpoise as a qualifying interest, followed on from a series of harbour porpoise surveys at eight sites throughout Ireland, including Dublin Bay and North County Dublin, during 2008 (Berrow *et al.*, 2008; 2014). Six single platform surveys were carried out at each site between July and October with density estimates calculated for each survey day and for all surveys combined (i.e., pooled estimates). These showed that density estimates were highest for the Blasket Islands SAC, North County Dublin and Dublin Bay.

In 2013, the National Parks and Wildlife Service (NPWS) commissioned a survey of the newly designated Rockabill to Dalkey Island SAC (Berrow & O'Brien, 2013). Density estimates were calculated for five of the six survey days and ranged from 1.13 harbour porpoise per km^2 to 2.61 harbour porpoise per km^2. The overall density was 1.44 which derived an abundance estimate of 391 harbour porpoise within the SAC (Berrow & O'Brien, 2013). A second survey of the Rockabill to Dalkey Island SAC was carried out in 2016 (O'Brien & Berrow, 2016). Density estimates between each survey were very consistent, ranging from 1.37 porpoises per km^2 to a maximum of 1.87 porpoises per km^2, with an overall density of 1.55±0.17 porpoises per km^2 with a very low CV of 0.10. Harbour porpoise abundance ranged

from 374 individuals to 511 individuals with an overall estimate of 424±46 with 95% CI of 335-536. Single platform line-transect surveys using distance sampling and acoustic monitoring were also carried out in summer at a further five regional sites (Northwest, West, Southwest, North Irish Sea, South Irish Sea) around Ireland between 2010 and 2012 (Ryan *et al.*, 2010; Berrow *et al.*, 2011; 2012). These sites were generally situated between 6-12 nm offshore and the surveys recorded all cetacean species encountered. Harbour porpoises were recorded at all sites but densities were highest in the Irish Sea with 1.58±0.22 porpoises per km^2 recorded and with an associated CV of 0.14 (Berrow *et al.*, 2011).

Density estimates in 2016 were remarkably consistent to surveys carried out in 2013, with 1.44 harbour porpoise per km^2 recorded compared to 1.55 porpoise per km^2 from the 2013 survey. Sea conditions were good on both surveys with 61% of survey effort in 2013 ≤1 and 87% in 2016, although only four surveys were carried out during 2016. During both studies mean group size was similar which suggests that porpoise densities between the two periods were consistent.

In order to contribute to the Department Housing, Local Government & Heritage (DHLGH) site management and surveillance, visual monitoring of harbour porpoises was carried out in Rockabill to Dalkey Island SAC during the summer of 2021. This was the third dedicated line transect survey of harbour porpoises within this SAC which enabled ongoing trends in summer density estimates to be explored. The objectives of the survey in 2021 were to:

i) derive updated summer density and population estimates for harbour porpoises within the Rockabill to Dalkey Island SAC using robust sampling methods for small cetacean density/population estimation;

ii) estimate associated Coefficients of Variation and 95% Confidence Intervals

2 Methods

2.1 Survey site and Platform

The survey site and line-transect survey design is shown in Figure 1. The area of the Rockabill to Dalkey Island SAC is 273 km^2. Survey track lines were provided by the DHLGH to provide equal coverage probability within the SAC but repeatable over time. Standardized visual survey design for the site, measuring c128km in total transect length was provided by DHLGH. To allow for the greatest coverage of the SAC new survey lines (comprising of start, end and turning points) have been provided each survey year, thus there has been no repetition of survey lines across survey years.

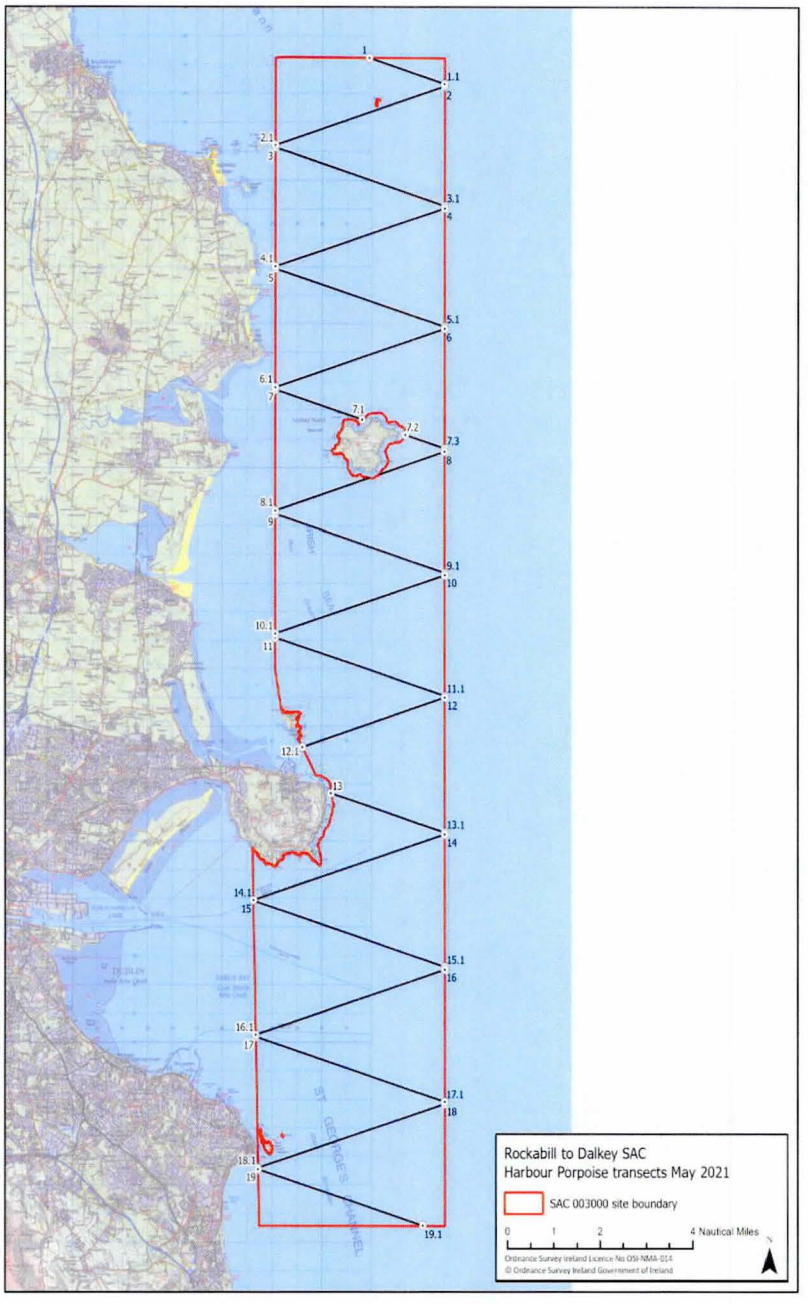


Figure 1 Rockabill to Dalkey Island SAC showing DHLGH track lines selected for coverage in 2021.

Two vessels both operating out of the out of Dún Laoghaire, Co Dublin were used during this survey. The MV Beluga, skippered by Jeff Brownlee of Aquamarine Ltd. was used for three of the six surveys and MV Gaviota operated by Dublin Boat Ltd. for the remaining three surveys. MV Beluga had been

used as the survey platform on all previous harbour porpoise surveys of the Rockabill to Dalkey Island SAC carried out by the IWDG. Both vessels provided a primary observation platform 3.1m above the waterline (Figure 2).



a. b.

Figure 2 Survey vessels **a.** MV Beluga and b. MV Gaviota. Note: flying bridges suitable for line-transect surveying.

COVID-19

HSE guidelines were followed over the duration of this contract. Local observers were used if possible to minimise the need for travel and overnight accommodation and social distancing was easily maintained throughout all surveys due to the size of the vessels.

2.2 Survey methodology

Conventional single platform line-transect surveys were carried out within the boundaries of the SAC along the pre-determined track-lines. Transect lines were designed to try and get full coverage of the site over the study period to ensure that no potentially important porpoise concentrations were overlooked and to provide equal coverage probability. The survey conditions prescribed by DHLGH in which surveys were to be carried out included Beaufort Force/Sea state 2 or less and good light conditions with a visibility of 6km or more.

The survey vessel travelled at a speed of 16-20 km hr^{-1} (9-10 knots), while on survey effort, which was 2-3 times the average speed of the target species (harbour porpoise) as recommended by Dawson *et al.* (2008). Two primary observers were positioned on the flying bridge, which provided an eye-height above sea-level of between 4-5m depending on the height of each individual observer. Primary observers watched with the naked eye from dead ahead to 90° to port or starboard depending on which side of the vessel they were stationed. All sightings were recorded but sightings more than 200-500m (truncation distance depends on each detection function, see Fig 4) from the track-line were not used in the distance sampling model to improve fit. Calves/juveniles were defined as porpoises ≤ half the length of the accompanying animal (adult) and in very close proximity to it. Small animals seen alone were also classified as juveniles. Sightings off-effort while transiting between track-lines or to the study site were recorded but not included in further data analysis.

During each transect the position of the survey vessel was tracked continuously through a GPS receiver connected to a laptop computer, while survey effort including environmental conditions (sea-state, wind strength and direction, glare, etc.) were reviewed every 15 minutes following a prompt from the LOGGER software (© IFAW). When a sighting was made the position of the vessel was recorded immediately and the angle of the sighting from the track of the vessel and the estimated radial distance of the sighted animal(s) from the vessel were recorded. These data were communicated to the recorder in the wheelhouse via VHF radio. The angle was recorded to the nearest degree using an angle board

attached to the vessel immediately in front of each observer. Accurate distance estimation is essential for distance sampling. Measuring sticks (Heinemann, 1981) were made by each primary observer to assist in distance estimation. Environmental conditions were recorded at the start and end of each track-line and if they changed during a track.

2.3 Density and abundance estimation

Distance sampling was used to derive a density estimate and to calculate a corresponding abundance estimate for each individual survey where possible. The software programme DISTANCE (Version 6, University of St Andrews, Scotland) was used for calculating the detection function, which is the probability of detecting an object a certain distance from the track-line. The detection function was used to calculate the density of animals on the track-line of the vessel. During this survey we assumed that all animals on the track-line were observed, i.e., that g(0) = 1, given the strict operational and environmental conditions under which surveys took place. The DISTANCE software allows the user to select a number of models in order to identify the most appropriate for the data. It also allows truncation of sighting outliers when estimating variance in group size and testing for evasive movement prior to detection.

To calculate density, "survey" was used as the sample regime with sightings used as sampling observations. Estimates of abundance and density obtained via the DISTANCE modelling process were calculated and presented for each survey day. An overall pooled abundance/density estimate was derived from all track-lines surveyed combined across all survey days. This was necessary in order to obtain sufficient sightings for a statistically robust estimate using the DISTANCE model (the minimum required is 40—60; Buckland *et al.*, 2001). In conducting this pooled analysis, we assumed that there were no significant changes in distribution within the site between sample days or any immigration into or emigration out of the site. Data were also sorted into sea-state and density estimates were also derived with survey effort and sightings carried out in sea-state 0, sea-state 0+1 and sea-state 0+1+2 (all data).

The data were fitted to a number of models available in the DISTANCE software. The Half-Normal model with cosine adjustments was found to provide the best fit according to the Akaike Information Criterion delivered by the model. The recorded sighting data were grouped into equal distance bands (the width of which was modified during each model run to get the best fit) up to 500m from the track-line. The DISTANCE model determines the influence of cluster size on variability by using a size-bias regression method with the log(n) of cluster size plotted against the corresponding estimated detection function g(x). A Chi-squared test associated with the estimation of each detection function was provided by the DISTANCE model. If found to be statistically significant it indicated if the detection function was a good fit and that whether the corresponding estimates were robust.

The proportions of the variability accounted for by the encounter rates, detection probability and group size (cluster size) were presented with each detection function. Variability associated with the encounter rate reflects the number of sightings on each track-line. The detection probability reflects how far the sightings were from the track-line and cluster size reflects the range of estimated group sizes recorded on each survey.

2.4 Mapping cetacean survey and encounter data

Maps of the study area and associated survey data were created in Irish Grid (TM65_Irish Grid) with ArcMap 10.2 while maps of the prescribed survey area, survey track-lines and coordinates were obtained from DHLGH. Data concerning transects, effort, sightings, abundance and density were stored

in a single MS Access database, which was queried and processed via GIS to produce sighting distribution maps.

3 Results

Six survey days were completed in the Rockabill to Dalkey Island SAC during the present study. Favourable conditions, defined as sea-state ≤2 with good light and visibility ≥6km, were recorded during all six surveys (Table 1). No swell or precipitation was recorded. No surveys were carried out in June but four were completed in July and two in August 2021. It seems unlikely that this would have had any major impacts on the results as harbour porpoise are highly mobile and large fluctuations in the number of sightings per survey is typical even over very short periods (days) between surveys. The lack of surveys in September may have resulted in an underestimate of calves (neonates see Table 6).

Table 1 Overall environmental conditions during surveys of the Rockabill to Dalkey Island SAC during 2021.

Date	Swell (m)	Visibility (km)	Wind strength (knots)	Wind direction	Cloud cover	Precipitation
7 Jul	None	11-15	6	200	5/8	None
12 Jul	None	6-10	2	270	1/8	None
17 Jul	None	6-10	2	270	1/8	None
21 Jul	None	16-20	5	270	2/8	None
19 Aug	None	6-10	3	110	7/8	None
28 Aug	None	11-15	4	100	2/8	None

Sea-state can be influenced by wind and tide and can change throughout the survey. Sea-state was ≤2 for the whole of four surveys (surveys 3-6) and 97.1% of survey 1. Sea-state 0 (12 and 21 July) and sea-state 1 (17 July and 28 August) dominated for two surveys each (Table 2). Only on one survey (19 August) was sea-state 2 recorded for >50% of survey effort (Table 2).

The total survey effort in the Rockabill to Dalkey Island SAC per survey day was very consistent ranging from 116-123km per survey (Table 2), the differences were due to tidal restrictions around the islands on some days, which affected the safe distance to which the survey vessel could approach islands and requests from Dublin Port VTS to avoid the traffic separation zone entering Dublin Port. A total of 728 km was surveyed during this survey (Table 2).

The number of sightings per survey ranged from 12 to 29 with a total of 137 overall (Table 2). The highest numbers of sightings were recorded on surveys 4 and 6 (21 July and 28 August), and the lowest number on surveys 1 and 2 (7 and 12 July), but the differences were relatively small suggesting there was little monthly trends in detection rates. The total number of individual porpoises recorded per survey also varied from 12 to 42 with a total of 181 overall (Table 2).

Table 2 Sea-state and on-effort sighting data for harbour porpoises recorded in the Rockabill to Dalkey Island SAC during 2021.

Sample Day	Date	Total effort (km) in sea-state ≤2	Sea-state (% of total survey time)			Number of sightings	Total no. of animals
			0	1	2		
1	7 Jul	116.4	23.5	36.3	37.4	12	12
2	12 Jul	123.0	62.2	23.5	14.3	19	25
3	17 Jul	122.2	27.7	63.1	9.1	22	29
4	21 Jul	124.2	67.0	31.8	1.2	29	32
5	19 Aug	120.1	0.0	42.1	57.9	26	41
6	28 Aug	122.1	14.2	60.5	25.3	29	42
Total		**728**				**137**	**181**

Track-lines surveyed and all harbour porpoise sightings within the Rockabill to Dalkey Island SAC during each survey day are shown in Figures 3a-f. Three surveys (surveys 1, 4 and 6) were surveyed from south to north and three (surveys 2, 3 and 5) were surveyed from north to south. On passage to the northern start of the tracklines the vessels travelled north around Howth Head and along the coast inside Lambay Island to avoid as transiting through the SAC as much as possible. Surveys also occurred at different states of the tide. This randomised the effect of time of day and tidal state throughout the six surveys, which may have influenced porpoise distribution.

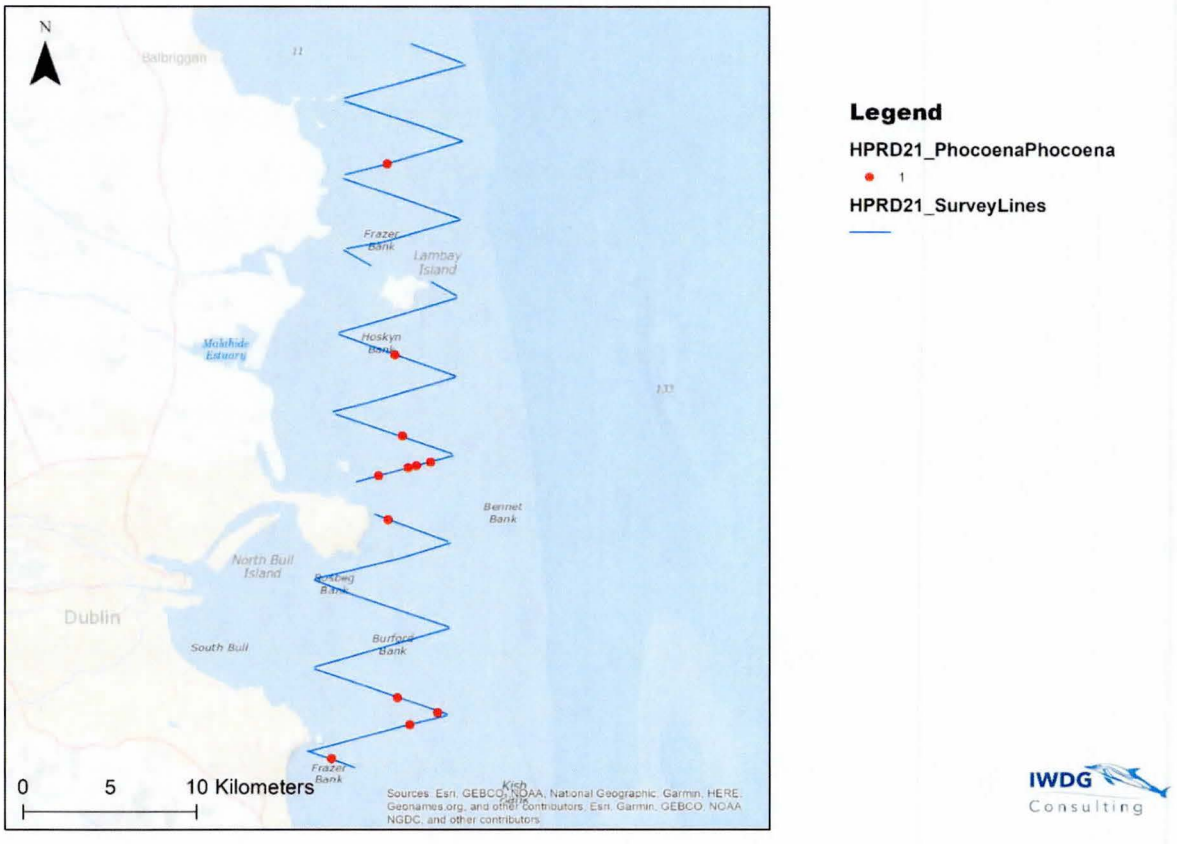


Figure 3a Track-lines and distribution of harbour porpoise sightings on 7 July 2021.

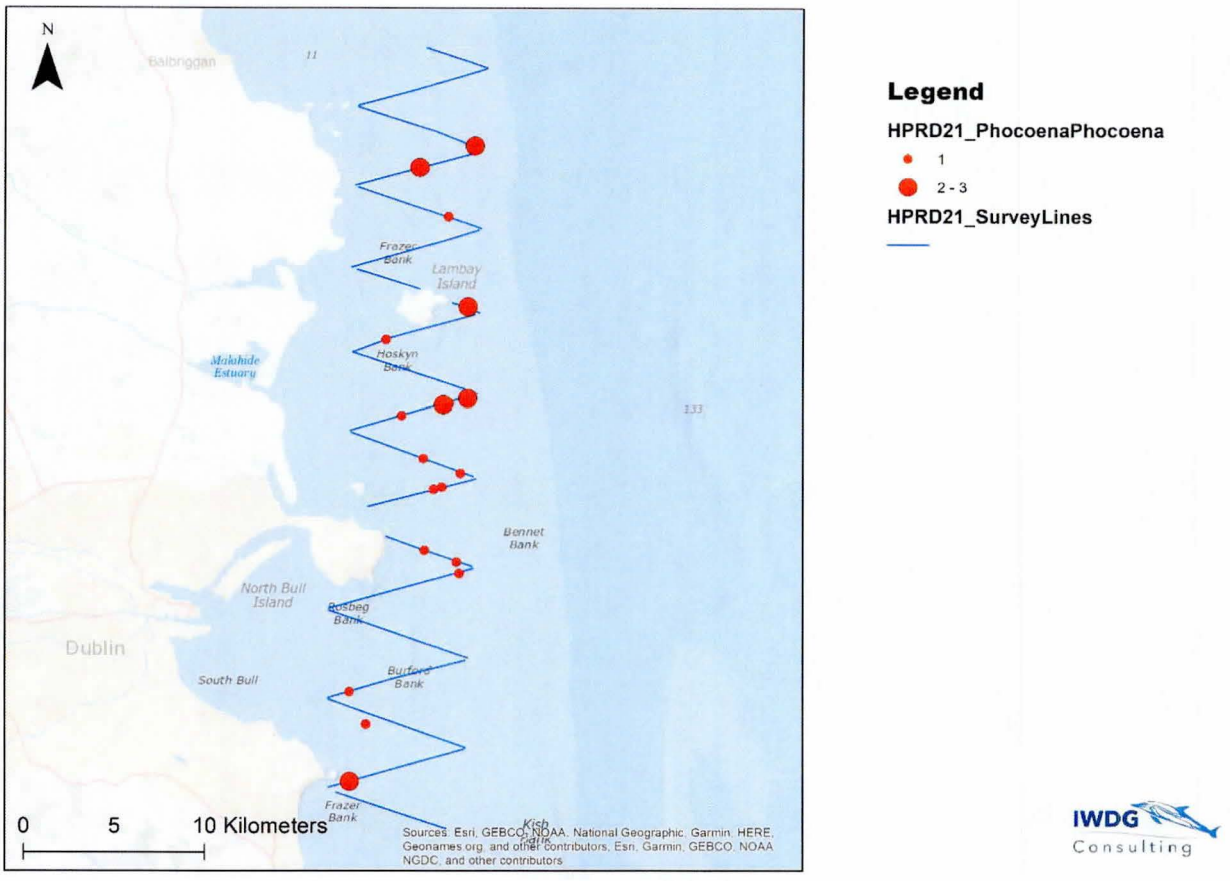


Figure 3b Track-lines and distribution of harbour porpoise sightings on 12 July 2021.

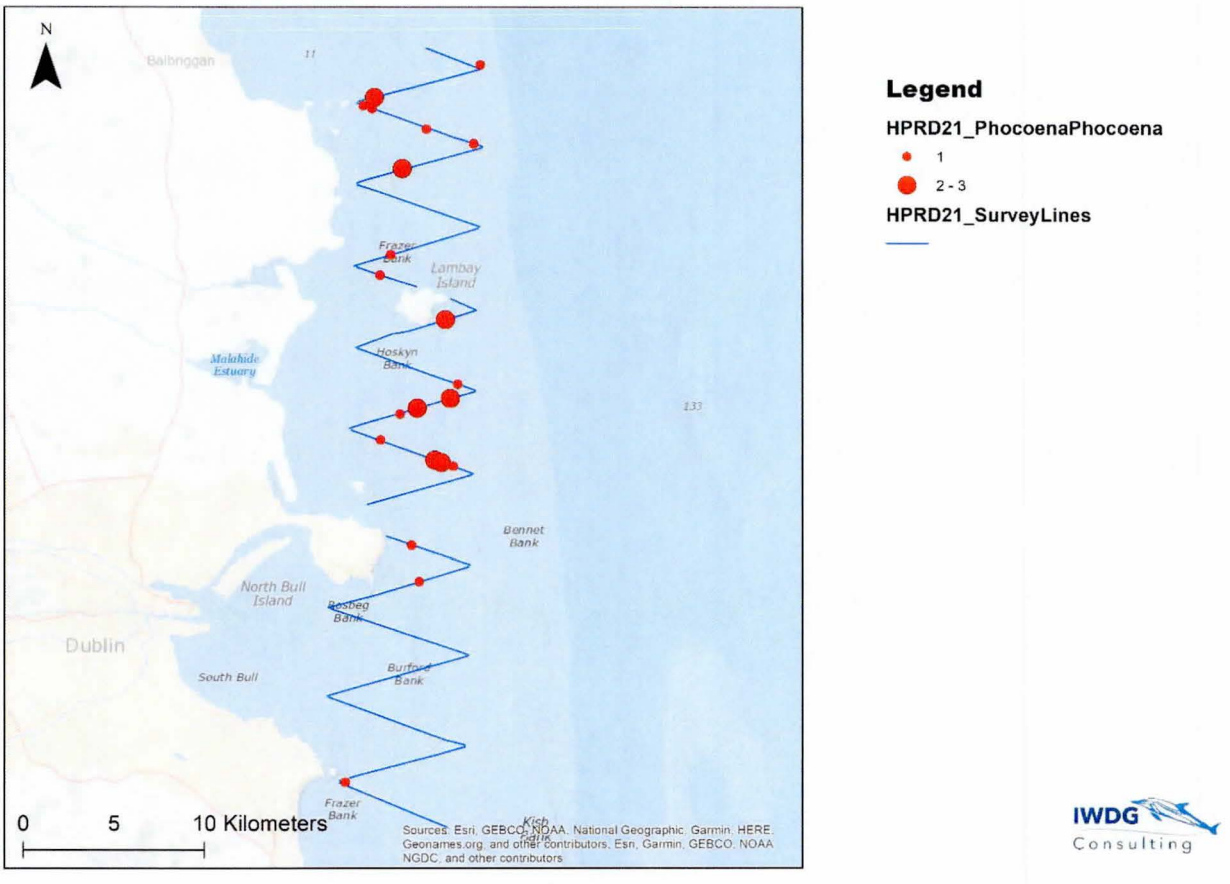


Figure 3c Track-lines and distribution of harbour porpoise sightings on 17 July 2021.

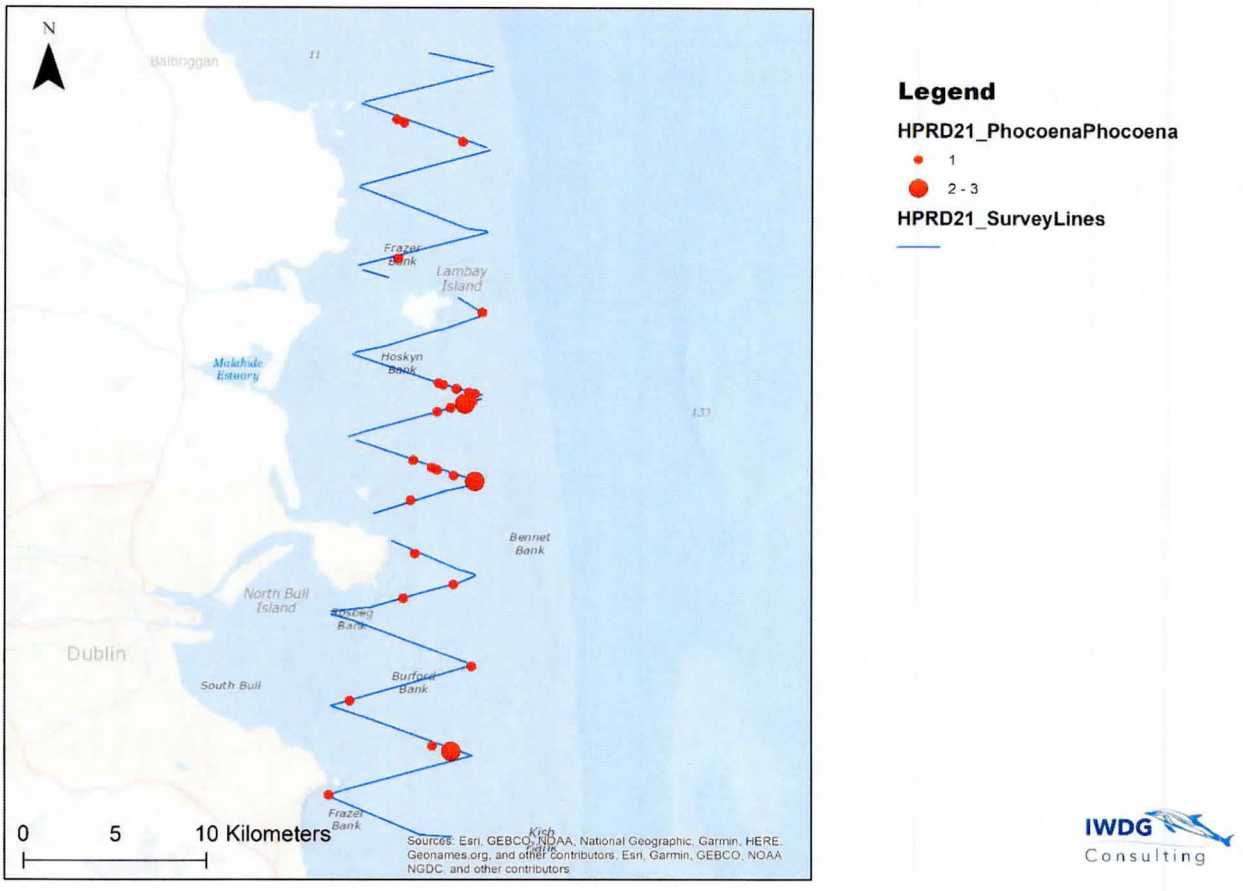


Figure 3d Track-lines and distribution of harbour porpoise sightings on 21 July 2021.

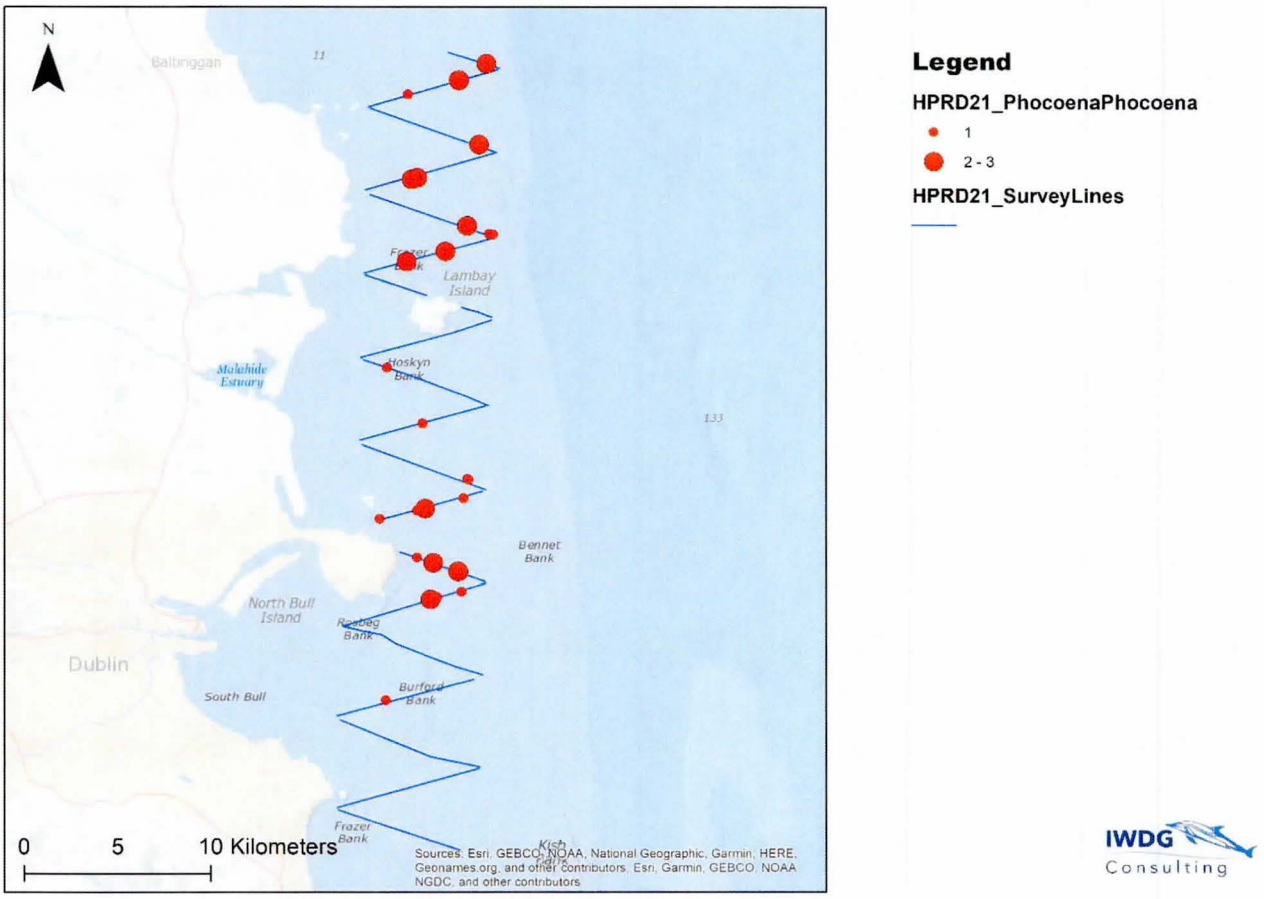


Figure 3e Track-lines and distribution of harbour porpoise sightings on 19 August 2021.

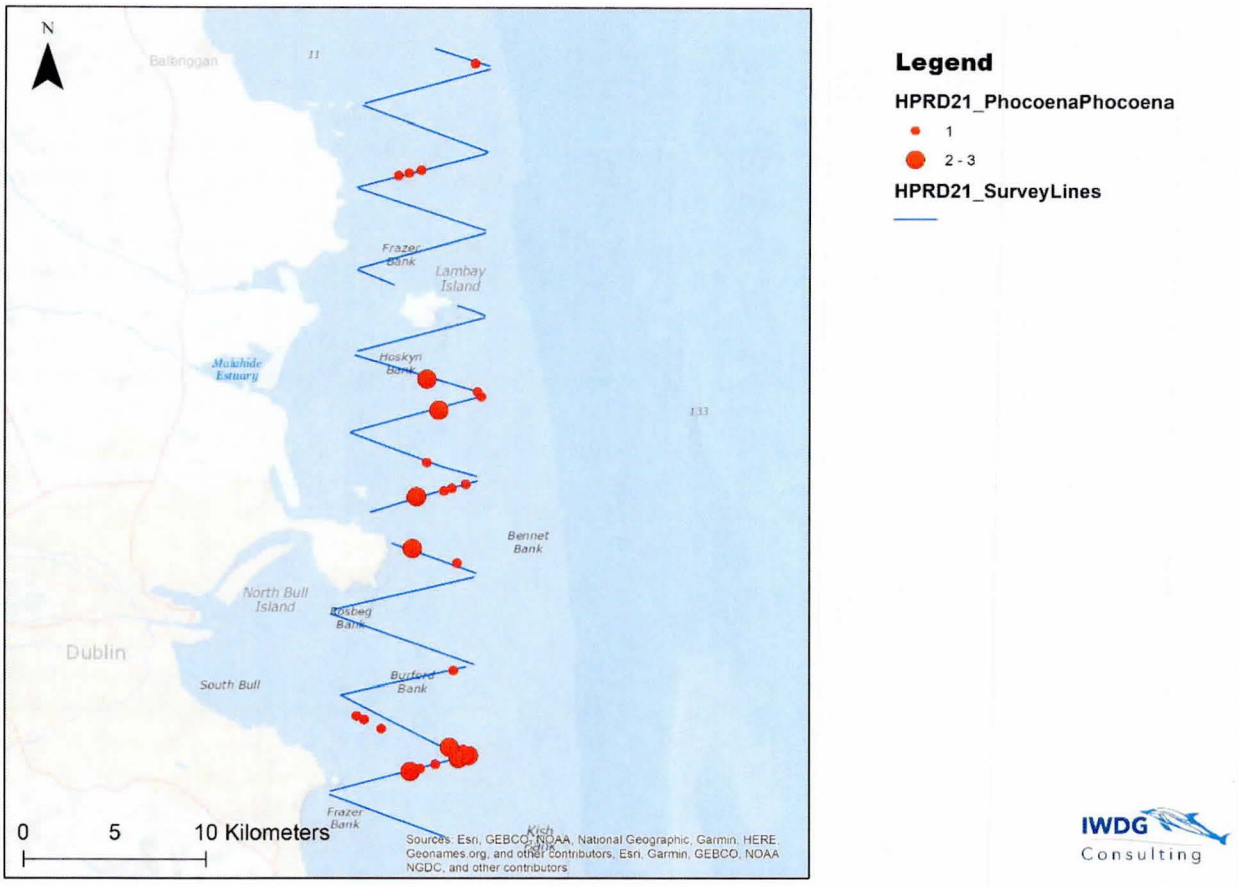


Figure 3f Track-lines and distribution of harbour porpoise sightings on 28 August 2021.

Harbour porpoises were evenly distributed throughout the track-lines. Clusters of sightings were frequently recorded south of Lambay Island with the highest concentrations in this area of surveys 2, 3, 4 and 6. Clusters were reported south of Rockabill to the north of the survey area on surveys 3 and 5 and to the south off east of Dalkey Island on survey 6.

3.1 Density and abundance estimation

Density estimates for harbour porpoises within the SAC were calculated for each survey day and all days combined (Table 3). It should be noted that only 12 sightings were recorded on Survey 1 and the results of the analysis should be treated with caution (Table 3).

The detection functions for harbour porpoise during all surveys are shown graphically in Figure 4af. Using the Chi-squared test for goodness of fit to the DISTANCE model, data for five of the surveys (Surveys 1, 2, 4, 5 and 6) were good fits (P>0.54) but for survey 3 the model was a poor fit (P=0.14; Table 3). Its not clear why a better fit couldn't be established as the number of sightings (n=22) was good. The goodness of fit for all data combined (Figure 4g) was good (Chi ^{2} = 0.52). Surveys were carried out in good sea conditions (Table 2) and porpoises frequently observed from >300m from the track-line. Data were truncated at 250-300m, which has led to sightings being pooled into wide distance categories (Figure 4a-g).

Evasive reactions of porpoises from the survey vessel, which is typical of harbour porpoise which can react to vessels from considerable distance, were only evident on survey 5 (Fig 4e). Evasive reactions could lead to an underestimate of animal density, as animals are already moving away from the track-line when first detected, but the effect of this in the current survey was likely to be very small as the

influence of sightings on the overall density estimate decreases with increasing distance from the track-line (Buckland *et al.* 2001).

Table 3 Model data used in the harbour porpoise abundance and density estimation process for each survey of the Rockabill to Dalkey Island SAC in 2021 (Note: A half-normal model with cosine series adjustments with data truncated at 250-300m was used).

Sample Day	Chi² P value	Effective Strip Width (m)	Mean Cluster size ± SE	Variability (D)		
				Detection	Encounter	Cluster
1[1]	0.62	104	1.00±0.00	100	-	0
2	0.79	154	1.28±0.11	85	-	15
3[2]	0.14	175	1.33±0.11	85	-	15
4	0.66	126	1.11±0.06	96	-	4
5	0.54	190	1.58±1.15	78	-	22
6	0.54	208	1.42±0.15	80	-	20
Overall	**0.52**	**134**	1.31±0.04	**63**	**33**	**4**

Mean group (cluster) size was greatest on surveys 5 and 6 (1.58 and 1.42; Table 4), which was towards the end of the survey period. The proportion of variability in the data accounted for by the detection probability was as expected highest for all surveys. Variability associated with cluster size (Table 3) was greatest for surveys 5 and 6 which coincided with the greatest mean group size. This reflects the number of groups with 3 individuals recorded during surveys 5 (3 groups) and survey 6 (5 groups) while no groups this big were recorded during the first four surveys. Overall, the sources of variability were highest for detection rate and lowest for cluster size which is to be expected as there was relatively low variability in the number of sightings per survey (range 12-29; Table 2).

Table 4 Estimated density, abundance (N) and group sizes of harbour porpoise recorded during surveys of the Rockabill to Dalkey Island SAC, 2021.

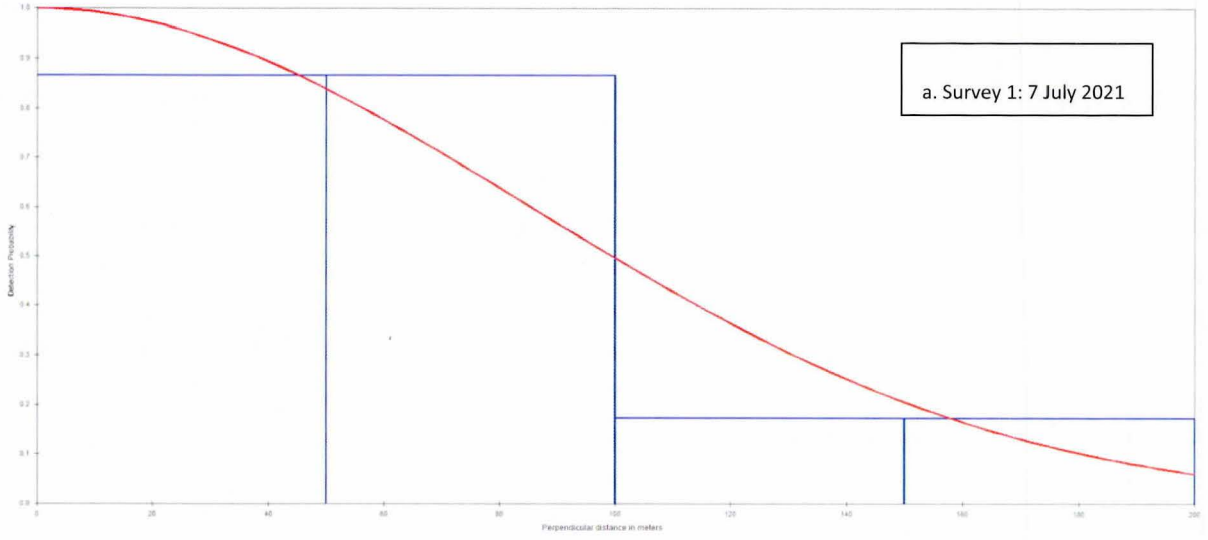
Sample Day	Density (95% CI) per km²	SE	CV	Abundance (95% CI)	Mean group size (95% CI)
1[1]	0.50 (0.29-0.84)	0.12	0.24	136 (80-229)	1.00 (0.00-0.00)
2	0.66 (0.43-1.01)	0.14	0.21	180 (117-276)	1.28 (1.06-1.53)
3[2]	0.63 (0.42-0.96)	0.13	0.20	172 (114-262)	1.33 (1.13-1.57)
4	0.98 (0.61-1.55)	0.22	0.23	266 (167-425)	1.11 (1.00-1.25)
5	0.80 (0.52-1.21)	0.17	0.21	218 (144-332)	1.58 (1.30-1.92)
6	0.72 (0.48-1.10)	0.15	0.21	198 (130-300)	1.42 (1.15-1.76)
Overall	**0.83 (0.59-1.17)**	**0.14**	**0.17**	**227 (161-321)**	**1.31 (1.22-1.42)**

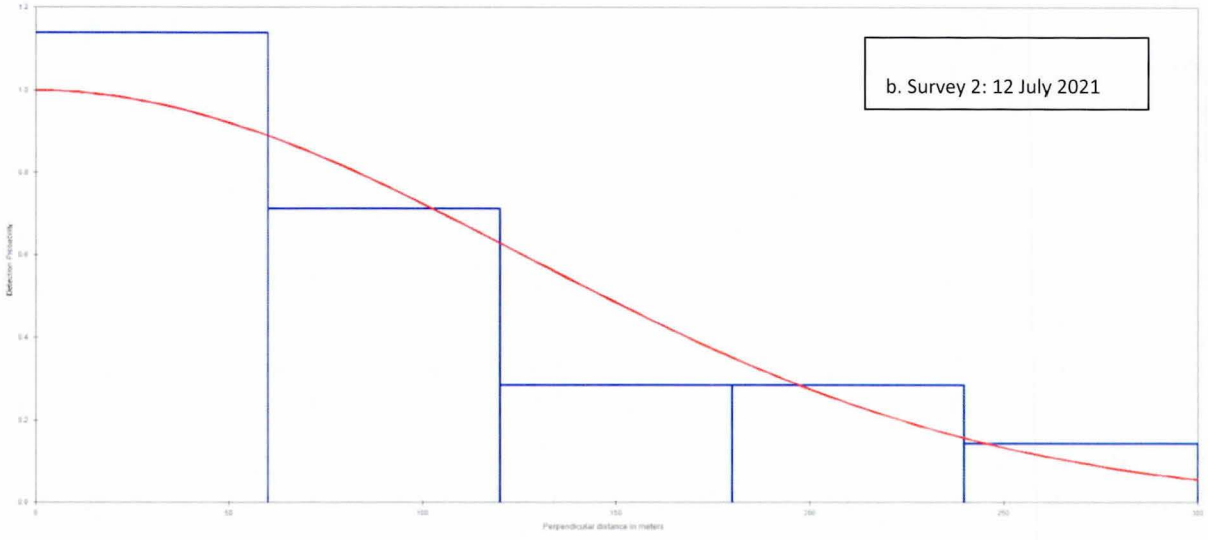
[1] treat with caution, low number of sightings (n=12)

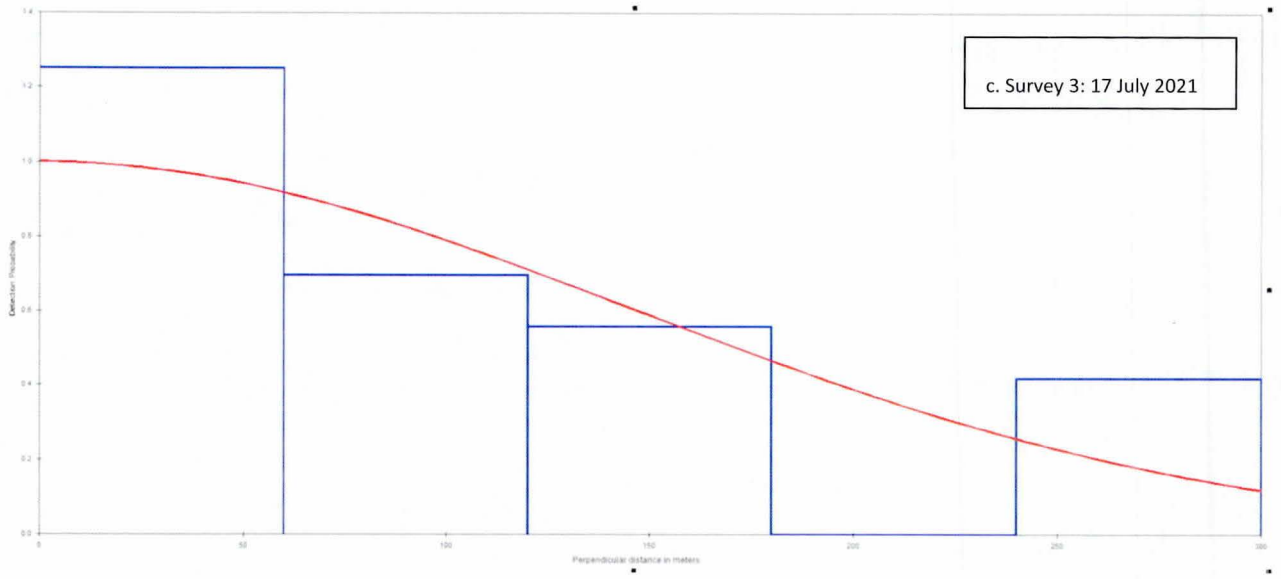
[2] treat with caution, as poor fit to model

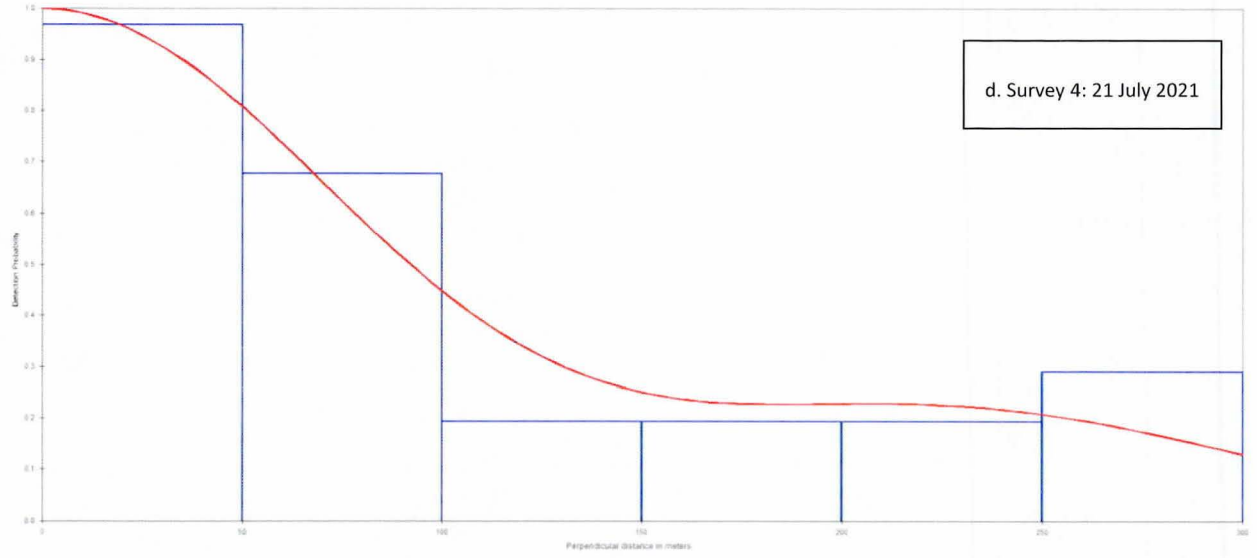
Density and abundance estimates for harbour porpoise in the Rockabill to Dalkey Island SAC during 2021 are presented in Table 4. Despite differences in the number of sightings per survey and mean group size the density estimates did not vary that much ranging from 0.50 to 0.98 harbour porpoises per km^2, with one-half between 0.66 and 0.80 (Table 4). The highest density (0.98) was recorded on survey 4 (21 July). The lowest density estimate was on survey 1 (0.50) with only 12 harbour porpoise sighting and the lowest mean group size (1.00±0.0) (Table 4).

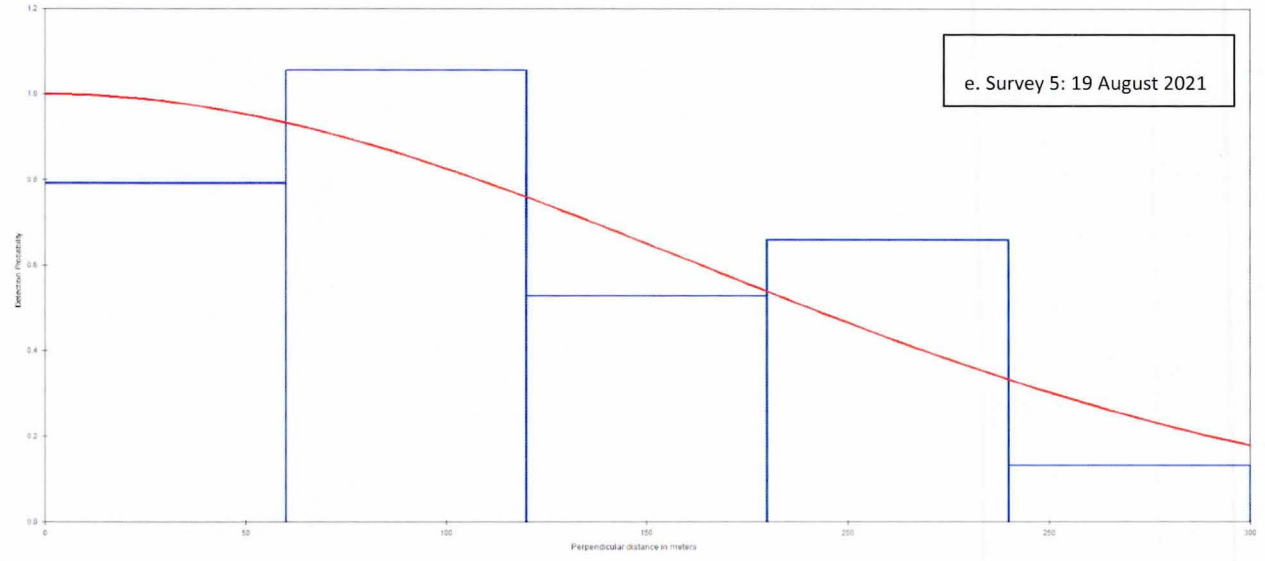
The overall density estimate was 0.83±0.14 with a 95% Confidence Intervals of 0.59 to 1.17 (Table 4). This estimate had a low CV of 0.17 and produced an abundance estimate of 227±39 porpoises with 95% Confidence Intervals of 163 -321 porpoises (Table 4).






c. Survey 3: 17 July 2021
Detection Probability
Perpendicular distance in meters


d. Survey 4: 21 July 2021
Detection Probability
Perpendicular distance in meters


e. Survey 5: 19 August 2021
Detection Probability
Perpendicular distance in meters

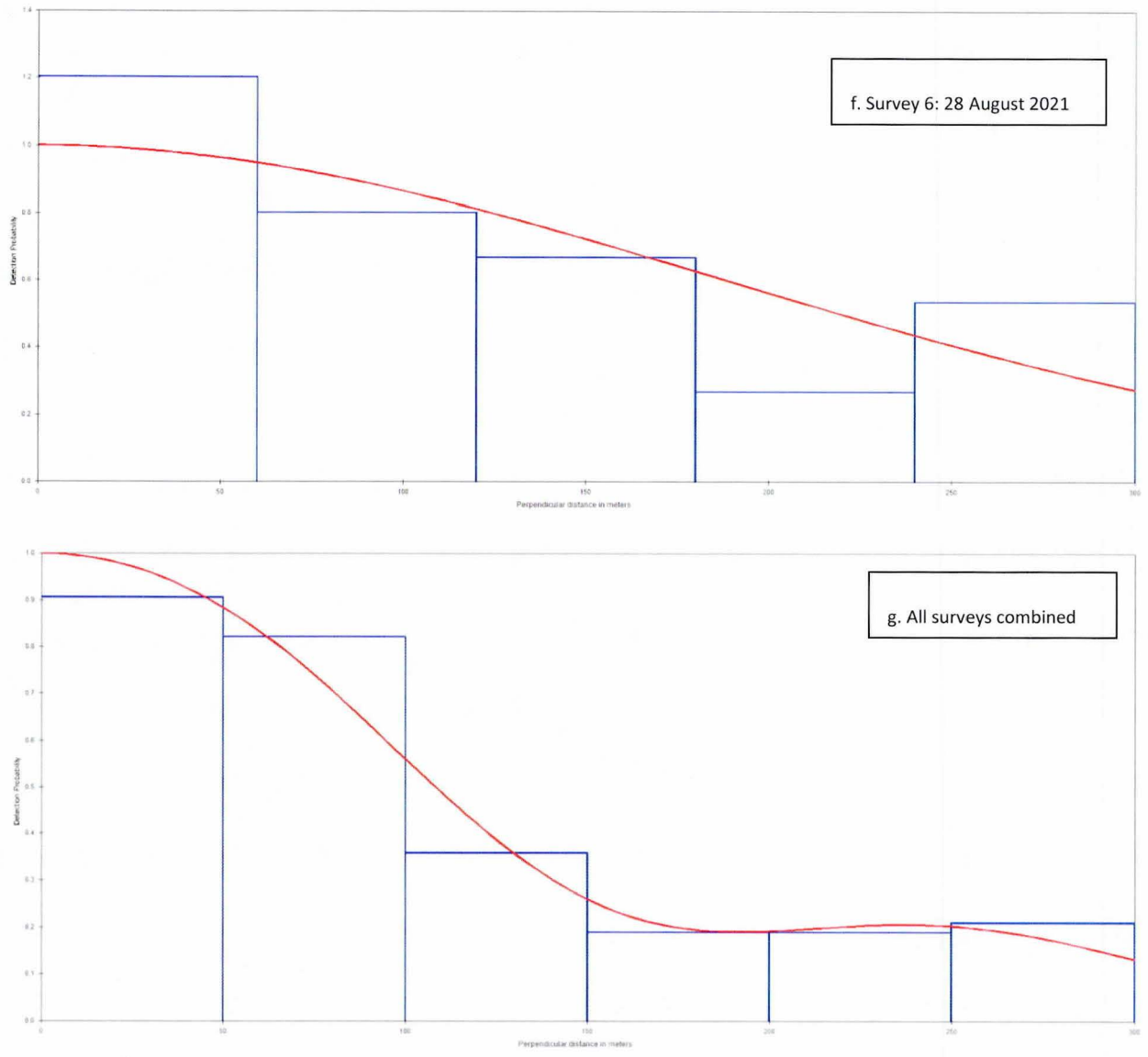


Figure 4 a-g Detection function plots for each survey of harbour porpoises in the Rockabill to Dalkey Island SAC, 2021. (Note: detection probability is on the y-axis and perpendicular distance from the track-line on the x-axis).

3.2 Density and abundance estimation in different sea-states

In order to explore the potential effect of sea-state on density estimates, the data for all surveys were pooled and stratified by sea-state. Detection functions were then calculated for increasing sea-state (Table 5, Figure 5a-b.). A detection function was determined for all sightings in sea-state 0 over the six surveys combined, followed by a similar analysis for sea-state 0+1 and sea-state 0+1+2 (Figure 5 a-b). There was a total of 59 sightings in sea-state 0, 58 in sea-state 1 and 20 in sea-state 2 (Table 5). There were no sightings in the small amount of effort (1.34 km) carried out in sea-state 3. Total sighting effort (in km) was calculated for each sea-state and used in the analysis. Note all sightings and effort in sea-state 0+1+2 is the same as All Surveys presented in Table 4.

Density estimates classified by sea-state 0 and sea-state 0+1 were lower than for all data combined (sea-state 0+1+2) (0.83 harbour porpoise per km^2). Density estimates for all data collected in sea-state 0 and sea-state 0+1were only 0.51 and 0.40 porpoises per km^2 (Table 5). These data also suggest it is appropriate to pool the survey data from all survey days and in all sea-states.

Although the CV for the estimate in sea-state 0 (0.23) was the highest for all categories, the total survey effort (239.1km) was low compared to the total survey data available (728.0km) and we suggest that data for all sea-states combined (sea-state 0+1+2) is the best estimate of the density of harbor porpoises in the Rockabill to Dalkey Island SAC during July and August 2021.

Table 5 Density, abundance (N) and group size estimates of harbour porpoise in the Rockabill to Dalkey Island SAC, during 2021 across increasing sea-states.

Sea-state Class	Effort (km)	Sightings	Chi ² P value	Mean group size ± SE	Density (per km²)	SE	CV	N (95% CI)
0	239.1	59	0.65	1.13	0.51	0.11	0.23	138 (84-229)
0+1	552.6	117	0.24	1.21	0.40	0.08	0.19	109 (74-161)
0+1+2	728.0	137	0.52	1.31	0.83	0.14	0.17	227 (161-321)

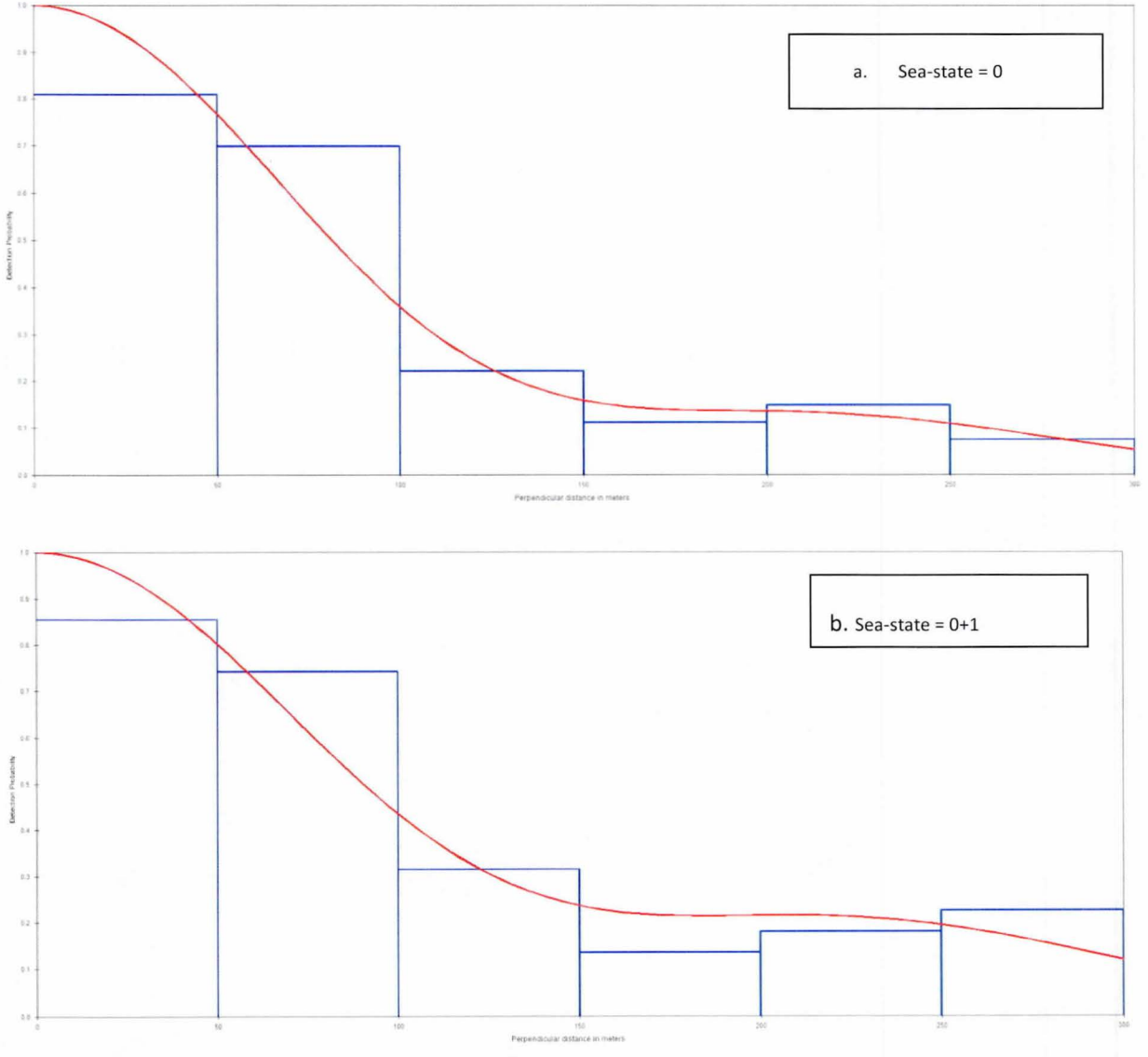


Figure 5 a&b Detection function plots for harbour porpoise surveys in the Rockabill to Dalkey Island SAC, 2021 according to different sea-state classes. (Note: detection probability is on the y-axis and perpendicular distance from the track-line on the x-axis).

3.3 Proportion of juveniles and calves

The proportion of juvenile porpoises and calves to all porpoises (including adults) was calculated for each survey (Table 6). The proportion of juveniles per survey ranged from 0% to 7.1% and calves from 0 to 4.9% on each survey. The observed proportion of juveniles to adults was highest on surveys 4 and 6 (21 July and 28 August) and adults to calves on survey 5 (19 August). Calves were all recorded on second and on the last two surveys in August. The proportion of young porpoises (juveniles and calves combined) recorded on survey days ranged from 6.3% to 9.5% and was 5.5% overall (Table 6).

Table 6 The numbers and proportions of adult harbour porpoises, juveniles and calves recorded during surveys of the Rockabill to Dalkey Island SAC, 2021.

Survey	Number of sightings	Number of Individuals	Adults	Juveniles	Calves	% juveniles	% calves
1	12	12	12	0	0	0	0
2	19	25	21	0	2	0	8.0
3	23	29	29	0	0	0	0
4	29	32	30	2	0	6.3	0
5	26	41	39	0	2	0	4.9
6	29	42	41	3	1	7.1	2.4
Overall	**137**	**181**	**172**	**5**	**5**	**2.8**	**2.8**

Table 7 The numbers and/or proportions of adult harbour porpoises, juveniles and calves recorded during surveys of the Rockabill to Dalkey Island SAC, 2021.

Survey	Number of sightings	Number of Individuals	Adults	Juveniles	Calves	% juveniles	% calves
2021	137	181	172	5	5	2.8	2.8
2016	152	246	221	10	14	9.8	5.7
2013	201	292	272	14	6	6.8	2.0
2008[3]	82	111	102	1	8	8	7.2
2008[3]	56	69	65	1	3	6	4.6

3.4 Additional marine mammal and megafauna sightings

Outside of Harbour porpoises, sightings of other marine mammals were quite scarce. Grey seal (*Halichoerus grypus*) were the most frequently recorded other marine mammal species and was recorded on four of the six surveys (Table 8). Short-beaked common dolphin (*Delphinus delphis*) was the only other marine mammal species recorded, occurring on two surveys in July and August. A group of 30

[3] from Berrow *et al.* (2008)

individuals were recorded at the end of the fifth survey, north of Rockabill Island. The limited species diversity of marine mammals is consistent with previous surveys although ther species recorded was different. During the survey in 2013 a single minke whale was reported and during 2016 only seals, with a total of 12 grey and common seal sightings and no cetaceans.

Table 8 Other marine mammal species recorded during surveys in Rockabill to Dalkey Island SAC, 2021.

Survey	Date	Number of sightings (total number of individuals)	
		Common dolphin	Grey seal
1	7 Jul	-	2 (2)
2	12 Jul	-	4 (4)
3	17 Jul	-	-
4	21 Jul	1 (1)	3 (3)
5	19 Aug	1 (30)	-
6	28 Aug	-	6 (6)
Overall		**2 (31)**	**15 (15)**

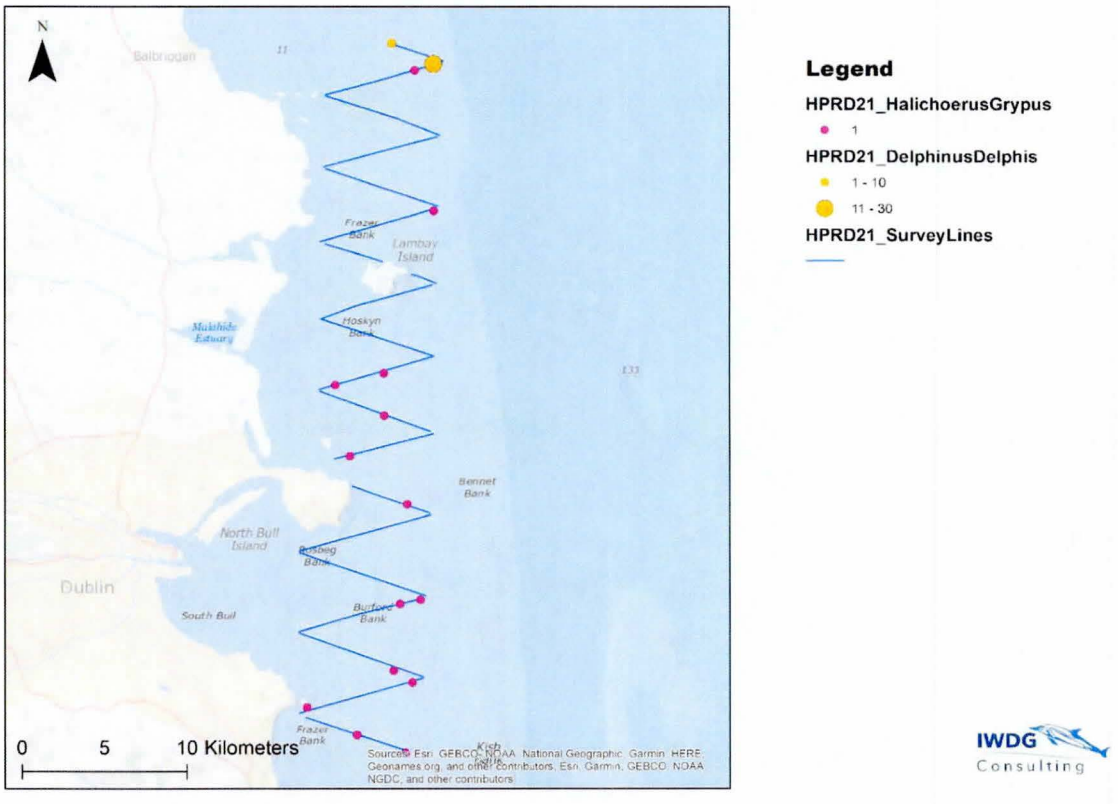


Figure 6 Distribution of marine mammals other than harbour porpoises recorded during surveys of Rockabill to Dalkey Island SAC during 2021.

4 Discussion

This was the third dedicated survey of harbour porpoises in the Rockabill to Dalkey Island Special Area of Conservation (SAC) since it was designated in 2013. Similar single platform line transect surveys were also carried out in 2008 and combined with 2013 and 2016 now provide some measure of inter-annual trends in density and the status of this qualifying interest. The survey carried out in 2021 was very successful in that sea conditions were very favourable throughout all six surveys and porpoises were recorded on all surveys in quite consistent numbers.

Distance sampling has been used to derive density and abundance estimates for harbour porpoise within the site. Statistical inference using distance sampling rests on the validity of several assumptions (Buckland *et al.*, 2001). These include the assumption that objects are spatially distributed according to some stochastic process. If transect lines are randomly placed within the study area we can safely assume that objects are uniformly distributed with respect to the perpendicular distance from the line in any given direction. During the current survey randomised pre-determined track-lines were provided by DHLGH which provided equal coverage probability within the SAC. Another assumption is that objects on the track-line are always detected (i.e., g(0)=1) and are detected at their initial location prior to any movement in response to the observer. Finally, if objects occurring on or near to the track-line are not detected the resulting density estimate will be an underestimate.

To minimise the effect of animal movement on the detection rate and detection function it is recommended that the speed of the observation platform is at least twice the speed of the object, as performed in this study. If this is the case, then movement of the object causes few problems in line-transect sampling (Buckland *et al.*, 2001). Typically for broad-scale surveys of harbour porpoise g(0)= 0.30-0.40 (Hammond *et al.*, 2002), or even as low as 0.21 (Hammond *et al.*, 2013). Thus, less than half of the animals on the track-line may only be detected. If this was the case during the present survey then we could perhaps double the density estimate to obtain a truer density estimate. Without a double-platform line-transect methodology it is not possible to accurately determine the number of porpoise detections on the track-line that were missed. The detection functions derived for individual surveys in the current analysis also suggested that there was some evidence of evasive movement relative to the survey boat on one of the six surveys, which resulted in a poor fit to the DISTANCE model. Such factors will tend to lower the density estimates and increase the CVs delivered via the modelling process. However, these sources of variability were consistent throughout the present survey and are also consistent with previous surveys carried out at the site (Berrow *et al.*, 2008; Berrow & O'Brien, 2013, O'Brien & Berrow, 2016).

The ability to visually detect harbour porpoises at sea, and thus the accuracy of density and abundance estimates, is extremely dependent on sea-state. During the present study all transect lines were carried out in sea-state 2 or less (as per contractual obligations), since the ability to detect harbour porpoises decreases significantly in sea-states ≥3 (Teilmann, 2003). In the present study, when the data were stratified by sea-state the best estimate was using data from sea-states up to 2, which supports the decision to survey sites in conditions up to and including sea-state 2 and use the pooled data.

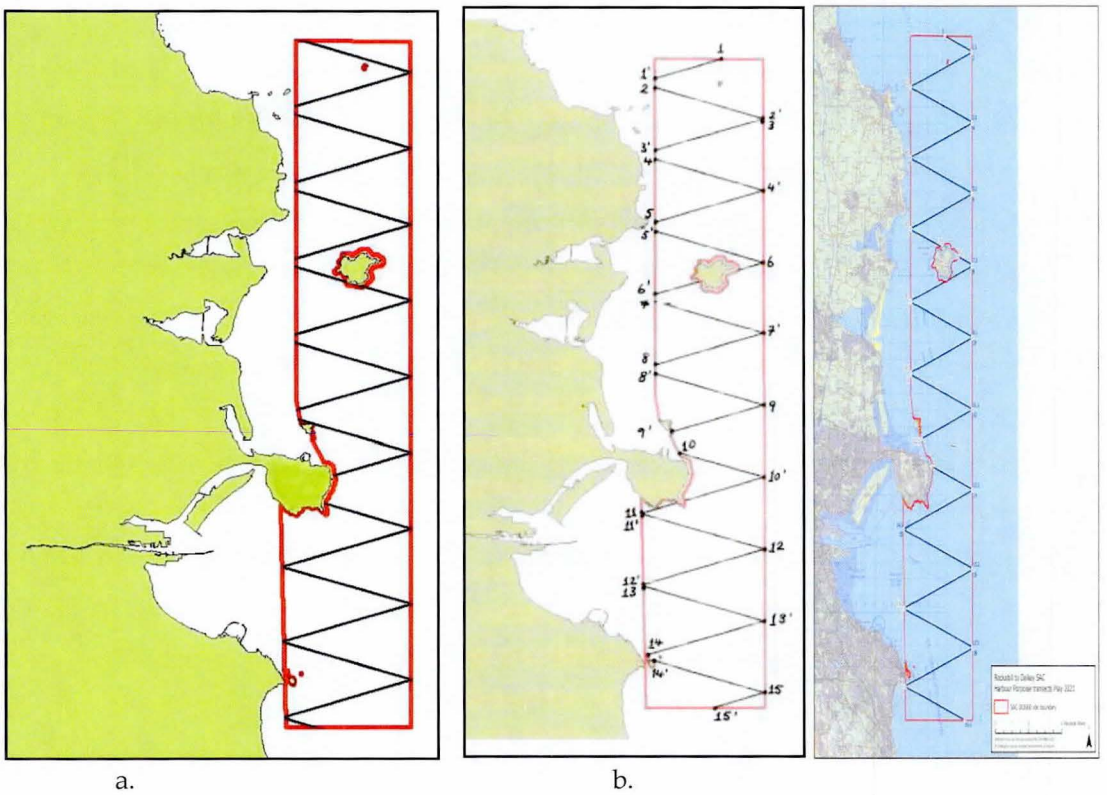
4.1 Harbour porpoise density estimates in Rockabill to Dalkey Island SAC

Abundance estimates were carried out in Dublin Bay and North County Dublin during the summer of 2008 as part of a wide ranging survey to identify sites with elevated harbour porpoise densities (Berrow *et al.* 2014). After designation in 2013, a survey was carried out along pre-determined track-lines in a zig-zag survey design (Berrow & O'Brien, 2013) (see Fig 7a). This was repeated in 2016 (O'Brien & Berrow, 2016) using similar track-lines but different start and end points but with the same total transect length (Fig 7b). During the current survey a similar zig-zag survey design was used but the orientation

of the track-lines were reversed within the same survey block but again with the same total transect length (see Fig 7c). The results of these surveys are presented in Table 9.

Table 9 Density, abundance and group size estimates for harbour porpoise within Rockabill to Dalkey Island SAC from 2008 to 2021.

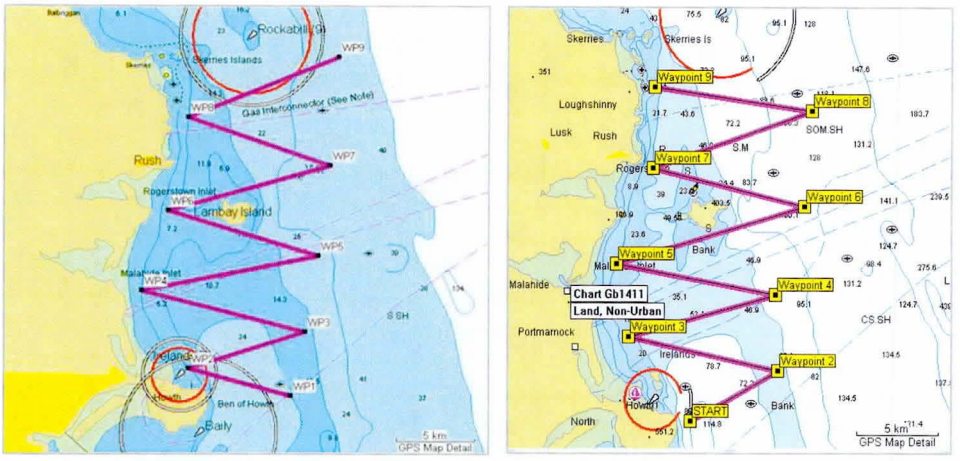
	Year	Density ± SE (per km²)	Mean group size	Abundance ± SE	CV	Reference
Rockabill to Dalkey Isl SAC	2021	0.83±0.14	1.31	227±39 (161-321)	0.17	This study
Rockabill to Dalkey Isl SAC	2016	1.55±0.17	1.62	424±45 (335-536)	0.10	O'Brien & Berrow (2016)
Rockabill to Dalkey Isl SAC	2013	1.44±0.09	1.47	391±25 (344-445)	0.09	Berrow & O'Brien (2013)
North County Dublin	2008	2.03	1.41	211±47 (137-327)	0.23	Berrow *et al.* (2008)
Dublin Bay	2008	1.19	1.19	138±33 (86-221)	0.24	Berrow *et al.* (2008)



a. b.

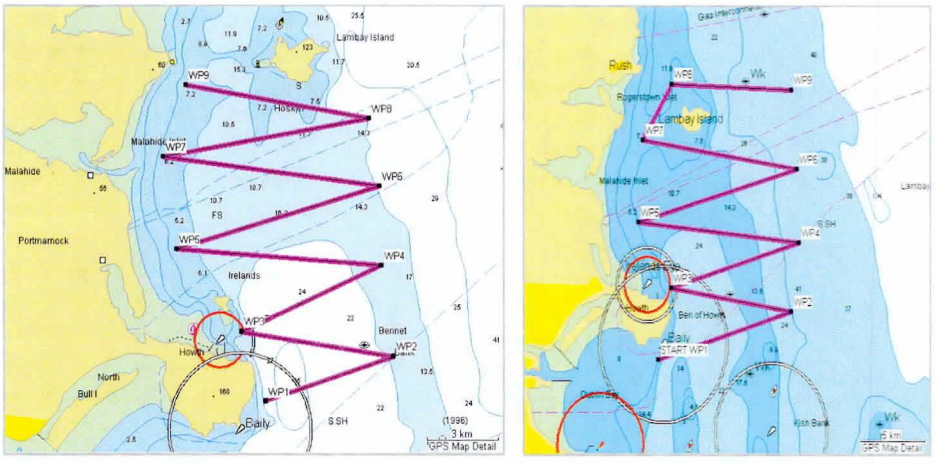
Figure 7 Zig-zag survey design used during harbour porpoise surveys of Rockabill to Dalkey Island SAC in a. 2013 b. 2016 and c. 2021

As part of an environmental assessment of a proposed sewage outfall pipe, 11 dedicated surveys using distance sampling were carried out between April 2015 and January 2017 (Meade *et al.*, 2017). Four of these were carried out between Howth Head and Rockabill Island and seven between Howth Head and Lambay Island an area considered to be most favourable for harbour porpoise (Fig 8).



a. April 2015

b. August and November 2015



c February 2016 and January 2017

d. August and October 2016

Figure 8a-d Track-lines used during harbour porpoise surveys for the Greater Dublin drainage Project between April 2015 and January 2017 (from Meade *et al.*, 2017).

Table 10 Estimated density, abundance (N) and group sizes of harbour porpoise recorded for the Greater Dublin Drainage project (from Meade *et al.*, 2017).

Date	Density (per km2)	SE	CV	Mean group size (95% CI)
Apr 2015	0.78	54	0.33	1.44 (1.00-2.12)
Aug 2015	1.91	114	0.32	1.85 (1.48-2.30)
Nov 2015	1.76	50	0.36	1.17 (1.12-1.31)
Feb 2016	0.61	12	0.23	1.00
Aug 2016	2.29	70	0.15	1.53 (1.25-1.85)
Oct 2016	0.97	54	0.28	1.37 (1.00-1.89)
Jan 2017	0.89	38	0.21	1.35 (1.07-1.69)

Density estimates are shown in Table 10 and ranged from 0.78-1.91 harbour porpoise per km^2 in the wider survey area and 0.61-2.29 harbour porpoise per km^2 between Howth Head and Lambay Island.

These data provide baselines for marine mammal surveys currently underway off the east coast of Ireland. Site surveys for offshore windfarms and other coastal developments to estimate density and abundance of marine mammals, especially harbour porpoises to assess environmental impacts use a

variety of methodologies and platforms. These uncorrected density estimates (where g(0) is assumed to be 1) should be used as reference values as the data were collected in ideal sea conditions, on suitable platforms and with experienced observers.

Proportion of juveniles and calves

The proportion of young recorded in 2021 was lower than that reported at the same site in 2016. The proportion of calves was similar to that reported in 2013 but the proportion of juveniles was less than that reported in 2013. No surveys were carried out in September 2021 but were during September 2013 and 2016, which have had a small influence of this metric as adults with calves are more frequently reported later in the season. This may have resulted in a lower estimate of the proportion of calves present.

Although the proportion of young to adults was considerably less than that reported by Sonntag *et al.* (1999) from the Isle of Sylt in Germany, with up to 18% calves, the proportion is consistent with other studies at around 3-5% (Hammond *et al.*, 2002; Evans and Hammond, 2004). Calving success and survival may fluctuate greatly between years and although the proportion of young reported here is low only more regular surveying will be able to determine if this is within the ranges of normal annual variability or part of a long term decline.

4.3 Trends in harbour porpoise density estimates in Rockabill to Dalkey Island SAC

Although line-transect survey designs were notably different in 2008, the model outputs are worth comparing with more recent surveys (Table 9). Density estimates in 2013 and 2016 were similar to that reported in 2008 especially for North County Dublin, suggesting there had been little change in porpoise densities over this eight year period. The density estimate in 2021 (0.83 harbour porpoise per km^2) is around 44% of that reported in 2013 and 2016. The number of sightings per survey were similar in 2013 and 2016 but down by around 17% on the mean of the previous surveys. The total number of individuals recorded was also down by 26% on those recorded in 2016 but very similar to the total number of individuals recorded in 2013 however the total survey effort was also lower in 2013 around 30%. Mean group size (1.81) was very similar to that recorded in 2016 (1.86, Table 10).

The data here were collected during favourable sea conditions, on excellent platforms and with experienced surveyors and we are satisfied the density estimate is accurate. Thus there does seem to have been a real decrease in the density of harbour porpoises recorded in the Rockabill to Dalkey Island SAC during 2021, compared to the two previous surveys in 2013 and 2016. This is of concern and the drivers of the local distribution and abundance of harbour porpoises in this SAC needs to be explored.

This decrease in densities in the only Special Area of Conservation for harbour porpoises off Irelands' east coast should be put into a wider context. The most recent harbour porpoise surveys, using the same methodology, in the other two SACs with harbour porpoise as qualifying interests, namely Roaringwater Bay and Islands SAC in Co Cork and Blasket Islands SAC in Co Kerry also reported significant declines in harbour porpoise densities. O'Brien & Berrow (2020) reported a 70% decline in porpoise densities in the Roaringwater Bay and Islands SAC between 2016 and 2020 and a 53% decline between 2020 and 2013. O'Brien & Berrow (2018) reported a 56% decline in harbour porpoise densities between 2014 and 2018 in the Blasket Islands SAC. This suggests that the drivers of the decline in harbour porpoise densities is widespread in Irish coastal waters.

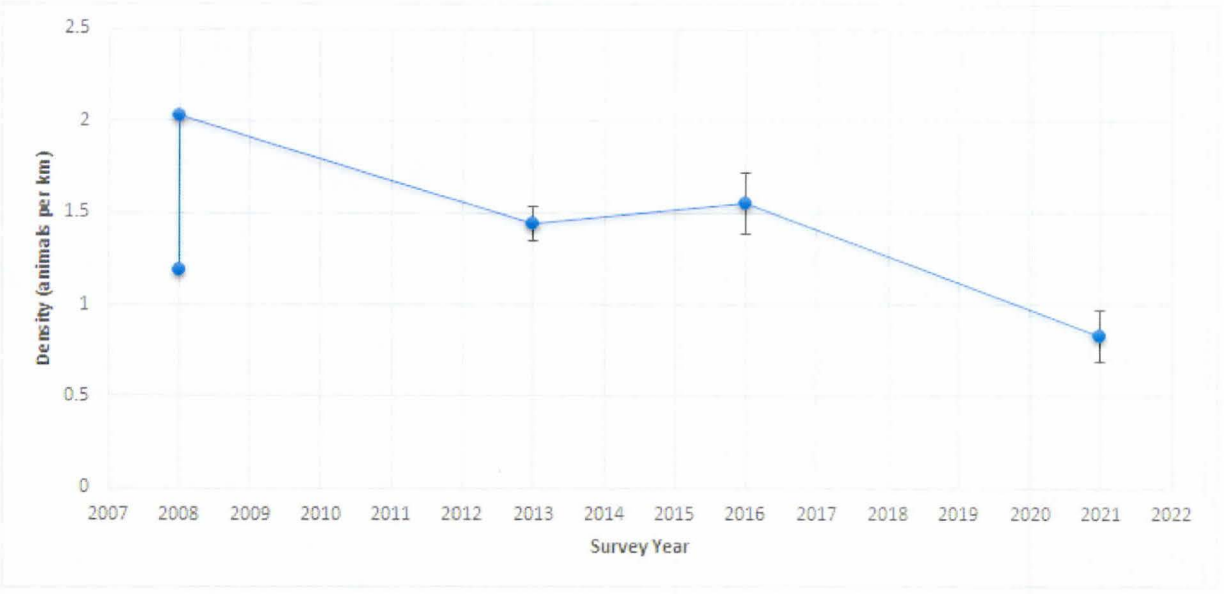


Figure 9 Changes in the recorded density of harbour porpoises in the Rockabill to Dalkey Island SAC over time.

This does not necessarily imply a decline in overall population size but perhaps changes in distribution and habitat use at a local scale. The distribution and abundance of top predators such as harbour porpoises is strongly influenced by the availability of preferred prey. The diet of porpoise in Ireland is not well known, but it is thought to be a mixture of pelagic and benthic fish including sandeels and gobies as well as crustaceans (Rogan, 2008). One possible reason for a decline in density within the Rockabill to Dalkey Island SAC was a change in the distribution of their preferred prey outside of the SAC boundaries, resulting in lower densities of porpoises within the site. A better understanding of the ecology of harbour porpoise in this region, including their diet and foraging ecology, is required in order to interpret this apparent decline in abundance between survey years.

4.4 Recommendations

1. These surveys should be continued and given the decrease reported here repeated again in 2022 to determine if this is an outlier, or part of a trend. We recommend annual surveys to explore short-term (annual) changes in densities.

2. Given the variability in density estimates from distance sampling, consideration should be given to establishing fixed acoustic monitoring stations to derive acoustic indices from which to monitor population status. It is possible that acoustic datasets when put into appropriate models could identify changes at a higher resolution than boat-based visual surveys and offer year round coverage.

3. It is unclear what the drivers of short and long-term changes in the distribution and abundance of harbour porpoises within the Rockabill to Dalkey Island SAC. The most likely driver is the availability of preferred prey which may fluctuate locally over short periods. We recommend a study of the diet of harbour porpoises off the east coast of Ireland should be considered including seasonal components.

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Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

6.3

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

International Journal of One Health
Available at www.onehealthjournal.org/Vol.8/No.1/6.pdf

REVIEW ARTICLE
Open Access

The One Health concept for the threat of severe acute respiratory syndrome coronavirus-2 to marine ecosystems

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Received: 21-01-2022, **Accepted:** 22-03-2022, **Published online:** 23-06-2022

doi: www.doi.org/10.14202/IJOH.2022.48-57 **How to cite this article:** Bukha KK, Sharif EA, Eldaghayes IM (2022) The One Health concept for the threat of severe acute respiratory syndrome coronavirus-2 to marine ecosystems, *Int J One Health*, 8(1): 48-57.

Abstract

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a global health threat. This virus is the causative agent for coronavirus disease 2019 (COVID-19). Pandemic prevention is best addressed through an integrated One Health (OH) approach. Understanding zoonotic pathogen fatality and spillover from wildlife to humans are effective for controlling and preventing zoonotic outbreaks. The OH concept depends on the interface of humans, animals, and their environment. Collaboration among veterinary medicine, public health workers and clinicians, and veterinary public health is necessary for rapid response to emerging zoonotic pathogens. SARS-CoV-2 affects aquatic environments, primarily through untreated sewage. Patients with COVID-19 discharge the virus in urine and feces into residential wastewater. Thus, marine organisms may be infected with SARS-CoV-2 by the subsequent discharge of partially treated or untreated wastewater to marine waters. Viral loads can be monitored in sewage and surface waters. Furthermore, shellfish are vulnerable to SARS-CoV-2 infection. Filter-feeding organisms might be monitored to protect consumers. Finally, the stability of SARS-CoV-2 to various environmental factors aids in viral studies. This article highlights the presence and survival of SARS-CoV-2 in the marine environment and its potential to enter marine ecosystems through wastewater. Furthermore, the OH approach is discussed for improving readiness for successive outbreaks. This review analyzes information from public health and epidemiological monitoring tools to control COVID-19 transmission.

Keywords: coronavirus disease 2019, marine environment, One Health, sewage, shellfish, zoonosis.

Introduction

The One Health (OH) approach, as identified by the World Health Organization (WHO), is not new. However, it has recently become more important [1]. The approach recognizes that the health and well-being of animals, humans, and the environment are intricately linked [2]. All three play an essential role in the emergence of various diseases, and the majority of human infectious diseases have animal origins [3]. The interaction between animal health and public health has been recognized by the "One Medicine" concept, which is an intersection of human health and veterinary science [4].

The quality of marine environments is essential for maintaining public health [3]. Marine pollution poses severe threats to marine animals and human health [5]. Moreover, marine systems are often contaminated by human excreta, agricultural activities, household garbage, and wild animals. Contamination in the marine environment may negatively affect marine ecosystems through pathogenic microbes and chemical substances [1,5,6].

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Marine ecosystems are often affected by microbiological pollution when sewage from human and animal origin is discharged into the sea. Pollutants carried by untreated wastewater to the marine ecosystem reach fish food chains [6]. Marine organisms can thus be a source of pathogenic microorganisms for terrestrial and aquatic animals and humans [7]. Further, bacteria and viruses from animals and humans can affect seawater quality and accumulate in shellfish [5,8].

Coronavirus disease 2019 (COVID-19) is caused by sever acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [9,10]. The WHO declared (SARS-CoV-2) as a medical and public health emergency [11]. In December 2019, COVID-19 began in Wuhan, China [12,13]. The surge in this disease in Asia and Europe led the WHO to declare the outbreak as a pandemic in March 2020 [14].

SARS-CoV-2 permeates the environment, especially aquatic and marine habitats and wild animals [15]. An increased concern developed concerning the occurrence of coronaviruses in the aquatic environment during the outbreak of COVID-19. Globally, increased awareness of the risk of coronaviruses from sewage arose following the discovery of SARS-CoV-2 in sewage in several countries [16]. This finding was an early sign of a community outbreak of COVID-19 [17].

The spread of coronaviruses within the environment is an increasing challenge to public health [18].

Filter-feeding organisms accumulate and transmit these microbes to humans [18], thus playing an important role in fecal-oral transmission [19]. Coronaviruses are detected in marine mammals, and the survival of coronaviruses in aquatic environments depends on water temperature, organic matter, and light intensity [7].

The OH concept will help address COVID-19, which is thought to have originated from animals, and then transmitted to humans. Further, waterborne transmission of SARS-CoV-2 is recognized. Many authors report coronaviruses in sewage treatment plants, and wastewater is an important means of virus transmission. Further, filter-feeding shellfish can be used as markers for seawater quality. To date, only limited studies of SARS-COV-2 in wastewater and aquatic waters are available. This review identifies the best OH actions to control the incidence and outbreak of COVID-19. In addition, the review gathers current knowledge of SARS-CoV-2 in marine systems as receiving waters for treated and untreated sewage and its effects on aquatic animals.

SARS-CoV-2

SARS-CoV-2 is the causative agent for the ongoing COVID-19 pandemic first identified in a Wuhan seafood market in China in late 2019. The virus is 50-200 nanometers in diameter and characterized by club-shaped projections on its surface. It is a positive-sense, single-stranded RNA virus with four structural proteins. SARS-CoV-2 is categorized in the genus Betacoronavirus of the viral family, Coronaviridae [20].

No Betacoronaviruses were isolated from marine mammals based on the literature review. In contrast, Alphacoronaviruses and Gammacoronaviruses are reported in these animals [21,22]. SARS-CoV-2 might be shed for lengthy periods in feces of COVID-19 patients, [23-27]. Hence, SARS-CoV-2 is detected in wastewater management facilities [28] and could be introduced to aquatic habitats through sewage outfalls.

Zoonoses and the OH concept

Many authors have embraced the "One Health" concept [3]. In 1984, the international organizations and scholarly bodies adopted this approach [29]. The OH approach integrates direct impacts of environmental epidemiology on animal and human health. Human, animal, and ecological health are thus inextricably interdependent [4,30]. The concept encourages collaboration among physicians, veterinarians, wildlife biologists, ecologists, agriculturists, biomedical engineers, and epidemiologists to comprehensively improve health [3].

Humans, animals, and the environment are significant in the emergence and spread of various diseases. Infectious diseases in humans often emerge in foods of animal origin [3,31]. Zoonoses are diseases caused by many pathogens, such as viruses, bacteria, fungi, and parasites, that are naturally transmissible between non-human vertebrates and humans [32,33]. Zoonoses currently make up approximately 60% of the roughly 1350 infectious diseases known to affect humans [33,34]. Vectors transmit almost 20% of these illnesses [35]. Zoonotic diseases lead to millions of death annually [36]. Further, zoonotic pathogens spread broadly across national and continental boundaries, as is reflected in the global transmission of SARS-CoV-2 [33]. Wild animals are often vectors for the movement of zoonotic pathogens to peridomestic, then livestock animals, and, finally, indirectly to humans (Figure-1). Therefore, OH is vital for controlling zoonotic diseases [29].

Importance of the OH approach for COVID-19

The outbreak of COVID 19 is an ideal case for analyzing how the OH approach can be used for zoonotic diseases [37]. SARS-CoV-2 was reported in cats, lions, and tigers in a zoo. The virus may also be transmitted from humans to domestic cats [30]. Thus, OH can be used to investigate the role of wild animals in the epidemiology of coronaviruses [38]. The OH approach is particularly relevant because it includes the control of zoonoses that spread between humans and animals and incorporates food safety and combating antibiotic resistance [34,37]. OH concepts that use disease surveillance and eradication through collaboration between veterinarians that address wild animal and livestock populations, public health experts, and ecologists may yield a more rapid resolution to outbreaks [29]. Collaboration between human medicine and veterinary medicine might enhance public health outcomes (Figure-2). Further, global zoonotic disease prevention through increased vaccination and increased use of technology may improve animal living conditions [34]. Nevertheless, the OH approach remains challenging for most nations [2].

Marine viral pathogens and human health

Waterborne microbes, such as bacteria, viruses, and parasites, can be transmitted to humans through exposure to marine waters or the consumption of contaminated seafood [39]. Coastal habitats and marine microbes are considered reservoirs for newly emergent pathogens [40]. Viruses are the most abundant microbes in seawater and are found in concentrations of about 10-fold greater than prokaryotic organisms [41]. Viruses are abundant in surface water and sub-surface sediments [41]. Further, viruses in the marine environment are more persistent than *Escherichia coli* [42]. The ability of viruses to survive in the marine environment and their transport from sources to shellfish habitats or marine beaches are reported. Overall, viral pathogens are believed to cause most waterborne marine diseases [43].

Human stools contain various viral pathogens that enter marine ecosystems by discharging wastes from infected individuals [42]. Many viruses are

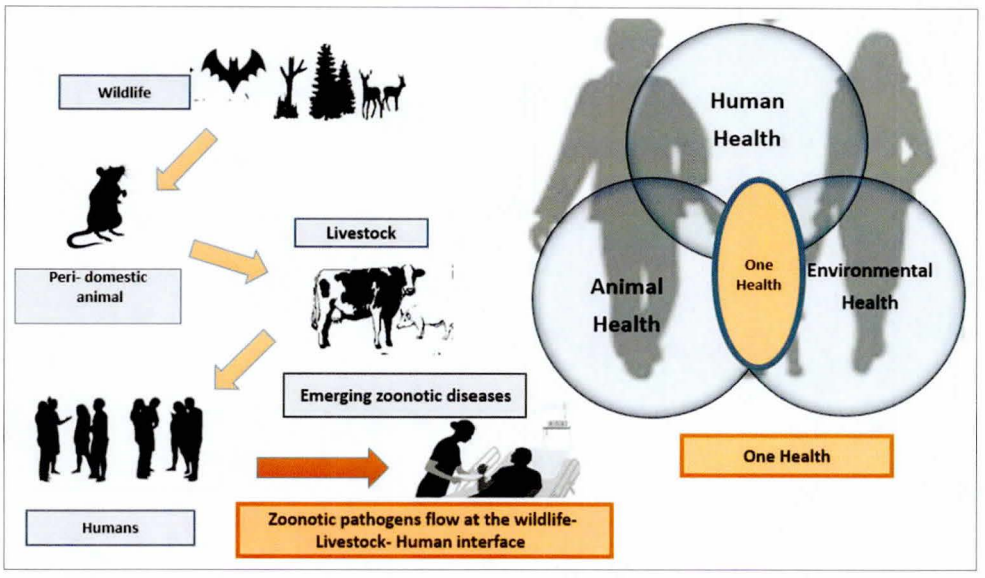


Figure-1: Emerging zoonotic diseases. (The figure was generated using Microsoft PowerPoint and Adobe Illustrators by KKB).

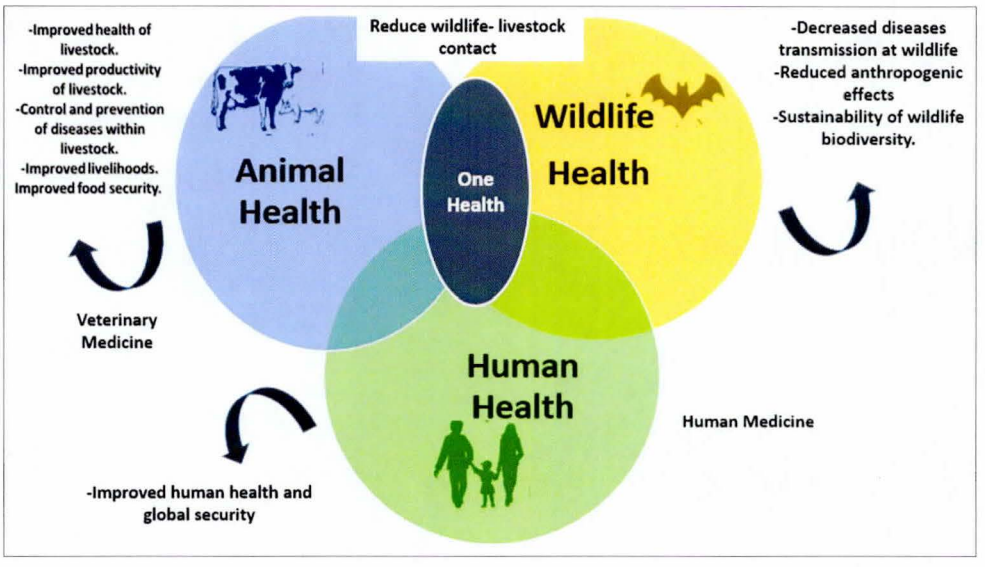


Figure-2: One Health concept to address emerging zoonotic diseases. (The figure was generated using Microsoft PowerPoint and Adobe Illustrators by KKB).

transmitted through the fecal-oral route [44]. Viral pathogens in the marine environment are known threats to public health, including enterovirus, adenovirus, astrovirus, reovirus, rotavirus, calicivirus, and *Norovirus*. Infections by viruses in the latter genus represent 21% of enteric viral illnesses [5] and are responsible for many notifiable diseases in humans due to ingesting contaminated water or seafood [45]. Coronaviruses are enteric viruses and are associated with gastroenteritis in humans [46].

Several viruses in aquatic environments pose significant public health threats. Viruses in sewage may contaminate drinking water, recreational waters, and shellfish that threaten public health [43]. These pathogens cause many illnesses, such as gastroenteritis, hepatitis, fever, meningitis, and conjunctivitis [47]. In addition, respiratory and enteric diseases are associated with consuming contaminated seafood [39]. Accumulation of viruses in shellfish increases during periods of low water temperature, and a higher incidence of human viral gastroenteritis occurs through shellfish consumption during these periods [43].

Decay rates of viable coronaviruses in the aquatic environment

A Sala-Comorera *et al.* [48] first published an analysis of the viability of SARS- CoV-2 in the aquatic environment. Viruses remained viable and infectious in marine water for just 1-2 days depending on water temperature. Infectivity coronavirus decreased rapidly in seawater and rivers, especially at high water temperatures. Marine and river water contaminated with fecal matter from COVID-19 infected patients is unlikely to show high levels of infectious coronaviruses due to rapid inactivation [48]. In natural waters, environmental factors, such as UV light, organic matter, and other microorganisms, would also alter decay

rates of viable coronavirus [49]. Still, the behavior of SARS-CoV-2 in the gastrointestinal tract of humans is some evidence for fecal-oral transmission [26,50]. SARS-CoV-1 may also be transmitted in this fashion [51]. Wong *et al.* [52] suggested that coronavirus can actively replicate in the gastrointestinal tract of infected individuals.

Presence of SARS-CoV-2 on the toilet

Coronaviruses are usually spread by respiratory and fecal aerosols [53]. The spread of viruses in sewage is also through solid waste or aerosols from toilets. Such findings confirm fecal-oral transmission [54]. Toilets pose a particular risk for SARS-CoV-2 transmission due to aerosolization of feces and urine of infected individuals [55]. Coronaviruses are detected in feces and urine [56], suggesting a risk of aerosol transmission from flushing toilets [57].

Fever, cough, rhinorrhea, dyspnea, muscle ache, lethargy, neurological manifestation, or diarrhea are recognized symptoms of COVID-19. However, SARS-CoV-2 is detected in the stools of patients who do not suffer gastrointestinal tract upset [56]. Overall, toilets in hospitals are the most contaminated areas and the primary source of infection [11]. A toilet may be shared by patients of hospitals in large isolation rooms. Therefore, personal spaces overlap with toilet area contamination and generate an additive effect [53]. Two hospitals in Wuhan, China, showed high coronavirus concentrations in toilets but low concentrations in isolation wards and aerosols in ventilated patient rooms [58]. Moreover, aerosols in hospital toilets contain the most detected coronavirus [53].

Stools of patients be positive for coronavirus for many weeks, even if the respiratory tract is negative [56]. Thus, surfaces, such as over-bed tables, nurse call buttons, and bed rails should be cleaned at least twice daily [59]. Conversely, stools from toilets are discharged into sewer networks and undergo dilution. Viral pathogens in stools may be transformed within sewerage systems. The coronavirus may survive for several hours in feces and several days in urine [54]. Nevertheless, detecting SARS-CoV-2 in sewage is considered an early signal of outbreak [54].

Fate of SARS-CoV-2 in the urban water cycle (UWC)

Human viruses are excreted in urine, feces, and other body fluids [60]. The persistence of coronaviruses in these wastes in sewage is a health and environmental issue [17]. As mentioned, coronavirus enters water systems through individuals infected with COVID-19. Traces in sewage are associated with the discharge of urine or feces from such individuals [61]. Overall, SARS-CoV-2 is reported in wastewater and effluents [61].

The UWC is spatiotemporal interaction among hydrological processes [61]. The cycle consists of wastewater treatment plants (WWTPs), stormwater runoff management, and a drinking water distribution system [60]. SARS-CoV-2 has been assessed in wastewater samples from many nations, such as France, India, Italy, Australia, Netherlands, Japan, Turkey, Spain, the USA, the UAE, and other countries [62-66]. In Australia, coronavirus was found in 22% of sewage samples with viral concentrations as low as 1.2×10^2 copies/L [61]. The presence of SARS-CoV-2 in sewage suggests the presence of a viable virus [67].

Fate of SARS-CoV-2 coronavirus in wastewater

Coronaviruses in aquatic environments are due to untreated and treated sewage [60]. Release of treated, partially treated, and untreated sewage into aquatic systems is common. Discharges in developing countries to receiving waters are comprised of up to 80% partially treated wastewater [14]. The volume of sewage discharged from urban cities of India was 61.754 million liters per day [14]. Moreover, several Mediterranean countries dump wastewater into coastal waters without treatment, and this practice has a substantial negative impact on the aquatic flora and fauna of the Mediterranean Sea [68]. The highest concentration of viral particles is in raw wastewater, while the lowest concentration is in secondary and tertiary treated wastewater [60].

The concentration of coronavirus in feces is typically 10^2-10^8 copies per gram of stool [13]. SARS-CoV-2 persisted in stool for 3 days and in urine for 17 days [17]. Overall, coronavirus showed maximum presence in the stool of infected individuals for up to 14 days after the onset of the illness [17]. A high concentration of virus was found in the feces of hospitalized individuals with COVID-19. Furthermore, the virus can be isolated from the lungs of patients but not from feces [11]. SARS-CoV-2 in the stool of infected individuals was observed on the 5th day after the onset of symptoms, and traces of virus were still present after 30 days [60]. Virus shedding was seen in the stools of infected individuals from day 1 to 33 after a negative nasopharyngeal swab [66]. In China, the presence of coronavirus in stools was observed before the onset of symptoms [69].

Detection of SARS-CoV-2 is confirmed in municipal sewage of several countries worldwide [9,14,70-72]. In Italy, SARS-CoV-2 was found in river samples, and in Turkey was seen in primary and activated waste sludges from seven WWTPs [17,60]. Coronavirus was not detected in China in raw sewage but was reported in treated sewage of Wuchang Fangcang hospital. These reports highlight low efficacy of disinfection for WWTPs in this hospital [16]. Furthermore, no coronavirus was found in wastewater samples from Spanish WWTPs [60]. In France, high concentrations of SARS-CoV-2 were found in sewage during the spring season, and low concentrations were observed during the summer season [18,73].

Wastewaters typically undergo three treatment stages in WWTPs: Primary, secondary, and tertiary [74]. In the United States, Sherchan *et al.* [66] observed

that wastewater samples did not produce positive results for SARS- CoV-2 after secondary and tertiary treatment, indicating that these processes can remove the virus [17]. The current development of new treatments for COVID-19 patients may increase viral incidence in wastewater treatment facilities, which might increase the risk for aquatic organisms. The lack of a standardized protocol for detecting coronavirus in sewage is considered a significant challenge [17].

Fate of SARS-CoV-2 in the marine environment

In some countries, wastewater is discharged into shallow coastal waters [75]. Such discharges represent the threat of viable pathogens to wild marine ecosystems [74]. SARS-CoV-2 may be introduced to the marine environment through contact with infected swimmers or wastewater outfalls [76]. Moreover, marine contamination may enhance the zoonotic transmission of coronavirus to marine mammals [77]. Further, COVID-19 has adverse direct and indirect impacts on marine ecosystems (Figure-3). The virus may be viable and infective for many days and weeks in wastewater and the aquatic environment [13]. Still, after introduction to the environment, coronaviruses are subject to physical dilution and physiochemical stresses, such as salinity, temperature, ultraviolet (UV) radiation, and pH [77-80].

The ocean rapidly dilutes wastewater. Nevertheless, dilution may be insufficient to reduce viral risks [47]. Human pathogens are often unstable in the marine environment, leading to loss of viability over short periods. This phenomenon is more apparent in the marine environment than in rivers [47]. Conversely, sediments can act as viral reservoirs in marine environments [60]. Guo *et al.* [77] suggested that continuous discharge of untreated sewage carrying coronaviruses can pollute tens of thousands of km^2 of marine areas. Therefore, fish movement is considered a major route for the long-distance spread of viral pathogens [12].

Coronaviruses prefer dry and cold environments for survival and spread. Warm and humid conditions are not well-matched with virus viability [77]. The health of marine environments is critical for protecting human health. Contaminants may reach the food chain of fish in the marine environment through wastewater discharge. At present, plans and future programs for joint Oceans and Human Health efforts are being discussed [6]. However, pollution of the marine environment by municipal sewage is considered the main mode of transmission for human enteric viruses [18]. Even so, natural disasters have damaged marine environments and led to a range of negative consequences for human health [81]. Marine animals are vulnerable to pollution by detergents, pharmaceuticals, and nanoparticles from wastewater [74]. Several marine mammal species are susceptible to SARS-CoV-2 since they exhibit the virus-host receptor, ACE2 [74,77].

Shellfish and monitoring of SARS-CoV-2

Filter-feeding animals are ubiquitous in the marine environment [82]. Further, viruses are the leading cause of outbreaks of foodborne diseases [83]. Filter-feeding organisms are a long-standing source of such illnesses [19]. Further, shellfish, such as oysters and other bivalves, are vulnerable to contamination by enteric viruses in surrounding waters [83]. Moreover, shellfish may threaten human health due ability to filter and bioaccumulate pathogens [45]. Viral foodborne outbreaks are associated with raw or undercooked shellfish consumption [83].

Bivalve mollusks, such as mussels, clams, or oysters, are vectors of human viral pathogens. These marine animals are a fundamental part of marine ecosystems [84]. Oysters are highly commercialized seafood and are often consumed undercooked or raw [19]. Oysters can concentrate viral pathogens up to 99 times [83]. Mussels are sessile filter-feeders, used as the best choice bioindicator for monitoring

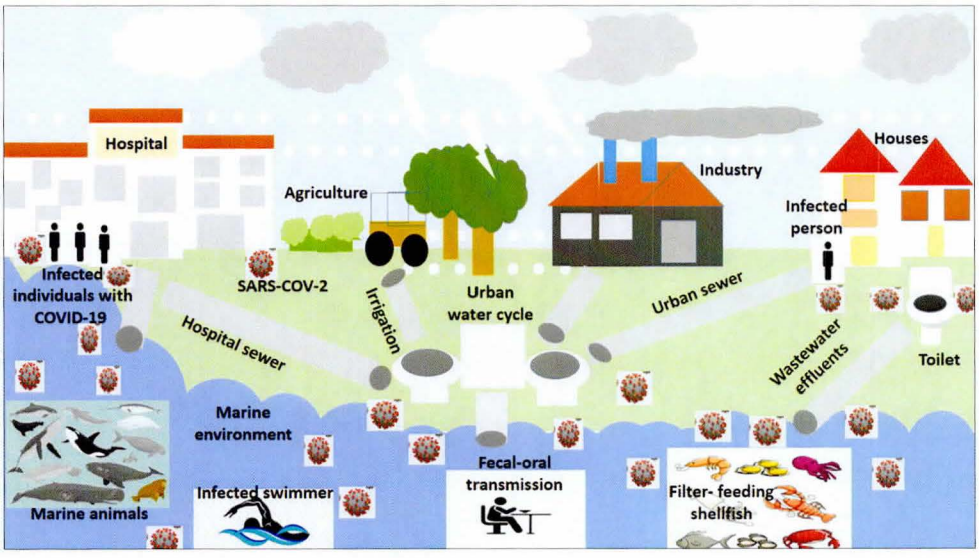


Figure-3: Fate of severe acute respiratory syndrome coronavirus 2 coronavirus in the marine environment. (The figure was generated using Microsoft PowerPoint and Adobe Illustrators by KKB).

pollution [85]. These animals feed by filtering water through their gills [83].

Most outbreaks of shellfish-associated noroviruses are linked to raw and undercooked oyster consumption [86]. Several locations on the French Coast reported the absence of SARS-CoV-2 in shellfish samples [19]. Further, SARS-CoV-2 is not a foodborne virus but can survive in cold-chain food sources. Furthermore, the virus does not replicate in cold-blooded animals. Therefore, it is unlikely that human consumption of aquatic animals can transmit SARS-CoV-2 or other marine coronaviruses [41]. Overall, SARS-CoV-2 is transmitted between humans through airborne aerosols, respiratory droplets, direct contact with fomites, fecal-oral transmission, and consumption of infected seafood (Figure-4).

Effects of environmental factors on SARS-CoV-2

Virus replication requires host intracellular resources [60]; replication is not possible outside host cells. Viability will depend on environmental conditions, such as temperature, salinity, pH, and UV light [87]. Coronaviruses are enveloped viruses with club-shaped surface spikes that give the appearance of a crown. Spikes of this virus range from 9 to 12 nm [88]. Enveloped viruses are less stable than non-enveloped viruses against various environmental stress factors due to the ease of disruption of lipids and proteins of the envelope [16].

Environmental factors are essential to the spread of COVID-19, highlighting the transformation of the disease seasonally. Seasonal outbreaks of this virus may be driven by their response to suitable changes in the weather [89]. In Singapore, factors, including temperature, humidity, and water vapor, were positively correlated with viral transmission [90,91]. Humidity and temperature are assumed to favor the spread of coronaviruses [92]. Furthermore, Basray *et al.* [93] reported a positive correlation of SARS-CoV-2 with different temperature ranges and a negative correlation with humidity. Climate factors affect the incidence of COVID-19 in Pakistan. Temperature and population density played an important role in transmitting coronaviruses [89].

High temperature minimizes viral populations due to the denaturation of proteins and increased activity of exoenzymes [60]. Overall, virus survival decreases in high temperatures; maintaining temperatures >60°C for more than 60 min usually inactivates viruses [94]. At 4°C, viruses may persist for 14 days [95,96]. Coronavirus remains viable on glass surfaces, plastic, and stainless steel for 2 and 4 days at 24°C room temperature, while on paper, it survives for 30 min and 3 h on tissue paper [95-97]. Some researchers suggested that SARS-CoV-2 is still active for 25 days at 5°C in the aquatic environment [80,97,98].

pH and salinity are also significant factors that affect infectivity and survival of coronaviruses in seawater. pH may affect viral survival by directly affecting viral capsid protein conformation [99]. However, viruses can survive in water with pH values ranging from 3 to 10 [96]. In addition, high salt concentrations in seawater may inactivate viruses. The highest viral presence was shown for low salinity coastal waters and surface coastal sediments [41].

Coronaviruses are inactivated in water by exposure to solar or UV radiation [11]. Solar light may inactivate coronavirus rapidly on surfaces, and showing that sunlight is vital for reducing viral transmission risk [95]. Exposure of SARS-CoV-2 infected water to UV radiation disrupts and destroys the integrity of viral DNA [60].

The high concentration of organic matter in many water bodies increases the survival of viruses due to physical protection afforded by particles from detergents, antiviral agents, and UV light [60].

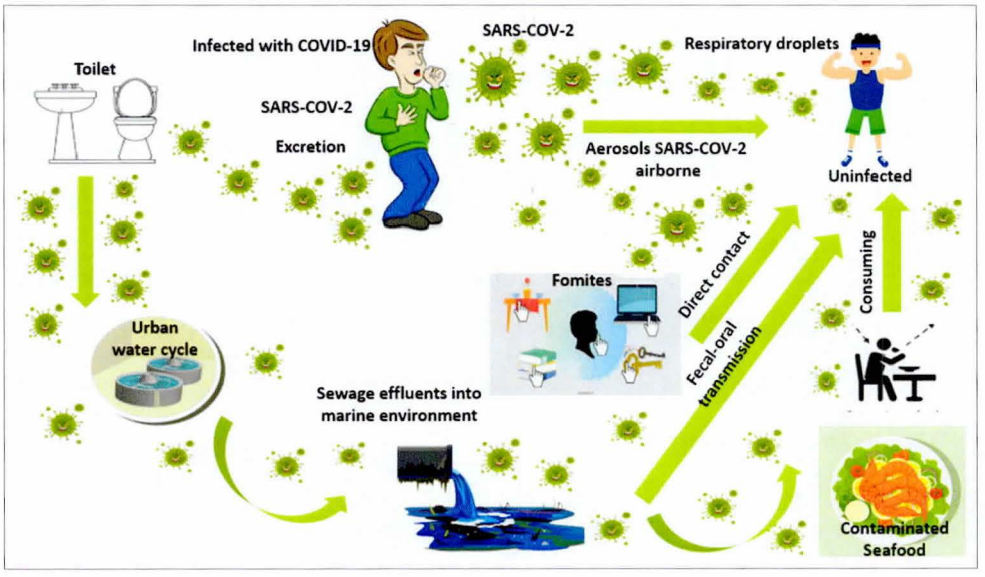


Figure-4: Mechanism of coronavirus disease 2019 transmission. (The figure was generated using Microsoft PowerPoint and Adobe Illustrators by KKB).

Disinfectants inactivate viruses by altering viral proteins. Therefore, disinfection remains the best means for inactivating coronaviruses in water [11].

Conclusion

The increasing global threat from zoonotic disease supported the emergence of OH. OH was subsequently modified by incorporating expertise and data from animal, human, and ecosystem health. OH supports research and development to prevent and control animal diseases to enhance food security. The recent COVID-19 outbreak has spread rapidly and unexpectedly worldwide at the cost of many human lives. Poor wastewater treatment and the resulting possibility of SARS-COV-2 transmission is considered a significant challenge; the discharge of untreated wastewater could expose the public to infection. Lack of basic sanitation and sufficiently treated wastewater in developing countries may exacerbate COVID-19 outbreaks. Viruses that reach the marine environment contribute to reduced marine water quality caused by human sewage and refuse that negatively affect both ecosystems and public health.

Detection of coronaviruses in wastewater raises the possibility of analyzing sewage for future epidemiological monitoring of SARS-CoV-2. Fecal-oral transmission can evade measures for countering COVID-19 outbreaks. The OH concept is an excellent choice to guide coordination among scientific sectors early in an outbreak. The evolution of the OH concept supports the development of more equitable actions at the animal, human, and environmental interfaces. The OH contribution to novel coronavirus control can only be achieved through prevention and therapeutic options. The general operationalization of OH understands disease ecologies within environmental factors, such as weather parameters, pathogen transmission through aerosols, wastewater surveillance, sanitization measures, and environmental hygiene. Further studies are needed to understand the survival of coronavirus in wastewater and the measurement of SARS-CoV-2 in wastewater aerosols, and the assessment of associated risks.

Authors' Contributions

KKB: Collected the literature and wrote the first draft of the review article. EAS and IME: Participated in the drafting and revision of the review article. All authors have read and approved the final manuscript.

Acknowledgments

The authors did not receive any funds for this study. The authors would like to thank the first author Khawla for designing and preparing all figures in this article.

Competing Interests

The authors declare that they have no competing interests.

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Veterinary World (Publisher of International Journal of One Health) remains neutral with regard to jurisdictional claims in published institutional affiliation.

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Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

7.1

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

7.1

Council of the EU

PRESS
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PRESS RELEASE
59/24
29/01/2024

Urban wastewater: Council and Parliament reach a deal on new rules for more efficient treatment and monitoring

This press release has been updated on 1 March 2024 to include the text of the Council and Parliament provisional agreement.

The Council and the European Parliament's negotiators today reached a **provisional political agreement** on a proposal to review the urban wastewater treatment directive. The revised directive is one of the key deliverables under the EU's zero-pollution action plan.

> Today's agreement with the Parliament puts us on the right track to reach our zero-pollution objective for Europe. It paves the way for the highest standards to be set for treating urban wastewater and monitoring it so that it does not release harmful substances, like microplastics or PFAS, into the environment.
>
> *Alain Maron, minister of the Government of the Brussels-Capital Region, responsible for climate change, environment, energy and participatory democracy*

While the current directive has proven highly effective in reducing water pollution and improving the treatment of wastewater discharges over the last three decades, this revision aims to update the directive by extending its scope and aligning it with the European Green Deal's objectives.

By recognising the wastewater treatment sector's potential to contribute to significantly reducing EU greenhouse gas (GHG) emissions, the new rules introduce a deadline to reach energy neutrality in the sector, as well as an extended producer responsibility (EPR) scheme to ensure fair contribution of the most polluting sectors to wastewater treatment for micropollutants.

The deal is provisional pending formal adoption by both institutions.

Scope of the directive

To address pollution from small agglomerations, the co-legislators extended the scope of the directive to include all agglomerations of **1 000 population equivalent** (p.e.) and above, as opposed to the 2 000 p.e. in the current directive. For the purpose of this directive, population equivalent is a parameter used to define quantities of wastewater in terms of the potential water pollution load caused by one person per day, 'one population equivalent' being the daily organic biodegradable load having a five-day biochemical oxygen demand of 60 g of oxygen per day.

Wastewater collecting systems and management plans

The co-legislators agreed that the obligation to set up urban wastewater **collecting systems** should be extended to all agglomerations of 1 000 p.e. or more. They also postponed the deadline for compliance with this obligation from 2030 to 2035 to allow for sufficient time to adjust to the new requirements. They introduced a number of derogations, including for smaller agglomerations discharging into coastal waters, discharges in less sensitive areas, and for those member states that most recently joined the EU, such as Romania, Bulgaria and Croatia.

If the establishment of a collecting system is not justified, feasible or cost-effective, member states can use **individual systems** to collect and treat urban wastewater.

The text sets deadlines for member states to establish an **integrated urban wastewater management plan** covering agglomerations of over 100 000 p.e. by 2033, and at-risk agglomerations between 10 000 and 100 000 p.e. by 2039. Such integrated management plans will be reviewed at least every six years, in line with the Water Framework Directive.

Wastewater treatments

The Council and Parliament extended the obligation to apply **secondary treatment** (i.e. the removal of biodegradable organic matter) to urban wastewater before it is discharged into the environment to all agglomerations of 1 000 p.e. or more by 2035. Derogations apply to smaller agglomerations and member states that have recently joined the EU and have therefore already had to make more recent significant investments to implement the current directive (i.e. Romania, Bulgaria and Croatia).

The co-legislators also aligned the thresholds and timelines for **tertiary treatment** (i.e. the removal of nitrogen and phosphorus) and **quaternary treatment** (that is, the removal of a broad spectrum of micropollutants). By **2039** and **2045** respectively, Member states will have to ensure the application of tertiary and quaternary treatment in larger plants of **150 000 p.e.** and above, with intermediate targets in 2033 and 2036 for tertiary treatment and in 2033 and 2039 for quaternary treatment. The co-legislators agreed to extend tertiary and quaternary treatment obligations by 2045 for smaller agglomerations of 10 000 p.e. and above that discharge in areas meeting certain risk-based criteria. They introduced a derogation from the tertiary treatment's requirement when treated urban wastewater is reused for agricultural irrigation, provided that there are no environmental and sanitary risks.

Extended producer responsibility

To cover the additional costs entailed by quaternary treatment and in line with the 'polluter pays principle', producers of pharmaceuticals and cosmetics leading to urban wastewater pollution by micropollutants would need to contribute a minimum of 80% of the costs of this additional treatment, through an **extended producer responsibility** (EPR) scheme.

The co-legislators agreed to leave member states some flexibility on how to allocate the remaining costs. The costs for gathering and verifying data on products placed on the market will need to be borne by the producers, too. The co-legislators tasked the Commission with assessing the potential impact of this provision on the accessibility

and affordability of medicines.

Energy neutrality and renewables

The co-legislators agreed that the urban wastewater treatment sector could play a significant role in significantly reducing GHG emissions and helping the EU achieve its climate neutrality objective. They introduced an **energy neutrality target**, meaning that **by 2045** urban wastewater treatment plants will have to produce energy from renewable sources, based on regular energy audits, with progressive intermediate targets. This energy can be produced on or off-site, and up to 35% of non-fossil energy can be purchased from external sources. This percentage only applies to the final target.

Next steps

The provisional agreement will now be submitted to the member states' representatives within the Council (Coreper) and to the Parliament's environment committee for endorsement. If approved, the text will then need to be formally adopted by both institutions, following revision by lawyer-linguists, before it can be published in the EU's Official Journal and enter into force.

Background

The urban wastewater treatment directive was adopted in 1991. The objective of this directive is to 'protect the environment from adverse effects of wastewater discharges from urban sources and specific industries'. Under the current directive, member states are required to ensure that wastewater from all agglomerations above 2 000 inhabitants is collected and treated according to EU minimum standards. Member states also have to designate sensitive areas, according to criteria included in the Directive, for which stricter standards and deadlines apply.

The Commission conducted an evaluation of the directive in 2019. This evaluation confirmed that the implementation of the directive has led to a significant reduction in pollutant releases. One of the key reasons for the directive's effectiveness lies in the simplicity of its requirements, which allows for straightforward enforcement. Today 98% of EU wastewaters are adequately collected and 92% adequately treated.

However, the evaluation showed that there are still sources of pollution that are not yet adequately addressed by the current rules. These include pollution from smaller agglomerations, storm water overflows and micropollutants that damage the environment. Additionally, the evaluation highlighted the urban wastewater sector as one of the largest consumers of energy in the public sector.

The new rules, proposed by the Commission in October 2022, aim to address these remaining issues and improve the sector's contribution to achieving the EU's climate goals. The European Parliament and Council adopted their positions on the proposed revision on 5 and 16 October 2023, respectively.

- Council and Parliament provisional agreement on urban wastewater
- Council adopts position on new rules for more efficient treatment of urban wastewater (press release, 16 October 2023)

- Commission proposal to revise the urban wastewater treatment directive
- Wastewater treatment (background information)

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7.T

European Parliament
2019-2024

TEXTS ADOPTED

P9_TA(2024)0222

Urban wastewater treatment

European Parliament legislative resolution of 10 April 2024 on the proposal for a directive of the European Parliament and of the Council concerning urban wastewater treatment (recast) (COM(2022)0541 – C9-0363/2022 – 2022/0345(COD))

(Ordinary legislative procedure – recast)

The European Parliament,

– having regard to the Commission proposal to Parliament and the Council (COM(2022)0541),

– having regard to Article 294(2) and Article 192(1) of the Treaty on the Functioning of the European Union, pursuant to which the Commission submitted the proposal to Parliament (C9-0363/2022),

– having regard to Article 294(3) of the Treaty on the Functioning of the European Union,

– having regard to the opinion of the European Economic and Social Committee of 22 February 2023[1],

– having regard to the opinion of the Committee of the Regions of 6 July 2023[2],

– having regard to the Interinstitutional Agreement of 28 November 2001 on a more structured use of the recasting technique for legal acts[3],

– having regard to the letter of 14 September 2023 sent by the Committee on Legal Affairs to the Committee on the Environment, Public Health and Food Safety in accordance with Rule 110(3) of its Rules of Procedure,

– having regard to the provisional agreement approved by the committee responsible under Rule 74(4) of its Rules of Procedure and the undertaking given by the Council representative by letter of 1 March 2024 to approve Parliament's position, in accordance with Article 294(4) of the Treaty on the Functioning of the European Union,

– having regard to Rules 110 and 59 of its Rules of Procedure,

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1 OJ C 146, 27.4.2023, p. 35.
2 OJ C, C/2023/250, 26.10.2023, ELI: http://data.europa.eu/eli/C/2023/250/oj
3 OJ C 77, 28.3.2002, p. 1.

– having regard to the opinion of the Committee on Agriculture and Rural Development,

– having regard to the report of the Committee on the Environment, Public Health and Food Safety (A9-0276/2023),

A. whereas, according to the Consultative Working Party of the legal services of the European Parliament, the Council and the Commission, the Commission proposal does not include any substantive amendments other than those identified as such in the proposal and whereas, as regards the codification of the unchanged provisions of the earlier acts together with those amendments, the proposal contains a straightforward codification of the existing texts, without any change in their substance;

1. Adopts its position at first reading hereinafter set out[4], taking into account the recommendations of the Consultative Working Party of the legal services of the European Parliament, the Council and the Commission;

2. Calls on the Commission to refer the matter to Parliament again if it replaces, substantially amends or intends to substantially amend its proposal;

3. Instructs its President to forward its position to the Council, the Commission and the national parliaments.

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[4] This position replaces the amendments adopted on 5 October 2023 (Texts adopted, P9_TA(2023)0355).

P9_TC1-COD(2022)0345

Position of the European Parliament adopted at first reading on 10 April 2024 with a view to the adoption of Directive (EU) 2024/... of the European Parliament and of the Council concerning urban wastewater treatment (recast) *

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinion of the European Economic and Social Committee[1],

Having regard to the opinion of the Committee of the Regions[2],

Acting in accordance with the ordinary legislative procedure[3],

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* TEXT HAS NOT YET UNDERGONE LEGAL-LINGUISTIC FINALISATION.

1 OJ C 146, 27.4.2023, p. 35

2 OJ C OJ C, C/2023/250, 26.10.2023, ELI: http://data.europa.eu/eli/C/2023/250/oj

3 Position of the European Parliament of 10 April 2024.

Whereas:

(1) Council Directive 91/271/EEC[4] has been substantially amended several times[5]. Since further amendments are to be made, that Directive should be recast in the interests of clarity.

(2) Water is a primary good which belongs to everyone and is for everyone and which, as a natural resource that is essential, irreplaceable and indispensable to life, needs to be considered and integrated in its three dimensions: social, economic and environmental.

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4 Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment (OJ L 135, 30.5.1991, p. 40).

5 See Annex VII, Part A.

(3) Directive 91/271/EEC sets the legal framework for the collection, treatment and discharge of urban wastewater and the discharge of biodegradable wastewaters from certain industrial sectors. ***Urban wastewaters can be formed by different mixtures of domestic wastewaters, urban runoff and non-domestic wastewater from other origins. Wastewater from institutions such as offices, schools, kitchens with food preparation, etc. which are predominantly originated from the human metabolism, qualifies as domestic wastewaters as well. The*** objective ***of Directive 91/271/EEC*** is to protect the environment from being adversely affected by insufficiently treated urban wastewater discharges. ***It has contributed to achieve the objectives established under Directive 2000/60/EC of the European Parliament and of the Council[6] and other relevant legislation.*** This Directive should continue to pursue the same objective, whilst also contributing to the protection of public health ***in accordance with the One Health approach aiming at sustainably balancing and optimizing the health of people, animals, and ecosystems***, when for instance urban wastewater is discharged in bathing waters or in water bodies used for the abstraction of drinking water, or when urban wastewater is used as an indicator for parameters relevant for public health. It should also ***ensure*** access to sanitation and to key information related to the governance of the urban wastewater collection and treatment activities.

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6 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L 327, 22.12.2000, p. 1).

The Directive should also aim at increasing synergies with climate change adaptation and actions to restore urban ecosystems notably trough integrated urban wastewater management planning, whilst making optimal use of digitalisation. Finally, this Directive should contribute to the progressive ***reduction*** of greenhouse gas (GHG) emissions from urban wastewater collection and treatment activities, notably by further reducing nitrogen emissions but also by promoting energy efficiency and production of renewable energies, and thus should contribute to the 2050 objective of Climate Neutrality established under Regulation (EU) 2021/1119 of the European Parliament and of the Council[7]. ***In line with Article 193 of Treaty on the Functioning of the European Union, Member States may go beyond the minimum requirements set out in this Directive, for instance by applying more stringent deadlines or thresholds than those included in this Directive, and/or by reaching energy and/or climate neutrality more rapidly and/or by imposing additional requirements for or broadening the spectrum of the application of their national Extended Producer Responsibility systems.***

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7 Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') (OJ L 243, 9.7.2021, p. 1).

(4) In 2019, the Commission performed an evaluation of Council Directive 91/271/EEC under the Regulatory Fitness and Performance Programme[8] (the 'evaluation'). It became apparent from that exercise that certain provisions of the Directive needed to be updated. Three important sources of remaining load of pollution from urban wastewater that could be avoided were identified, namely storm water overflows and ***polluted discharges of*** urban runoff, potentially mal-functioning individual systems (i.e. systems treating domestic wastewater that is not entering collecting systems) and small agglomerations that are currently not completely covered by Directive 91/271/EEC. Those three sources of pollution constitute a significant pressure on surface water bodies in the Union. Moreover, the report of the evaluation also highlighted the need to improve the transparency and governance of the urban wastewater activities, to seize the opportunity offered by the urban wastewater treatment sector to use its potential for renewable energy development and make tangible steps towards energy neutrality as a contribution to climate neutrality and to harmonise urban wastewater surveillance of health parameters, such as the COVID-19 virus and its variants, as a support for public health action.

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8 Commission Staff Working Document, Executive Summary of the Evaluation of the Council Directive 91/271/EEC of 21 May 1991, concerning urban ***wastewater*** treatment (SWD(2019) 701 final).

(5) Small agglomerations constitute a significant pressure on 11 % of the surface water bodies in the Union[9]. To better tackle the pollution from such agglomerations, and to prevent discharges of untreated urban wastewater into the environment, the scope of this Directive should include all agglomerations of 1 000 population equivalent (p.e.) and above.

(6) In order to ensure effective treatment of urban wastewater before discharge into the environment, all urban wastewaters from agglomerations of 1 000 p.e. and above should be collected in centralised collecting systems***, unless Member States justify a derogation for the use of individual systems under this Directive. When delineating their agglomerations, Member States should take into account the indicative reference threshold of 10 to 25 p.e. per hectare above which the population, possibly combined with economic activities, located in a specific area are considered sufficiently concentrated***. Where ***collecting*** systems are already in place, Member States should ensure that all sources of ***domestic*** wastewater are connected to them.

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9 EEA report, European waters: Assessment of status and pressures 2018, No 7/2018.

(7) ***Significant investments will be necessary to implement the new requirements introduced by this recast Directive. It is therefore necessary to take account the specific situation of each Member States and, where necessary, adapt the deadlines for the implementation of some demanding requirements. For instance, Member States having a large number of small agglomerations concerned by the new requirements of the Directive in terms of collection and treatment of urban wastewater for agglomerations between 1 000 and 2 000 p.e., should be allowed to extend the deadlines for compliance with these new requirements in their first national implementation plan. This should also be the case for Member States having a large number of facilities (above 50 %) to be upgraded to tertiary treatment in line with the new requirements of the revised Directive. Agglomerations below 2 000 p.e. where collecting systems are already in place and discharging urban wastewater into treatment plants located in a different agglomeration should not be counted in the calculation of the percentage related to these time derogations. Moreover, a few Member States who acceded to the Union most recently had to make more recent investments to implement the requirements of the previous Directive. These Member States are marked in addition with high amounts of rural areas with a high outflux of population from their rural areas in addition to an ageing rural population. It is therefore necessary to take account the specific situation of Romania, Bulgaria, and Croatia, by allowing them to extend the deadlines for compliance with these new requirements in their first national implementation plan.***

(8) ***When archaeologically valuable sites are encountered during infrastructural works, such as the building of collecting systems or urban wastewater treatment plants, these works are often delayed due to the need to perform archaeological studies on the site in accordance to national law. Therefore, it makes sense to adapt the implementation deadlines in these specific cases. More specifically, when Member States establish that due to the necessity to preserve cultural heritage, the achievement of the required infrastructure is particularly difficult, they should be allowed to adapt the implementation deadlines in specific areas, and update accordingly their national implementation programme. The extensions of the deadlines should be set for each area and kept as short as possible, not exceeding 8 years. Cultural heritage should be intended according to the definition in Article 1 of the 1972 UNESCO World Heritage Convention.***

(9) ▌Where it can be demonstrated that the establishment of a centralised urban wastewater collecting system ***or the connection to a collecting system*** would produce no ***benefit for the environment or human health, or be technically not feasible*** or involve excessive costs, ***and only in these cases,*** Member States should be allowed to use individual systems to ***collect, store and/or*** treat urban wastewater, as long as they ensure the same level of ***protection of the environment and human health as secondary and tertiary treatment.*** Individual systems ***can include different types of collection, storage and treatment systems such as nature-based solutions, small-sized treatment*** systems***, temporary tanks combined with regular evacuation to treatment plants.*** Member States should ***also exchange best practice on the use and operation of individual*** systems ▌.

(10) ***For this purpose, Member States should establish national, regional or local registers to identify individual systems and temporary storages used on their territory and take all necessary measures to ensure that the design of such systems is adequate, that the systems are properly maintained and that they are subject to a regular compliance control on the basis of a risk-based approach. In particular, Member States should ensure that individual systems used for the collection, storage and/or treatment of urban wastewater are impervious and leak-proof, and that monitoring and inspection of the systems are carried out at regular and fixed intervals. Taking into account the disproportionate costs for adapting the design to the new design requirements, the new requirements on design should not apply to systems established prior to the entry into force of this Directive. Where individual systems are used to collect and/or treat more than 2 % of the urban wastewater load at national level from agglomerations of 2 000 p.e. and above, Member States should provide the Commission with justifications for the reasons for the use of individual systems instead of collecting systems, the level of compliance of those systems with established standards under this Directive and measures taken to reduce the use of such systems. The Commission should be empowered to adopt implementing acts to establish the format of the reporting and the level of details of the information to be provided by national authorities.***

(11) ***As a result of precipitation such as rain, snow or meltwater***, storm water overflows and urban runoff, represent a sizeable remaining source of pollution discharged into the environment. Those emissions are expected to increase due to the combined effects of urbanisation and progressive change of the rain regime linked with climate change. ***Urban wastewater management infrastructures are therefore particularly vulnerable to climate change.*** Solutions to reduce that source of pollution should be defined at local level taking into account the specific local conditions. They should be based on an integrated quantitative and qualitative water management in urban areas. Therefore, Member States should ensure that integrated urban wastewater management plans are established at local level for all agglomerations of 100 000 p.e. and above as those agglomerations are responsible for a significant share of the pollution emitted. Furthermore, integrated urban wastewater management plans should also be put in place for agglomeration of between 10 000 p.e. and 100 000 p.e. where storm water overflows or urban runoff poses a risk for the environment or public health. ***In these plans, measures should be set out that aim at limiting the pollution from storm water overflows to no more than 2 % of the annual collected urban wastewater load calculated in dry weather flow conditions calculated on the basis of the pollutants in Tables 1 and 2 in Annex I.***

(12) ***These plans should include measures to reduce the pollution from storm water overflows and also address the potentially significant pollution coming from separately collected urban runoff, for instance the pollution coming from first rains after long dry periods in densely populated areas. These plans should also include measures to prevent pollution at source and favour nature-based solutions over those that would require the establishment of grey infrastructure. These measures could include preventive temporary measures aimed at avoiding the entry of unpolluted rain waters into collecting systems or temporary storage, including natural water retention, and appropriate treatment of these heavy loaded first rains. Member States are encouraged to increase green and blue spaces in urban areas and should take into account the Urban Greening platform which provides guidance and knowledge to support towns and cities. In order to ensure an adequate coverage of the integrated urban wastewater management plans and a comprehensive solution to storm water problems, those plans should be established for drainage areas of the concerned agglomerations.***

(13) In order to ensure that the integrated urban wastewater management plans are cost-effective, it is important that they are based on best practices in advanced urban areas. Therefore, the measures to be considered should be based on a thorough analysis of the local conditions and should favour a preventive approach aiming at limiting the collection of unpolluted rain waters and optimising the use of existing infrastructures ***to generate energy savings and contribute to emission reduction***. With a preference for 'green' ***and 'blue'*** developments ***and investments***, new grey infrastructures should only be envisaged where absolutely necessary. In order to protect the environment, in particular the coastal and marine environment, and public health***, including the protection of surface, ground and drinking water,*** from being adversely affected by the discharge of insufficiently treated urban wastewater, secondary treatment should be applied to all discharges of urban wastewater from agglomerations of 1 000 p.e. and above.

(14) In order to protect the environment, in particular the coastal and marine environment, and public health from being adversely affected by the discharge of insufficiently treated urban wastewater, secondary treatment should be applied to all discharges of urban wastewater from agglomerations of 1 000 p.e. and above. Due to the expansion of the scope of the Directive including smaller agglomerations, Member States should be given sufficient time to establish the required infrastructures to meet these obligations. Similarly, enough time should be given to Member States to adapt their treatment infrastructures for agglomerations discharging their wastewaters into coastal waters, or 'less sensitive areas' where secondary treatment was not required under Council Directive 91/271/EEC.

(15) ***Discharges to high mountain areas (above 1 500 m altitude), and small agglomerations below 2 000 p.e. in cold climate areas with an annual average temperature below 6 degrees where it is difficult to apply an effective biological treatment because of low temperatures should be allowed to use less stringent treatment than secondary treatment, provided that detailed studies demonstrate that such discharges do not have adverse effects on the environment and human health. Similarly, discharges into deep marine waters from smaller agglomerations of less than 150 000 p.e. located in less populated outermost regions, with less than 275 000 inhabitants characterised by difficult topography, such as steep slopes and discharging their urban wastewaters into deep marine waters in the open ocean, favouring a high level of dilution of these urban wastewater discharges into the receiving waters, should also benefit from this derogation. Nevertheless, in order to ensure an equal treatment of all Member States and in order to ensure a high level of protection of the environment and human health on the whole territory of the European Union, this derogation should be limited to 20 years – which is the time required to progressively upgrade the remaining facilities to secondary treatment in these areas where secondary treatment might be more difficult to apply. These derogations should be granted provided that detailed studies demonstrate that such discharges do not have adverse effects on the environment and human health and do not impact the compliance of the receiving waters with other relevant European legislation such as the Bathing Water Directive, the Water Framework Directive or the Marine Strategy Framework Directive.***

(16) The evaluation showed that significant reductions of nitrogen and phosphorus emissions were achieved through the implementation of Directive 91/271/EEC. Nevertheless, urban wastewater treatment plants remain, according to the evaluation, an important pathway of those pollutants into the environment, directly leading to eutrophication of water bodies and seas in the Union. Part of this pollution can be avoided as technological progress and best practices in place show that emission limit values established under Directive 91/271/EEC for nitrogen and phosphorus are outdated and should be strengthened***, especially for larger treatment plants***. Tertiary treatment should be systematically imposed to all urban wastewater treatment plants ***150 000*** p.e. and above, as such plants represent an important remaining source of nitrogen and phosphorus discharge.

(17) Tertiary treatment should also be mandatory in agglomerations of 10 000 p.e. and above that are discharging in areas subject to, or at risk of, eutrophication. In order to ensure that efforts to limit eutrophication are coordinated at the level of the relevant basins for the whole catchment zone, ***and to ensure a consistent designation of sensitive areas across the European Union,*** areas where eutrophication is considered an issue according to currently available data should be listed in this Directive. Additionally, to ensure coherence between relevant Union legislation, Member States should identify other areas subject to, or at risk of, eutrophication on their territory, ***and identify whether the areas are nitrogen- or phosphorus-sensitive*** notably on the basis of data collected under Directive 2000/60/EC, Directive 2008/56/EC of the European Parliament and of the Council[10] and Council Directive 91/676/EEC[11]. The reinforcement of the limit values, a more coherent and inclusive identification of the areas sensitive to eutrophication and the obligation to ensure tertiary treatment for all large facilities will, in combination, contribute to limit eutrophication. Since this will require additional investments on the national level, Member States should be given sufficient time to establish the required infrastructure.

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10 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (OJ L 164, 25.6.2008, p. 19).

11 Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (OJ L 375, 31.12.1991, p. 1).

(18) Recent scientific knowledge underpinning several Commission strategies[12] ***highlights*** the need to take action to address the issue of ***micropollutants***, which are now detected ***usually*** in all waters in the Union. Some of those micropollutants are hazardous for public health and the environment even in ***low concentrations, of micrograms per litre or below. Whilst the primary, secondary and tertiary treatment already remove some micropollutants,*** an additional treatment, i.e. quaternary treatment, should be introduced in order to ensure that a large spectrum of ***the remaining micropollutants are*** removed from urban wastewater. Quaternary treatment should first focus on organic ***micropollutants***, which represent a significant part of the pollution and for which removal technologies are already designed. The treatment should be imposed based on the precautionary ***principle*** combined with a risk-based approach. Therefore, all urban wastewater treatment plants of ***150 000*** p.e. and above should provide quaternary treatment, as those facilities represent a significant share of ***micropollutant*** discharges in the environment and the removal of ***micropollutants*** by urban wastewater treatment plants at such scale is cost-effective ***For these treatment plants of 150 000 p.e. and above, Member States should ensure a prioritisation of the required investments so that the facilities where the risks for human health and the environment are the highest are equipped without delays.***

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12 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A European Strategy for Plastics in a Circular Economy (COM/2018/028 final); Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee, European Union Strategic Approach to Pharmaceuticals in the Environment (COM(2019) 128 final); Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Chemicals Strategy for Sustainability Towards a Toxic-Free Environment (COM(2020) 667 final); Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' (COM/2021/400 final).

For agglomerations of ▌ 10 000 p.e. and ***above***, Member States should be required to apply quaternary treatment to areas identified as sensitive to pollution with ***micropollutants*** based on clear criteria, which should be specified. Such areas should include locations where treated urban wastewater discharge to water bodies result in low dilution ratios, or where the receiving water bodies are used for the production of drinking water***, for shellfish production*** or as bathing waters. ***Member States should have the possibility not to apply quaternary treatment in these areas when a risk assessment shows that there is no potential danger from micropollutants to human health and/or the environment. For all other types of water bodies in*** agglomerations of ▌ 10 000 p.e. and ***above***, Member States ***should assess the risks that the discharge of micropollutants in urban wastewater poses on*** the environment or to public health on the basis of a standardised risk assessment ***and apply quaternary treatment only where needed according to the results of the risk assessment. Where there are several urban wastewater treatment plants in an agglomeration of above 10 000 p.e. identified as sensitive to pollution with micropollutants, only those discharging into the area at risk should be required to apply quaternary treatment***. In order to give Member States enough time to plan and deliver the necessary infrastructures, the requirement of quaternary treatment should progressively apply until ***2045*** with clear interim objectives.

(19) In order to ensure the continued compliance of discharges from wastewater treatment plants with the requirements for secondary, tertiary and quaternary treatment, samples should be taken in accordance with the requirements of this Directive and those samples should comply with the parametric values that it sets out. In order to take into account possible technical variations in the results from those samples, a maximum number of samples failing to conform to those parametric values should be laid down.

(20) The quaternary treatment necessary to remove ***micropollutants*** from urban wastewater will imply additional costs, such as costs related to monitoring and new advanced equipment to be installed in certain urban wastewater treatment plants. In order to cover these additional costs and in accordance with the polluter-pays principle expressed in Article 191(2) of the Treaty on the Functioning of the European Union (TFEU), it is essential that the producers placing on the Union market products containing substances which, at the end of their life, are found as ***micropollutants*** in urban wastewaters ('***micropollutant*** substances') take responsibility for the additional treatment required to remove those substances, generated in the context of their professional activities. A system of extended producer responsibility is the most appropriate means to achieve this, as it would limit the financial impact on the taxpayer and water tariff, while providing an incentive to develop greener products. ***In this context, the extended producer responsibility should apply regardless of whether the products are placed on the market, or whether their individual components were manufactured in a Member State or third country, or whether the producers have a registered office in the European Union or the product is placed on the market via a digital platform.*** Pharmaceuticals and cosmetic residues currently represent the main sources of ***micropollutants*** found in urban wastewater requiring an additional treatment (quaternary treatment). Therefore, extended producer responsibility should apply to those two product groups. ***Based on the results of the urban wastewater monitoring and the most recent scientific data, the Commission should regularly evaluate whether other industrial sectors should be included in the Extended Producer Responsibility system.***

(21) ***According to the available data, the potential increase of costs of the products or the potential reduction of the profit margins of the industries placing the products on the Union market due to the application of the extended producer responsibility would be marginal at EU level and would not endanger the affordability, availability and accessibility to these products on the EU market. Member States should however take into consideration the possible impacts of the application of the requirements of the Extended Producer Responsibility on the accessibility, availability and affordability of products at national level, in particular medicines, placed on the Union market and the level playing field. Member States can take action to ensure sufficient funds are available, including by financing part of the costs for the quaternary treatment. Given that Member States might choose different implementation approaches, attention should be paid to the functioning of the internal market and in any forthcoming evaluation of the Directive the Commission should assess any potential impacts in this regard.***

(22) Exonerations from the extended producer responsibility obligations should nevertheless be ***possible. This should be the case*** where ***the total amount of substances contained in*** products ▌ placed on the ***Union*** market ***by a producer amount to*** small quantities, i.e. less than ***1 tonne per year***, since the additional administrative burden for the producer would in such cases be disproportionate compared to the environmental benefits. Exonerations should also be possible ***for the part of their products for which*** the producer can demonstrate that no ***micropollutants*** are generated at the end of life of a product ***or*** where it can be proven that the residues from a product are rapidly biodegradable in the wastewaters and the environment or not reaching the urban wastewater treatment plants. The Commission should be empowered to adopt implementing acts to establish detailed criteria to identify the products placed on the ***Union*** market that do not generate ***micropollutants*** in wastewaters at the end of their life***, their hazardousness and their biodegradability***. When developing these criteria, the Commission should take into account ***criteria already set in Regulation (EC) No 1272/2008 of the European Parliament and of the Council[13] on classification, labelling and packaging of substances and mixtures, but also*** scientific or other available technical information, including relevant international standards. ***These criteria should be established before the Extended Producer Responsibility systems enter into force.***

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13 Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (OJ L 353, 31.12.2008, p. 1).

(23) In order to avoid possible internal market distortions, minimum requirements for the implementation of the extended producer responsibility should be established in this Directive, while the practical organisation of the system should be decided at national level. ***In order to favour the substitution of substances and products generating micropollutants residues in urban wastewater,*** the contributions of the producers should be proportionate to the quantities of the products they place on the market and the ***hazardousness*** of their residues. The contributions should cover, but not exceed, the ***investment and operational*** costs for the monitoring activities for ***micropollutants***, the collection, reporting and impartial verification of statistics on the quantities and hazardousness of products placed on the ***Member States*** market, and the application of the quaternary treatment to urban wastewater in an efficient manner**.** ***These contributions should also cover operational costs of already established quaternary treatment at the entry into force of the Directive when it is necessary to meet the obligations of the extended producer responsibility systems. It should also cover part of the investment costs of these established quaternary treatments taking into account the depreciation of the investments and the deadlines of the financing obligations established in*** this Directive. Since urban wastewater is treated collectively, it is appropriate to introduce a requirement for producers to join a centralised organisation which can implement their obligations under the extended producer responsibility on their behalf.

(24) The evaluation has also shown that the wastewater treatment sector offers the opportunity to significantly reduce its own energy consumption and to produce renewable energy, for example by better use of the available surfaces in urban wastewater treatment plants for solar energy production or by producing biogas from sludge ***as well as by heat or kinetic energy or other renewable energy sources***. The evaluation also illustrated that, without clear legal obligations, only partial progress can be expected in this sector. In this context, Member States should be required to ensure that the total annual energy used by all urban wastewater treatment plants on their national territory treating a load of 10 000 p.e. and above does not exceed the production of energy from renewable sources as defined in Article 2(1) of Directive (EU) 2018/2001 of the European Parliament and of the Council[14], by those urban wastewater treatment plants. ***In order to take into account the specificities of each urban wastewater treatment plant, optimise the investments needed and provide for the required flexibility to reach the energy neutrality objective, while ensuring that the potential for renewable energy production and for energy savings is fully seized, that objective should be met at national level and not for each treatment plant. All renewable energies produced by the urban wastewater treatment plants operators or their owners, whether on-site or off-site, such as hydraulic, solar, thermal, wind energy or biogas, should be taken into account.*** That objective should be progressively met with interim targets by 31 December ***2045. A limited amount of non-fossil energy, not directly linked to urban wastewater treatment activities, may be purchased from external sources in 2040 and 2045, through the use of a derogation linked to conditions***. Reaching this energy neutrality target will contribute to ***notably*** reduce the avoidable greenhouse gas (GHG) emissions from the sector ▌, while supporting the achievement of the 2050 climate neutrality objectives and related national and Union objectives, ▌ such as the objectives set out in Regulation (EU) 2018/842 of the European Parliament and of the Council[15].

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14 Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018, p. 82).

15 Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013 (OJ L 156, 19.6.2018, p. 26).

However, initiatives to achieve energy neutrality should not lead to an increased emission of methane and nitrous oxide. In line with Directive (EU) 2018/2001, Member States should facilitate permit granting procedures for renewable energy projects required to reach energy neutrality of this sector. Encouraging EU-based biogas or solar energy production while enhancing energy efficiency measures in line with the Energy Efficiency First principle[16] ***and making an optimal use of digitalisation***, which means taking utmost account of cost-efficient energy efficiency measures in shaping energy policy and making relevant investment decisions, will also help reduce the Union energy dependence, one of the objectives expressed in the Commission 'Repower EU' Plan[17]. It is also in line with Directive (EU) 2018/844 of the European Parliament and of the Council[18] and with Directive (EU) 2018/2001 in which urban wastewater treatment sites are qualified as 'go-to' areas for renewables, meaning a location designated as particularly suitable for the installation of plants for the production of energy from renewable sources. In order to reach the objective of energy neutrality via optimal measures for each urban wastewater treatment plant and for the collection system, Member States should ensure that energy audits***, as defined in*** Directive ***(EU) 2023/1791 of the European Parliament and of the Council[19], are carried out*** every four years. Those audits should ***also*** include an identification of the potential for ***reduction of energy consumption, cost-effective recovery and use of waste heat, either onsite or via a district energy system, or*** cost-effective use or production of renewable energy following the criteria set out in Annex VI to Directive 2012/27/EU ***of the European Parliament and of the Council[20]. The generation of renewable energy by or on behalf of the owners or operators of the urban wastewater treatment plant should not comprise the***

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16 Commission Recommendation (EU) 2021/1749 of 28 September 2021 on Energy Efficiency First: from principles to practice — Guidelines and examples for its implementation in decision-making in the energy sector and beyond.

17 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: REPowerEU Plan (COM/2022/230 final).

18 Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency (***OJ L 156, 19.6.2018, p. 75)***.

19 Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (JO L 231, 20.9.2023, p. 1).

20 Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (OJ L 315, 14.11.2012, p. 1).

(25) Since achievements in methane emission reduction bring more effective greenhouse gas reductions than carbon dioxide emission reductions proportionately, and due to the wastewater sector being identified as one of the main emitting sectors for methane emissions, the wastewater sector should monitor and aim to reduce methane emissions as outlined in the Global Methane Pledge, similar to the Methane Emissions Reduction in the Energy Sector Regulation, to ensure the wastewater sector's contribution towards the achievement of the climate neutrality target by 2050 at the latest, as set out in the European Climate Law.

(26) Since the transboundary nature of water pollution requires cooperation between neighbouring Member States or third countries in addressing such pollution and identifying measures to tackle its source, Member States should be required to inform each other or the third country if significant water pollution originating from urban wastewater discharges in one Member State or third country impacts or is likely to impact the water quality of another Member State or third country. Such information should be immediate in case of incidental pollution significantly affecting downstream water bodies ***and responses should be communicated in a timely manner. Where Member States have previous agreements between them or with third countries on environmental water issues, cooperation through these agreements may be taken into account***. The Commission should be informed and, if necessary, participate in meetings at the request of Member States. It is also important to tackle the transboundary pollution from third countries sharing the same water bodies with some of the Member States. For the purpose of dealing ***with*** pollution coming or arriving in third countries, the cooperation and coordination with third countries may be carried out in the framework of the United Nations Economic Commission for Europe (UNECE) Water Convention[21] or other relevant regional Conventions such as the Regional Seas or Rivers Conventions.

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21 UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes as amended, along with decision VI/3 clarifying the accession procedure.

(27) In order to ensure the protection of the environment and human health, Member States should ensure that the ***collecting systems and*** urban wastewater treatment plants built to comply with the requirements of this Directive are designed, constructed, operated, and maintained to ensure sufficient performance under all normal local climatic conditions. ***As urban wastewater infrastructure has been recognised as critical entities under Directive (EU) 2022/2557 of the European Parliament and of the Council[22] on the resilience of critical entities, Member States should also ensure that urban wastewater treatment plants and collecting systems are assessed as regards their vulnerability to extreme events occurring due to climate change when they are being designed, constructed, and operated.***

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22 Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities and repealing Council Directive 2008/114/EC (OJ L 333, 27.12.2022, p. 164).

(28) Urban wastewater treatment plants also receive non-domestic wastewater, including industrial wastewater, which can contain a range of pollutants not explicitly covered by Directive 91/271/EEC, such as heavy metals, ***microplastics, micropollutants*** and other chemicals***, including per- and polyfluoroalkyl substances (PFAS). This non-domestic wastewater may come from industries, or commercial establishments, or hospitals and other medical facilities, etc***. In most instances, there is a poor understanding and knowledge of such pollution which could deteriorate the functioning of the treatment process and contribute to the pollution of the receiving waters, but also prevent the recovery of sludge and the ***reuse*** of treated wastewater. Member States should therefore regularly monitor and report on such non-domestic pollution that enters the urban wastewater treatment plants and is discharged into water bodies. To prevent pollution from non-domestic wastewater discharges at source, releases from industries or enterprises connected to collecting systems should be subject to prior ***regulations and/or specific*** authorisation ***by the competent authority or appropriate body***. In order to ensure that collecting systems and urban wastewater treatment plants are technically capable of receiving and treating the incoming pollution, the operators who manage urban wastewater treatment plants receiving non-domestic wastewater should be consulted ***and informed*** before those permits are issued ***or the regulations are adopted,*** and should be able to consult***, on request,*** the issued permits in order to be able to adapt their treatment processes. Where non-domestic pollution is identified in the incoming waters, Member States should take appropriate measures to reduce pollution at source, by enhancing the monitoring of pollutants in collecting systems so that the pollution sources can be identified and, where necessary, by reviewing the authorisations provided to relevant, connected urban wastewater treatment plants. ▌

(29) ***The water resources of the Union are increasingly under pressure, resulting in permanent or temporary water scarcity in some areas of the Union. The Union's ability to respond to the increasing pressures on water resources could be improved through a wider reuse of treated urban wastewater, limiting freshwater abstraction from surface and groundwater bodies. Therefore, the reuse of treated urban wastewater should be encouraged and applied whenever appropriate, especially in water-stressed areas, and for all appropriate purposes, whilst ensuring minimum ecological flow of the receiving waters and taking into account the need to ensure that the objectives of good ecological and chemical status of the receiving bodies, as defined in Directive 2000/60/EC, are met. To achieve this, Member States should carry out monitoring of the impact of the reuse of treated urban wastewater on minimum ecological flow of receiving waters in their assessment of impacts carried out under Directive 2000/60/EC. The potential for the reuse of treated wastewater should be assessed taking into account the river basin management plans established under the Water Framework Directive 2000/60/EC and Member States' decisions under Article 2(2) of Regulation (EU) 2020/741 of the European Parliament and of the Council[23], whilst taking into account the need to ensure that the objectives of good ecological and chemical status of the receiving bodies, as defined in Directive 2000/60/EC, are met. The reinforcement of the requirements for the treatment of urban wastewater, and the actions to better monitor, track and reduce pollution at source, will have impacts on the quality of treated urban wastewater, and will therefore support water reuse. Where water reuse serves the purpose of agricultural irrigation, it should be carried out in accordance with Regulation (EU) 2020/741. Where appropriate to ensure the safe reuse of treated urban wastewater, Member States should consider quaternary treatment for the urban wastewater that is reused or will be reused. Measures on promoting the reuse of treated wastewater and on the actual reuse should be considered in strategies on water resilience at Member States level, when such strategies are available.***

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23 Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse (OJ L 177, 5.6.2020, p. 32).

(30) ***The nutrients contained in urban wastewaters may be useful in cases where treated urban wastewaters is reused in agriculture in accordance with Regulation (EU) 2020/741. In those cases, Member States may benefit, under specific conditions to ensure the highest level of protection of the environment and human health, from a derogation to the obligation to apply tertiary treatment in accordance with Article 7 of this Directive only for the part of the treated urban wastewater that is reused in agriculture.***

(31) In order to ensure a proper implementation of this Directive and notably the respect of the emission limit values, it is important to monitor discharges of treated urban wastewater into the environment. The monitoring should be done through the establishment at national level of ▌ mandatory prior ***regulation and/or prior*** authorisation system in order to discharge the treated urban wastewater into the environment. In addition, in order to prevent unintentional discharges of biomedia ***in*** the environment from urban wastewater treatment plants using this technique, it is essential to include in the discharge authorisations specific obligations to continuously monitor and prevent such discharges. ***Such biomedia are usually made of plastic and might include inter alia biocarriers, biobeads or polystyrene beads.***

(32) ***Where necessary, Member States should adapt their urban wastewater collection and treatment infrastructures to the evolution of their population and the associated load of domestic wastewater in order to remain compliant with the requirements of this Directive. The possible impact of discharges on water bodies resulting from the construction and adaptation of such infrastructures should not be considered as a breach of their obligations under Directive 2000/60/EC provided that all the conditions laid down under this Directive are fulfilled.***

(33) In order to ensure the protection of the environment, direct discharges of biodegradable non-domestic wastewater into the environment from certain industrial sectors should be subject to prior authorisation on national level and appropriate requirements. Those requirements should ensure that direct discharges from certain industrial sectors are subject to secondary, tertiary and quaternary treatment as necessary for the protection of human health and the environment***, and that, in the final analysis, the parameters set for treated wastewaters are respected or the same level of environmental protection is ensured***.

(34) According to Article 168(1) TFEU, Union action complements national policies and is to be directed towards improving public health and preventing diseases. In order to ensure optimal use of relevant public health data from urban wastewaters, urban wastewater surveillance should be set up and used for preventive or early warning purposes, for instance in the detection of specific viruses in urban wastewater as a signal of the emergence of epidemics or pandemics. Member States should establish a ▌ dialogue and coordination between competent authorities responsible for public health and competent authorities responsible for urban wastewater management. In the context of that coordination, ***clear allocation of the roles and responsibilities and costs among those competent authorities should be determined. Member States should develop*** a list of parameters relevant for public health to be monitored in urban wastewaters ▌ as well as the frequency and location of the sampling ***taking into account the recommendations of the European Center of Disease Prevention and Control (ECDC), by the Health Emergency Preparedness and Response Authority (HERA) and the World Health Organisation (WHO) among others and consider the following*** health ***parameters for inclusion in such a list: SARS-CoV-2 and its variants, poliovirus, influenza virus, emerging pathogens and any other public health parameters that may be considered relevant***. Based on information gathered during the COVID-19 pandemic and experience gained from the implementation of the Commission Recommendation on a common approach to establish a systematic surveillance of SARS-CoV-2 and its variants in wastewaters in the EU (the 'recommendation'), ***in case of a health emergency, Member States should required to monitor relevant health parameters in urban wastewater***. In order to ensure that harmonised methods are used, Member States should, to the extent possible, use sampling and analysis methods set out in the recommendation for the monitoring of SARS-CoV-2 and its variants.

(35) The Union recognises the importance of tackling the issue of antimicrobial resistance (AMR) and adopted in 2017 the European One Health Action Plan against AMR[24]. According to the World Health Organisation (WHO), wastewater is recognised and documented as major sources of antimicrobial agents and their metabolites, as well as antimicrobial-resistant bacteria and their genes. In order to increase the knowledge on the main sources of AMR, it is necessary to introduce a monitoring obligation for the presence of AMR in urban wastewaters to further develop our scientific knowledge and potentially take adequate action in the future.

(36) This Directive acknowledges the 'One Health' approach, as recognised by the World Health Organization, to be an integrated and unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. The 'One Health' approach recognises that the health of humans, domestic and wild animals, plants, and the wider environment, including ecosystems, are closely interlinked and interdependent.

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24 Communication from the Commission to the Council and the European Parliament: A European One Health Action Plan against Antimicrobial Resistance (AMR) (COM/2017/0339 final).

(37) In order to protect the environment and human health, Member States should identify the risks caused by urban wastewaters management. ***A broad chemical screening including chemical mixtures, and/or biological effect-based methods, to identify substances that cause concern including for aquatic life, drinking or bathing water quality can be part of the risk assessment.*** On the basis of that identification, and where necessary to comply with the requirements of the Union water legislation, Member States should take more stringent measures for the urban wastewater collection and treatment than the measures required to comply with the minimum requirements set out in this Directive. ***In line with Article 191(2) of the Treaty on the Functioning of the European Union and in addition to the measures provided for or taken in accordance with Article 11(3) of Directive 2000/60/EC, Member States should promote in priority control at source to prevent pollution from urban wastewater of receiving water bodies. In particular, Member States should take preventive measures to limit the possibilities that intentionally and unintentionally released micro-plastics reach urban wastewater and sludge.***

(38) Depending on the situation, those more stringent measures can include, inter alia, the establishment of collecting systems, the development of integrated urban wastewater management plans or the application of secondary, tertiary or quaternary treatment to urban wastewater for agglomerations or urban wastewater treatment plants that do not reach the p.e. thresholds triggering the application of the standard requirements. They can also include more advanced treatment than the treatment necessary to respect the minimum requirements or disinfection of treated urban wastewaters necessary to comply with Directive 2006/7/EC of the European Parliament and of the Council[25].

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25 ***Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC (OJ L 64, 4.3.2006, p. 37).***

(39) Sustainable Development Goal 6 and the associated target requiring Member States to 'achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations' by 2030[26]. ***Sanitation facilities should allow the safe management and disposal of human urine, faeces and menstrual blood and changing of menstrual products.*** Furthermore, Principle 20 of the European Pillar of Social Rights[27] states that everyone has the right to access essential services of good quality, including water and sanitation. Against that background, and in accordance with the recommendations in the WHO Guidelines for Sanitation and Health[28] and the provisions of the Protocol on Water and Health[29] Member States should tackle the issue of access to sanitation at national level. That should be done through actions ***ensuring*** access to sanitation for all, for example by setting up sanitation facilities in public spaces, as well as by encouraging the availability of appropriate sanitation facilities in public administrations and public buildings free of charge ***or*** making them affordable to all***, including all kind of facilities and services, such as flush and dry toilets***. They should be safely managed, which implies that they should be accessible to all ***where appropriate*** at all times, including for people with particular needs, such as children, older persons, persons with disabilities and homeless people, that they should be placed in a location that ensures ***maximum*** safety of users, and that they should be hygienically and technically safe to use. Such facilities should also be sufficient in number to ensure that the needs of people are met and waiting times are not unreasonably long. ***The sufficient number of sanitation facilities in public spaces should be decided at appropriate level, taking into account the principle of subsidiarity.***

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26 ***Resolution adopted by the United Nations General Assembly on 25 September 2015 (A/70/L.1).***

27 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Establishing a European Pillar of Social Rights (COM/2017/0250 final).

28 WHO Guidelines on Sanitation and Health, 2018.

29 Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes, 17 June 1999.

(40) The specific situation of minority cultures, such as Roma and Travellers, whether settled or not, and in particular their lack of access to sanitation, was acknowledged in the Communication from the Commission of 7 October 2020 'A Union of Equality: EU Roma strategic framework for equality, inclusion and participation', which calls for increasing effective equal access to essential services. Overall, it is appropriate that Member States pay particular attention to vulnerable ***groups or groups that are*** marginalised ***due to factors related to their socio-economic situation, ethnicity, sexuality, gender, disability, homelessness, legal status, religious conviction or other reasons*** by taking the necessary measures to ***ensure*** access to sanitation for those groups. It is important that the identification of those groups is coherent with Article 16(1) of Directive (EU) 2020/2184 of the European Parliament and of the Council[30]. Measures to improve access to sanitation by vulnerable and marginalised groups might include providing sanitation facilities in public ***and private*** spaces for free or for a low service fee ***as well as in public administration buildings***, improving or maintaining the connection to adequate systems to collect urban wastewater, and raising awareness of the nearest sanitation facilities.

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30 Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (OJ L 435, 23.12.2020, p. 1).

(41) According to the EU Human Rights Guidelines on Safe Drinking Water and Sanitation[31], particular attention should be given to the needs of women and girls, as they are particularly at risk and exposed to attacks, sexual and gender-based violence, harassment and other threats to their safety when accessing sanitation facilities outside their homes. This is in line with the Council Conclusions on Water Diplomacy[32], which reaffirm the importance of integrating a gender perspective into water diplomacy. Therefore, Member States should pay particular attention to women and girls as being a vulnerable group and should take the necessary measures to improve or maintain a safe access to sanitation for them.

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31 EU Human Rights Guidelines on Safe Drinking Water and Sanitation (10145/19).

32 Council Conclusions on Water Diplomacy (13991/18).

(42) The evaluation concluded that sludge management could be improved to better align it with the principles of the circular economy and of the waste hierarchy as defined in Article 4 of Directive 2008/98/EC ***of the European Parliament and of the Council***[33]. The actions to better monitor and reduce pollution at source from non-domestic discharges will help improving the quality of the sludge produced and ensure its safe use in agriculture. In order to ensure a proper and safe recovery of nutrients, including the critical substance phosphorus, from the sludge, ***a*** minimum ***combined reuse and recycling rate*** should be defined at Union level ***giving Member States the flexibility to choose whether to reuse and/or to recycle the urban wastewater and/or sludge to recover phosphorus. This combined minimum reuse and recycling rate should take into account the phosphorus contents in sludge which can vary from one area to another. It should also take into account the level of saturation of each national market, e.g. the availability other sources of phosphorus from organic sources, for instance from livestock farming, and the possibilities of its absorption. Member States should be encouraged to monitor micro-pollutants in sludge, particularly where there is a risk of accumulation of micro-pollutants in sludge, and when it is reused in agriculture to increase the knowledge on its presence and to protect human health and the environment. The proper and safe recovery of nutrients and their reuse in agriculture should be encouraged to support the resilience and sustainability of the agricultural sector and contribute to the strategic autonomy of the EU fertiliser industry. In that context Member States should, while taking into account national and local valorisation options, take measures to encourage the production and purchasing of recovered nutrients from urban wastewater and sludge. When re-using sludge in agriculture particular attention should be paid to micro-plastics. In that sense micro-plastics should be systematically monitored when sludge is reused in agriculture. This information is indispensable for the safe management of sludge in agriculture and any possible review of relevant EU policy.***

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33 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008, p. 3).

(43) ***Adequate*** monitoring is necessary to verify compliance with the new requirements concerning ***micropollutants***, non-domestic pollution, energy neutrality, ▌ storm water overflows and urban runoff. ***Monitoring should be supported, where technically feasible and appropriate, through the use of digital tools. In particular for the operational management of collecting systems and urban wastewater treatment plants use of digital tools should be systematically considered.*** To verify the ***compliance*** of the quaternary treatment concerning the reduction of ***micropollutants*** in urban wastewater discharges, it is sufficient to monitor a limited set of representative ***micropollutants***. The monitoring frequencies should be ***built on*** the current best practices, as currently practiced in Switzerland. To remain cost-effective, those obligations should be adapted to the size of the urban wastewater treatment plants and of the agglomerations. The monitoring will also contribute to provide data for the overall Environmental Monitoring Framework as set up under the 8th Environmental Action Programme[34], and more specifically feed the Zero Pollution Monitoring Framework underpinning it[35].

(44) Microplastics and relevant micropollutants should be monitored, where relevant, in storm water overflow discharges and in discharges of urban runoff from separate systems with a representative sampling programme allowing for concentration estimation in view of water quality modelling. GHG emissions should be monitored, where relevant, supported by calculations and modelling.

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34 Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030 (OJ L 114, 12.4.2022, p. 22).

35 ▌ Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' (COM/2021/400 final).

(45) ***To ensure the protection of the environment and that adequate action is taken under any risk assessment to be carried out for the implementation of this Directive as well as for the implementation of other Union legislation, Member States should monitor a broad spectrum of pollutants at the inlets and outlets of the urban wastewater treatment plants. To avoid unnecessary burden, only pollutants that can be expected to be found in urban wastewater should be monitored taking into account the high variety of pollutants which could reach urban wastewater treatment plants, including from non-domestic wastewater sources. Member States should have the possibility to reduce the monitoring frequency if pollutants are not found in subsequent sampling campaigns. More specifically recent data shows that PFAS are found in urban wastewater, sometimes at high concentrations. The most recent scientific evidence shows that PFAS is a concern to public health and the environment due to their persistence. It is therefore essential to better understand the pathways of PFAS into the environment and to monitor them in the inlet and outlet of the urban wastewater treatment plants. This monitoring should start in the first instance where the discharges reach catchment areas used for the abstraction of drinking water, due to high risks of being exposed to PFAS and their impact on health.***

(46) In order to reduce administrative burden and better use the possibilities offered by digitalisation, the reporting on the implementation of the Directive should be improved and simplified by removing the obligation for Member States to report every two years to the Commission and for the Commission to publish bi-yearly reports. It should be replaced by a requirement for Member States to improve, with the support of the European Environment Agency (EEA), the existing national standardised data sets established under Directive 91/271/EEC, and to regularly update ***them. These data sets will be used by the Commission to verify compliance with this Directive. The reporting model would be developed by the EEA in collaboration with Member States.*** Access to the national databases should be provided to the Commission and the EEA. In order to ensure complete information on the application of this Directive, the data sets should include information on compliance of urban wastewater treatment plants with the treatment requirements (pass/fail, loads and concentration of pollutants discharged), on the level of achievement of the objectives of energy neutrality, on GHG emissions of the treatment plants above 10 000 p.e. and on measures taken by the Member States in the context of storm water overflows/ urban runoff, access to sanitation and treatment by individual systems. Moreover, full coherence with Regulation (EC) No 166/2006 of the European Parliament and of the Council[36] should be ensured to optimise the use of the data, as well as to support full transparency. ***The information collected through this data set should support a comparison and an exchange of best practices at Union level of performance of urban wastewater treatment plants. The administrative burden of providing information and data to the public should at all times respect the principle of proportionality.***

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36 Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC (OJ L 33, 4.2.2006, p. 1).

(47) ***The implementation of the Directive is financed through water tariffs and public budgets, including European funding. In the future, the Extended Producer Responsibility should ensure that the costs of the quaternary treatment are at least partially borne by the concerned industries and complemented by other types of financing. In the past, the implementation of the Directive was also substantially supported by the Union's Cohesion Policy and programmes under Horizon 2020 and LIFE.*** In order to ensure a timely and proper implementation of this Directive, it is essential that Member States establish a national implementation programme including long-term programming of the required investments accompanied with a financing strategy. Those national programmes should be reported to the Commission. To limit administrative burden, that requirement should not apply to Member States ***in which more than 95 % of the agglomerations are compliant with Articles 3 to 8. To continue the adequate implementation of the Directive, the Commission should consider the national implementation programmes reported by Member States for the preparation of the next multiannual financial framework post 2027 and those following thereafter and the Member States should put in place the required system of producer responsibility without delay.***

(48) The urban wastewater collection and treatment sector is specific, operating as a captive market, with public and small enterprises being connected to the collecting system without having the possibility to choose their operators. It is therefore important to ensure public access to operators' key performance indicators, such as the level of treatment achieved, the costs of treatment, the energy used and produced, and the related GHG emissions and carbon footprint. In order to make the public more aware of the implications of urban wastewater treatment, key information on the annual wastewater collection and treatment costs for each household should be provided***, at least in agglomerations above 10 000 p.e., and preferably above 1 000 p.e.,*** in an easily accessible manner, for instance on the invoices, while other detailed information should be accessible ***in a user-friendly format*** online, on a website of the operator or the competent authority.

(49) Directive 2003/4/EC of the European Parliament and of the Council[37] guarantees the right of access to environmental information in the Member States in line with the 1998 Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (the 'Aarhus Convention'). The Aarhus Convention encompasses broad obligations related both to making environmental information available upon request and actively disseminating such information. It is important that the provisions of this Directive related to access to information and data-sharing arrangements complement that Directive, by establishing the obligation to make available to the public online information on the collection and treatment of urban wastewater in a user-friendly manner, without creating a separate legal regime.

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37 Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC (OJ L 41, 14.2.2003, p. 26).

(50) The effectiveness of this Directive and its aim of protecting public health in the context of the Union's environment policy require that natural or legal persons, or where appropriate their duly constituted organisations, be able to rely on it in legal proceedings and that the national courts be able to take this Directive into consideration as an element of Union law in order, inter alia, to review decisions of a national authority where appropriate. In addition, according to settled case law of the Court of Justice, under the principle of sincere cooperation laid down in Article 4(3) of the Treaty on European Union (TEU), it is for the courts of the Member States to ensure judicial protection of a person's rights under Union law. Furthermore, Article 19(1) TEU requires Member States to provide remedies sufficient to ensure effective judicial protection in the fields covered by Union law. ***This should be done according to national rules, without depriving the provision on compensation of its practical effect.*** In addition, in accordance with the Aarhus Convention, members of the public concerned should have access to justice in order to contribute to the protection of the right to live in an environment which is adequate for personal health and well-being.

(51) To adapt this Directive to scientific and technical progress, the power to adopt acts in accordance with Article 290 TFEU should be delegated to the Commission in respect of amending certain parts of the Annexes with regard to the ***adaptation of monitoring to state of the art methods for monitoring, also with a view of making optimal use of digital tools and taking into account the relevant methods used in other relevant Union legislation, and evaluation of results for the*** requirements for the secondary, tertiary and quaternary treatment, and the requirements for specific authorisations for discharges of non-domestic wastewater into collecting systems and urban wastewater treatment plants and in respect of supplementing this ***Directive by specifying*** minimum ***combined*** reuse and recycling ***rate*** for phosphorus ***from sludge and from urban wastewater taking into account available technologies and resources as well as the economic viability for phosphorous recovery***. It is of particular importance that the Commission carries out appropriate consultations during its preparatory work, including at expert level, and that those consultations be conducted in accordance with the principles laid down in the Interinstitutional Agreement on Better Law-Making. In particular, to ensure equal participation in the preparation of delegated acts, the European Parliament and the Council receive all documents at the same time as Member States' experts, and their experts systematically have access to meetings of Commission expert groups dealing with the preparation of delegated acts.

(52) In order to ensure uniform conditions for the implementation of this Directive, implementing powers should be conferred on the Commission for the adoption of standards for the design of individual systems, for the adoption of monitoring and assessment methods for the indicators of the quaternary treatment ***and the objectives regarding energy neutrality***, for the establishment of common conditions and criteria for the application of the exoneration for certain products from extended producer responsibility, for establishing methodologies to support the development of integrated urban wastewater management plans***, for the development of alternative indicators to load-based indicative objective of pollution reduction based for instance on volume, number of occurrence of sewer overflows, volume of the discharged urban runoff, or other relevant alternative indicators, and for establishing methodologies*** to measure antimicrobial resistance***, direct and indirect greenhouse gas emissions and microplastics*** in urban wastewater ***and sludge, for the establishment of a minimum list of relevant pollutants likely to be found in urban wastewaters including a methodology for identifying relevant pollutants likely to be found and criteria for revising the exclusion of some pollutants to be monitored, for the establishment of a harmonised methodology for measuring 'PFAS Total' and 'Sum of PFAS' in urban wastewater*** and for the adoption of the format of, and modalities for, presenting the information to be provided by Member States and compiled by the EEA on the implementation of this Directive. Those powers should be exercised in accordance with Regulation (EU) No 182/2011 of the European Parliament and of the Council[38].

38 Regulation (EU) No 182/2011 of the European Parliament and of the Council of 16 February 2011 laying down the rules and general principles concerning mechanisms for control by Member States of the Commission's exercise of implementing powers (OJ L 55, 28.2.2011, p. 13).

(53) Member States should lay down rules on penalties applicable to infringements of national provisions adopted pursuant to this Directive and should take all measures necessary to ensure that they are implemented. The penalties should be effective, proportionate and dissuasive, ***and should, as applicable, take*** into account ***the financial situation of the natural or legal person held responsible***.

(54) Pursuant to the Interinstitutional Agreement on Better Law-Making[39], the Commission should carry out an evaluation of this Directive within a certain period of time from the date set for its transposition. That evaluation should be based on experience gained and data collected during the implementation of this Directive, on any available WHO recommendations, and on relevant scientific, analytical, and epidemiological data. In the evaluation, particular attention should be given to ***an analysis of the adequacy of the public health parameters used in urban wastewater surveillance, an analysis of the added values of a mandatory monitoring of public health parameters, an analysis of*** the possible necessity to adapt the list of products to be covered by extended producer responsibility ***schemes including the conditions for exonerations, an analysis of the possible impacts on the functioning of the internal market of the potentially different contribution rates for producers set by Member States, an analysis of the feasibility and appropriateness*** of the ***development of an Extended Producer Responsibility system for*** products ***generating Per- and Polyfluoroalkyl Substances (PFAS) and microplastics, an analysis of the added value and the appropriateness of requiring mandatory national water reuse plans including national targets and measures, evaluate the objective of energy neutrality in order to analyse the technical and economic feasibility and environmental and climate benefits to achieve a higher energy autonomy of the sector, an evaluation of the possibilities for measuring direct and indirect greenhouse gas emissions emitted*** from the ***urban wastewater sector, an evaluation of the possibility and the time required to reach climate neutrality*** of the urban wastewater treatment ***sector, the opportunity and feasibility to set Union minimum reuse and recycling rates for nitrogen from sludge and/or from urban wastewater.***

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39 Interinstitutional Agreement between the European Parliament, the Council of the European Union and the European Commission on Better Law-Making (OJ L 123, 12.5.2016, p. 1).

(55) Directive 91/271/EEC provides for specific deadlines for Mayotte due to its inclusion in 2014 as an outermost region within the meaning of Article 349 of the Treaty on the Functioning of the European Union. Therefore, the application of the obligations to establish collecting systems and apply secondary treatment to urban wastewater from agglomeration of 2 000 p.e. and above should be deferred with respect to Mayotte.

(56) It is appropriate to consider the specific situation of Mayotte and the other Union's outermost regions, as listed in Article 349 of the TFEU, which provides for specific measures to support those regions. In terms of urban wastewater treatment of these territories, special attention should be given to the difficult topography and insularity.

(57) In order to ensure the continuity of the protection of the environment, it is important that Member States maintain at least the current level of tertiary treatment until the new requirements for the reduction of phosphorus and nitrogen become applicable. Therefore, Article 5 of Council Directive 91/271/EC should continue to apply until those new requirements become applicable.

(58) Since the objectives of this Directive, namely to protect the environment and public health, to progress towards climate neutrality of urban wastewater collection and treatment activities, to improve access to sanitation and to ensure a regular surveillance of parameters relevant to public health, cannot be sufficiently achieved by the Member States but can rather, by reason of the scale and effects of the action, be better achieved at Union level, the Union may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 TEU. In accordance with the principle of proportionality as set out in that Article, this Directive does not go beyond what is necessary in order to achieve those objectives.

(59) The obligation to transpose this Directive into national law should be confined to those provisions which represent a substantive amendment as compared to the earlier Directive. The obligation to transpose the provisions which are unchanged arises under the earlier Directive.

(60) This Directive should be without prejudice to the obligations of the Member States relating to the time-limits for the transposition into national law of the Directives set out in Annex VII, Part B,

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Subject matter

This Directive lays down rules on the collection, treatment, and discharge of urban wastewater ▌, to protect the environment and human health***, in line with the One Health approach,*** while progressively ***reducing*** greenhouse gas emissions ***to sustainable levels,*** improving the energy balance of urban wastewater collection and treatment activities ***and contributing to the transition towards a circular economy***. It also lays down rules on access to sanitation ***for all***, on transparency of the urban wastewater sector**,** on the regular surveillance of public health relevant parameters in urban wastewaters ***and on the implementation of the polluter-pay principle***.

Article 2

Definitions

For the purpose of this Directive, the following definitions apply:

(1) 'urban wastewater' means ***any of the following:***

(a) domestic wastewater;

(b) the mixture of domestic wastewater and non-domestic wastewater;

(c) the mixture of domestic wastewater and urban runoff;

(d) the mixture of domestic wastewater, non-domestic wastewater and urban runoff;

(2) 'domestic ***wastewater***' means wastewater from residential settlements***, services and institutions*** which originates predominantly from the human metabolism ***and/or*** from household activities;

(3) 'non-domestic wastewater ▌' means ***wastewater, other than domestic*** wastewater ***and urban runoff,*** which is discharged ▌ from premises used for ▌ the exercise of a trade ***or*** industrial ***or economical*** activities;

▌

(4) 'agglomeration' means an area where the ***population (expressed in population equivalent), combined or not with economic activities is sufficiently concentrated*** for urban wastewater to be collected and conducted to ***one or more*** urban wastewater treatment ***plants and/or to one or more*** final discharge ***points***;

(5) 'urban runoff' means ***precipitation*** from agglomerations collected by combined or separate sewers;

(6) 'storm water overflow' means discharge of untreated urban wastewater ***into*** receiving waters from combined sewers caused by ***precipitation or system failures***;

(7) 'collecting system' means a system of conduits which collects and conducts urban wastewater;

(8) 'combined sewer' means a ***single*** conduit that collects and conducts urban wastewater ***including urban runoff***;

(9) 'separate sewer' means a conduit that separately collects and conducts either of the following:

(a) domestic wastewater;

(b) non-domestic wastewater;

(c) a mixture of domestic and non-domestic wastewater;

(d) ***urban runoff;***

(10) '***1*** population equivalent' or '(***1*** p.e.)' means the ***organic biodegradable load*** per day having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day;

(11) 'primary treatment' means treatment of urban wastewater by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD5 of the incoming wastewater is reduced by at least 20 % before discharge and the total suspended solids of the incoming wastewater are reduced by at least 50 %;

(12) 'secondary treatment' means treatment of urban wastewater by a process generally involving biological treatment with a secondary settlement or ***another*** process ***which reduces biodegradable organic matter from urban wastewater***;

(13) 'tertiary treatment' means treatment of urban wastewater by a process which ***reduces*** nitrogen ***and/or*** phosphorus from urban wastewaters;

(14) 'quaternary treatment' means treatment of urban wastewater by a process which ***reduces*** a broad spectrum of ***micropollutants from*** urban wastewaters;

(15) 'sludge' means ***organic and inorganic residue*** resulting from the treatment of urban wastewater ***from an urban wastewater treatment plant (excluding grit, grease, other debris and any other screenings and residues from the pre-treatment step)***;

(16) 'eutrophication' means the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, 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;

(17) 'micro-pollutant' means a substance ***as defined in Article 3(1) of Regulation (EC) No 1907/2006 of the European Parliament and of the Council***[40], including its breakdown products, that is usually present in the ***aquatic*** environment***,*** urban ***wastewater and/or sludge*** and which can be considered hazardous to human health or the environment based on ***the relevant*** criteria set out in Part 3 and Part 4 of Annex I to Regulation (EC) ***No 1272/2008 even in low concentrations***;

(18) 'dilution ratio' means the ratio ***of the last five years average*** of annual flow of the receiving waters at the point of discharge ***to the last five years average of*** the annual ***discharge*** volume of urban wastewater ***into surface waters;***

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40 Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

(19) 'producer' means any manufacturer, importer or distributor that on a professional basis places products on the market of a Member State, including by means of distance contracts as defined in Article 2(7) of Directive 2011/83/EU ***of the European Parliament and of the Council***[41] means;

(20) 'Producer Responsibility Organisation' means ***a nationally recognised*** organisation established ***to enable*** producers ***to fulfil*** their obligations under ***Articles 9 and 10***;

(21) 'sanitation' means facilities and services for the safe***, hygienic, secure, and socially and culturally acceptable management and*** disposal of human urine ***and*** faeces, and ***for the changing and disposal of*** menstrual ***products, that provide privacy and ensures dignity***;

(22) 'antimicrobial resistance' means the ability of micro-organisms to survive or to grow in the presence of a concentration of an antimicrobial agent which is usually sufficient to inhibit or kill micro-organisms of the same species;

(23) 'One Health' means One Health as defined in Article 3, point (7), of Regulation (EU) 2022/2371 of the European Parliament and of the Council[42]***;***

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41 Directive 2011/83/EU of the European Parliament and of the Council of 25 October 2011 on consumer rights, amending Council Directive 93/13/EEC and Directive 1999/44/EC of the European Parliament and of the Council and repealing Council Directive 85/577/EEC and Directive 97/7/EC of the European Parliament and of the Council (OJ L 304, 22.11.2011, p. 64).

42 ***Regulation (EU) 2022/2371 of the European Parliament and of the Council of 23 November 2022 on serious cross-border threats to health and repealing Decision No 1082/2013/EU (OJ L 314, 6.12.2022, p. 26).***

(24) 'public concerned' means the public affected or likely to be affected by, or having an interest in, the ***taking of a decision*** for the implementation of the obligations laid down in ***Articles 6, 7 or 8 of*** this Directive***; for the purposes of this definition,*** non-governmental organisations promoting the protection of human health or the environment ***and meeting any requirements under national law shall be deemed to have an interest***;

(25) '▌ biomedia' means ***any support, usually made of plastic,*** used for the development of the bacteria needed for the treatment of urban wastewaters;

(26) 'placing on the market' means the first making available of a product on the market of a Member State;

(27) 'load' means the amount of organic biodegradable matter measured as BOD5 in urban wastewater, expressed in p.e., or any pollutant or nutrient, expressed in mass unit per time;

(28) 'individual system' means a sanitation facility that collects, stores, treats and/or disposes of domestic wastewater, from buildings or parts of buildings not connected to a urban wastewater collecting system.

Article 3

Collecting systems ***and calculation of the load expressed in p.e.***

1. Member States shall ensure that all agglomerations ***of 2 000 p.e.*** and above comply with the following requirements:

   (a) they are provided with collecting systems;

   (b) all their sources of domestic wastewater are connected to the collecting system.

2. ▌ Member States shall ensure that agglomerations ***between 1 000 and 2 000 p.e. comply with the requirements of paragraph 1 by 31 December 2035.***

   ▌

   Member States may derogate from the deadline referred to in this paragraph for a maximum period of:

   (i) 8 years when on … [day of entry into force of the Directive]

   - ***less than 50 % of these agglomerations are provided with collecting systems; or***
   - ***less than 50 % of the urban wastewater load of these agglomerations is collected in collecting systems;***

(ii) 10 years when on … [day of entry into force of the Directive],

- *less than 25 % of these agglomerations are provided with collecting systems; or*
- *less than 25 % of the urban wastewater load of these agglomerations is collected in collecting systems.*

Croatia, Bulgaria and Romania may derogate from the deadline referred to in this paragraph for a maximum period of:

(i) 12 years when on … [day of entry into force of the Directive],

- *less than 50 % of these agglomerations are provided with collecting systems; or*
- *less than 50 % of the urban wastewater load of these agglomerations is collected in collecting systems;*

(ii) 14 years when on … [day of entry into force of the Directive],

- *less than 25 % of these agglomerations are provided with collecting systems; or*
- *less than 25 % of the urban wastewater load of these agglomerations is collected in collecting systems.*

When Member States derogate from the deadline referred to in this paragraph, they shall ensure that their first national implementation programme referred to in Article 23 includes:

(i) the number of agglomerations between 1 000 and 2 000 p.e. that lack complete collecting system … [day of entry into force of the Directive]; and

(ii) a plan detailing the necessary investments to reach full compliance for these agglomerations within the extended deadlines; and

(iii) the technical or economic reasons justifying the extension of the deadlines referred to in this paragraph.

The extensions of the deadline referred to in this paragraph shall be effective only if the conditions of the first subparagraph are fulfilled. The Commission shall notify the Member States if these conditions are not fulfilled by … [the last day of the sixth month after the deadline referred to in Article 23(2)].

3. ***The load of an agglomeration expressed in p.e. shall be calculated on the basis of the maximum average weekly load generated in that agglomeration during the year, excluding unusual weather situations such as those due to heavy rain.***

4. Collecting systems shall fulfil the requirements of Part A of Annex I.

▌

Article 4

Individual systems

1. ***Member States may derogate*** from Article 3 ***only if*** the establishment of a collecting system ***or the connection to a collecting system*** is not justified either because it would produce no environmental ***or human health*** benefit***, or it is not technically feasible,*** or because it would involve excessive cost***. If derogating from Article 3***, Member States shall ensure that individual systems for the ***collection, storage and/or when applicable,*** treatment of urban wastewaters ***are used in agglomerations of 1 000 p.e. and above, or part of these agglomerations***.

2. Member States shall ensure that ***the*** individual systems ***referred to in paragraph 1*** are designed, operated and maintained in a manner that ***achieves*** the same level of ***human health and environmental protection*** as the secondary and tertiary treatments referred to in Articles 6 and 7.

3. Member States shall ensure that ***individual systems that are used in*** agglomerations ***of 1 000 p.e. and above*** are registered in a registry and that regular inspections ***or other means of regular checks or control*** of those systems***, on the basis of a risk-based approach,*** are carried out by the ***competent*** authority ***or other body authorised at national, regional or local level***.

4. The Commission is empowered to adopt ***implementing acts to ensure uniform application of*** this Directive by ***specifying*** minimum requirements ***for:***

(a) the design, operation, and maintenance of individual systems referred to in paragraphs 1 and 2; and

(b) the regular inspections referred to in paragraph 3, including the establishment of a minimum frequency of such inspections depending on the type of individual systems, and based on a risk-based approach.

Those implementing acts shall be adopted by … [36 months from the entry into force of this Directive] in accordance with the examination procedure referred to in Article 28(2).

The requirements related to design referred to in paragraphs 2 and 4 shall not apply to individual systems referred to in paragraph 1 which were established before the date of entry into force of this Directive.

5. Member States that use individual systems to ***collect and/or*** treat more than 2 % of the urban wastewater load ***at national level*** from agglomerations of 2 000 p.e. and above shall provide the Commission with a justification for the use of individual systems ▌. That justification shall:

(a) demonstrate that the conditions for using individual systems set out in paragraph 1 are fulfilled;

(b) describe the measures taken in accordance with paragraphs 2 ***and 3***;

(c) demonstrate compliance with the minimum requirements referred to in paragraph ***4*** where the Commission has exercised its ***implementing*** power under that paragraph;

(d) demonstrate that the use of the individual system does not prevent Member States to comply with the environmental objectives established in Article 4 of Directive 2000/60/EC.

6. The Commission is empowered to adopt implementing acts establishing the format for submitting the information referred to in paragraph ***5***. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2).

Article 5

Integrated urban wastewater management plans

1. By 31 December ***2033***, Member States shall ensure that an integrated urban wastewater management plan is established for ***drainage areas of*** agglomerations of 100 000 p.e. and above.

2. ***At the latest six months after the next update of the River Basin Management Plan made pursuant to Article 13(7) of Directive 2000/60/EC following the adoption of this Directive or by 22 June 2028***, Member States shall establish a list of agglomerations of between 10 000 p.e. and 100 000 p.e. where, considering historic data***, modelling*** and state-of-the-art climate projections***, including seasonal variations, as well as the pressures and the assessment of impacts undertaken under the River Basin Management Plan***, one or more of the following conditions apply:

   (a) storm water overflow ▌ poses a risk to the environment or human health;

   (b) storm water overflow represents more than ***2 %*** of the annual collected urban wastewater load ***of the parameters referred to in Table 1 and, where relevant, Table 2 of Annex I***, calculated in dry weather ***flow***;

(c) storm water overflow ▌ prevents the fulfilment of any of the following:

(i) the requirements established under Article 5 of Directive (EU) 2020/2184;

(ii) the requirements set out in Article 5(3) of Directive 2006/7/EC;

(iii) the requirements set out in Article 3 of Directive 2008/105/EC of the European Parliament and of the Council[43];

(iv) the environmental objectives set out in Article 4 of Directive 2000/60/EC;

(v) the requirements set out in Article 1 of Directive 2008/56/EC;

(vi) the requirements established under Article 3 of Directive 2006/118/EC of the European Parliament and of the Council[44];

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43 Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council (OJ L 348, 24.12.2008, p. 84).

44 ***Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration (OJ L 372, 27.12.2006, p. 19).***

(d) relevant points in separate sewers have been identified where urban runoff is expected to be polluted in such a way that its discharge into receiving waters can be considered as a risk to the environment or human health or prevents the fulfilment of any of the Directives referred to in point (c).

Member States shall review the list referred to in the first subparagraph every ***six*** years after its establishment and update it where necessary.

3. By 31 December ***2039***, Member States shall ensure that an integrated urban wastewater management plan is established for ***drainage areas of*** agglomerations referred to in paragraph 2.

4. Integrated urban wastewater management plans shall be made available to the Commission on request.

5. Integrated urban wastewater management plans shall include at least the elements set out in Annex V ***and prioritise green and blue infrastructure solutions wherever possible***.

6. The Commission is empowered to adopt implementing acts to ***ensure uniform application of this Article by specifying***:

(a) ▌ methodologies for the identification of the measures referred to in point 3 of Annex V;

(b) ▌ methodologies for the determination of alternative indicators to verify whether the indicative objective of pollution reduction referred to in point 2 (a) of Annex V is achieved;

(c) ▌ the format by which integrated urban wastewater management plans are to be made available to the Commission where requested in accordance with paragraph 4.

Those implementing acts shall be adopted ***by … [36 months from the entry into force of this Directive] in accordance with the examination procedure referred to in Article 28(2)***.

7. ***Member States shall ensure that integrated urban wastewater management plans are reviewed at least every six years after their establishment and updated where necessary. Following an update of the list referred to in paragraph 2, Member States shall ensure that integrated management plans are established for agglomerations within six years of their inclusion in that list.***

Article 6

Secondary treatment

1. ***Member States shall ensure that discharges from urban wastewater treatment plants serving*** agglomerations of 2 000 p.e. and above ***meet the relevant requirements for secondary treatment set out in Part B and Table 1 of Annex I*** in accordance with ***the methods for monitoring and evaluation of results laid down in Part C of Annex I*** before discharge ***into receiving waters. Without prejudice to the possibility of using alternative methods as referred to in point 1, Part C of Annex I, the maximum permitted number of samples which fail to conform to the parametric values of Table 1 of Part B of Annex I is set out in Table 4 of Part C of Annex I.***

For agglomerations of between 2 000 p.e. and 10 000 p.e. which are discharging into coastal ***waters as defined under Directive 2000/60/EC and which apply appropriate treatment in accordance with Article 7 of Council Directive 91/271/EEC on … [the date of entry into force of this Directive]***, the obligation set out in the first paragraph shall not apply until … ***[last day of the twelfth year after the entry into force of this Directive]***.

2. ***For agglomerations discharging into less sensitive areas as referred to in Article 6(1) of Council Directive 91/271/EEC on … [date if entry into force of this Directive], the obligations set out in the first paragraph shall apply on … [last day of the twelfth year after the entry into force of this Directive].***

3. ***Member States shall ensure that discharges from urban wastewater treatment plants serving*** agglomerations of between 1 000 p.e. and 2 000 p.e., ***by 31 December 2035 meet the relevant requirements for secondary treatment set out in Part B and Table 1 of Annex I*** in accordance with ***the methods for monitoring and evaluation of results laid down in Part C of Annex I*** before discharge ***into receiving waters. Without prejudice to the possibility of using alternative methods as referred to in point 1, Part C of Annex I, the maximum permitted number of samples which fail to conform to the parametric values of Table 1 of Part B of Annex I is set out in Table 4 of Part C of Annex I.***

Member States may derogate from the deadline referred to in this paragraph for a maximum period of:

(i) 8 years when on … [day of entry into force of the Directive]:

- *in less than 50 % of these agglomerations their discharges are not subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I; or*
- *less than 50 % of the urban wastewater load of these agglomerations is subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I;*

(ii) 10 years when on … [day of entry into force of the Directive]:

- *in less than 25 % of these agglomerations their discharges are not subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I; or*
- *in less than 25 % of the urban wastewater load of these agglomerations is subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I.*

Croatia, Bulgaria and Romania may derogate from the deadline referred to in this paragraph for a maximum period of:

(i) 12 years when on … [day of entry into force of the Directive],

- ***in less than 50 % of these agglomerations their discharges are not subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I; or***
- ***less than 50 % of the urban wastewater load of these agglomerations is subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I;***

(ii) 14 years when on … [day of entry into force of the Directive]

- ***in less than 25 % of these agglomerations their discharges are not subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I; or***
- ***in less than 25 % of the urban wastewater load of these agglomerations is subject to secondary treatment on their territory, in accordance with Part B and Table 1 of Annex I.***

When Member States derogate from the deadlines referred to in this paragraph, they shall ensure that their first national implementation programme referred to in Article 23 includes:

(i) the number of agglomerations between 1 000 and 2 000 p.e. that lack secondary treatment … [day of entry into force of the Directive]; and

(ii) a plan detailing the necessary investments to reach full compliance for these agglomerations within the extended deadlines; and

(iii) the technical or economic reasons justifying the extension of the deadlines referred to in this paragraph.

The extensions of the deadlines referred to in this paragraph shall be effective only if the conditions of the first subparagraph are fulfilled. The Commission shall notify the Member States if these conditions are not fulfilled by … [the last day of the sixth month after the deadline referred to in Article 23(2)].

4. *Urban wastewater discharges may be subject to treatment less stringent than that prescribed in paragraphs 1 and 3 until … [last day of the twentieth year after the entry into force of the Directive] where they are discharged into:*

(a) waters situated in high mountain regions (over 1 500 m above sea level) where it is difficult to apply an effective biological treatment due to low temperatures; or

(b) deep marine waters when it concerns a discharge of wastewater from agglomerations of less than 150 000 p.e. in less populated outermost regions in the meaning of Article 349 TFEU where the topography and geography of the territory makes it difficult to apply an effective biological treatment; or

(c) waters from small agglomerations between 1 000 and 2 000 p.e. situated in regions with a cold climate where it is difficult to apply an effective biological treatment due to low temperatures if the average quarterly water temperature of the inlet is below 6° C.

The conditions to apply the first subparagraph are that Member States concerned provides the Commission with detailed studies demonstrating that such discharges do not adversely affect the environment and human health and they do not prevent the receiving waters to meet the relevant quality objectives and the relevant provisions of other relevant Union legislation.

5. The load expressed in p.e. shall be calculated on the basis of the maximum average weekly load entering the urban wastewater treatment plant during the year, excluding unusual ***weather*** situations ***such as those*** due to heavy rain.

Article 7

Tertiary treatment

1. By 31 December ***2033***, Member States shall ensure that discharges from ***30*** % of urban wastewater treatment plants treating a load of ***150 000*** p.e. and above and not applying tertiary treatment on … [the date of entry into force of this Directive] ***meet the relevant requirements for*** tertiary treatment in accordance with ***Part B and Table 2 of Annex I before discharge into receiving waters***.

By 31 December 2036, Member States shall ensure that discharges from 70 % of urban wastewater treatment plants treating a load of 150 000 p.e. and above and not applying tertiary treatment on … [the date of entry into force of this Directive] meet the relevant requirements for tertiary treatment in accordance with Part B and Table 2 of Annex I before discharge into receiving waters.

By 31 December ***2039***, Member States shall ensure that all urban wastewater treatment plants treating a load of ***150 000*** p.e. and above ***meet the relevant requirements for*** tertiary treatment in ***Part B and Table 2 of Annex I before discharge into receiving waters***.

2. By 31 December ***2027***, Member States shall establish ***and publish*** a list of areas on their territory that are sensitive to eutrophication***, and shall include with that list information on whether they are phosphorus- and/or nitrogen-sensitive areas*** and update that list every ***six*** years starting on 31 December ***2033***.

The list referred to in the first subparagraph shall include the areas identified in Annex II.

The requirement set out in the first subparagraph shall not apply where a Member State implements tertiary treatment in accordance with paragraph 5 in its entire territory.

▌

3. ▌ Member States shall ensure that ***discharges from agglomerations of 10 000 p.e. and above meet the relevant requirements for*** tertiary treatment ***set out in Part B and Table 2 of Annex I*** before discharge into areas included in a list referred to in paragraph 2 ***by:***

(a) 31 December 2033 for 20 % of these agglomerations;

(b) 31 December 2036 for 40 % of these agglomerations;

(c) 31 December 2039 for 60 % of these agglomerations;

(d) 31 December 2045 for all of these agglomerations.

4. *Member States may derogate from the deadline referred to in point (d) of paragraph 3 for a maximum of eight years on the conditions that:*

(i) *at least 50 % of the concerned agglomerations are not applying tertiary treatment according to the requirements set out in Council Directive 91/271/EEC or do not meet the requirements of Table 2 as referred to in Annex I of this Directive on … [day of entry into force of the Directive]; and*

(ii) *the first national implementation programme submitted under Article 23(2) includes:*

- *the number of agglomerations referred to in paragraph 3 lacking tertiary treatment according to the requirements set out in Council Directive 91/271/EEC or not meeting the requirements of Table 2 as referred to in Annex I of this Directive on … [day of entry into force of the Directive]; and*
- *a plan detailing the necessary investments to reach full compliance for these agglomerations within the extended deadline; and*
- *the technical or economic reasons justifying the extension of the deadline referred to in point (d) of paragraph 3.*

The extensions of the deadlines referred to in this paragraph shall be effective only if the conditions of the first subparagraph are fulfilled. The Commission shall notify the Member States if these conditions are not fulfilled by … [the last day of the sixth month after the deadline referred to in Article 23(2)]. However, urban wastewater treatment plants treating a load of 150 000 p.e. and above shall still meet the deadlines set in paragraph 1.

5. *Discharges of urban wastewater referred to in paragraphs 1 and 3 shall meet the relevant requirements in Part B and Table 2 of Annex I in accordance with the methods for monitoring and evaluation of results laid down in Part C of Annex I. The annual mean of the samples for each parameter referred to in Table 2 of Annex I shall be conform to the relevant parametric values set out in that table.*

6. *For urban wastewater treatment plants that are in construction, under major refurbishment of their tertiary treatment or were commissioned after 31 December 2020 and before the date of entry into force of this Directive, the requirements relating to the nitrogen parameter set out in this Article shall apply at the latest five years later from the deadlines established in paragraphs 1 and 3.*

▌

7. The Commission is empowered to adopt delegated acts in ***what concerns tertiary treatment in*** accordance with the procedure referred to in Article 27 to amend ***Part*** C of Annex I in order to adapt the ▌ methods ***for monitoring and evaluation of results*** to technological and scientific progress.

8. By way of derogation from paragraphs 3 and 5, Member States may decide that an individual urban wastewater treatment plant situated in an area included in a list referred to in paragraph 2 shall not be subject to the requirements set out in paragraphs 3 and 5 where it can be shown that the minimum percentage of reduction of the overall load entering all urban ***wastewater*** treatment plants in that area is ▌ :

(a) at least 75 % for total phosphorus and at least 75 % for total nitrogen from the date of entry into force of this Directive;

(b) 82,5 % for total phosphorus and 80 % for total nitrogen by 31 December ***2039***;

(c) ***87,5*** % for total phosphorus and ***82,5 %*** for total nitrogen by 31 December ***2045***.

9. Discharges from urban ▌ wastewater treatment plants of 10 000 p.e. and above into a catchment area of an area sensitive ***to*** eutrophication included in a list referred to in paragraph 2 shall ***also*** be subject to paragraphs 3, ***5*** and 8.

10. Member States shall ensure that discharges from urban wastewater treatment plants which are situated in an area included in a list referred to in paragraph 2 following one of the regular updates of the list required by that paragraph fulfil the requirements laid down in paragraphs 3 and 5 within seven years of the inclusion in that list ▌.

11. ***Where the number of urban wastewater treatment plants that needs to be upgraded to meet the objectives referred to in paragraphs 1 and 3 at national level is not an integer, the number of urban wastewater treatment plants shall be rounded to the nearest integer. In case of equidistance, the number shall be rounded down.***

Article 8

Quaternary treatment

1. ▌ Member States shall ensure that discharges from urban wastewater treatment plants treating a load of ***150 000*** p.e. and above ***meet the relevant requirements for*** quaternary treatment ***of urban wastewater set out in Part B and Table 3 of Annex I*** in accordance with ***the methods of monitoring and evaluation of result laid down in Part C of Annex I before discharge into receiving waters by:***

(a) ▌ 31 December ***2033 for discharges from 20 % of these*** urban wastewater treatment plants***;***

(b) 31 December 2039 for discharges from 60 % of these urban wastewater treatment plants;

(c) 31 December 2045 for all discharges from these urban wastewater treatment plants.

The maximum permitted number of samples which fail to conform to the parametric values of Table 3 of Part B of Annex I is set out in Table 4 of Part C of Annex I.

2. On 31 December 2030, Member States shall have established a list ▌ of areas on their national territory where the concentration or the accumulation of ***micropollutants from urban wastewater treatment plants represent*** a risk for human health or the environment. Member States shall review that list ***in 2033, and*** thereafter ***every six years*** and update it if necessary.

The list referred to in the first subparagraph shall include the following areas ▌ :

(a) ***catchment areas*** for abstraction ***points*** of water intended for human consumption as ***characterised in accordance with*** Article ***8(2)***, point ***(a),*** of Directive (EU) 2020/2184 ***unless the risk assessment in accordance with Article 8(2), point (b), of that Directive indicates that the discharge of micropollutants from urban wastewater treatment plants does not constitute a potential risk that might cause deterioration of the water quality to the extent that it could constitute a risk to human health***;

(b) bathing water falling within the scope of Directive 2006/7/EC ***unless the bathing water profile referred to in Article 6 and Annex III of that Directive indicates that the discharge of micropollutants from urban wastewater does not affect bathing waters and impair bathers' health***;

(c) ***areas where aquaculture activities,*** as defined in Article ***4***, point ***(25), of Regulation (EU) No 1380/2013 of the European Parliament and of the Council***[45]***, take place unless the competent national authorities are satisfied that the discharge of micropollutants from urban wastewater cannot affect the safety of the foodstuff in its finished form.***

The list referred to in the first subparagraph shall also include the following areas based on an assessment of the risks for human health or the environment that the discharge of micropollutants in urban wastewater poses on:

(a) lakes as defined in Article 2, point (5), of Directive 2000/60/EC;

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45 Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (OJ L 354, 28.12.2013, p. 22).

(b) rivers as defined in Article 2, point (4), of Directive 2000/60/EC or other water streams where the dilution ratio is below 10;

▌

(c) areas where additional treatment is necessary to meet the requirements set out in Directives 2000/60/EC***, 2006/118/EC*** and 2008/105/EC***;***

(d) special areas of conservation as defined in Article 1, point (l), of Council Directive 92/43/EEC[46] and special protection areas classified under Article 4(1), fourth subparagraph, of Directive 2009/147/EC of the European Parliament and of the Council[47] constitutive of the Natura 2000 ecological network.

(e) coastal waters as defined in Article 2, point (7), of Directive 2000/60/EC;

(f) transitional waters as defined in Article 2, point (6), of Directive 2000/60/EC;

(g) marine waters as defined in Article 3, point (1), of Directive 2008/56/EC.

The risk assessment referred to in the second subparagraph shall be communicated to the Commission on request.

▌

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46 Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7).

47 Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (OJ L 20, 26.1.2010, p. 7).

3. The Commission is empowered to adopt implementing acts establishing the format of the risk assessment referred to in paragraph 2, second subparagraph, and the method to be used for that risk assessment. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2).

4. Member States shall ensure that ***agglomerations of 10 000 p.e and above meet the requirements for quaternary treatment set out in Part B and Table 3 of Annex I accordance with the methods of monitoring and evaluation of result laid down in Part C of Annex I*** before discharge into areas included in a list referred to in paragraph 2 ***by:***

(a) 31 December 2033 for 10% of these agglomerations;

(b) 31 December 2036 for 30 % of these agglomerations;

(c) 31 December 2039 for 60 % of these agglomerations;

(d) 31 December 2045 for 100% of these agglomerations.

The maximum permitted number of samples which fail to conform to the parametric values of Table 3 of Part B of Annex I is set out in Table 4 of Part C of Annex I.

The Commission is empowered to adopt delegated acts in ***what concerns quaternary treatment in*** accordance with the procedure referred to in Article 27 to amend ***Part*** C of Annex I in order to adapt the ▌ methods ***for monitoring and evaluation of results*** to technological and scientific progress.

5. ***Member States shall ensure that discharges from urban wastewater treatment plants which are situated in an area included in a list referred to in paragraph 2 following one of the regular updates of the list required by that paragraph, fulfil the requirements laid down in paragraph 4 and in Part B and Table 3 of Annex I within seven years of the inclusion in that list, but not later than the deadlines set out in paragraph 4.***

6. ▌ The Commission ***may*** adopt implementing acts to establish the monitoring and sampling methods to be used by the Member States to determine the presence and quantities in urban wastewater of the indicators set out in Table 3 of Annex I. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2).

7. ***Where the number of urban wastewater treatment plants that needs to be upgraded to meet the objectives referred to in the points (a) and (b) of the first subparagraph of this Article at national level is not an integer, the number of urban wastewater treatment plants shall be rounded to the nearest integer. In case of equidistance, the number shall be rounded down.***

8. ***Without prejudice to the other provisions under this Article, to ensure that the reuse of treated urban wastewater is safe for human health and the environment, Member States shall, where appropriate, treat the urban wastewater that is reused or foreseen to be reused in accordance with the requirements for quaternary treatment set out in Part B and Table 3 of Annex I. In case the treated urban wastewater is reused for agricultural purposes, the outcome of the risk assessments carried out under Regulation (EU) 2020/741 shall be taken into account.***

Article 9

Extended producer responsibility

1. Member States shall take measures to ensure that ***by … [the last day of the third year from the date of entry into force of this Directive],*** producers who place any of the products listed in Annex III on the market have extended producer responsibility.

Such measures shall ensure that those producers cover:

(a) ***at least 80 % of*** the full costs for complying with the requirements set out in Article 8, including the ***investments and the operational*** costs for the quaternary treatment of urban wastewater to remove ***micropollutants*** resulting from the products and their residues they place on the market, for the monitoring of ***micropollutants*** referred to in Article 21(1), point (a)***; and***

(b) the costs for gathering and verifying data on products placed on the market; and ***other costs required to exercise their extended producer responsibility.***

▌

2. Member States shall exonerate producers from their extended producer responsibility under paragraph 1 where the producers can demonstrate any of the following:

(a) the quantity of the ***substances contained in the products*** they place on the ***Union*** market is below ***1 tonne*** per year;

(b) the ***substance in*** products they place on the market ***are rapidly biodegradable in wastewaters or*** do not generate micro-pollutants in wastewaters at the end of their life.

▌

3. The Commission is empowered to adopt implementing acts to establish detailed criteria on the uniform application of the condition laid down in paragraph 2, point (b), to specific categories of products ***and their biodegradability or hazardousness***. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2) ***no later than … [the last day of the second year from the date of entry into force of this Directive]***.

4. Member States shall ensure that producers referred to in paragraph 1 exercise their extended producer responsibility collectively ***through an organisation that fulfils the minimum requirements set out in Article 10***.

Member States shall ensure that:

(a) the producers referred to in paragraph 1 are required to once every year provide the producer responsibility organisations with the following:

(i) the annual quantities of the products listed in Annex III that they place on the market in the context of their professional activity;

(ii) information on the ***hazardousness*** of the products referred to in point (i) in the wastewaters ***and on their biodegradability*** at the end of their life;

(iii) when relevant, a list of products exonerated in accordance with paragraph 2;

(b) the producers referred to in paragraph 1 are required to contribute financially to the producer responsibility organisations in order to cover the costs arising from their extended producer responsibility;

(c) each producer's contribution, as referred to in point (b), is determined based on the quantities and ***hazardousness*** in the wastewaters of the ***substances contained in the*** products that are placed on the market;

(d) producer responsibility organisations are subject to annual independent audits of their financial management, including their capacity to cover the costs referred to in paragraph ***1***, the quality and adequacy of the information collected under point (a) and the adequacy of the contributions collected under point (b);

(e) necessary measures to inform consumers about waste prevention measures, take-back and collection systems, the impact of inappropriate means of waste disposal of the products listed in Annex III, as well as their mis- and over-use, on the collection, treatment, and discharge of wastewater are taken.

5. Member States shall ensure that:

(a) the roles and responsibilities of all relevant actors involved, including producers referred to in paragraph 1, producer responsibility organisations, private or public operators of urban wastewater treatment plants and local competent authorities, are clearly defined;

(b) urban wastewater management objectives are established in order to comply with the requirements and deadlines set under Article 8(1), (4) and (5) and any other quantitative or qualitative objectives that are considered relevant for the implementation of the extended producer responsibility;

(c) a reporting system is in place to gather data on the products referred to in paragraph 1 placed on the market of the Member State by the producers and data on the quaternary treatment of wastewater, as well as other data relevant for the purposes of point (b) ***of this paragraph;***

(d) competent authorities communicate and exchange the necessary data with other relevant competent authorities on a regular basis in order to fulfil the requirements of Articles 9 and 10 of this Directive.

▌

Article 10

Minimum requirements for producer responsibility organisations

1. Member States shall take the necessary measures to ensure that any producer responsibility organisation established under Article 9(4):

(a) has a clearly defined geographical coverage coherent with the requirements set out in Article 8;

(b) has the necessary financial and organisational means to meet the extended producer responsibility obligations of the producers, ***including financial guarantees to ensure the continuity of the quaternary treatment of urban wastewater in accordance with Article 8 of this Directive in all circumstances***;

(c) makes publicly available information about:

(i) its ownership and membership;

(ii) the financial contributions paid by producers ***in line with the requirements referred to in point (c) of the second subparagraph of Article 9(4)***;

(iii) the activities that it ***undertakes*** every year, including clear information on how its financial means are used.

▌

Member States shall ensure that such measures include a national recognition procedure of the producer responsibility organisations certifying their compliance with the requirements set out in this paragraph prior to their effective establishment and operation.

The provision of information to the public under this Article shall be without prejudice to preserving the confidentiality of business information in conformity with the relevant Union and national law.

2. Member States shall establish an adequate monitoring and enforcement framework to ensure that producer responsibility organisations ***fulfil*** their obligations ***in a transparent manner***, that the financial means of producer responsibility organisations are properly used and that all actors having extended producer responsibility report reliable data to the competent authorities and, when requested, to the producer responsibility organisations.

3. Where, in the territory of a Member State, there are multiple producer responsibility organisations, the Member State concerned shall appoint at least one body independent of private interests or entrust a public authority to oversee the implementation.

4. Member State shall ensure that the producers established on the territory of another Member State ***or in a third country,*** and placing products on ***the Member State's*** market:

(a) appoint a legal or natural person established on its territory as an authorised representative for the purposes of fulfilling the extended producer responsibility obligations on its territory; or

(b) take equivalent measures to point (a).

5. ***To ensure that the Extended Producer Responsibility system is implemented as optimally as possible, notably from a cost-benefit perspective,*** Member States shall ***organise regular dialogues on the implementation of the Extended Producer Responsibility system. This could include support for identifying measures to be taken by the competent authorities:***

(a) to reduce micro-pollutant pressure at source, and

(b) to determine the most appropriate technologies for quaternary treatment.

This dialogue ***shall take place*** between relevant stakeholders ***and associations of stakeholders where relevant,*** involved in the implementation of extended producer responsibility, including producers and distributors, producer responsibility organisations, private or public operators of urban wastewater treatment plants local authorities and civil society organisations.

▌

6. ***By … [the date of entry into force of this Directive], the Commission shall provide for the organisation of exchange of information, experience and best practices between Member States on the implementation of Articles 9 and 10 and notably on:***

(a) the measures to control the establishment, the recognition and functioning of Producer Responsibility Organisations;

(b) the measures to control the compliance of producers with their obligations defined in this Directive;

(c) the effective implementation of:

(i) the coverage of the cost as referred to in Article 9(1), and

(ii) the control of the methods of calculation of producers contributions by the extended producer responsibility organisation as referred to in point (c) of Article 9(4);

(d) the exonerations provided according to Article 9;

(e) any other issue in relation to the effective implementation of Articles 9 and 10;

(f) the possible impacts of the application of the requirements referred to in Article 9 on the accessibility, availability and affordability of medicines placed on the Union market.

The Commission shall publish the results of the exchange of information, experience and best practices on these and other relevant aspects, and where relevant, provide recommendations and/or guidelines to Member States.

7. Based on the information provided by the Member States, the Commission shall establish and regularly update a list of the requests for exonerations received by Member States from producers under Article 9(2). This list shall be made available on request to the national competent authorities of the Member States.

Article 11

Energy neutrality ▌

1. Member States shall ensure that energy audits***, as defined in Article 2, point (32), of Directive (EU) 2023/1791,*** of urban wastewater treatment plants and collecting systems ***in operation*** are carried out every four years. Those audits shall ***include an identification of the potential for cost-effective measures to reduce the use of energy and enhance the use and*** production of renewable energy, with a particular focus to identify and utilise the potential for biogas production ***or the recovery and use of waste heat either onsite or via a district energy system***, while reducing ***greenhouse gas*** emissions. The first audits shall be carried out:

   (a) by 31 December ***2028*** for urban wastewater treatment plants treating a load of 100 000 p.e. and above and the collecting systems connected to them;

   (b) by 31 December ***2032*** for urban wastewater treatment plants treating a load of between 10 000 p.e. and 100 000 p.e. and the collecting systems connected to them.

2. Member States shall ensure that, ***at national level,*** the total annual energy from renewable sources ▌ as defined in Article 2(1) of Directive (EU) 2018/2001 ***generated on- or off-site by or on behalf of the owners or the operators of*** urban wastewater treatment plants treating a load of 10 000 p.e. and above, ***and independently of whether this energy is used on- or off-site of the urban wastewater treatment plant by their owners or operators,*** is equivalent to at least:

(a) ***20*** % of the total annual energy used by such plants by 31 December 2030;

(b) 40 % of the total annual energy used by such plants by 31 December 2035;

(c) ***70*** % of the total annual energy used by such plants by 31 December ***2040***;

(d) 100 % of the total annual energy used by such plants by 31 December ***2045***.

The generation of renewable energy by or on behalf of the owners or operators of the urban wastewater treatment plant cannot comprise the purchase of renewable energy.

3. *By way of derogation from paragraph 2, if a Member State does not reach the objective referred to in paragraph 2(d) despite having implemented all energy efficiency measures and all measures to enhance the production of renewable energy notably identified in the energy audits referred to in paragraph 1 of this Article, Member States may exceptionally allow the purchase of energy from non-fossil fuel sources. These purchases shall be limited to a maximum of 35 % of non-fossil fuel energy in relation to the objective referred to in paragraph 2(d).*

4. *By way of derogation from paragraph 2, if a Member State does not reach the objective referred to in paragraph 2(c) despite having implemented all energy efficiency measures and all measures to enhance the production of renewable energy notably identified in the energy audits referred to in paragraph 1 of this Article, Member States may exceptionally allow the purchase of energy from non-fossil fuel sources. These purchases shall be limited to a maximum of 5 percentage points of the requirement in paragraph 2(c). This derogation shall be granted only to Member States that can demonstrate by 31 December 2040 that 35 % external non-fossil fuel energy as referred to in the derogation of paragraph 2(a) will need to be purchased to reach the objective referred to in paragraph 2(d), taking into account all energy efficiency measures and all measures to enhance the production of renewable energy notably identified in the energy audits referred to in paragraph 1 of this Article.*

5. ***The Commission may adopt an implementing act for establishing the methods to assess whether the objectives in paragraph 2 have been met. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2).***

Article 12

Transboundary cooperation

1. ***Without prejudice to relevant existing international agreements or arrangements on environmental water issues,*** where waters within the area of jurisdiction of a Member State are adversely affected by discharges of urban wastewater from another Member State or third-country, the Member State whose waters are affected shall notify the other Member State or the third country and the Commission of the relevant facts.

This notification shall be immediate in case of ▌ pollution that may significantly affect downstream water bodies. ***In the event of any discharge affecting health or the environment in another Member State, the Member State in whose territory the discharge has occurred shall ensure that the competent authority of the other Member State and the Commission are immediately informed.***

2. ***Member States shall respond to each other in a timely manner, subject to the type, importance and possible consequences of the incident, after the notification by another Member State in accordance with paragraph 1.***

The Member States concerned shall cooperate in order to identify the discharges in question and the measures to be taken at source to protect the waters that are affected in order to ensure conformity with this Directive.

3. The concerned Member States shall inform the Commission of any cooperation referred to in paragraph 1. The Commission shall participate in such cooperation at the request of the concerned Member States.

Article 13

Local climatic conditions

Member States shall ensure that the urban wastewater treatment plants built to comply with the requirements set out in Articles 6, 7 ***and 8*** are designed, constructed, operated and maintained to ensure sufficient performance under all normal local climatic conditions. ***Without prejudice to measures taken under paragraph 1 of Article 13 of Directive (EU) 2022/2557***, seasonal variations of the load ***and the vulnerability to climate change*** shall be ***assessed and*** taken into account ***when designing, constructing and operating the urban wastewater treatment plants and collecting systems***.

Article 14

Discharges of non-domestic wastewater

1. Member States shall ensure that the discharges ***of*** non-domestic wastewater into collecting systems and urban wastewater treatment plants ***are*** subject to prior ***regulations and/or*** specific authorisations by the competent authority ***or appropriate body***.

▌

Where specific authorisations are provided for discharges into collecting systems and wastewater treatment plants, Member States shall ensure that the competent authority:

(a) consults ***and informs*** the operators of collecting systems and urban wastewater treatment plants into which the non-domestic wastewater is discharged before granting specific authorisations;

(b) ***on request*** allows the operators of collecting systems and urban wastewater treatment plants receiving non-domestic wastewater discharge to consult the specific authorisations ▌ in their catchment areas ***preferably prior to them being granted;***

(c) where prior regulations are provided for discharges into collecting systems and urban wastewater treatment plants, Member States shall ensure that the operators of collecting systems and urban wastewater treatment plants into which the non-domestic wastewater is discharged, are consulted before the prior regulations are adopted.

The prior regulations and/or specific authorisations referred to in this paragraph shall ensure the following:

(a) the water quality requirements set out in other Union legislation, including Directives 2000/60/EC and 2008/105/EC, are fulfilled, and, when applicable, that quality and quantity of relevant discharges of non-domestic wastewater is monitored. In particular the pollutant load in the discharge from the urban wastewater treatment plant does not deteriorate the status of the receiving water body and does not prevent that water body from achieving such status, in accordance with the objectives set out in Article 4 of Directive 2000/60/EC;

(b) the released polluting substances do not impede the operation of the urban wastewater treatment plant, do not damage collecting systems, urban wastewater treatment plants and associated equipment or the capacity to recover resources, including the reuse of treated water and the recovery of nutrients or other material from urban wastewater or sludge;

(c) the released polluting substances do not harm the health of the staff working in collecting systems and urban wastewater treatment plants;

(d) the urban wastewater treatment plant is designed and equipped to abate the released polluting substances;

(e) where an urban wastewater treatment plant treats discharges from an installation holding a permit referred to in Article 4 of Directive 2010/75/EU of the European Parliament and of the Council[48]*, the pollutant load from the discharges of that plant does not exceed the pollutant load that would be discharged of the discharges were released directly from the installation and were compliant with the emission limit values applicable according to this Directive.*

Member States shall ensure that for the discharge of non-domestic wastewater into collecting systems and urban waste water treatment plants that discharge in catchment areas for abstraction points of water intended for human consumption, no specific authorisation is granted or no prior regulation allows such a discharge of non-domestic wastewater without taking into account the risk assessment and risk management of the catchment areas for abstraction points of water intended for human consumption as mentioned in Article 8 of Directive (EU) 2020/2184 and the risk management measures on the basis of this Article.

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48 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ L 334, 17.12.2010, p. 17).

2. Member States shall ***ensure that competent authorities or appropriate bodies*** take the appropriate measures, including a review ***and, where necessary, revocation*** of the ***prior regulations and/or specific authorisations***, to identify, prevent and reduce as far as possible the sources of pollution in non-domestic wastewater referred to in paragraph 1 ***of this Article*** where any of the following situations arise:

(a) pollutants have been identified at the inlets and outlets of the urban wastewater treatment plant under the monitoring of Article 21(3);

(b) sludge arising from urban wastewater treatment is to be used in accordance with Council Directive 86/278/EEC[49];

(c) treated urban wastewater is to be reused in accordance with Regulation (EU) 2020/741 ***or reused for purposes other than agricultural purposes***;

(d) the receiving waters are used for abstraction of water intended for human consumption as defined in Article 2, point (1), of Directive (EU) 2020/2184;

(e) the pollution of the non-domestic wastewater discharged into the collecting system, or the urban wastewater treatment plant poses a risk to the operation of that system or plant.

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49 Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (OJ L 181, 4.7.1986, p. 6).

3. The ***prior regulations and*** specific authorisations referred to in paragraph 1 ***of this Article*** shall fulfil the requirements set out in ***paragraph 1, third subparagraph***. The Commission is empowered to adopt delegated acts in accordance with the procedure referred to in Article 27 to amend ***requirements referred to in paragraph 1, third subparagraph,*** in order to adapt it to technical and scientific progress in the field of environmental protection.

4. The specific authorisations referred to in paragraph 1 shall be reviewed and ▌, where necessary, adapted at least every ***ten*** years ▌.

The prior regulations referred to in paragraph 1 shall be reviewed at regular intervals and, where necessary, adapted.

If the characteristics of the non-domestic wastewater, the urban wastewater treatment plant or the receiving water body change significantly, the specific authorisations shall be reviewed and adapted to these changes.

Article 15

Water reuse and discharges of urban wastewater

1. Member States shall systematically promote the reuse of treated wastewater from all urban wastewater treatment plants ***where appropriate, especially in water-stressed areas, and for all appropriate purposes. The potential for the reuse of treated wastewater shall be assessed taking into account the river basin management plans established under the Water Framework Directive 2000/60/EC and Member States' decisions under Article 2(2) of Regulation (EU) 2020/741. Member States shall ensure that when treated wastewater is reused or if the reuse is planned, it does not endanger the ecological flow in the receiving waters and there is no adverse effect for the environment and human health***. Where treated wastewater is reused for agricultural irrigation, it shall comply with the requirements established under Regulation (EU) 2020/741. ***When strategies on water resilience at Member States level are available, measures on promoting the reuse of treated wastewater and on the actual reuse shall be considered in these strategies***.

Where treated urban wastewater is reused for agricultural irrigation, Member States may derogate from the requirements for tertiary treatment in Table 2 of Annex I, for the fraction of treated urban wastewater that is exclusively destined for reuse in agricultural irrigation, where all of the following can be demonstrated:

(a) the nutrient content in the fraction reused does not exceed the demand of the targeted crops; and

(b) there are no risks for the environment, particularly in relation to eutrophication of the waters in the same catchment area; and there are no risks to human health particularly in relation to pathogenic organisms; and

(c) the treatment plant has enough capacity to treat or store urban wastewater, in order to avoid discharge to receiving waters that is not meeting the requirements set out in Part B and Table 2 of Annex I in accordance with the control methods laid down in Part C of Annex I.

▌

2. Member States shall ensure that ***at least all*** discharges from urban wastewater treatment plants ***of 1 000 p.e. and above are*** subject to ***prior regulations and/or*** specific ***authorisations***. ***Such regulations and/or authorisations*** shall ensure that the requirements set out in Part B of Annex I are fulfilled.

3. The ***prior regulations and/or*** specific authorisations referred to in paragraph 2 shall be reviewed at least every ***ten*** years and, if necessary, adapted. ***The provisions of the specific authorisations shall be updated in the cases where the characteristics of incoming urban wastewaters or the discharges from the urban wastewater treatment plant or of the receiving water body change significantly to ensure that those requirements set out in Part B of Annex I remain fulfilled***.

4. Member States shall take all necessary measures to adapt their urban wastewater collection and treatment infrastructures to address increased loads of domestic wastewater, including the construction of new infrastructures where necessary.

By doing so, Member States shall be considered to comply with the environmental objectives set out in Article 4 of Directive 2000/60/EC if all the following conditions are met:

(a) the construction or expansion of an urban wastewater treatment plant to treat increased loads or otherwise untreated loads of domestic wastewater is subject to prior authorisation in accordance with this Directive;

(b) the benefits of the urban wastewater treatment plant in point (a) cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, including the consideration of alternative points of discharge of urban wastewater plants, that would contribute to achieve the environmental objectives in Article 4 of Directive 2000/60/EC;

(c) all technically feasible mitigating measures are taken to minimize the negative impacts of the urban wastewater treatment plant on the affected water bodies and are set out in the authorisations referred to in Articles 14 and 15 of this Directive; those measures shall include, where so is required more stringent treatment requirements than those applied prior to the increase of domestic wastewater load, aiming to meet the requirements of the directives referred to in Part B, point 6, of Annex I of this Directive;

(d) all technically feasible mitigating measures are implemented to minimize the negative impact of other activities causing similar pressures in the same water bodies.

If failure to prevent deterioration or failure to achieve the objectives in Article 4 of Directive 2000/60/EC in a body of surface water is the result of an authorisation in point (a), these authorisations in point (a) shall be specifically set out and the abovementioned conditions explained in the River Basin Management Plans required under Article 13 of Directive 2000/60/EC.

Article 16

Biodegradable non-domestic wastewater

1. Member States shall establish requirements for the discharge of biodegradable non-domestic wastewater that are appropriate to the nature of the industry concerned and that ensure at least the same level of environmental protection as the requirements set out in part B of Annex I.

2. The requirements referred to in paragraph 1 ***of this Article*** shall apply when the following conditions are fulfilled:

   (a) the wastewater originates from plants treating a load of 4 000 p.e. and above that belong to the industrial sectors listed in Annex IV and that do not carry out any of the activities listed in Annex I to Directive 2010/75/EU;

(b) the wastewater does not enter an urban wastewater treatment plant before it is discharged to receiving waters ('direct discharge').

Article 17

Urban wastewater surveillance

1. Member States shall set up a national system for cooperation and coordination between competent authorities responsible for public health and competent authorities responsible for urban wastewater treatment with regard to:

(a) the identification of ***relevant*** public health parameters***, that are to be monitored at least in the inlet of urban wastewater treatment plants, taking into account available recommendations by the European Center of Disease Prevention and Contral (ECDC), by the Health Emergency Preparedness and Response Authority (HERA) and the World Health Organisation (WHO) among others and including for instance those in the following list:***

(i) SARS-CoV-2 virus and its variants;

(ii) poliovirus;

(iii) influenza virus;

(iv) emerging pathogens;

(v) any other public health parameters that are considered relevant by the competent authorities of the Member States for monitoring;

(b) the clear allocation of roles, responsibilities and costs among operators and relevant competent authorities, including where related to sampling and analysis;

(c) the determination of the location and the frequency of urban wastewater sampling and analysis for each public health parameter identified in accordance with ***point (a)***, ***thus regarding*** the available health data and the needs in terms of public health data and, where relevant, the local epidemiological situations;

(d) the organisation of an appropriate and timely communication of the monitoring results to the competent authorities responsible for public health and***, where relevant, competent authorities for drinking water in order to facilitate the implementation of the Article 8 of the Directive (EU) 2020/2184 on the quality of the water intended for human consumption and*** to Union platforms, where such platforms are available***, and in accordance with applicable law on protection of personal data***.

2. When a public health emergency is declared by the competent authority responsible for public health in the Member State, ***relevant public health parameters*** shall be monitored in urban wastewaters from ***a representative distribution*** of the national population***, to the extent that the relevant health parameters are found in the urban wastewaters***. This monitoring shall continue until ***the*** competent authority declares that the public health emergency ***has ended, or during a longer period if deemed useful for other purposes, according to the same competent authority***.

To determine whether there is a public health emergency, the competent authority shall ***consider Commission decisions adopted pursuant to Article 23(1) of Regulation (EU) 2022/2371,*** assessments of the European Centre for Disease Prevention and Control, decisions of the World Health Organisation (WHO) taken in accordance with the International Health Regulations.

3. For agglomerations of 100 000 p.e. and above, Member States shall, by … ***[the last day of the second year from the date of adoption of the implementing act in the following subparagraph], ensure that antimicrobial resistance is monitored in urban wastewater***.

By … [18 months from the date of entry into force of this Directive], the Commission shall adopt implementing acts in accordance with the procedure referred to in Article ***28(2)*** to ensure ***a*** uniform application of this Directive by establishing a ***minimum frequency of sampling and a*** harmonised methodology for measuring antimicrobial resistance in urban wastewaters***, taking into account at least all available data from national public health authorities and national authorities responsible for monitoring antimicrobial resistance***.

4. Results from monitoring referred to in this Article shall be reported in accordance with Article 22(1), point (g).

Article 18

Risk assessment and management

1. By ***31 December 2027***, Member States shall identify ***and assess*** the risks caused by urban wastewater discharges to the environment and human health***, taking into account seasonal fluctuations and extreme events*** and at least those related to the following:

(a) the quality of a water body used for the abstraction of water intended for human consumption as defined in Article 2, point (1), of Directive (EU) 2020/2184;

(b) the quality of bathing water falling within the scope of Directive 2006/7/EC;

▌

(c) the quality of a water body where aquaculture activities as defined in Article 4, point (25), of Regulation (EU) No 1380/2013 take place;

(d) the status of the receiving groundwater body as defined in Article 2 of Directive 2000/60/EC as well as all other environmental objective as stated in Article 4 of that Directive for the receiving groundwater body;

(e) the status of the marine environment as defined in point 5 of Article 3 of Directive 2008/56/EC;

(f) the status of the receiving surface water body as defined in Article 2 of Directive 2000/60/EC as well as all other environmental objective as stated in Article 4 of that Directive for the receiving surface water body.

2. Where risks have been identified in accordance with paragraph 1, Member States shall adopt appropriate measures to address them, which shall include where appropriate the following measures:

(a) taking additional measures to prevent and reduce pollution from urban wastewater at source, where required to safeguard the quality of the receiving water body in complement to the measures referred to in Article 14(2);

▌

(b) establishing collecting systems in accordance with Article 3 for agglomerations with a p.e. of less than 1 000;

(c) applying secondary treatment in accordance with Article 6 to discharges of urban wastewater from agglomerations with a p.e. of less than 1 000;

(d) applying tertiary treatment in accordance with Article 7 to discharges of urban wastewater from agglomerations with a p.e. of less than 10 000;

(e) applying quaternary treatment in accordance with Article 8 to discharges of urban wastewater from agglomerations with a p.e. of less than 10 000, ***in particular where urban wastewater is discharged into water bodies used for abstraction of water intended for human consumption, bathing water, areas where aquaculture activities take place and when treated urban wastewater is reused for agricultural purposes***;

(f) establishing integrated urban wastewater management plans in accordance with Article 5 for agglomerations below 10 000 p.e. and adoption of measures referred to in Annex V;

(g) applying more stringent requirements for the treatment of collected urban wastewaters than the requirements set out in Annex ***I***, Part B.

3. The identification of the risks carried out in accordance with paragraph 1 of this Article shall be reviewed every ***six years aligned with the timing of the review of the River Basin Management Plans developed under the Directive 2000/60/EC and starting on 31 December 2033***. A summary of the identified risks accompanied with a description of the measures adopted in accordance with paragraph 2 of this Article shall be included in the ***appropriate River Basin Management Plans and in the*** national implementation programmes referred to in Article 23 and communicated to the Commission on request. ***That summary shall be made available to the public***.

Article 19

Access to sanitation

Without prejudice to the principles of subsidiarity and proportionality, whilst taking into account local and regional perspectives and circumstances for sanitation, Member States shall take all necessary measures to ***ensure*** access to sanitation for all, in particular for vulnerable and marginalised groups.

For that purpose, Member States shall by ***12 January 2029***:

(a) identify ▌ people without access, or with limited access, to sanitation facilities, ***paying special attention to*** vulnerable and marginalised groups, and provide reasons for such lack of access;

(b) assess the possibilities ***and improve*** access to sanitation facilities for ***such*** people ▌;

(c) for all agglomerations of 10 000 p.e. and above, encourage the establishment of a sufficient number of sanitation facilities in public spaces, which are freely and, in particular for women, safely accessible ***and in such case ensure appropriate information to the public;***

(d) for all agglomerations of 5 000 p.e. and above encourage competent authorities to make available a sufficient number of free sanitation facilities in public buildings, in particular in administrative buildings;

(e) ***encourage the making available of sanitation facilities for all, for free or for a low service fee, in restaurants, shops and similar private spaces accessible to the public.***

Article 20

Sludge and resource recovery

1. Member States shall ***encourage the recovery of valuable resources and*** take the necessary measures to ensure that sludge management routes are conform to the waste hierarchy provided for in Article 4 of Directive 2008/98/EC. Such routes shall***:***

(a) maximize prevention***;***

(b) ***prepare for reuse, recycling and other recovery*** of resources***, in particular phosphorous and nitrogen, taking into national or local valorisation options;***

(c) minimize the adverse effects on the environment ***and human health***.

2. The Commission is empowered to adopt delegated acts in accordance with the procedure referred to in Article 27 to supplement this Directive by ***specifying a combined*** minimum reuse and recycling ***rate*** for phosphorus ***from sludge and from urban wastewater not reused under the derogation of Article 15(1), taking*** into account available technologies***, resources and the economic viability*** for phosphorus ***recovery and taking into account phosphorus contents of the*** sludge ***and the level of saturation of the national market with organic phosphorus from other sources while ensuring that there is safe sludge management and no adverse impact on human health and the environment. The Commission shall adopt those delegated acts by … [3 years after entry into force of this Directive]***.

Article 21

Monitoring

1. Member States shall ensure that competent authorities ***or appropriate bodies*** monitor:

   (a) discharges from urban wastewater treatment plants in order to verify compliance with the requirements of Part B of Annex I in accordance with the methods for monitoring and evaluation of results laid down in Part C of Annex I; this monitoring shall include loads and concentrations of the parameters listed in Part B of Annex I;

(b) amounts, composition and destination of sludge***, taking into account requirements of Directive 86/278/EEC for sludge intended to be used in agriculture***;

(c) ***where the derogation of Article 15(1) is used, the quantities per year and per month of*** urban wastewater ***reused in agriculture that is subject to a derogation referred to in Article 15(1); the nutrient content of the fraction*** reused ***for agricultural irrigation and the period during which that fraction is reused compared to the monthly*** water ***and nutrient demand of the crops targeted by this reused urban wastewater***;

(d) the greenhouse gases***, including at least CO_2, N_2O, CH_4, emitted from*** urban wastewater treatment plants of ▌ 10 000 p.e. ***and above by means of analysis, calculations or modelling where appropriate;***

(e) the energy used and produced by urban wastewater treatment plants owners or their operators of 10 000 p.e and above regardless of whether it is used or generated on- or off-site, in line with the requirements referred to in paragraph 2 of Article 11, as well as the energy purchased under derogations referred to in paragraphs 3 and 4 of Article 11 where these derogations are applied.

2. For all agglomerations ***referred to in Article 5, paragraphs 1 and 3***, Member States shall ensure that competent authorities***, appropriate bodies or operators of the collecting system carry out representative monitoring, at relevant points, of*** storm water overflows ***into water bodies and of discharges of*** urban runoff ***from separate systems, in order to estimate the concentration and loads of the parameters listed in Table 1 of Annex I, and, where relevant, of Table 2, as well as the content of microplastics and relevant pollutants. Member States may use the results of this monitoring in view of modelling where deemed appropriate***.

3. For all agglomerations of 10 000 p.e. ***and above***, Member States shall ***ensure that competent authorities or appropriate bodies*** monitor, at the inlets and outlets of urban wastewater treatment plants, the concentration and loads in the urban wastewater of the following elements:

   (a) pollutants ***that are likely to be found in urban wastewaters*** listed in:

      (i) Annexes VIII and X to Directive 2000/60/EC, the Annex ***I*** to Directive 2008/105/EC, Annex I to Directive 2006/118/EC and Part B of Annex II to Directive 2006/118/EC;

(ii) the Annex to Decision 2455/2001/EC of the European Parliament and of the Council[50];

(iii) Annex II to Regulation (EC) No 166/2006;

(iv) Annexes I and II to Directive 86/278/EEC;

(b) parameters listed in Part B of Annex III to Directive (EU) 2020/2184, where urban wastewater is discharged in a catchment area referred to in Article 8 of that Directive; ***where for PFAS Member states can choose to use one or both parameters 'PFAS Total' and/or 'Sum of PFAS' when a methodology is available in accordance with the implementing act referred to in paragraph 5;***

(c) Annex I of Directive 2006/7/EC where there are direct discharges from urban wastewater treatment plants into bathing water areas during the bathing season, which might prevent compliance with Directive 2006/7/EC;

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50 Decision No 2455/2001/EC of the European Parliament and of the Council of 20 November 2001 establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC (OJ L 331, 15.12.2001, p. 1).

(d) the presence of ***microplastics;***

(e) pollutants listed under points (a) and (b) may be excluded from the monitoring under this paragraph as long as it can be demonstrated, inter alia on the basis of monitoring results, that they are absent in urban wastewaters.

For all agglomerations of above 10 000 p.e., Member States shall ***ensure that competent authorities or appropriate bodies*** monitor the presence of ***microplastics*** in the sludge ***when relevant and, notably, when it is reused in agriculture***.

The monitoring referred to in ***paragraph 3*** shall be carried out with the following frequencies:

(a) at least two samples per year, with maximum 6 months between the samples, for agglomerations of ***150 000*** p.e. and more;

(b) at least one sample every ***two*** years for agglomerations of between 10 000 p.e. and ***150 000*** p.e.

This monitoring frequency may be halved in subsequent years if the monitoring results for the pollutants referred to in paragraph 3 are below applicable Environmental Quality Standards under Directive 2008/105/EC during three successive samples. The monitoring frequency should be reviewed at least every year.

4. The Commission is empowered to adopt implementing acts to ensure a uniform application of this Directive by establishing ***methodologies*** for measuring ***and estimating, modelling direct and indirect greenhouse gas emissions from urban wastewater treatment plants, and microplastics*** in urban wastewater and sludge. ***The Commission shall provide the methodologies by … [30 months from the date of entry into force of this Directive] in accordance with the procedure referred to in Article 28(2).***

▌

5. ***The Commission shall adopt implementing acts in accordance with the procedure referred to in Article 27 to ensure the uniform application of this Directive by establishing a methodology for measuring 'PFAS Total' and 'Sum of PFAS' in urban wastewater Those implementing acts shall be adopted by … [24 months from the entry into force of this Directive] in accordance with the examination procedure referred to in Article 28(2).***

6. ***Based on the report of the Member States, the Commission may adopt implementing acts in accordance with the procedure referred to in Article 28(2) to ensure a uniform application of paragraph 3 of this Article by specifying a minimum list of relevant pollutants likely to be found in urban wastewater and by developing a methodology for identifying relevant pollutants likely to be found, taking into account the local conditions and the risk assessment carried out under relevant Union legislation as well as criteria and frequency for revising the exclusion of some pollutants as set out in paragraph 3, point (e).***

Article 22

Information on monitoring of implementation

1. Member States, assisted by the European Environment Agency (EEA), shall:

(a) by 31 December ***2028***, set up a data set containing information collected in accordance with Article 21 including information concerning the parameters referred to in Article 21(1), point (a), and the results of the tests with regard to the pass/fail criteria established in Part C of Annex I and update that data set annually thereafter; ▌

(b) by 31 December ***2028***, set up a data set indicating the percentage of urban wastewater which is collected and treated in accordance with Article 3 and update that data set annually thereafter;

(c) by 31 December ***2028***, set up a data set containing information on ***the implementation of*** Article ***4(5)*** and on the percentage of the urban wastewater load from agglomerations above 2 000 p.e. which is treated in individual systems and update that data set annually thereafter;

(d) by 31 December ***2028***, set up a data set containing information on the number of samples collected and the number of samples taken in accordance with Part C of Annex I that have failed ***and update that data set annually thereafter***;

(e) by 31 December ***2030***, set up a data set containing information on ***greenhouse*** gas emissions with a breakdown between different gasses and on the total energy used and renewable energy produced by each urban wastewater treatment plant of 10 000 p.e. and above as well as a calculation of the percentage of achievement of the targets set out in Article 11(2)***, the percentage of energy purchased from non-fossil fuel sources and, when available accompanied by a break-down of the different types of non-fossil fuel energy sources used, where the derogation referred to in Article 11(3) is used,*** and update that data set annually thereafter;

(f) by 31 December ***2030***, set up a data set containing information on measures taken in accordance with point 3 of Annex V and update that data set annually thereafter;

(g) by 31 December ***2030***, set up a data set containing the monitoring results referred to in accordance with Article 17(1) and ***(3)*** and update that data set annually thereafter;

(h) by 31 December ***2030***, set up a data set containing the list of areas identified as sensitive to eutrophication ▌ and update that data set ***in accordance with Article 7(2)***;

(i) by 31 December 2030, set up a data set containing the list of areas identified as areas where the concentration or the accumulation of ***micropollutant*** represents a risk for human health or the environment and update that data set ***in accordance with Article 8(2)***;

(j) by 12 January 2029, set up a data set containing information on measures taken to improve access to sanitation in accordance with Article 19, points ***(a), (b), (c)***, including information on the share of their population that has access to sanitation ***in agglomerations of 10 000 p.e. and above*** and update that data set every 6 years thereafter;

(k) by December 2030, Member States where biomedia are used shall set up a data set containing the type of biomedia used and a short description of the measures taken by urban wastewater treatment plants using biomedia to avoid spills into the environment, and update that data set every five years thereafter;

(l) by 31 December 2030, set up a data set containing the monitoring results referred to in point (c) of Article 21(1) with a comparison of the monthly water and nutrient demand of the crops targeted by the reused fraction of treated urban wastewater referred to in Article 15(1), and update that dataset annually thereafter.

2. Member States shall ensure that the Commission and the EEA have ▌ access to the data sets referred to in paragraph 1.

3. The information reported by Member States in accordance with Article 5 of Regulation (EC) No 166/2006 shall be taken into account for the reporting required under this Article ***for those pollutants related with urban wastewaters***.

   With regard to the information referred to in paragraph 1, the EEA shall provide the public with access to relevant data through the European Pollutant Release and Transfer Register established under Regulation (EC) No 166/2006.

4. The Commission is empowered to adopt implementing acts specifying the format of the information to be provided in accordance with paragraph 1. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2) ***by 31 December 2028 for information referred to in points (e), (f), (g), (i), (j), (k) and (l) of paragraph 1. The Commission may adopt implementing acts in accordance with the examination procedure referred to in Article 28(2) to specify the format of the information to be provided in accordance with points (a), (b), (c), (d) and (h) of paragraph 1***.

Article 23

National implementation programme

1. By … [the ***first*** day of the ***thirty sixth*** month after the date of entry into force of this Directive], Member States shall establish a national implementation programme for this Directive.

Those programmes shall include:

(a) an assessment of the level of implementation of Articles 3 to 8;

(b) the identification and planning of investments required to implement this Directive for each agglomeration, including an indicative financial estimation, ***including when available an estimation of the financial contribution from the producer responsibility organisations established in accordance with Article 10 of this Directive,*** and a prioritisation of those investments related to the size of the agglomeration and the ***level of*** environmental impact of untreated urban wastewater ***and related risks for environment or human health***;

(c) an estimate of investments needed to renew, ***upgrade or replace*** existing urban wastewater infrastructures, including collecting systems, based on ***depreciation rates, technical and operational conditions, and with the aim to prevent possible leakage, infiltration and misconnected inflow into the collecting networks, and using, where appropriate, digital instruments;***

(d) the identification, or at least an indication, of potential sources of public financing, when needed to complement user charges.

(e) any information required under Articles 6(4) and 7(7) where applicable.

Member States may continue using the available Union funding for the implementation of the provisions of this Directive, in order to ensure that all citizens benefit equally from efficient collection and treatment of urban wastewater. Member States may equally exchange best practices on how to improve absorption of Union Funds.

When Member states establish, during the implementation of national implementation programme, that due to the necessity to preserve cultural heritage it is not possible to respect the deadlines referred to in Article 3(2) and/or Article 6(3) in specific areas, Member States shall update their national implementation programme. This update shall contain a list of the agglomerations with areas concerned, a detailed justification demonstrating that the achievement of the required infrastructures is particularly difficult due to the necessity to preserve cultural heritage, and an adjusted timeline to finalise the required infrastructures in these areas. Extensions of the deadlines referred to in Article 3(2) and/or Article 6(3) shall be set area-specific, kept as short as possible and shall not exceed 8 years. The updated national implementation programme shall be submitted to the Commission by 31 December.

▌

2. By … [the first day of the thirty-sixth month after the date of entry into force of this Directive], Member States shall submit to the Commission their national implementation programmes, except where they demonstrate, based on the monitoring results referred to in Article 21, that they are in compliance with Articles 3 to 8.

3. Member States shall update their national implementation programmes at least every ***6*** years. They shall submit them to the Commission by 31 December, except where they can demonstrate that they are in compliance with Articles 3 to 8.

▌

4. The Commission is empowered to adopt implementing acts establishing the methods and formats for submission of the national implementation programmes. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2).

Article 24

Information to the public

1. Member States shall ensure that adequate***, easily accessible,*** and up-to-date information on urban wastewater collection and treatment is available to the public online, in a user-friendly and customised way, ***for*** each agglomeration ***of above 1 000 p.e. or each relevant administrative area***. The information shall include at least the data listed in Annex VI.

   The information referred to in paragraph 1 shall also be provided by other means upon justified request.

2. In addition, ***where costs are recovered totally or partly through a water tariff system,*** Member States shall ensure that all ***households in agglomerations of above 10 000 p.e., and preferably above 1 000 p.e.,*** connected to collecting systems receive regularly and at least once a year, in the most appropriate ***and easily accessible*** form, ***for example and where available*** on their invoice or by ***digital means such as*** smart applications ***or websites***, without having to request it, the following information:

(a) information on the compliance of the collection and treatment of urban wastewater with Articles 3, 4, 6, 7 and 8, including a comparison between the actual releases of pollutants in receiving waters with the limit values set out in Tables 1, 2 and 3 of Annex I; ***this information shall be presented in a manner that allows for easy comparison, for example in the form of a percentage of compliance;***

(b) the volume or estimated volume of urban wastewater collected and treated per year or per billing period for the household or the connected entity in cubic meter, together with trends and the price of urban wastewater collection and treatment for ***that*** household (cost per litre and cubic meter);

(c) a comparison of the yearly volume of urban wastewater collected and treated for the household per year and an indication of the average volume of a household in the concerned agglomeration;

▌

(d) a link to the online content referred to in paragraph 1.

Where information regarding individual usage is not available, the information in points (a) to (d) above will be provided at agglomeration level in a user-friendly manner via a website or smart application.

3. The Commission may adopt delegated acts in accordance with the procedure set out in Article 27 to amend paragraph 2 ***of this Article*** and Annex VI by updating the information to be provided to the public online and to the ***households*** connected to collecting systems in order to adapt these requirements to technical progress and the availability of data in the field.

4. The Commission may adopt implementing acts specifying the format and the methods of presenting the information to be provided in accordance with paragraphs 1 and 2. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 28(2).

Article 25

Access to Justice

1. Member States shall ensure that, in accordance with the relevant national legal system, members of the public concerned have access to a review procedure before a court of law, or another independent and impartial body established by law to challenge the substantive or procedural legality of decisions or acts or omissions subject to Articles 6, 7 or 8 of this Directive when at least one of the following conditions is met:

   (a) they have a sufficient interest;

   (b) they maintain the impairment of a right, where administrative procedural law of a Member State requires this as a precondition.

   The review procedure shall be fair, equitable, timely and not prohibitively expensive, and shall provide for adequate and effective redress mechanisms, including injunctive relief as appropriate.

2. Standing in the review procedure shall not be conditional on the role that the concerned member of the public played during a participatory phase of the decision-making procedures under this Directive.

3. Member States shall determine at what stage the decisions, acts or omissions referred to in paragraph 1 may be challenged.

4. Member States shall ensure that practical information is made available to the public on access to administrative and judicial review procedures referred to in this Article.

Article 26

Compensation

1. Member States shall ensure that, where damage to human health has occurred as a result of a violation of national measures that were adopted pursuant to this Directive, the individuals affected have the right to claim and obtain compensation for that damage from the relevant natural or legal persons***, in accordance with national rules***.

2. Member States shall ensure that, as part of the public concerned, non-governmental organisations promoting the protection of human health or the environment and meeting any requirements under national law are allowed to represent the individuals affected ▌. Member States shall ensure that a claim for a violation leading to a damage cannot be pursued twice, by the individuals affected and by the non-governmental organisations referred to in this paragraph.

3. Member States shall ensure that national rules and procedures relating to claims for compensation are designed and applied in such a way that they do not render impossible or excessively difficult the exercise of the right to compensation for damage caused by a violation pursuant to paragraph 1.

▌

4. Member States ***may establish*** the limitation periods for bringing actions for compensation referred to in paragraph 1 ▌. Such periods shall not begin to run before the violation has ceased and the person claiming the compensation knows ***or can reasonably be expected to know*** that he or she suffered damage from a violation pursuant to paragraph 1.

5. Member States shall ensure that information is made available to the public on their right to claim compensation for damage.

Article 27

Exercise of the delegation

1. The power to adopt delegated acts is conferred on the Commission subject to the conditions laid down in this Article.

2. The power to adopt delegated acts referred to in Articles **/**7(7), 8(5), 14(3), 20(2), and 24(3)**/** shall be conferred on the Commission for a period of five years from … [the date of entry into force of this Directive]. The Commission shall draw up a report in respect of the delegation of power not later than nine months before the end of the five-year period. The delegation of power shall be tacitly extended for periods of an identical duration unless the European Parliament or the Council opposes such extension not later than three months before the end of each period.

3. The delegation of power referred to in Articles **/**7(7), 8(5), 14(3), 20(2), and 24(3)**/** may be revoked at any time by the European Parliament or by the Council. A decision to revoke shall put an end to the delegation of the power specified in that decision. It shall take effect the day following the publication of the decision in the *Official Journal of the European Union* or at a later date specified therein. It shall not affect the validity of any delegated acts already in force.

4. Before adopting a delegated act, the Commission shall consult experts designated by each Member State in accordance with the principles laid down in the Interinstitutional Agreement of 13 April 2016 on Better Law-Making.

5. As soon as it adopts a delegated act, the Commission shall notify it simultaneously to the European Parliament and to the Council.

6. A delegated act adopted pursuant to Articles /7(7), 8(5), 14(3), 20(2), or 24(3)/ shall enter into force only if no objection has been expressed either by the European Parliament or by the Council within a period of two months of notification of that act to the European Parliament and the Council or if, before the expiry of that period, the European Parliament and the Council have both informed the Commission that they will not object. That period shall be extended by two months at the initiative of the European Parliament or of the Council.

Article 28

Committee

1. The Commission shall be assisted by ***the*** committee for the adaptation to scientific and technical progress and implementation of the directive on urban ***wastewater*** treatment ***established by Directive 91/271/EEC. That committee shall be a committee within the meaning of Regulation (EU) No 182/2011***.

2. Where reference is made to this paragraph, Article 5 of Regulation (EU) No 182/2011 shall apply.

Article 29

Penalties

1. ***Without prejudice to the obligations of Member States under Directive 2008/99/EC of the European Parliament and of the Council***[51]***,*** Member States shall lay down the rules on penalties applicable to infringements of national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for shall be effective, proportionate and dissuasive. ▌

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51 Directive 2008/99/EC of the European Parliament and of the Council of 19 November 2008 on the protection of the environment through criminal law (OJ L 328, 6.12.2008, p. 28).

2. Member States shall ensure that the penalties established pursuant to this Article give due regard to the following, as applicable:

(a) the nature, gravity, and extent of the ***infringement***;

(b) ***where appropriate,*** the intentional or negligent character of the violation;

(c) the population or the environment affected by the ***infringement***, bearing in mind the impact of the infringement on the objective of achieving a high level of protection of human health and the environment***;***

(d) the repetitive or singular character of the infringement.

(e) the financial situation of the natural or legal person held responsible.

3. Member States shall without undue delay notify the Commission of the rules and measures referred to in paragraph 1 and of any subsequent amendments affecting them.

Article 30

Evaluation

1. By 31 December ***2033*** and by 31 December 2040, the Commission shall carry out an evaluation of this Directive based in particular on the following elements:

(a) the experience gained through the implementation of this Directive;

(b) the data sets referred to in Article 22(1);

(c) relevant scientific, analytical and epidemiological data, including results from research projects funded by the Union;

(d) WHO recommendations, where available;

This evaluation shall, at minimum, contain an analysis of:

(a) the adequacy of the public health parameters referred to Article 17(1) to be monitored by Member States;

(b) the added-value of mandatory monitoring of specific public health parameters;

(c) ▌ the possible need to adapt the list of products to be covered by extended producer responsibility to the evolution of the range of products placed on the market, improved knowledge on the presence of ***micropollutants*** in wastewaters**,** their impacts on public health and the environment, data resulting from the new monitoring obligations on ***micropollutants*** in the inlets and outlets of the urban wastewater treatment plants ***and an analysis of the need to revise the condition for exoneration from extended producer responsibility referred to in point (a) of Article 9(2);***

(d) the added value and the appropriateness of requiring mandatory national water reuse plans including national targets and measures taking into account the evolution of the European policies and legislation related to water management;

(e) the objective of energy neutrality in order to analyse the technical and economic feasibility and environmental and climate benefits to achieve a higher energy autonomy of the sector;

(f) the possibilities for measuring direct and indirect greenhouse gas emissions emitted from the urban wastewater sector, including emissions of other greenhouse gases than those referred to in point (d) of paragraph 1 of Article 21, and for setting requirements for actual measurements in connection with the monitoring taking into account the most recent methodologies for greenhouse gas emissions of the urban wastewater sector set out by the Intergovernmental Panel on Climate Change;

(g) the possible impacts on the functioning of the internal market of the potentially different contribution rates for producers set by Member States and that are referred to in Article 9(1);

(h) the feasibility and appropriateness of the development of an Extended Producer Responsibility system for products generating Per- and Polyfluoroalkyl Substances (PFAS) and microplastics in urban wastewater based notably on the monitoring data from Article 21 on PFAS and microplastics in the inlets and outlets of the urban wastewater treatment plants;

(i) the possibility and the time required to reach climate neutrality of the urban wastewater treatment sector;

(j) the opportunity and feasibility to set Union minimum reuse and recycling rates for nitrogen from sludge and/or from urban wastewater.

The Commission shall present a report on the main findings of the evaluation referred to in the first subparagraph to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions ***accompanied, where the Commission finds it appropriate, by relevant legislative proposals***.

2. Member States shall provide the Commission with the information necessary for the preparation of the report referred to in paragraph 1, second subparagraph.

Article 31

Review

Every five years, the Commission shall present a report to the European Parliament and the Council on the implementation of this Directive***. On the basis of this report, the Commission may send early warnings to Member States that are failing or at risk of failing to meet the objectives and deadlines of Articles 3, 5, 6, 7, 8 and 11***.

Article 32

Repeal and transitional provisions

1. Directive 91/271/EC, as amended by the acts listed in Part A of Annex VII to this Directive, is repealed with effect from … [the first day of the ***thirty first*** month after the date of entry into force of this Directive] without prejudice to the obligations of the Member States relating to the time limits for the transposition into national law of the Directives set out in Part B of Annex VII to this Directive.

2. ***In respect of Mayotte,*** Article 3(1) and Article 6(1) shall apply from 31 December ***2030 and Article 3(2) and Article 6(3) shall apply from … [last day of the fifteenth year after the entry into force of this Directive]***

First indent of paragraph 1a of Article 3 and first indent of paragraph 1a of Article 4 of Council Directive 91/271/EEC shall continue to apply until 30 December 2030.

3. ***Without prejudice to the previous subparagraph,*** for urban wastewater discharges from agglomerations of 10 000 p.e. and ***above***, Article 5 of Council Directive 91/271/EC shall continue to apply***:***

(a) until 31 December 2033 for agglomerations that are not required to comply with the requirements set out in Article 7(3) by … [the date of entry into force of this Directive];

(b) until 31 December 2036 for agglomerations that are not required to comply with the requirements set out in Article 7(3) by 31 December 2033;

(c) until 31 December 2039 for agglomerations that are not required to comply with the requirements set out in Article 7(3) by 31 December 2036;

(d) until 31 December 2045 for agglomerations that are not required to comply with the requirements set out in Article 7(3) by 31 December 2039;

(e) until 31 December 2053 for agglomerations to which the derogation referred to in Article 7(4) applies.

4. References to the repealed Directive shall be construed as references to this Directive and shall be read in accordance with the correlation table in Annex VIII.

Article 33

Transposition

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with Articles [...] and Annexes [...] [refer to the articles and annexes which have been amended in substance by comparison with the repealed Directives] by ... [the last day of the ***thirtieth*** month after the date of entry into force of this Directive] ▌. They shall immediately communicate the text of those measures to the Commission ▌.

   When Member States adopt those measures ▌, they shall contain a reference to this Directive or be accompanied by such a reference on the occasion of their official publication. They shall also include a statement that references in existing laws, regulations and administrative provisions to the Directive repealed by this Directive shall be construed as references to this Directive. Member States shall determine how such reference is to be made and how that statement is to be formulated.

2. Member States shall communicate to the Commission the text of the main ***measures*** of national law which they adopt in the field covered by this Directive.

Article 34

Entry into force

This Directive shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union.*

Articles [...] and Annexes [...] [refer to the articles and annexes which are unchanged by comparison with the repealed Directive] shall apply from ... [the first day of the twenty-fourth month after the date of entry into force of this Directive].

Article 35

Addressees

This Directive is addressed to the Member States.

Done at Brussels,

For the European Parliament
The President

For the Council
The President

ANNEX *I*

REQUIREMENTS FOR URBAN WASTEWATER

Part A

Collecting systems

Collecting systems shall take into account wastewater treatment requirements.

The design, construction and maintenance of collecting systems shall be undertaken in accordance with the best technical knowledge not entailing excessive costs, notably regarding:

– volume and characteristics of urban wastewater,

– prevention of leaks ***of wastewater, infiltration and misconnected inflow into the collecting systems***,

– limitation of pollution of receiving waters due to storm water overflows***, considering the relevant requirements in Article 5 and Annex V***.

Part B

Discharge from urban wastewater treatment plants to receiving waters

1. ***Urban*** wastewater treatment plants shall be designed or modified so that representative samples of the incoming wastewater and of treated effluent can be obtained before discharge to receiving waters.

2. Discharges from urban wastewater treatment plants ***and urban wastewater*** treatment ***plants serving agglomerations referred to in*** Articles 6, 7 and 8 shall meet the requirements shown in Table 1 ***of this Annex***.

3. Discharges from urban wastewater treatment plants referred to in ***Article 7(1) or from urban wastewater treatment plants serving agglomerations referred to in Article 7(3)*** shall, in addition to the requirements referred to in point 2, meet the requirements ▌ in Table 2 of this Annex***, except in cases where Article 7(8) is applied.***

4. Discharges from urban wastewater treatment ***plants*** referred to in Article 8(1) ***or from urban wastewater treatment plants serving agglomerations*** referred to in ***Article 8(4) shall*** meet the requirements set out in Table 3 ***of this Annex***.

5. Authorisations ***and/or regulations*** for discharges from urban wastewater treatment plants using ***biomedia shall include:***

- ***a description of the technologies incorporating biomedia used in the treatment of urban wastewater treatment plant, including the type and volume of*** biomedia ***used in the plant and a description of the measures taken to avoid biomedia releases in the environment;***
- an obligation to permanently monitor and prevent all biomedia ***releases*** in the environment***;***
- ***an obligation to report without delay any significant releases of biomedia into receiving waters to competent authorities***.

6. More stringent requirements than those set out in Tables 1, ***2*** and 3 shall be applied where necessary to ensure that the receiving waters fulfil the requirements laid down in Directives 2000/60/EC, 2008/56/EC, 2008/105/EC and 2006/7/EC ▌.

7. The points of discharge of urban wastewater shall be chosen, as far as possible, so as to minimize ***harmful*** effects on receiving waters.

▌

Part C

Methods for monitoring and evaluation of results

1. Member States shall ensure that a monitoring method is applied which fulfils the requirements set out in points 2 to 5. ***Where relevant, all methods of analysis shall comply with minimum performance criteria as the ones defined in the Directive 2009/90/EC and other relevant rules.***

   Alternative methods to those referred to in points 2, 3 and 4 may be used provided that it can be demonstrated that equivalent results are obtained.

   Member States shall provide the Commission with all relevant information concerning the applied monitoring method.

2. Flow-proportional or time-based 24-hour samples shall be collected at the same well-defined point in the outlet and, if necessary, in the inlet of the urban wastewater treatment plant. However, any time-based samples used to monitor micropollutants shall be 48-hour samples.

   Good international laboratory practices aiming at minimizing the degradation of samples between collection and analysis shall be applied.

3. The minimum annual number of samples shall be determined according to the size of the treatment plant and be collected at regular intervals during the year:

1 000 to 9 999 p.e.:	One sample per month ***(see Note 1)***
10 000 to 49 999 p. e.:	Two samples per month For micropollutants, one sample per month
50 000 to ***149 999*** p.e.:	One sample per week. For micropollutants, two samples per ***month***
150 000 p.e. or ***above***:	***Two samples per week*** For micropollutants, two samples per ***month***

Note 1: For agglomerations concerned by seasonal activity, intervals of maximum two months without sampling are accepted provided that additional samples are taken during the months of seasonal activity. A total of 12 samples shall be taken throughout the year.

4. The treated ***urban*** wastewater shall be assumed to conform to the relevant parameters if, for each relevant parameter considered individually, samples of the water show that it complies with the relevant parametric value in the following way:

(a) for the parameters specified in Table 1 ***and Table 3***, a maximum number of samples which are allowed to fail the requirements, expressed in concentrations and/or percentage reductions, is specified in Table 4;

(b) for the parameters of Table 1 expressed in concentrations, the failing samples taken under normal operating conditions must not deviate from the parametric values by more than 100 %, except for the parameter total suspended solids, for which deviations from the parametric values of up to 150 % may be accepted;

(c) for those parameters specified in Table 2 the annual mean of the samples for each parameter shall be conform to the relevant parametric values set out in that table. ▌ The values for concentration or for the minimum percentage of reduction shall apply;

(d) for the parameters specified in Table 3, ***the frequency of sampling referred to in paragraph 3 of Part C of Annex I means that one sample is taken in the inlet and one sample is taken in the outlet of the urban wastewater treatment plant in order to verify compliance with the minimum percentage of removal of Table 3 of Annex I. The average percentage of removal of all substances used in the calculation shall be used in order to assess whether the required 80 % minimum percentage of removal has been reached.***

5. The samples shall be taken so that they reflect the pollution during dry weather ***flow***. Extreme values for the water quality in question shall not be taken into consideration when they are the result of unusual situations due to heavy rain.

6. Analyses concerning discharges from lagooning shall be carried out on filtered samples; however, the concentration of total suspended solids in unfiltered water samples of such discharges shall not exceed 150 mg/l.

Table 1: Requirements for discharges from urban waste water treatment plants subject to Article 6 of the Directive. The values for concentration or for the percentage of reduction shall apply.			
Parameters	Concentration	Minimum percentage of reduction ***(see Note 4)***	Reference method of measurement
Biochemical oxygen demand (BOD_5 at 20 °C) without nitrification (see Note 1)	25 mg/l O_2	70-90 40 under Article ***6(4)***	Homogenized, unfiltered, undecanted sample. Determination of dissolved oxygen before and after five-day incubation at 20 °C ± 1 °C, in complete darkness. Addition of a nitrification inhibitor
Chemical oxygen demand (COD) (see Note 2)	125 mg/l O_2	75	Homogenized, unfiltered, undecanted sample Potassium dichromate
Total Organic Carbon (see Note 2)	37 mg/l	75	EN 1484
Total suspended solids	35 mg/l (see Note 3)	90 (see Note 3)	– Filtering of a representative sample through a 0,45 µm filter membrane. Drying at 105 °C and weighing – Centrifuging of a representative sample (for at least five mins with mean acceleration of 2 800 to 3 200 g), drying at 105 °C and weighing

Note 1: The parameter can be replaced by another parameter: total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD_5 and the substitute parameter.

Note 2: Member States shall measure either the Chemical oxygen demand (COD) or the Total Organic Carbon.

Note 3: This requirement is optional.

Note 4: Reduction in relation to the load of the influent.

Table 2: Requirements for tertiary treatment of discharges from urban wastewater treatment plants referred to in Article 7(1) ***or from urban waste water treatmet plants serving agglomerations referred to in Article*** 7(3). ***For discharges from urban wastewater treatment plants referred to in Article 7(1), both parameters shall apply. For agglomerations referred to in Article 7(3), one*** or both parameters may be applied depending on the local situation. The values for concentration or for the percentage of reduction shall apply.

Parameters	Concentration	Minimum percentage of reduction (see Notes 1 ***and 2***)	Reference method of measurement
Total phosphorus ***(see Note 4)***	***0,7 mg/l (10 000 – 150 000 p.e.)*** ***0,5 mg/l (more than 150 000 p.e.)***	***87,5 (10 000 – 150 000 p.e.)*** ***90 (more than 150 000 p.e.)***	Molecular absorption spectrophotometry
Total nitrogen ***(see Note 4)***	***10 mg/l (10 000 – 150 000 p.e.)*** ***8 mg/l (more than 150 000 p.e.)*** ***(see Note 5)***	***80*** ***(see Note 3)***	Molecular absorption spectrophotometry

Note 1: ***R***eduction ***in relation to the load of the influent or to the load generated in an agglomeration if the same level of environmental protection can be ensured.***

Note 2: If a fraction of treated urban wastewater is used for agricultural irrigation, nutrients in that fraction may be included in the calculation of the influent load and be excluded from the discharged load.

Note 3: ***In exceptional situations due to specific local circumstances n***atural nitrogen retention ***may*** be taken into account in the calculation of the minimum percentage reduction ***in Member States where natural nitrogen retention was taken into account in the calculation of the minimum percentage reduction of nitrogen referred to under Table 2 of Annex I of Council Directive 91/271/EEC and where it is demonstrated that part of the nitrogen originated from urban wastewater can be eliminated in the receiving waters until … [last day of the twentieth year after the entry into force of the Directive] for the calculation of the minimum percentage reduction of nitrogen referred to in Table 2 of Part B of Annex I if all the following conditions are fulfilled:***

(1) ***the average hydraulic retention time of the discharged effluent is at least 1,5 years before it reaches the area sensitive to nitrogen designated under Article 7(2);***

(2) ***continuous monitoring and assessment programme of the total nitrogen parameter is ensured:***

- ***(a)*** ***in the outlets of all urban wastewater treatment plants and where relevant in the urban runoff from agglomerations of 10 000 p.e. and above located in the catchment area of the area designated sensitive to nitrogen under Article 7(2); and***
- ***(b)*** ***in the relevant inlets of the concerned area designated under Article 7(2); and***

(c) at the representative sampling locations in the receiving waters and relevant water bodies in the catchment area of the concerned area designated under Article 7(2);

(3) the minimum percentage reduction for nitrogen of Table 2 is met; this percentage shall be calculated on the basis of the data collected from continuous monitoring and assessment programme referred to in point (2);

(4) it can be demonstrated that nitrogen releases from urban wastewater treatment plants in the catchment area are not harmful for the environment, including for biodiversity, and human health and do not modify the ecosystem;

(5) the concentration of nutrients in the areas referred to in point (c) of condition (2) are compliant with the condition set under Annex V.1.2.1 of Directive 2000/60/EC to define good ecological status of those areas;

(6) the use of natural nitrogen retention is reported to the Commission in accordance with Article 22(1)(a), as well to potentially affected neighboring Member States, together with all the elements necessary to verify that conditions (1), (2), (3), (4) and (5) above are fulfilled.

Note 4: This requirement shall apply on … [date of adoption of this Directive] to existing urban wastewater treatment plants obliged to meet the deadlines established under Article 7(1) and to agglomerations under Article 7(3). Until these deadlines are met, the obligations of Article 32(3) shall apply to these urban wastewater treatment plants.

Note 5: Where the temperature in the effluent of the biological reactor is below 12 °C the results of the samples taken may be excluded from the calculation of the annual mean for nitrogen as referred to in point (4)(c) of Part C of this Annex where all the following can be demonstrated:

(1) no adverse effect to the environment is ensured;

(2) excessive costs and/or excessive energy consumption would be required to reach the values for nitrogen in Table 2.

Where the temperature in the effluent of the biological reactor is below 5 °C the results of the samples taken may be excluded from the calculation of the annual mean for nitrogen as referred to in point (4)(c) of Part C of this Annex.

Table 3: Requirements for quaternary treatment of discharges from urban wastewater treatment plants referred to in Article 8(1) and ***or from urban wastewater treatment plants serving agglomerations referred to in Article 8(4)***.	
Indicators	Minimum percentage of removal ***in relation to the load of the influent***
Substances that can pollute water even at low concentrations (see Note 1)	80 % (see Note 2)

Note 1: The concentration of the organic substances referred to in points (a) and (b) shall be measured.

(a) Category 1 (substances that can be very easily treated):

(i) Amisulprid (CAS No 71675-85-9),

(ii) Carbamazepine (CAS No 298-46-4),

(iii) Citalopram (CAS No 59729-33-8),

(iv) Clarithromycin (CAS No 81103-11-9),

(v) Diclofenac (CAS No 15307-86-5),

(vi) Hydrochlorothiazide (CAS No 58-93-5),

(vii) Metoprolol (CAS No 37350-58-6),

(viii) Venlafaxine (CAS No 93413-69-5);

(b) Category 2 (substances that can be easily disposed of):

(i) Benzotriazole (CAS No 95-14-7),

(ii) Candesartan (CAS No 139481-59-7),

(iii) Irbesartan (CAS No 138402-11-6),

(iv) mixture of 4-Methylbenzotriazole (CAS No 29878-31-7) and ***5***-methyl-benzotriazole (CAS No 136-85-6).

Note 2: The percentage of removal shall be calculated ***on dry weather flow*** for at least six substances. The number of substances in category 1 shall be twice the number of substances in category 2. If less than six substances can be measured in sufficient concentration, the competent authority shall designate other substances to calculate the minimum percentage of removal when it is necessary. The average of the ***specific*** percentages of removal of all ***single*** substances used in the calculation shall be used in order to assess whether the required 80 % minimum percentage of removal has been reached.

Table 4: ***Requirement for samples***	
Series of samples taken in any year	Maximum permitted number of samples which fail to conform
4-7	1
8-16	2
17-28	3
29-40	4
41-53	5
54-67	6
68-81	7
82-95	8
96-110	9
111-125	10
126-140	11
141-155	12
156-171	13
172-187	14
188-203	15
204-219	16
220-235	17
236-251	18
252-268	19
269-284	20
285-300	21
301-317	22
318-334	23
335-350	24
351-365	25

ANNEX *II*

AREAS SENSITIVE TO EUTROPHICATION

1. Areas located in the catchments of the Baltic Sea, the Black Sea, ▌ the North Sea ***and*** the Adriatic Sea identified as sensitive to eutrophication under ***Directives*** 2008/56/EC ***or 2000/60/EC***;

2. Natural freshwater lakes, other freshwater bodies, estuaries and coastal waters which are found to be eutrophic or which in the near future may become eutrophic if protective action is not taken.

   The following elements shall be taken into account when considering which nutrient should be reduced by further treatment:

   (a) lakes and streams reaching lakes/reservoirs/closed bays which are found to have a poor water exchange, whereby accumulation may take place. In these areas, the removal of phosphorus should be included unless it can be demonstrated that the removal will have no effect on the level of eutrophication. Where discharges from large agglomerations are made, the removal of nitrogen may also be considered;

(b) estuaries, bays and other coastal waters which are found to have a poor water exchange, or which receive large quantities of nutrients. Discharges from small agglomerations are usually of minor importance in those areas, but for large agglomerations, the removal of phosphorus and/or nitrogen should be included unless it can be demonstrated that the removal will have no effect on the level of eutrophication;

3. Surface freshwaters intended for the abstraction of drinking water which could contain more than the concentration of nitrate laid down under the relevant provisions of Directive (EU) 2020/2184 ***if*** protective action is not taken;

4. Areas where further treatment than that prescribed in Article 7 of this Directive is necessary to comply with other Union acts in the environmental field, including in particular water bodies covered by Directive 2000/60/EC which are at risk of not maintaining or achieving good ecological status or potential.

5. Any other areas found by the Member States to be sensitive to eutrophication.

ANNEX *III*

LIST OF PRODUCTS COVERED BY EXTENDED PRODUCER RESPONSIBILITY

1. Medicinal products for human use falling within the scope of Directive 2001/83/EC of the European Parliament and of the Council[52].

2. Cosmetic products falling within the scope of Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products[53].

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52 Directive 2001/83/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to medicinal products for human use (OJ L 311, 28.11.2001, p. 67).

53 Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products (OJ L 342, 22.12.2009, p. 59).

ANNEX *IV*

INDUSTRIAL SECTORS

1. Milk-processing
2. Manufacture of fruit and vegetable products
3. Manufacture and bottling of soft drinks
4. Potato-processing
5. Meat industry
6. Breweries
7. Production of alcohol and alcoholic beverages
8. Manufacture of animal feed from plant products
9. Manufacture of gelatine and of glue from hides, skin and bones
10. Malt-houses
11. Fish-processing industry

ANNEX *V*

CONTENT OF THE INTEGRATED URBAN WASTEWATER MANAGEMENT PLANS

1. An analysis of the initial situation of the drainage area of the concerned agglomeration, including at least the following:

   (a) a detailed description of the network of collecting systems, the urban wastewater and urban runoff storage ***and conducting*** capacities of that network and the existing urban wastewater treatment capacities in case of rainfall;

   (b) ***In case of combined sewers,*** a dynamic analysis of the flows of urban wastewaters in case of rainfall**,** based on ***monitoring data or*** the use of hydrological, hydraulic and water quality models that take into account state-of-the-art climate projections and including an estimate of the pollution loads ***of the parameters referred to in Table 1 and, where relevant, Table 2 of Annex I as well as microplastics and relevant pollutants*** released in receiving waters in case of rainfall;

   (c) In case of separate sewers, a detailed description of the monitoring requirements at relevant points of separate systems where discharges of urban runoff are expected to be polluted as identified under Article 5(2), point (d), to identify relevant and feasible measures as required in point 3 of this Annex.

2. Objectives for the reduction of pollution from storm water overflows ▌, including the following:

(a) an indicative ***non-binding*** objective that storm water overflow ▌ represents ***a small percentage that cannot be*** more than ***2 %*** of the annual collected urban wastewater load calculated in dry weather conditions.

This indicative ***non-binding objective*** shall be met by:

(i) 31 December ***2039*** for all agglomerations of 100 000 p.e. and above;

(ii) 31 December ***2045*** for agglomerations of 10 000 p.e. and above ***referred to in*** Article 5;

(b) the progressive ***reduction of macroplastics.***

3. The measures to be taken to achieve the objectives referred to in point 2 ***in accordance with the deadlines set in point 2 of this Annex*** accompanied with a ***timeline for the implementation of the measures and a distinction between measures already in place and to be taken. It shall also contain a*** clear identification of the actors involved and their responsibilities in the ***implementation*** of the integrated plan.

4. When assessing which measures to be taken under point 3, Member States shall ensure that their competent authorities consider at least the following:

(a) firstly, preventive measures aiming at avoiding the entry of unpolluted rain waters into collecting systems, including measures promoting natural water retention or rainwater harvesting, and measures increasing green ***and blue*** spaces ***in urban areas in order to reduce storm water overflows*** or limiting impermeable surfaces in the agglomerations;

(b) secondly, measures to better manage and optimize the use of existing infrastructure including collecting systems, storage volumes, urban wastewater treatment plants with the aim to ensure that ***releases of untreated urban wastewater or polluted*** urban ***runoff*** into receiving waters are minimised;

(c) finally, where necessary to achieve the objectives referred to in point 2, additional mitigation measures including the adaptation of the infrastructure for the collection, storage and treatment of urban wastewater***, such as connecting newly built urban areas to separate sewers, where relevant,*** or the creation of new infrastructures with a priority to green ***and blue infrastructure*** vegetated ditches, treatment wetlands and storage ponds designed in order to support biodiversity**.** Where relevant, water reuse shall be considered in the context of the development of the integrated urban wastewater management plans referred to in Article 5.

ANNEX *VI*

INFORMATION TO THE PUBLIC

(1) The competent authority and the operator(s) responsible for urban wastewater collection and treatment services, including information on the ownership structure of the operators and their contact information.

(2) The total urban wastewater load expressed in population equivalents (p.e.) generated in the agglomeration, with details on the share of that load (in %) that is:

(a) collected and treated in urban wastewater treatment plants;

(b) treated by registered individual systems;

(c) not collected or treated.

(3) Where relevant, a justification for why a certain load of urban wastewater is not collected or treated.

(4) Information on the quality of the urban wastewater discharged from the agglomeration to each receiving water body, including the following elements:

(a) annual average concentrations and the load of pollutants covered by Article 21 released by each urban wastewater treatment plant;

(b) an estimate of the load of the discharges from individual systems for the parameters referred to in Tables 1 and 2 of Annex I;

(c) ***for agglomerations above 10 000 p.e.,*** an estimate of the load of the discharges from combined sewer and ▌ storm water overflows for the parameters referred to in Tables 1 and 2 of Annex I.

(5) total annual investment costs and total annual operational costs, with a distinction between collection and treatment costs, total annual costs related to staff, energy, consumables, administration and other costs as well as average annual investment and operational costs per ▌ cubic meter of urban wastewater collected and treated, ***and per average household where costs are recovered totally or partly through a water tariff system or per agglomeration level in other cases***;

(6) information on how the costs referred to in point (5) are covered and, where costs are recovered through a tariff system, information on the structure of the tariff per cubic meter of urban wastewater collected and treated information on the structure of the tariff either per cubic meter of urban wastewater collected and treated or per cubic meter of water supplied, including fixed and variable costs and a breakdown between costs for collection, treatment, administration and other costs;

(7) investment plans for urban wastewater collection and treatment infrastructures at agglomeration level, with foreseen impacts on urban wastewater services tariffs, and intended financial and societal benefits;

(8) for each urban wastewater treatment plant ***of 10 000 p.e. and above***:

(a) the total load (in p.e.) treated and the energy required to treat the urban wastewater (in kWh total and per cubic meter);

(b) the total renewable energy produced (GWh/year) each year, including a breakdown per source of energy;

▌

(9) the total ***direct*** greenhouse gas emissions (in tonnes of CO_2 equivalent) produced or avoided per year by the operation of urban wastewater collection and treatment infrastructures ***of 10 000 p.e. and above*** in each agglomeration and, ***when*** available, the total ***indirect*** greenhouse gas emissions (in tonnes of CO_2 equivalent) produced ***notably*** during the construction of those infrastructures;

(10) a summary of the nature and statistics regarding complaints and of the answers provided by the urban wastewater treatment plant operators on matters falling within the scope of this Directive.

(11) upon justified request, consumers shall be given access to historical data for information under points (2), (4), (8) and (9), dating back up to 10 years, and not earlier than … [day of entry into force of the Directive].

ANNEX *VII*

Part A

Repealed Directive

with list of the successive amendments thereto

(referred to in Article [19])

Council Directive 91/271/EEC (OJ L 135, 30.5.1991, p. 40)	
Commission Directive 98/15/EC (OJ L 67, 7.3.1998, p. 29)	
Regulation (EC) No 1882/2003 of the European Parliament and of the Council (OJ L 284, 31.10.2003, p. 1)	only Annex III, point 21
Regulation (EC) No 1137/2008 of the European Parliament and of the Council (OJ L 311, 21.11.2008, p. 1)	only Annex, point 4.2
Council Directive 2013/64/EU (OJ L 353, 28.12.2013, p. 8)	only Article 1

Part B

Time-limits for transposition into national law

Directive	Time-limit for transposition
91/271/EC	30 June 1993
98/15/EC	30 September 1998
2013/64/EU	31 December 2018 as regards Article 1(1), (2) and (3) 30 June 2014 as regards Article 1(5), point (a) 31 December 2014 as regards Article 1(5), point (b)

ANNEX *VIII*

Correlation Table

Directive 91/271/EC	This Directive
Article 1	Article 1
Article 2, introductory wording	Article 2, introductory wording
Article 2, points 1 to 4	Article 2, points 1 to 4
–	Article 2, points 5 and 6
Article 2, point 5	Article 2, point 7
–	Article 2, points 8 and 9
Article 2, point 6	Article 2, point 10
Article 2, point 8	Article 2, point 12
–	Article 2, points 13 and 14
Article 2, point 10	Article 2, point 15
Article 2, point 11	Article 2, point 16
–	Article 2, point 17 to 25
Article 3(1)	Article 3(1)
–	Article 3(2)
Article 3(2)	Article 3(3)
Article 3(1), third subparagraph	Article 4(1)
–	Article 4(2)
–	Article 4(3)
–	Article 4(4)
–	Article 4(5)
–	Article 5
Article 4(1)	Article 6(1)
–	Article 6(3)
–	Article 6(4)
Article 4(4)	Article 6(5)
–	Article 7(1)
–	Article 7(2)

Directive 91/271/EC	This Directive
Article 5(2)	Article 7(3)
–	Article 7(7)
Article 5(4)	Article 7(8)
Article 5(5)	Article 7(9)
Article 5(7)	Article 7(10)
–	Article 8
–	Article 9
–	Article 10
–	Article 11
Article 9	Article 12(1)
–	Article 12(3)
Article 10	Article 13
Article 11(1)	Article 14(1)
–	Article 14(2)
–	Article 14(3)
Article 11(3)	Article 14(4)
–	Article 15(1)
Article 12(2)	Article 15(2)
Article 12(3)	Article 15(3)
–	Article 16
–	Article 17
–	Article 18
–	Article 19
–	Article 20
Article 15(1)	Article 21(1)
–	Article 21(2)
–	Article 21(3)
–	Article 22

Directive 91/271/EC	This Directive
Article 17(1)	Article 23(1)
–	Article 23(2)
–	Article 23(3)
–	Article 23(4)
–	Article 24
–	Article 25
–	Article 26
–	Article 27
Article 18	Article 28
–	Article 29
–	Article 30
–	Article 31
–	Article 32
Article 19	Article 33
–	Article 34
Article 20	Article 35
Annex I	Annex I(A)
Annex I(B)	Annex I(B)
Annex I(C)	Annex I(C)
Annex I(D)	Annex I(D)
Annex II	Annex II
–	Annex III
Annex III	Annex IV
–	Annex V
–	Annex VI
–	Annex VII
–	Annex VIII

Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

8.1

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

8.1

A REVIEW OF AND REPORT

ON

CERTAIN MATTERS RELATING

TO

DUBLIN CITY COUNCIL'S

RINGSEND WASTEWATER TREATMENT PLANT

Prepared by:

Brendan Fehily

For

The Minister for Environment, Heritage and Local Government

Mr. John Gormley TD

October 2008

TABLE OF CONTENTS

PAGE

1. NON-TECHNICAL SUMMARY 1

1.1 Introduction 1
1.2 The Original Design 1
1.3 Population 2
1.4 Trade and Industry 2
1.5 Pollution Load 3
1.5.1 Commuters to Work 3
1.5.2 Domestic Tourism 4
1.5.3 Other Sources 4
1.5.4 Cumulative Additional Loads 4
1.6 Nutrient Removal Standards 5
1.7 The Odour Issue 5
1.7.1 The Environmental Impact Statement (EIS) 6
1.7.2 The Contract Documents 6
1.7.3 Odour Treatment Plant 7
1.8 The Wastewater Treatment Plant 8
1.9 The Cambi Process 9
1.10 Conclusions 9
1.11 Recommendations 10

2. INTRODUCTION 11

2.1 Terms of Reference 11

3. THE BASIS FOR, AND TIMING OF, THE DETERMINATION OF THE DESIGN CAPACITY OF THE TREATMENT PLANT 13

3.1 Introduction 13
3.2 Design Capacity 14
3.2.1 Pollution Load 14
3.2.2 Design Flows to Treatment 18

***4.* VOLUME AND TIMING OF ACTUAL LOADS BY COMPARISON TO LOAD PROJECTIONS 19**

4.1 Introduction 19
4.2 Pollution Load Survey (PR No. 1) 19
4.3 MACL/MCOS/EC Harris Report April 2000 20
4.4 Estimates of Industrial PE Loadings in the Ringsend Catchment 2003 22
4.5 2006 Loadings 22
4.6 Discussion and Comment 23
4.6.1 Designated Load V Average Daily Load 23
4.6.2 Measured Load V Design Load 23

TABLE OF CONTENTS

PAGE

5. IPC LICENSED DISCHARGE LOADS V ACTUAL DISCHARGE LOADS 24

5.1 COMMENT 25
5.2 TRADE LICENCES 26

6. THE APPROPRIATENESS OF THE DESIGN CAPACITY DETERMINED HAVING REGARD TO THE INFORMATION AVAILABLE AT THAT TIME 27

6.1 INTRODUCTION 27
6.2 POPULATION TRENDS 27
6.2.1 Unaccounted for Populations 28
6.2.2 Daily Commuters 29
6.2.3 Tourism 30
6.3 COMMERCIAL LOADINGS 30
6.4 INDUSTRIAL LOADINGS 33
6.5 TANKERED WASTE 34
6.6 FLOW TO TREATMENT 34
6.7 A COMMENT ON MACL/MCOS/EC HARRIS REPORT 34

7. CONSIDERATION GIVEN TO NUTRIENT REDUCTION REQUIREMENTS IN THE CONTEXT OF WATER QUALITY STANDARDS APPLYING TO THE RECEIVING WATERS 36

7.1 INTRODUCTION 36
7.2 RESOLUTION OF DUBLIN CORPORATION (SIC) 37
7.3 EFFLUENT STANDARDS FOR RINGSEND WASTEWATER TREATMENT PLANT 38
7.4 REVIEW OF EFFLUENT STANDARDS 39
7.5 OTHER REPORTS 41
7.5.1 EPA Memorandum to DoEHLG (December,2007) 41
7.6 ALGAL BLOOMS IN DUBLIN BAY 42
7.7 THE URBAN WASTE WATER TREATMENT REGULATIONS (SI NO. 254 OF 2001) 43
7.8 STANDARDS CURRENTLY IN PLACE AT RINGSEND 44
7.9 CONSULTANTS BRIEF FOR RINGSEND WASTEWATER TREATMENT PLANT EXPANSION 44

8. THE ODOUR ISSUE 46

8.1 INTRODUCTION 46
8.2 ENVIRONMENTAL IMPACT STATEMENT (EIS) 47
8.3 THE CONTRACT DOCUMENTS 48
8.4 ODOUR PROVISIONS IN ORIGINAL DESIGN 48
8.5 ODOUR INCIDENTS 49
8.6 ODOUR SURVEYS 51
8.7 OTHER REMEDIAL WORKS 53
8.8 CONTRACTUAL DIFFICULTIES 53
8.9 COMMENT AND SUMMARY 54

TABLE OF CONTENTS

PAGE

9. CONCLUSIONS AND RECOMMENDATIONS 56

9.1 CONCLUSIONS 56
9.2 RECOMMENDATIONS 57

1. NON-TECHNICAL SUMMARY

1.1 Introduction

This report examines the decisions made in the design of the new Wastewater Treatment Plant at Ringsend, Dublin, in the light of events which have occurred since the new works was commissioned in June 2003. In particular, it explores the reasons why the new works is frequently working above its design capacity and reports on the incidence of odours at the works and beyond and the effectiveness of the measures taken to mitigate them.

1.2 The Original Design

Before the new works were commissioned in 2003, the sewage of Dublin City received primary treatment only at Ringsend. The primary sludge was disposed of at sea. Under the Urban Wastewater Directive, secondary treatment became mandatory and the dumping of sludge at sea had to cease by the end of 1998.

Initially, the plan was to provide secondary treatment at Ringsend for the flows from Dublin City, the Dodder Valley and Dun Laoghaire only. A separate study examined the possibility of providing a treatment plant for the North Dublin Area. Ultimately, it was concluded that the most economically favourable solution was to combine the two schemes by laying an undersea pipeline from Sutton to Ringsend and to expand the Ringsend works to cater for the entire Dublin Region.

Wastewater treatment plants are usually designed to treat wastewater coming from two main sources:

- The residential population (domestic load) and
- Trade and Industry (non-domestic load)

It is considered good engineering practice to design a works for some future design year, say, twenty years on and to make informed projections of population growth and industrial development up to the design year. In the case of Ringsend, the design year chosen was 2020.

1.3 Population

To arrive at the likely domestic pollution load in 2020, it was necessary to make projections of the population of Dublin and the Greater Suburbs to the year 2020. Fortunately, good basic information on population and growth is available from the national Census. From time to time also, the CSO and others make population predictions for the purposes of social and economic planning.

On the basis of information current in the 90's, it was estimated that the existing population of the catchment areas draining to Ringsend would grow at 0.8% per annum up to a population of 1,987,000 persons in 2020. This figure was used as the basis for calculating the domestic load for the new works at Ringsend.

To date, projections used in the design have been proved to be on target when compared with the more recent Censuses of 2002 and 2006.

1.4 Trade and Industry

Trade and industrial discharges to the public sewerage system are normally made under licences issued by the constituent local authorities. In the case of large industries, control is exercised by the Environmental Protection Agency (EPA) under Integrated Pollution, Prevention and Control (IPPC) licences. All licences are issued with conditions attached which stipulate the maximum allowable discharges to the public sewer in terms of pollution load and flow. Because of licences, it is possible to compute the existing pollution load from trade and industry in the catchment area.

Normally, trade and industry are charged with the cost of treatment of their effluent under the Polluter Pays Principle. In considering the design load from trade and industry, it was anticipated that, once new charges were levied for secondary treatment at Ringsend, there would be an immediate move to improve housekeeping within industry to reduce their discharges to sewer because of the additional cost. This had been the universal experience in Europe and there was no reason to believe that Dublin would be any different.

For this reason, it was decided to take the summation of the maximum allowable discharges contained in existing licences and to design for 60% of this load at the treatment plant.

In the event, the decision to pitch trade and industry loads at 60% of their maximum value has so far proved to be correct. From investigations carried out for this report on IPPC licences, industrial loadings for the year 2006 were well within the design criteria laid down for the new works in 1998 and amounted to only 36% of the allowable discharges under IPPC (see Section 5).

There is less certainty about the discharges coming from trades licensed by the constituent local authorities. However, investigations carried out by Dublin City Council in the years 2003 and 2006 seem to indicate that trade licence discharges were being kept within the 60% envelope. There was some evidence that the total licensed discharges had increased by about 36% between 1998 and 2003. Subsequent action by DCC had reduced this excess considerably so that by the year 2006, it is estimated that the combined total of discharges to Ringsend from trade and IPPC licences was within the design figure.

If the domestic load and the loads coming from trade and industry are within the design parameters, why then is the new works at Ringsend being frequently overloaded?

1.5 Pollution Load

Section 4 of this report gives details of various pollution load surveys carried out between 1991 and 2006 at Ringsend. In all cases, the loads predicated on design population and industrial discharges fall short of the measured pollution load arriving at the Ringsend works. The clear inference is that additional pollution loads are arriving at Ringsend which were not foreseen in the design.

This report looks at various sources of additional pollution that might have arisen since the original design was decided upon and might be attributable to the extraordinary years of the Celtic Tiger from 1998 to 2006. A brief resume is given here.

1.5.1 Commuters to Work

The original design made allowance for 20,000 persons commuting to work daily from outside the design area. Recent studies made by the CSO would suggest that this figure is of the order of 90,000 persons in recent years, an increase of 70,000 persons. The pollution load attributable to commuters is taken as one-third of that of the resident population. Therefore, the 70,000 extra commuters translate into an equivalent population of **23,300** persons contributing to the new works at Ringsend.

1.5.2 Domestic Tourism

The CSO and Failte Ireland have made various attempts to quantify the movement of tourists into Ireland and within Ireland itself. The latter is termed domestic tourism. A high proportion of domestic tourism is accounted for by 'same day visits'. In the case of Dublin, it is estimated that same-day visits could amount to **36,000** per day or an equivalent population of **12,000** contributing to the domestic pollution load at Ringsend.

If commuters and same-day visitors are combined, an equivalent population of **35,300** persons may be unaccounted for in the design.

1.5.3 Other Sources

Notwithstanding the increased loading attributable to tourism, there is still a considerable load unaccounted for. The original design assumed that effluent discharges from commercial premises such as shops, offices, pubs, restaurants, sporting facilities and other commercial entities were already catered for in the allowances made for the domestic population in the design. In the opinion of this report, this decision underestimates the impact of commercial outlets on the pollution load discharged to public sewer.

Commercial loadings are reckoned with in the design of most wastewater facilities. The National Urban Wastewater Study published by the DoEHLG in 2004 states that commercial loadings are usually reckoned to be 16% of all domestic/residential loadings. If this reckoning had been applied to the design residential population for Ringsend, it would account for an additional population equivalent of nearly **190,000** people. Such an additional loading would go a long way to explain the present disparity between the measured load and the predicted design load at the Ringsend Works.

1.5.4 Cumulative Additional Loads

The cumulative additional load from commuters, tourism and the commercial sector could amount to **225,300 PE**. This does not take into account any additional loads from persons unaccounted for in the Census (see paragraph 6.2.1) or from a possible increase in affluence in Dublin leading to a higher per capita load from domestic sources than is allowed for in the Urban Wastewater Directive.

Taking all these factors into account, the present overloading of the Works does not seem improbable.

1.6 Nutrient Removal Standards

From the outset DCC have been aware of the problems posed by excess nutrients being discharged to Dublin Bay. There is no doubt that the new works at Ringsend has had a dramatic positive effect on the water quality in Dublin Bay. The question remains, however, whether the Ringsend WWTP is now in compliance with the Urban Wastewater Directive (S.I. No. 254 of 2001) which requires compliance with the nutrient standards since May, 2008. Clearly, the new standards impose very stringent limits on discharge of Nitrogen (N) and Phosphorous (P) which are unlikely to be met by the present treatment system.

In the case of nitrate nitrogen (NO_3), measures need to be put in place at Ringsend to de-nitrify the final effluent. In addition, phosphorous removal may be required to comply with the 'sensitive area' requirements. Alternatively, the final effluent can be conveyed to a point where the 'sensitive area' restrictions no longer apply.

Either way, there is still work to be done to make the Ringsend Works compliant with the new Regulations. The most sensible solution would seem to be to carry out these improvement works together with the final upgrading of the treatment plant.

1.7 The Odour Issue

The Public Health Act of 1878 was the first legislation to be introduced in Ireland to control nuisance but it is only since Environmental Impact Assessment (EIA) was introduced in the 90's after the establishment of the Environmental Protection Agency (EPA) that odour has been seriously addressed as a public nuisance. In December 2005, the Minister for the Environment, Heritage and Local Government made regulations with respect to odours and noise from wastewater treatment plants (S.I. 787).

The Regulations do not stipulate any numerical values for the control of odour nuisance and merely state *'a sanitary authority shall ensure that in formulating and improving plans for a wastewater treatment plant to be provided by the authority or on its behalf the plant is so designed and constructed as to ensure that it avoids causing nuisance through odours or noise'.*

1.7.1 The Environmental Impact Statement (EIS)

EIS No. 1 in relation to the Dublin Bay Project deals with the Ringsend Treatment Works. Section 7.1 of the EIS deals with odour.

The EIS describes how a predictive model for odour at the new works was carried out using the Industrial Source Complex model developed by the USEPA for emissions to air. The EIS adopted hydrogen sulphide (H_2S) as the most prominent indicator of odour in a wastewater treatment plant. This substance is highly odiferous (odour of rotten eggs) and is commonly used as a reliable indicator for odour intensity. The World Health Organisation (WHO) gives 3.5 parts per billion (ppb) of hydrogen sulphide as the level at which no odour is detectable.

Various inputs to the model indicated that odour at the site boundary would not exceed 8.4 ppb of H_2S without any odour treatment. The EIS further states that with 95% odour control, the level of H_2S at the site boundary would be undetectable. In the light of these results, the EIS set a standard to be achieved at the site boundary of 5 ppb of H_2S.

The EIS concluded that "the operation of the upgraded STW will, therefore, have no adverse odour impact on the existing environment and its users, and will represent a significant improvement over the operation of the existing works".

One of the inputs to the odour model was an assumption that the maximum concentration of sulphide at the works inlet would be I mg/l. In the event, measurements as high as 8.7 mg/l were recorded at the inlet. Obviously, the model predictions were hugely optimistic.

1.7.2 The Contract Documents

Although the EIS established an odour standard of 5 ppb at the site boundary, inexplicably, the Contract Documents (Volume 2 – Employer's Requirements) quoted a standard of 100 ppb H_2S at the site boundary i.e. twenty times higher than that quoted in the EIS. This was either a serious error of judgement or a mistake.

1.7.3 Odour Treatment Plant

The equipment originally provided in Contract No. 2 for odour treatment is listed in Section 7.4. The equipment consisted of 3 no. odour units which proved totally inadequate. Odour problems were experienced from the beginning of the commissioning of the works in May/June 2003.

Earlier, two sludge dryers had been provided by another contractor in Contract No. 1. The dryers had their own odour control unit and had worked reasonably satisfactorily from 1999 to 2003.

Between August 2003 and the time of writing (October 2008) the odour problems at Ringsend have been recurrent and, at times, severe. Several reports and surveys were carried out in an effort to contain the problem between 2003 and 2006 but many of the solutions were of a 'fire brigade' nature, (i.e. ad hoc responses to emergency situations rather than parts of an overall plan) and proved ultimately to be inadequate.

A significant number of odour problems were created by inadequate design and equipment failure. As a result, DCC found themselves in constant conflict with the Main Contractor, ABA. Difficult negotiations were always tempered by efforts to avoid complete breakdown of contractual arrangements and the inevitable litigation and virtual chaos that would have accompanied such breakdown. Certainly the odour problem would have been prolonged even further and the plant performance with respect to effluent to Dublin Bay would have been seriously jeopardised.

Throughout the disputes and negotiations with the Contractor, the fact that the Works was deemed to be overloaded gave him considerable leverage in his arguments. In the matter of odour control, he used the lenient standard of 100 ppb of H_2S at the site boundary to his advantage even though subsequent modelling would show that a level of 100 ppb at the site boundary would mean that significant odour would reach residential areas such as Ringsend, Irishtown and Sandymount.

In a final effort to resolve the odour problem, DCC commissioned Odour Ireland to carry out extensive odour measurements during 2005 and employed an independent international consultant CDM to bring forward solutions that would render the Ringsend Plant one of the best in the world on odour abatement control. The recommendations of the CDM Report are being fully implemented and are scheduled for completion by November 2008.

Parallel with the completion of the recommendations of the CDM Report, many of the disputes with the Main Contractor have been resolved, leading to repairs and renewals to the original plant which have resulted in the elimination of odour emissions from various other sections of the treatment plant.

It would be foolish to suggest that there will never again be an odour from the Ringsend Plant. Inevitably, plant breakdowns and accidental emissions will occur from time to time as in all other treatment plants of this nature but the odour abatement equipment now in place should ensure that such incidents will be minor and few and far between.

Nevertheless, constant vigilance and proper management will be required on the part of DCC to ensure that odour will no longer be a recurring nuisance for the nearby residents.

1.8 The Wastewater Treatment Plant

The performance of the treatment plant itself should also be acknowledged. Since 2004, the effluent standard to Dublin bay has been quite good apart from some poor results in early 2006 when some of the aeration equipment in the main treatment tanks (SBRs) failed and had to be replaced.

There are two-tier limits on the discharge for BOD as follows:

- Low Limit: < 25 mg/l BOD
- High Limit: > 25 < 50 mg/l BOD

In spite of all the teething troubles and overloading of the Works, the lower limit has been achieved over 80% of the time (excluding 2006 when it was 72%) and the higher limit achieved over 95% of the time (85% in 2006). So far in 2008 the works is compliant with the low limit (i.e. >95%).

As a consequence, the quality of water in Dublin Bay has improved to such an extent that Dollymount Strand has achieved Blue Flag status in 2007 and 2008, and will also enjoy Blue Flag status in 2009.

1.9 The Cambi Process

The positive side of the Cambi process should not be discounted. The process of hydrolysis renders the sludge more amenable to anaerobic digestion and increases the biogas yield significantly. The digester feed occurs at a much higher solids content than conventional digesters, thereby, reducing the size of the digester by 50%. The resultant sludge is considerably reduced in volume by virtue of conversion to biogas and is much more easily dewatered. It is also highly pasteurised.

Biogas on site feeds to a Combined Heat and Power (CHP) unit which provides 3 MW of power from gas generators and also provides heat which is used to generate steam for the hydrolysis process.

1.10 Conclusions

1. The population projections made in connection with the design of Ringsend Wastewater Treatment Plant have been shown to be on target up to the Census year of 2006.

2. The decision to take 60% of the licensed flows and loads of industry as the design load at Ringsend has proved to be correct up to the present.

3. Pollution loads arising from commercial sources such as shops, offices, restaurants, public houses and public buildings etc. were underestimated in the design. It is estimated that commercial sources could be contributing an equivalent population of **190,000** or more to the population load arriving at Ringsend.

4. Increases in prosperity and tourism may account for an extra **12,000** population equivalent from same-day visits to Dublin from the rest of the country.

5. Commuter journeys into Dublin have increased significantly. The design allowed for 20,000 commuters each having the effect of one third of a person, making the total population equivalent contribution 6,700 in the design. The CSO estimated from the 2006 Census that over 90,000 commuters come into the Greater Dublin Area every week-day i.e. a population equivalent of 30,000 or an increase of **23,300** over the design load.

6. The cumulative additional loads estimated from commuters, tourism and the commercial sector could amount to **225,300 PE.**

7. The monitoring of existing trade licences in all the local authority areas needs to be improved so that measurement of the actual loads being discharged are readily quantifiable.

8. Certain anomalies in the measurement of flow and load arriving at Ringsend WWTP need to be investigated.

9. The odour control equipment now installed at Ringsend is fit for purpose and should eliminate the odour nuisance experienced from time to time in the nearby residential areas since 2003.

1.11 Recommendations

1. The Consultants Brief for the final upgrading of Ringsend WWTP to its maximum capacity should be extended to include a comprehensive review of the measurement of the existing flow/load entering the works from the following sources:

   - Sutton Pumping Station
   - Dun Laoghaire Pumping Station
   - Middle-level Pumping Station
   - Dodder Valley Siphon

2. The adequacy of the flow/load recording equipment currently in use should be carefully checked and modified/upgraded as necessary.

3. The monitoring, control and measurement of all licensed trade discharges in each constituent local authority area contributing to the Ringsend Works should be significantly improved so that actual load versus allowable load can be readily quantifiable in terms of kg of BOD per day.

4. Trade licences should incorporate requirements for continuous review and improvement in a similar manner to IPPC licences.

5. All discharges from commercial premises should be licensed and routinely monitored.

6. The monitoring, control and measurement of transboundary flows/loads from one local authority area to another should be improved and adequate measures installed to achieve credible results.

7. Additional random spot-checks should be carried out on tanker loads of liquid waste being discharged on site at the inlet to Ringsend Wastewater Treatment Plant.

2. INTRODUCTION

2.1 Terms of Reference

The terms of reference for an independent examination and report to the Minister for the Environment, Heritage and Local Government in relation to the determination of the Phase 1 Design Capacity of Ringsend Wastewater Treatment Works and Related Matters are included in full as Appendix 1 of this report.

As defined in the Terms of Reference (TR), this document reviews and reports on the following matters in particular:

- The basis for, and the timing of, the determination of the design capacity of the treatment works;
- The volume and timing of actual loads arising (domestic and non-domestic) by comparison to the load projections when the design capacity was determined;
- A comparison of the IPC licenced discharge loads and the actual discharge loads from these licensees to the treatment works;
- The appropriateness of the design capacity determined having regard to the information available at that time;
- The consideration given to nutrient reduction requirements in the context of the water quality standards applying to the receiving waters (both prior to and after the designation of the Liffey Estuary as sensitive under the Urban Wastewater Treatment Directive in 2001); and
- The factors that contributed to the odour problems and the effectiveness of the actions taken to deal with such odours prior to October 2007 when the City Council, on foot of a contractual agreement with the contractor, issued instructions for additional works to resolve the odour issue.

Section 3 of this report deals with the basis for, and timing of, the determination of the design capacity of the treatment works.

Section 4 deals with the volume and timing of actual loads arising (domestic and non domestic) by comparison to the load projections when the design capacity was determined.

Section 5 deals with a comparison of the IPC Licence to discharge loads and the actual discharge loads from those licensees to the treatment works.

Section 6 deals with the appropriateness of the design capacity determined having regard to the information available at that time.

Section 7 deals with the consideration given to nutrient reduction requirements in the context of the water quality standards applying to the receiving waters.

Section 8 deals with the factors that contributed to the odour problems and the effectiveness of the actions taken to deal with such odours prior to October 2007.

Section 9 contains Conclusions and Recommendations.

3. THE BASIS FOR, AND TIMING OF, THE DETERMINATION OF THE DESIGN CAPACITY OF THE TREATMENT PLANT

3.1 Introduction

Information with regard to the determination of the design capacity of the treatment plant at Ringsend has been compiled from a desk study of the following documents:

- Preliminary Report on Ringsend Sewage Treatment Plant Expansion, May 1993 (referred to in the text as PR No. 1)
- Preliminary Report on North Dublin Drainage Scheme Catchment Area Study, September 1994 (referred to in the text as PR No. 4)
- Supplementary Report on Ringsend Wastewater Treatment Plant Works Expansion, October 1995 (referred to in the text as the SR)
- Environmental Impact Statement No. 1, Ringsend Treatment Works, Volume 1, Main report, January 1997
- Ringsend Wastewater Treatment Works, Contract No. 2, Volume 2 – Employer's Requirements, May 1998

PR No. 1 deals with the Ringsend Catchment only which includes Dublin City, Dun Laoghaire and large areas of South County Dublin such as the Dodder Valley, Tallaght, Walkinstown, Lucan and Clondalkin.

PR. No. 4 deals with the North Dublin Area including Finglas, Ballymun, Coolock, Portmarnock, Baldoyle, Dublin Airport and may also include Swords and Malahide. Part of this area was already serviced by a sewerage scheme which discharged at the Nose of Howth.

The SR (October 1995) examines the integration of the schemes outlined in PR's No. 1 and 4 into a common treatment plant at Ringsend. The area to be served by the integrated works is more or less coincident with the areas defined in the Census as Dublin City and the Greater Suburbs. The SR forms the basis of the final design parameters for Ringsend Wastewater Treatment Plant expansion. Between October 1995 and May 1998, when Contract No. 2 was prepared, several adjustments were made to the design parameters following consultations between MACL, DCC and DoEHLG.

The final design parameters are included in Volume 2, Employer's Requirements, of the Contract Documents for the Design/Build/Operate Contract for the new works (Contract No. 2).

3.2 Design Capacity

Design capacity has two components, namely;

1. Pollution Load
2. Flow to Treatment

3.2.1 Pollution Load

The pollution load for the design of the new works had two principal components namely; a domestic load arising from the resident population and an industrial load arising from licensed effluents from trade and industry. Other minor provisions were made for commuter population and hospitals.

3.2.1.1 Domestic Load from Population

Ringsend Catchment

PR No. 1 considered the population of the existing Ringsend catchment area only, which was determined from the 1991 Census. Various predictive models were used to project the likely population of the drainage areas up to the years 2015 and 2040 as shown in Table 3.1.

Table 3.1 shows the population projections made in PR No. 1.

Table 3.1: Population Projections made in PR No. 1

Source	Population 1991	Projected Populations	
		2015	2040
Preliminary Report (May 1993) PR No. 1	622,092	761,442	938,860

The SR (October 1995) revised the predictions in PR No.1. Firstly it included the population of some outlying areas such as Dunboyne, Clonee, Ashbourne, Saggart, Rathcoole, Newcastle and Baldonnel which increased the 1991 baseline population of 622,092 persons to 652,092 persons. In addition, the population predictions to 2015 and 2040 were adjusted downwards on the basis of a CSO Report at that time. The revised figures shown in the SR of October 1995 are shown in Table 3.2.

Table 3.2: Revised Figures shown in the SR of October 1995

Source	Population 1991	Projected Populations	
		2015	2040
Supplementary Report for (Oct 1995) SR	652,092	724,552	809,000

Between 1995 and 1998, the population projections were once more modified as further information became available (for example, results of the 1996 Census). Also a decision was made to revise the design year to 2020 instead of 2015 as previously postulated. The final design population for the Ringsend Catchment was based on the population shown in the SR for the year 1991 of 652,092 persons escalated at a rate of 0.8% per annum to 2020 which gave a design resident population for Ringsend of 830,911 persons. This was the figure used in the final design.

North Dublin

The North Dublin Drainage Area was the subject of a separate preliminary report (i.e. PR No. 4) which was completed in September 1994. The approach used to determine the design population for the North Dublin Drainage Area differed from that of the Ringsend Area in that North Dublin was treated as an area of strong potential development and various estimates of growth in housing and industry were made from planning and zoning information. PR No. 4 estimated the existing design population at 303,250 persons with a projected population of 411,250 persons by 2040. The SR took 303,250 as the 1991 population but reduced the projection figure for 2040 to 376,000.

The final design figure included in Contract 2 was the 1991 population escalated by 0.8% per annum to 2020 resulting in a design figure for Contract 2 of 314,139 persons.

Other Loads

In addition to indigenous population, it was determined that up to 20,000 persons commute to work in Dublin every day. Each commuter was reckoned to be equivalent to one third of a PE. Hence, the net allowance for commuting population was 6,700 PE.

A further allowance of 3,000 PE was made for hospital occupancy in the Dublin City Area and 1200 PE in North Dublin.

Combined Loadings

The combined design population for Ringsend and North Dublin was given in terms of a design year of 2020 which differed from the year 2015 given in earlier preliminary reports.

A minimum and a maximum population figure to be catered for in the design year of 2020 were quoted as follows:

- 2020 (low) 1,065,500 persons
- 2020 (high) 1,187,500 persons

The 2020 (high) figure was adopted in the final design.

3.2.1.2 Industrial Loadings

Ringsend Catchment

The second component of the pollution load is that produced by industrial activities. As for the population projection, industrial loading was determined separately for Ringsend and North Dublin in PR's no. 1 and no. 4 respectively and amalgamated in the SR of October 1995.

In the case of Ringsend, trade effluent discharges are licensed by the relevant sanitary authority i.e. Dublin Corporation or Dun Laoghaire Corporation and limits are set on allowable discharges to sewer for both pollution load and effluent.

A total of 227 trade licences were issued in the catchment area with a maximum allowable discharge in terms of pollution load of 36,596 kg BOD/day. It is important to note that this was intended to be a maximum figure and that the cumulative discharge from industry might be significantly less than this.

For design purposes it is common to convert the BOD load from industry to an equivalent population using a conversion rate of 60 g BOD/person/day giving an equivalent population of 609,933 persons (PE) for the Ringsend Catchment.

North Dublin

The design approach with respect to industrial loadings for the North Dublin Area differed from that used for the Ringsend Catchment in that significant allowances were made for light industrial expansion particularly in the region of Dublin Airport and the Malahide Road. The final allowances for industry in PR No. 4 (North Dublin) provided for BOD loadings of 19,585 kg/day growing to an ultimate load of 20,924 kg/day or a population equivalent of 326,417 and 348,733 respectively.

Combined Loads

The most significant decision affecting industrial loadings was made in the SR in October 1995. DCC instructed their consultants MACL to reduce all industrial loadings to 60% of the licensed loadings determined for the year 1991. This decision was based on the assumption that all industries would reduce their respective loadings to 50% of their 1991 allowable maxima once capital and operating charges were introduced by DCC to cover the cost of collection and treatment of industrial effluents. A 10% margin was to be added "to allow for difficulties in precisely identifying what load each industry will discharge" (Section 2.4 of SR).

Between the SR of October 1995 and the final determination of design loads for the new plant determined in 1998, further adjustments were made to the design loadings. Most notably, the industrial load allowance for the North Dublin Catchment was further reduced by 50% (i.e. down to 30% of the 1991 estimate). A design margin of 10% of the estimated population of North Dublin was added. In addition, the design year was altered to 2020.

The final design population equivalent was set at 1.64 M in 2020 (see Table 3.3 below). This is 47,000 less than that indicated in the SR and is set for 2020 i.e. five years on from 2015 the original design year.

Table 3.3: Final Design

	2020 (High)		
	Ringsend	**North Dublin**	**Total**
Resident Population	830,911	314,139	1,145,050
Hospitals/Commuters	9,700	1,200	10,900
Design Margin 10%		31,414	31,414
Industry	365,967	87,033	453,000
Total	1,206,578	433,786	1,640,364

3.2.2 Design Flows to Treatment

The total dry weather flow (DWF) to the Ringsend Wastewater Treatment Plant is based on three components, namely:

- Residential contributions;
- Infiltration;
- Industrial contributions.

Residential flows are based on a baseline flow of 130 litres/capita/day from the North Dublin Catchment and 180 litres/capita/day from the Ringsend Catchments. Infiltration flows from the North Dublin Catchment are maintained at 50 litres/capita/day while the allowance for Ringsend is much higher at 204 litres/capita/day because of the higher infiltration rates into the old sewers particularly in the tidal zone in Dublin City.

Industrial flows are taken as the sum of the maximum allowable discharges permitted under trade licences as indicated in the SR dated October 1995. The design flow for 2020 is computed by using the population predicted in the design year multiplied by the base line flows shown above for both Ringsend and North Dublin.

Infiltration rates are deemed constant over the design period while allowance has been made for an increase in trade effluent in the North Dublin Catchment.

Combined dry-weather and storm flows up to 11.1 m^3/sec will pass through the treatment plant. Storm holding tanks are provided at Sutton and Ringsend to cater for storm conditions. Stored storm water is returned for treatment once the storm peak has passed. In severe storm conditions, overflow facilities are provided at both Sutton and Ringsend. The peak storm flow to Ringsend to the design year 2020 is 22.6 m^3/sec.

The ultimate flows to Ringsend Wastewater Treatment Plant are controlled by the maximum pumping capacity at Dun Laoghaire, Sutton and the MLPS pumping stations. Once this capacity is exceeded, storm tanks and storm overflows come into operation.

The maximum throughput of the system without resorting to stormwater storage is 11.1 m^3/day which is approximately 2.5 times the dry weather flow (DWF).

If the treatment capability of the Ringsend works is extended, the DWF will increase but the storm flow hydraulics will remain the same leading to a slight reduction in the DWF/full flow ratio.

4. VOLUME AND TIMING OF ACTUAL LOADS BY COMPARISON TO LOAD PROJECTIONS

4.1 Introduction

Since the inception of the proposals to extend Ringsend Wastewater Treatment Plant in 1991, there have been a number of surveys of loads reaching the works at various times. The first assessment of load is detailed in PR. No. 1, Volume 2, Pollution Load Survey (PLS). Subsequently, the Consultants MACL/MCOS/EC Harris produced a report on measured loads at Ringsend in April 2000, at the request of DCC.

An estimate of actual industrial loadings was carried out by DCC in 2003, and industrial loadings were again reviewed in 2006 after a programme to reduce industrial discharges had been carried out by DCC in the period 2004-2006.

4.2 Pollution Load Survey (PR No. 1)

According to the PLS, the taking of 24 hour composite samples of the inflow to Ringsend only commenced in January 1991. The first series of analytical results were examined for the period April to November 1991. The estimated total average daily BOD load was 84,000 kg/day arriving at the works. At this stage, it is important to note that North Dublin was not contributing to the Ringsend load at that time.

Industrial loadings in the DC area were examined for the same period. 227 industries were licensed to discharge to sewer in the catchment. The sum of the maximum allowances provided in each trade licence amounted to 36,596 kg/BOD/day in 1991 or a population equivalent of 609,933 persons. This is a maximum figure and it should be noted that many of the industries were discharging much less than their allowable maximum.

The PLS states (Section 8.3) "there is a major discrepancy with the measured BOD and SS loads, received at Ringsend Station, which are 13% and 14% greater than the estimated load, based upon expected contributions from the connected population, communities etc, imported wastes and permitted waste discharges. In terms of population equivalent, the discrepancy represents between 120,000 and 160,000 PE".

4.3 MACL/MCOS/EC Harris Report April 2000

A report was issued from MACL/MCOS/EC Harris to Mr. B. White, Project Engineer, Dublin Bay Project in April 2000. The Consultants had been asked to report on the average measured loads arriving at the Ringsend Works excluding North Dublin (Sutton had not yet been connected). Figure 1 attached shows the result of the survey graphically. Note that the design loading for 2020 is shown on the left hand side of the graphic and an estimation of the likely load from North Dublin is shown on top of the measured loadings at Ringsend.

It is clear from Figure 1 that the ultimate design loading of 98,422 kg/BOD/day for the year 2020 contained in the Contract Documents of Contract 2 was actually exceeded in the years 1997 and 1999.

The report makes a number of observations about the survey results:

- there might have been anomalies in the flow measurement and sampling
- the (indicated) increase in load could be related to inaccuracies in flow measurement and the fact that the samplers were effectively sampling unscreened raw sewage which leads to greater variability.

In an effort to explain the load increases the report states that the population of Dublin as indicated by the CSO was increasing at 2% per annum. This statement is now known to be incorrect. The actual growth rate was 0.8% per annum as confirmed by the 2002 and 2006 Censuses.

The results of the analysis of flow and load data left an unexplained increase in BOD arriving at the works of the order of 12-13,000 kg/day which has a population equivalent of roughly **200,000** persons. It is interesting to compare this conclusion with the conclusion of the earlier Pollution Load Report in 1991 which warned of a discrepancy of between 120,000 and 160,000 PE between the measured BOD and the estimated loads arriving at Ringsend.

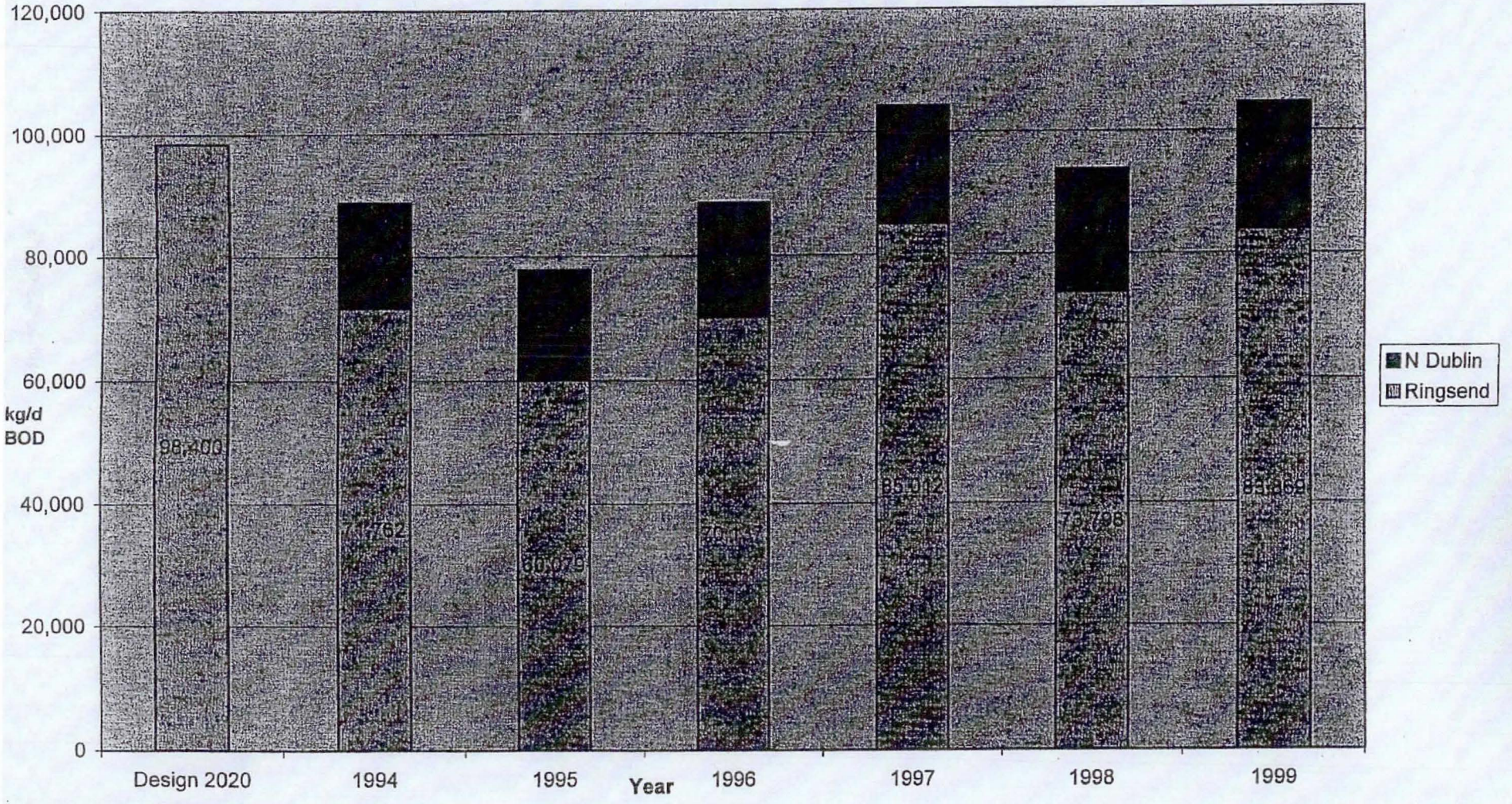
The MACL/MCOS/ECH report suggested a number of possible reasons for the disparity between measured and calculated loadings. These included:

- An increase in tourism not accounted for in the design
- An increase in economic activity
- An increase in affluence
- An increase in industrial loadings.

These issues are dealt with in Section 6 of this report.

Figure 1

Dublin Bay Project BOD Load, kg/d



4.4 Estimates of Industrial PE Loadings in the Ringsend Catchment 2003

A report by the Senior Executive Scientific Officer, Imelda Averill to Mr. B. White, Deputy City Engineer dated the 23rd March 2004 outlines an estimate of the industrial loadings for the year 2003 for the Ringsend Catchment including North Dublin, South Dublin, Fingal and Dun Laoghaire Rathdown. The aggregate population equivalent of the industrial load is estimated at 515,182 persons which is 13% more then the design load for industrial discharges in 2020. It should be pointed out, however, that the total licensed industrial discharge allowance had increased to 1,224,623 PE from a figure of 900,100 given in the SR in October 1995 i.e. an increase of 36% in the maximum allowable load to industry. The 2003 estimate of actual industrial load represented 42% of the total allocated load to industry. However, it exceeds the industrial design load at Ringsend (453,000 PE) by 62,182 PE or 13.7%.

Using a population growth of 0.8% per annum to 2003, the contributing population for domestic load would be 1,036,943. When this is added to the 515,182 PE (estimated industrial loading) the average daily load on the works should be 1,552,125 PE which is nearly 95% of the 2020 design load.

According to DCC, the estimated average load to Ringsend Wastewater Treatment Plant in 2003 was 1.89 M or **340,000** PE in excess of the estimated load.

4.5 2006 Loadings

By 2006, the PE allocation for the top 76 industries in the total catchment had been reduced to 937,087 PE. In her report dated 25/07/2007, Ms. Averill states that "less than 60% of the allocated PE was actually discharged based on effluent quality and flow monitoring in 2006", i.e. 60% of 937,087 = 562,525 PE. This situation was brought about by a concerted effort by Dublin City Council to reduce the BOD attributable to industry by a population equivalent of 300,000 in the 2004/2006 period. The success rate of their endeavours over the period was 77.2% or a reduction in PE of 231,537.

The predicted population for 2006 using a 0.8% per annum growth gives a population for 2006 of 1,062,029 persons. When this is added to the calculated industrial load of **562,252** persons the total becomes 1.62 M PE which should be the actual average loading in 2006.

The declared loading at Ringsend in 2006 was 1.90 M i.e. **280,000** PE more than the estimated actual load.

4.6 Discussion and Comment

4.6.1 Designated Load V Average Daily Load

According to the Urban Wastewater Directive, Article 4.4, the (designated) load of a treatment plant expressed in PE *"shall be calculated as the basis of the maximum weekly average load entering the treatment plant during the year".*

It is important to note that this load value is about 1.25 times higher than the average daily load. Consequently, when we talk of the average daily design load at Ringsend being 1.64 M PE, the designated maximum weekly average load will be about 1.64 x 1.25 = 2.05 m PE.

If the average daily loads in 2003 and 2006 were 1.89 and 1.90 M respectively, the designated loads would be 2.38 M which confirms a discrepancy of >300,000 PE between the actual load and the design load.

4.6.2 Measured Load V Design Load

The disparity between the actual measured load and the design load is consistently present right through the sampling regime from 1991 to 2006. As against this, the population projections used in arriving at the design load seem to be more or less on target. There is some evidence that the industrial pollution load increased significantly between 1998 and 2003 mainly due to new industries starting up, such as, Wyeth Medica in South Dublin. On the other hand, industrial charges have increased since the new treatment plant was commissioned in 2003 and industrial loadings seem to be dropping annually particularly those operating under IPPC licences. IPPC licences are subject to annual reassessment and continuous improvement under Environmental Management Systems (see Section 5). As a consequence, the estimated industrial load for 2006 seems to be more or less on target. The question must be asked where is the additional load coming from?

The results of the various surveys carried out leads one to the inevitable conclusion that a pollution load from some other source, or sources, is arriving at the Ringsend Treatment Plant which was not accounted for in the design loadings. These possible sources are discussed further in Section 6.

5. IPC LICENSED DISCHARGE LOADS V ACTUAL DISCHARGE LOADS

There are eleven IPPC Licences current in the Greater Dublin Catchment draining to Ringsend. These are as follows:

1 (a)	Diageo/Cooke's Lane and	P0301-01
1 (b)	Diageo/Crane/Rainsford Street	P0301-01
1 (c)	Diageo/Victoria Quay	P0301-01
2	Leo Laboratories, Clonard Road	P0008-01
3	Cadbury's Coolock	P0809-01
4	Wyeth Medica	P0652-01
5	Diageo/Bailey's	P0807-01
6	Bristol Myers Squib	P0552-02
7	Yamanouchi	P0007-03
8	SR Technics Ireland (Dublin Airport)	P0480-02
9	Helsinn Chemicals	P0125-02
10	Pfizer	P0019-01
11	Kepak, Clonee	P0167-02

From examination of the licences at EPA, Dublin, Table 5.1 shows the maximum licensed allowance in terms of PE together with the measured average load per day in PE for each of the eleven industries.

Table 5.1: Licensed Load V Average Daily Load

	Industry	**Licensed Allowance (PE)**	**Av. Load/day (PE)**
1.	Diageo Cooke's Lane Rainsford Street Victoria Quay	326,667	157,917
2.	Leo Laboratories	16,667	668
3.	Cadbury Coolock	22,500	6,952
4.	Wyeth Medica	61,667	1,450
5.	Diageo – Baileys	45,000	21,783
6.	Bristol Myers Squib	16,667	133
7.	Yamanouchi	2000 (2005)	40
8.	SR Technics Ireland (Dublin Airport)	8,533	1,797
9.	Helsinn Chemicals	1,667	647
10.	Pfizer	2,250	310
11.	Kepak Clonee	43,333	5,472
	Totals	**546,951**	**197,164**

Note: Actual load as a percentage of allowable load = 36%

5.1 Comment

The figures quoted above are for the most part for the year 2006. In a number of cases where information on 2006 was not to hand, the figures for 2005 or 2007 are used.

The actual average daily discharge is well within the requirement of the design allowances for industry contained in the design parameters for Contract 2. All IPPC Licences are subject to review each year. Some industries report occasional exceedances of their licensed load throughout the year, for example, due to the discharge of off-spec material or due to plant malfunction. However, such incidents are the exception to the rule and are infrequent.

If we take the largest licensee, namely Diageo, as an example, the actual loadings compared to the maximum allowable loadings over the last seven years is shown in Table 5.2.

Table 5.2: Percentage Usage of Maximum Allowance

Year	Percentage of Max. Allowance Availed of
2001	81.5%
2002	57.0%
2003	58.0%
2004	61.0%
2005	65%
2006	48%
2007	36%

It is clear from Table 5.2 that there was a dramatic improvement between 2001 and 2002 and then further dramatic improvement between 2004 and 2007 inclusive.

The Cooke's Lane Plant is the main contributor to the BOD load coming from Diageo, operating at about 63% of its allowable limit in 2006 and dropping to 47% of its allowable load in 2007 even though there was an increase in brewing activity in 2005. Also, the main process effluent from the Rainsford Street Plant was re-routed to Cooke's Lane in the same year.

Clearly, the predicted effect of charges for treatment at Ringsend has led to good housekeeping by this industry. This is evident in other cases also.

The implications of these findings for future design loadings at Ringsend is very positive and shows that, with proper technical and financial control, the industrial element of the design can be kept within the desired limits. When any new industry comes on stream, planning and environmental controls must ensure that effluent discharges are limited to the needs of DCC with respect to the Ringsend Wastewater Treatment Plant.

5.2 Trade Licences

The IPPC Licences shown above account for about 58% of the total load from industry. It is incumbent upon all four local authorities to ensure that the performance achieved under IPPC is replicated in the trade licence area.

Indeed it has to be said that the programme launched by the City/County Managers of the four authorities in 2006 to reduce the licensed industrial load in each of the four jurisdictions was very positive and was a significant step in the right direction.

Some private research carried out by Ms. Imelda Averill, Senior Executive Scientific Officer with DCC, in her thesis 'An Industrial Wastewater Management Strategy for Dublin' points management in the right direction in the control of commercial and industrial wastewater. The conclusions and recommendations contained in Chapter 6 of Ms. Averill's paper are exemplary. They are summarised below:

- An industrial wastewater catchment management strategy is necessary to avoid overloading of Ringsend WWTP.
- A survey of the top 500 non-domestic waster users including both commercial and trade users should be carried out.
- It is time that commercial wastewater was regulated in a similar manner to trade effluent.

The last recommendation is the key to a good strategy. The constituent local authorities need to pay more attention to pollution loads coming from trade and commercial sources. Now that metered records are available for water consumption, a strict monitoring regime needs to set up to control effluent discharges to sewer and institute charges for non-domestic usage.

6. THE APPROPRIATENESS OF THE DESIGN CAPACITY DETERMINED HAVING REGARD TO THE INFORMATION AVAILABLE AT THAT TIME

6.1 Introduction

This section examines the appropriateness of the design approach adopted in arriving at the final design loadings outlined in Section 3 having regard to the information available at that time.

6.2 Population Trends

The predictions of population growth used in the various reports were based on the best available information at the time and may be regarded as fair and reasonable. The predictions were for the most part based on the Censuses of 1986 and 1991 and on studies carried out by an Foras Forbartha on population projections for the East Region for the period 1986-2011. These predictions were further modified when the results of the 1996 Census became available.

The Employer's Requirements for Contract No. 2 stated that the domestic population was predicted to rise at a rate of between 0.36% and 0.8% per annum giving a design year (2020) domestic population range for the Design Build works of between approximately 1,065,500 and 1,187,500 PE. In the event, the latter figure was adopted as the Works design value.

At the time of writing, two further Censuses are available namely those of 2002 and 2006. The figure given in the 1991 Census for the population of Dublin City and the Greater Suburbs is 929,090 persons. Table 6.1 shows the growth in the population of Dublin City and Greater Suburbs between 1991 and 2006 according to the Census.

Table 6.1: Population Growth from Census

District	1991	1996	2002	2006
Dublin City	478,389	481,854	495,781	506,211 (1)
Greater Suburbs	450,701	470,838	508,833	539,558 (2)
Total	**929,090**	**952,692**	**1,004,614**	**1,045,769**

(1) Growth Rate = 0.4% per annum
(2) Growth Rate = 1.2% per annum
(3) Av. Growth Rate = 0.8% per annum

From Table 6.1, the average growth in the population of Dublin City and Suburbs between 1991 and 2006 (15 years) is almost exactly 0.8% per annum (compound). This is the growth rate postulated in the final design population included in Contract 2.

This result may seem surprising when one considers the exceptional economic growth in the period 1998-2006 but a more detailed analysis shows that the older part (i.e. Dublin City) grew at a moderately slow rate of 0.4% per annum while the population of North Dublin grew at a rate of 1.2% per annum reflecting the pace of development in this area.

It has to be concluded, therefore, that the population prediction used to arrive at a design population for the new plant at Ringsend was quite realistic and remarkably close to the growth curve up to 2006 at any rate.

The Greater Dublin Strategic Drainage Study completed in April 2005 predicts a population growth for the combined Ringsend and North Dublin Catchment of 1,456,590 to 2031. If one applies a growth rate of 0.8% to the 1991 figure the population in 2031 would be 1,313,954 persons. This is 142,636 less than the GDSDS prediction. In this regard, one must inevitably allow for the difference in climate between predictions made in the early 90's and predictions made in 2005. In the early 90's, the country had just emerged from a very depressed period during the entire decade of the 80's and predictions would have been of a very cautious nature, whereas in the year 2005 the Celtic Tiger was in full swing and, however judicious, predictions were bound to be far more optimistic than those of the early 90's. Indeed, it might well be said that considering the economic gloom of recent months that GDSDS predictions may now look over optimistic.

In conclusion, it may be stated that the population predictions contained in the various documents leading up to the determination of the design load for Ringsend did not underestimate the contributing population by the design year 2020. However there are a number of other issues in relation to movements within the population which might have had a significant effect on loadings at Ringsend in the short-term.

6.2.1 Unaccounted for Populations

It has been suggested that the Censuses of 2002 and 2006 did not 'capture' a sizeable proportion of foreign immigrants, particularly in the case of Dublin, and that there may be an added population of 50-100,000 resident in the Greater Dublin Area who did not respond to the Censuses.

The CSO, however, categorically rejects such a notion and states that the field supervisors and enumerators who carried out the Censuses would have known of this anomaly if it existed.

6.2.2 Daily Commuters

According to the SR, of October 1995, an assessment of the number of commuters who travel into the Ringsend catchment area was made in 1993 using traffic survey data supplied by DCC. It was estimated that approximately 20,000 people commuted to that drainage area on a daily basis.

This number of commuters equates to a population equivalent of 6,700 i.e. each commuter would have the effect of one third of a person based on 60 grams BOD/person/day. The consultants did not think it necessary to increase this figure to allow for the inclusion of the North Dublin Catchment.

While this assumption of commuter movement might have been valid at the time, it is likely that commuter traffic into Dublin City and the Greater Suburbs has increased significantly over the past ten years above the allowance made in the SR.

In the Census of 2006, the CSO included extra questions on the Census form in relation to people commuting to work from their place of residence. As a result of the information received, the CSO developed a programme called POWCAR which enabled them to estimate commuter movement.

The POWCAR programme indicates that 91,500 persons living outside the County Dublin Area commute into County Dublin on a daily basis. Apart from some small areas in North County Dublin, the catchment area for the Ringsend Wastewater Treatment Plant is more or less coincident with the area of County Dublin. Consequently, it may be taken that over 90,000 persons commute to work in the Ringsend Catchment Area each day.

This is 4.5 times the allowance made in the original design for Ringsend. If one takes the same allowance as was taken in PR No. 1 of 1/3 of a person per day the commuting load would represent 30,000 PE or 23,300 PE more than was allowed in the design.

6.2.3 Tourism

According to the SR, investigations carried out on the student and tourist population in Dublin City indicated that the exodus of students from Dublin during the summer holidays more than counter-balanced the peak tourist influx during the same period. Permanent residents who holidayed outside the catchment area would also assist in reducing the effect of tourism. It was concluded, therefore, that the net effect on the pollution flows to Ringsend would be insignificant.

Here again the assumptions about tourism may have been valid at the time. However, the CSO and Failte Ireland have recently published information on what they term domestic tourism i.e. overnight visits and same-day visits to Dublin from outside the catchment area. "Same-day visits" are made up of persons travelling to and from Dublin on the same day for whatever reason but excluding commuters. "Same-day" visits are reportedly 14 to 20 times more numerous than overnight visits.

The First Steps Tourism Satellite Account (TSA) for Ireland published by Failte Ireland in 2005, estimated the number of domestic same-day visits in the whole country to be 76.7 M. This figure was based on studies done in the UK because there are no official figures for Ireland.

According to the CSO, in 2007 Dublin accounted for 14% of all domestic trips including an overnight away from home. If the same percentage is applied to the national figure of 76.7 M same-day visits countrywide, it would account for 10.7 M domestic same-day visits to Dublin. The distribution of these visits is not entirely linear over the whole year according to the CSO. A fair estimation might be that 10% would occur in one month as a maximum (i.e. 1.07 M in any given month of 30 days duration) giving roughly 36,000 same-day trips into the Dublin Area. These trips are in addition to commuter trips and overnight trips.

Using the same conversion factor to PE as for commuters, the 36,000 same-day visits would generate **12,000** PE at the Ringsend Treatment Plant.

6.3 Commercial Loadings

According to the SR, commercial and institutional sources such as universities, colleges, prisons, hotels and guesthouses were included in the residential population figures. Consequently no special provision was made in the design loadings for such institutions.

There is no mention in the SR of commercial entities such as shops, offices, government buildings, public houses, restaurants and sporting facilities, all of which have a water demand and therefore an effluent. Most of these establishments are below the thresholds for trade effluent licensing but nevertheless contribute to the overall pollution load.

The approach taken by the consultants in determining potential loads from the commercial sector was that no additional allowance was necessary over and above the loadings attributed to the resident population, the assumption being that premises such as pubs, restaurants, offices, public buildings etc. are occupied daily by people resident in the Greater Dublin Area whose contribution to the design loadings is already included in the residential loadings.

This approach to non-domestic loads coming from the commercial sector is open to question. Many design manuals advocate an additional allowance for commercial sector loads amounting to 10-20% of the Census-based domestic load. For example, the EPA published a Manual on Treatment Systems for Small Communities, Business, Leisure Centres and Hotels in 1999. Table 3 of the manual gives typical flow and BOD allowances for pubs, restaurants, hotels, offices and amenity sites. Likewise, a standard text book which is used by many wastewater design engineers published by Metcalf and Eddy gives typical wastewater flow rates from commercial sources in the US over and above domestic loads.

In February 2004, the Department of Environment, Heritage and Local Government published the National Urban Wastewater Study (NUWS). Volume 2, Part A entitled Methodology, No. 4. Flow and Load Assessment, Section 5 states:

'existing and future commercial sector wastewater flow and load was generally estimated using the relationship

Commercial loading = 16% of all domestic/residential loading'

The Greater Dublin Strategy Drainage Study (GDSDS) projects non-domestic loadings to the years 2011 and 2031 for Dublin City and Greater Suburbs. In Paragraph 4.3 of the Final Strategy Report the GDSDS states the following *'for estimating non-domestic loads, the following assumptions have been made:*

- *Industrial land – 100 PE/hectare*
- *Science and Technology Land – 150PE/hectare*
- *Commercial Sites – 0.025 PE/m^2 (based on 20 m^2 floor space and 0.5 PE/employee)'*

While all the documents quoted above are of recent origin, the practice of including an extra load from the commercial sector is well established in engineering design of wastewater systems particularly in large urban areas. If the flow and load assessment indicated in the DoEHLG Manual had been used in the case of the Ringsend Catchment a further load provision of 16% of the domestic/residential loading would have been included in the design load for Ringsend. This would have amounted to 16% of 1,187,364 persons or 190,000 PE, approximately in the design year of 2020. If this provision had been put in the original design it would go a long way to explain the disparity between the actual measured load and the design load.

In the decade 1996 – 2006, it is also likely that there was a great acceleration in non-domestic loads in the Dublin Area due to increased domestic affluence and tourism. Developments such as Temple Bar, Dundrum Shopping Centre and the Liffey Valley Complex, to name but a few all occurred within this time frame.

It must be stated that part of the problem in Dublin was that there were no meters on commercial consumers in the 1990's and there was no way of measuring the water usage in these premises. Consequently, water usage was assumed to be part of the domestic load. Since the year 2000, DCC have launched a campaign to meter all commercial premises and it is understood that over 10,000 meters have been installed since that time.

Installation of meters should have a beneficial effect in so far as the usage of water and, therefore, the disposal of effluent from metered premises will be readily quantifiable.

It is understood that there are over 2,000 food service establishments (FSEs) in the Dublin City Council Area alone. Many of these premises were using kitchen macerators to dispose of kitchen waste and surplus food thus avoiding landfill charges but adding a considerable BOD load to the public sewer. It is understood that such practices are now forbidden. The combination of metering and the discontinuation of the use of kitchen macerators should contribute to an overall reduction in the BOD load coming from commercial premises.

6.4 Industrial Loadings

Initially, DCC had instructed MACL to design the Ringsend STW expansion for the incoming polluting loads based only upon projected domestic population plus the 1991 licence industrial discharge limits. Subsequently, however, following discussions with the 20 largest industrial contributors in the combined catchment of Ringsend and North County Dublin, DCC decided that the design industrial BOD should be reduced to 60% of the 1991 licensed loads.

This figure was based on a target reduction of industrial loads to 50% with a 10% margin to allow for difficulties in precisely identifying what load each industry will discharge.

This decision was prompted by the DoEHLG and was based primarily on experience in Continental Europe and, particularly, in Denmark where a surcharge fee is made against industrial companies where the discharge of amounts of organic matter is in excess of that present in domestic wastewater. It was reported that the effect of this charging led to a dramatic fall in the amount of industrial effluent being discharged to the Copenhagen Wastewater Treatment Plant where the total industrial loads were approximately halved over a 12 year period. Other plants in Denmark had similar experiences.

The decision to reduce the industrial loadings contained in the trade effluent licences to 60% of the original allowable capacity dramatically reduced the allowance for industry in the final design for the expansion of the Ringsend Wastewater Treatment Plant.

In the event, this decision seems entirely justified as the present industrial loading at Ringsend is reckoned to be well within the target of 60% of the allowable discharge on licences. In the case of IPPC licences, Section 5 has shown that with continuous improvement the industrial discharges are now less than 40% of the allowable load.

There was a brief period between 2003 and 2006 when the industrial loading exceeded the target design limit. There is no reason why the level of industrial loading cannot be controlled at the present level with good planning and proper licence conditioning of any new industries entering the design area and the continuous monitoring and control of existing industries.

6.5 Tankered Waste

DCC accepts about 20 tanker loads of waste at Ringsend WWTP every week. The average annual volume of waste so delivered is 40,000 m3 of liquid waste at a BOD equivalent to domestic waste (i.e. circa 250 mg/l). This volume would account for an average daily load of about 670 PE which is negligible.

6.6 Flow to Treatment

As already stated in Paragraph 2.2.7 the flows to the treatment plant are governed by the existing pumping regimes and the hydraulics of the pipelines discharging at Ringsend. The design flows determined for Contract 2 were governed by the hydraulics of the system and were appropriate for the proper functioning of the system.

The future development in the Ringsend Catchment may increase the dry weather flow to the works. On the other hand, any water conservation measures carried out by the four local authorities or any actions taken to reduce infiltration in the existing system will lead to a reduction in the dry weather flow. It is unlikely that the storm flow regime will change in the future.

6.7 A Comment on MACL/MCOS/EC Harris Report

Section 4.3 dealt with the MACL/MCOS/EC Harris Report to DCC in April 2000. The report suggested a number of possible reasons for the disparity between measured and calculated loadings. These included:

- An increase in tourism not accounted for in the design
- An increase in economic activity
- An increase in affluence
- An increase in industrial loadings

The first point has been dealt with in Section 6.2.3 in relation to tourism. Increases in economic activity and affluence may well have contributed to an increased load through the huge increase in food service establishments throughout the region already referred to in Section 6.3 particularly from 1998 onwards.

In assessing the pollution load derived from domestic sources, the Urban Wastewater Directive sets an average BOD load of 60 gm/capita/day and this figure was the figure adopted in the design for Ringsend. In more affluent societies such as the United States, Metcalf and Eddy suggest an average daily loading of 80 gm BOD/capita/day. There may be an argument to suggest that Dublin has increased in affluence during the past decade to such an extent that the average per capita loading has increased above 60 gm BOD/capita/day, thereby, accounting for some of the extra load arriving at Ringsend. Such an increase could only be verified by intensive monitoring of selected residential areas.

An increase in industrial loadings is not proven. In fact, the decisions with regard to industrial loadings seem to have been fully justified. However, the pollution load coming from the commercial sector should be defined in greater detail and action taken by all the local authorities, first, to ensure that such loads are monitored and quantified, and, second, to ensure that the Polluter Pays Principle is applied to all non-domestic loads coming from the commercial sector.

7. CONSIDERATION GIVEN TO NUTRIENT REDUCTION REQUIREMENTS IN THE CONTEXT OF WATER QUALITY STANDARDS APPLYING TO THE RECEIVING WATERS

7.1 Introduction

Effluent standards for wastewater treatment plants are usually based on a number of key parameters, such as:

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Suspended Solids (TSS)
- Ammoniacal Nitrogen (NH3)
- Total Phosphorous (P)

BOD is a measure of the amount of oxygen absorbed in the oxidation of organic matter present in wastewater over a period of 5 days. The BOD of a typical municipal sewage is about 250-300mg/l. Secondary treatment will normally reduce the BOD by over 90%.The UWWTD final effluent standard for BOD is < 25mg/l.

COD is a measure of the amount of organic material that can be oxidised chemically by a standard solution. For municipal sewage, the COD value is usually about twice that of BOD. The UWWTD final effluent standard for COD is 125mg/l. Traditionally BOD is the most commonly used parameter in wastewater treatment but COD has the advantage of being more readily determined (in a few hours rather than five days).

TSS is a measure of the particulate matter contained in sewage. A typical municipal sewage contains about 200-300mg/l of TSS. Secondary treatment will normally reduce the TSS content by over 90%. The UWWTD final effluent standard is < 35mg/l.

Most of the nitrogen in municipal sewage is in the form of Ammonia (NH3). During the treatment process, NH3 is converted to nitrate (NO3). Secondary treatment will normally reduce the level of NH3 to about 10mg/l. The UWWTD final effluent standard for NH3 is <18.75mg/l.

From the above definitions, it can be seen that secondary treatment will normally be sufficient to satisfy the requirements of the UWWTD provided that the discharge of effluent does not occur into receiving waters that are regarded as "sensitive" for whatever reason.

Further improvements in effluent quality can be achieved by additional, or tertiary, treatment. For example, nitrates (N) can be removed by a denitrifying process which can be added to secondary treatment. Phosphorous (P) can be removed by chemical or biological means from the final effluent and diverted to the sludge product where it will supplement the nutrient value of the processed sludge.

Nitrate removal may be required in sensitive waters to prevent eutrophication. Estuarine waters are particularly sensitive to Dissolved Inorganic Nitrogen (DIN) which can promote plant and algal growth. Phosphorous is also a key element in the promotion of plant and algal growth and even small quantities of P can cause problems of euthrophication in receiving waters.

Disinfection by irradiation is a form of tertiary treatment using ultra-violet rays (UV) to kill viruses and pathogenic bacteria in final effluent to ensure compliance with the Bathing Water Directive.

7.2 Resolution of Dublin Corporation (sic)

At a meeting of Dublin Corporation (sic) on the 14th June, 1993, the City Council adopted the DBWQMP with some revisions. The principal revision required "full design of tertiary treatment using Nitrogen Removal Activated Sludge Process"

This resolution pre-dated the Urban Waste Water Treatment Regulations (SI No.149 of 1994). Notwithstanding the resolution, the City Council did not amend the Water Quality Standards for Dublin Bay as set out in Appendix B of the DBWQMP Main Report Part 1. Compliance with the standards was met by the design for Contract No. 2.

The resolution posed a problem for the Design/Build procurement process in that it specified a particular type of treatment (i.e. Nitrogen Removal Activated Sludge) whereas the method of treatment was not specified in Contract 2 and the Contractor had merely to provide a design that satisfied the water quality standards laid down in the DBQMP. The upshot was that the City Council's resolution for 'Nitrogen Removal' per se has not been implemented to date.

A second resolution with respect to the provision of UV treatment for viruses has been implemented at Ringsend.

7.3 Effluent Standards for Ringsend Wastewater Treatment Plant

The effluent standards for the new treatment works had to satisfy the requirements of the following:

- The Dublin Bay Water Quality Management Plan (DBWQMP)
- The Urban Waste Water Treatment Regulations(SI No.419 of1994)
- The Quality of Bathing Water Regulations (SI. No.155 of 1992)

According to EIS No.1, the DBWQMP adopted the following strategy in relation to discharges of treated effluent from Ringsend WWTP:

- Secondary treatment initially based on a non-nitrifying process (i.e. carbonaceous treatment only)
- Monitoring and review of the effectiveness of this (strategy)
- Provision of nitrogen removal (at a later date) if monitoring and review indicated a requirement

The UWWT Regulations (SI No419 of 1994) did not treat Dublin Bay as a "sensitive area". Consequently, the required standard of effluent was to consist of the following:

- 25mgBOD/l
- 35mgTSS/l
- 125mgCOD/l
- 18.75mgAmmN/l

All on a 95 percentile basis (i.e.95% of all samples would conform with these standards). These were the standards adopted by DCC in the Employer's Requirements for Contract No. 2

The Bathing Water Directive (SI No155 of 1992) imposes conditions with respect to faecal coliform (FC) levels of 1,000 FC/100ml on a 80 percentile basis and 2,000 FC/100ml on a 95 percentile basis for bathing waters, the standard not to be exceeded by any two consecutive samples. UV irradiation was included in Contract No.2 to ensure compliance with the Bathing Water Directive and is operated during the bathing season.

7.4 Review of Effluent Standards

J.B.Barry and Partners, Consultants, were appointed by DCC to carry out an independent report on the proposed water quality standards for the Ringsend Works and reported to the Chairman of the Water Quality Management Committee in April.1998 (i.e. before Contract No 2 was determined)

The Brief required J.B. Barry and Partners Limited to:

i) Examine in detail the Water Quality Management Plan for Dublin Bay, including the accompanying Technical Reports (8 no.)
ii) Examine in detail the Environmental Impact Statement for the Ringsend Treatment Works (Volumes 1, 2 and 3)
iii) Review the proposed Effluent Quality Standards for the treated wastewater discharge from the Ringsend STW.
iv) Examine requirements for advanced treatments including:
   - Nitrification
   - Nitrogen Reduction
v) Make recommendations on Effluent Quality Standards for the Dublin Bay Project.

The Barry Report dwelt at length on the incidence of high algal growth in certain parts of Dublin Bay, particularly, in the South Bull Lagoon and the North Lagoon and on the potential effects of the effluent from Ringsend WWTP on these growths. .

Information with regard to algal growth in Dublin Bay was derived from two studies, in particular:

1. *"A Study of Algal Growth and Foreshore Quality" (Jeffrey et al) undertaken between May 1989 and October1990 and*
2. *Particulate Nutrient Inputs and their Role in Macro-algae Development in Dublin Bay" (by Wilson, Jeffrey, Dowley et al) carried out in 1993 under the STRIDE Operational Programme.*

Two macro-algal problems were identified in these studies:

- Development of filamentous green macro-algae mats on the inter-tidal flats of the lagoons (Bull Island) and to a lesser extent in the Tolka Basin
- Stranding and subsequent decay of brown macro-algae on the foreshores of Dollymount Strand, in particular, Ectocarpus produced in the sub-littoral zone. See Figure 2 attached.

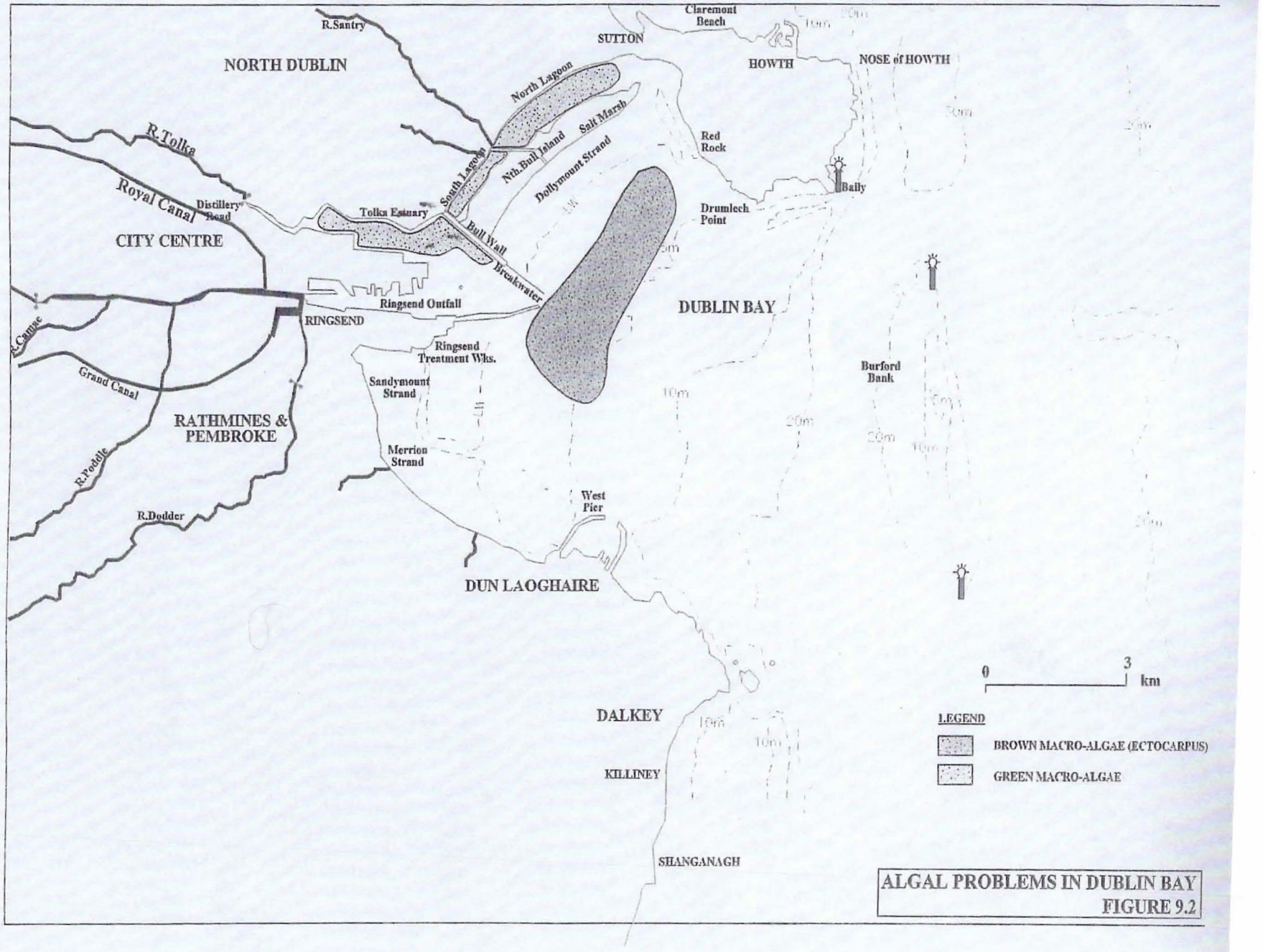
In the Study for the Dublin Bay WQMP (Technical Report No. 7) it is noted that the biomass of the dominant species of green macro-algae has increased in the North Bay areas since the 1970's. The study also notes that South Dublin Bay is characterised by low macro-algal cover and biomass.

According to the various reports, there is a key relationship between the algal growth and the amount of nutrient available in the form of particulate nitrogen (N). The Ringsend Works (as it was then) was a rich source of particulate N. However, when the new treatment plant came on stream, the report estimated that particulate N would be reduced by 84% based on an effluent standard of 35mgTSS/l.The Barry report concluded that the adoption of this standard for Total Suspended Solids (TSS) would obviate the necessity of providing denitrification for particulate N at the new Works. For this reason, this was the standard adopted for TSS in the new Works design.

In estuarine waters, Dissolved Inorganic Nitrogen (DIN) is commonly used as an indicator of eutrophication. The Barry report states that there was no evidence of DIN contributing to algal growth in the Bay. However, it was possible that increased discharges of DIN from Ringsend WWTP might have potential to promote algal growth. For this reason, the Barry report advised that the secondary treatment facilities provided at Ringsend should be designed and constructed in a manner which would allow full nitrification and denitrification capacity to be retro-fitted if future research showed this to be necessary.

With regard to Ammonia (NH3), the Barry report concluded that the proposed effluent standard of 18.75mg/l in the final effluent was appropriate in order to avoid toxicity problems to migratory fish.

Finally, the Barry report recommended that ongoing monitoring and research of Dublin Bay was of fundamental importance in any determination of future treatment requirements.



ALGAL PROBLEMS IN DUBLIN BAY
FIGURE 9.2

7.5 Other Reports

In March 2001, the EPA published a report entitled "An Assessment of the Trophic Status of Estuaries and Bays in Ireland" which proposed that the Liffey Estuary be considered eutrophic because it exceeded criteria in respect of DIN and P This decision led to the designation of the Liffey Estuary as a sensitive area under SI No.254.

In 2000, the DOEHLG approved the Dublin Bay Water Quality Monitoring Programme (June 2000 – 2005) which was a 5yr. Programme to be carried out by DCC with annual reportage of results. More recently (May, 2008), the DOEHLG approved a further monitoring programme to be carried out by DCC in consultation with the EPA. In 2008, a mobile monitoring unit was set up under the Eastern River Basin District management to carry out monitoring in the River Basin District including Dublin Bay.

Under the Draft European Communities Environmental Objectives (Surface Waters) Regulations, 2008, water quality in transitional and coastal waters are being determined and regulated for the first time. All the above studies will no doubt contribute to this determination.

7.5.1 EPA Memorandum to DoEHLG (December,2007)

In a Memorandum dated Dec 17, 2007, Shane O'Boyle of the Estuarine and Coastal Waters Section of the EPA reported to the DOEHLG as follows:

The Liffey Estuary has undergone a marked improvement in water quality in recent years with most of the observed improvement a result of the upgraded wastewater treatment facilities at Ringsend. The trophic status of the estuary has improved from eutrophic in 1995-1999 to potentially eutrophic in 1999-2003 and most recently to intermediate (eutrophic) in 2003-2006. The improvement in status is mainly due to a reduction in the levels of Dissolved Inorganic Nitrogen in the estuary, although since 2003 there are indications that the concentrations of oxidised nitrogen has increased.

The Memorandum has this to say about phosphorous (P):

'Levels of phosphorous (MRP) in winter remain elevated and in breach of the proposed Environmental Quality Standard (EQS) for this parameter. As required by the Water Framework Directive, programmes of measures will be required to ensure that levels of phosphorous in the Liffey estuary are compliant with the proposed EQS.

Given that the likely source of this breach is the Ringsend wastewater treatment plant then further nutrient measures may be required to reduce the loading of phosphorous from the plant to the estuary.'

The Memorandum concludes that, under certain conditions of salinity in the Bay, both N and P are likely to be important in ensuring that the potential for eutrophication to occur in the estuary and adjacent coastal waters is minimised.

7.6 Algal Blooms in Dublin Bay

Algal blooms in Dublin Bay have been reported for well over a hundred years. And the odours arising from their subsequent decay fully reported as a local nuisance.

In the Autumn of 2007, large amounts of algae were washed up on Sandymount Strand between mid-October and mid-November. Again in October 2008, there have been complaints of bad odour from masses of decaying algae at Sandymount.

Because of the bad history of odour from Ringsend WWTP, it is not surprising that local people suspect that the odours from the algae are being caused by the treatment plant

There is no direct connection between the algal problem and the Ringsend plant. However, there could well be a connection between the algal growth and the fact that sewage, both untreated and treated, has been entering a relatively shallow bay for hundreds of years. The commissioning of the new treatment plant can only have improved this situation.

The recent memorandum from the EPA (see above) has this to say about the present situation:

*'The occurrence of macro-algal blooms and strandings in the Tolka estuary and along the South Dublin seafront is also of continuing concern. Both of these events will be monitored as part of the Water Framework Directive and if their presence results in a water body failing to meet its environmental objective then further investigation of the source of the nutrients that are supporting these growths will be initiated. If this investigative monitoring reveals that nutrient loading from Ringsend is promoting these blooms then additional nutrient reduction measures may be required to ensure that at least good ecological status or good ecological potential, whichever is more appropriate, is achieved before Decem*ber *2015'.*

It remains to be seen whether future nutrient removal at Ringsend will have any positive effects on the problems of algal blooms in Dublin Bay.

7.7 The Urban Waste Water Treatment Regulations (SI No. 254 of 2001)

SI No.254 supersedes SI No 419 of 1994. The new Regulations define "Sensitive Areas" in the Third Schedule. Part 2 of the Third Schedule under "ESTUARIES" defines the Liffey Estuary as follows:

"From Islandbridge weir to Poolbeg Lighthouse, including the River Tolka Basin and South Lagoon"

Article 4 of the Regulations lays down more stringent requirements for discharges from wastewater treatment plants to areas designated as sensitive for Total Phosphorous (P) and Total Nitrogen (N) depending on the size of the plant. Clearly, Ringsend falls into the top bracket i.e.>100,000pe for which the P and N limits are 1mg/l and 10mg/l respectively. The limits shall be the annual mean of the samples taken of each parameter and extreme values shall not be taken into account.

Under the new Regulations, the position with regard to Dublin Bay is somewhat anomalous in that the vast majority of the Bay lies outside the sensitive area as designated in the Regulations. Nevertheless the discharge point from the Ringsend WWTP is undoubtedly within the designated sensitive area.

Article 5 of the Regulations states------"*Notwithstanding the provisions of Article4, more stringent requirements than those specified in Parts 1 and 2 of the Second Schedule shall be applied to discharges from a treatment plant where this is required to ensure that the receiving waters satisfy any other relevant Community Directive".*

It may be construed that the Bathing Water Directive (SI No.155 of 1992) is relevant in this context but the provisions of this Directive have already been catered for by the inclusion of UV treatment and nitrification at Ringsend.

7.8 Standards Currently in Place at Ringsend

The design adopted for Ringsend in Contract No. 2 conformed with the requirements of the UWWT Regulations quoted above. In the Contract Documents, the Contractor was made aware of a possible future requirement to install nitrification/denitrification and was instructed to take account of this in his design (Para. 2.3.1.5 of The Employer's Requirements).

Initially, the Contractor's design included for installing nitrifying measures in 50% of the sequence batch reactors (SBRs). During the construction period, the UWWT Regulations (SI.No254 of 2001) were revised to designate the Liffey Estuary as a "sensitive area". For this reason, DCC entered negotiations with the Contractor and it was agreed to alter the Contract so that full nitrification facilities were added to all the SBRs. Denitrification facilities would be added at some future date if required. In any event, the requirements of the new Regulations did not come into force for a seven year period (i.e. until May 2008). Denitrification measures have not been installed to-date.

The Employer's Requirements (Para. 2.5) specified some form of disinfection treatment of the final effluent. As part of Contract No.2, UV irradiation was installed at Ringsend and is operated during the bathing season i.e. 1st May to 1st of September each year.

While some P removal occurs during the treatment process, there is no dedicated phosphorous removal plant in operation at Ringsend.

7.9 Consultants Brief for Ringsend Wastewater Treatment Plant Expansion

A new brief for the ultimate expansion of the Ringsend WWTP was issued to Consultants CDM in December 2007. The Project Objectives contained in the brief include the following:

- Take account of receiving water quality requirements
- Take account of bathing water quality requirements
- Take account of classifications and systems standards emerging from the Easter River Basin District Study
- Take account of proposed future development of the Poolbeg Peninsula
- Take account of the imminent closure of the Poolbeg Power Station and the consequent reduction of cooling water discharge
- Take account of the condition of the existing discharge channel
- Consider the option of a long sea outfall versus the existing outfall to the Liffey Estuary, which is designated 'sensitive' waters

- Take account of the Water Framework Directive, in particular, compliance with the proposed Environmental Quality Standards (EQS)
- The EIS for the existing works includes a mathematical model of Dublin Bay developed by the Centre for Water Resources Research at UCD. Include for the cost of any necessary updating of this model.

The general requirements of the new brief are very comprehensive in relation to many of the issues raised in this current report. This report will not attempt to pre-empt the findings of the Consultants appointed to consider the matters listed above.

Clearly, there are decisions to be made with regard to the ultimate capacity of the Ringsend Works, the quality of the final effluent and the point of final discharge. To achieve these goals, further studies and models of Dublin Bay may be necessary and financial appraisals of the best practicable environmental options made. The final solution will need to be compliant with the aims of the Water Framework Directive for the entire Eastern River Basin District.

The question remains whether the present Works is compliant with the new Regulations and, if not, whether immediate action is required to rectify this non-compliance. It is clear that further substantial investment is about to be made in the final upgrading of the Works. It would seem more economically prudent to carry out all the improvement works at one time.

8. THE ODOUR ISSUE

8.1 Introduction

Traditionally, the primary focus of wastewater treatment has always been the quality of the final effluent discharged to receiving waters. The by-products of the treatment process such as sludges etc. have commanded less attention. Nevertheless, odour impact has been regarded as a potential nuisance and, for this reason, wastewater treatment plants tended to be located as far as possible from residential areas. Such location helped to mitigate any odour problems that might occur.

In not so distant times, in cities like Dublin and Cork, odour levels from industries such as brewing and meat-processing were very prevalent not to mention the stench from the Liffey or the Lee before direct discharges of sewage and industrial effluents were removed from both of these rivers. In more recent times, however, environmental awareness has heightened our sensitivities to odour from any source while, at the same time, modern methods of dealing with the by-products of treatment, such as sludge, tend to give rise to processes which are potentially more odour producing.

The Public Health Act of 1878 was the first legislation to be introduced in Ireland to control nuisance but it is only since environmental impact assessment (EIA) was introduced in the 90's after the establishment of the Environmental Protection Agency that odour has been seriously addressed as a public nuisance. In December 2005, the Minister for the Environment, Heritage and Local Government made Regulations under S.I. 787 for the regulation of odours and noise from wastewater treatment plants. S.I. 787 does not stipulate any numerical values for the control of odour nuisance and merely states *"a sanitary authority shall ensure that in formulating and improving plans for a wastewater treatment plant to be provided by the authority or on its behalf the plant is so designed and constructed as to ensure that it avoids causing nuisance through odours or noise."*

8.2 Environmental Impact Statement (EIS)

The EIS (No. 1) was prepared for Ringsend Treatment Works and was presented to Dublin Corporation in January 1997. Section 7.1 of the EIS, deals comprehensively with odour. The EIS concludes that concentrations of hydrogen sulphide (H_2S) is the most suitable indicator of odour at Ringsend. The World Health Organisation (WHO) air quality guidelines for Europe gives a nuisance threshold value of 3.5 parts per billion (ppb) as an hourly average concentration i.e. no nuisance will be experienced providing the average concentration of H_2S does not exceed 3.5 ppb in any hour.

An ambient odour survey was carried out in the vicinity of the existing works (i.e. primary settlement only) and showed that the operation of the existing works would from time to time, under adverse weather conditions, result in the occurrence of H_2S above the detection threshold at the fringes of existing development closest to the site.

In 1996, odour modelling was carried out using the Industrial Source Complex (ISC3) model which is an air dispersion model simulation package developed by the US Environmental Protection Agency (USEPA) and used worldwide as a regulatory tool for atmospheric emissions. Certain assumptions were made with regard to the likely generation of H_2S at each of the main on-site processes. Long-term meteorological data for the period 1962 to 1984 for the Dublin area was used.

The results of the modelling were very positive. With no odour control, the model predicted that the maximum concentration of H_2S at the site boundary would be from 1.1 to 8.4 ppb and with 95% odour removal on the main sources of odour, such as the screening plant and the sludge drying/dewatering building, this would be reduced to 0.1 to 1.0 ppb. As a consequence, the EIS adopted a minimum standard of 5 ppb of H_2S at the site boundary for the new works.

In the event, the modelling results given in the EIS proved hugely optimistic which leads one to believe that the input data on emission rates of H_2S contained in Table 7.1 of the EIS were very much under-rated. For example, one input to the model assumed a maximum design inlet wastewater sulphide concentration of 1.0 mg/l at a pH of 7.5. In an odour survey by Hyder Consulting reported to DCC in November 2003, levels of sulphide up to 8.7 mg/l are reported for the Sutton flow and 2.9 mg/l for the Dun Laoghaire flow at the inlet. If such values had been inserted in the model in the first place it is likely the subsequent predictions of odour at the boundary would have been far higher.

The EIS did not take into account the origins or effects of other odiferous substances, such as, mercaptan, volatile organic compounds (VOCs) and ammonia.

Nevertheless, the EIS did establish a requirement for a H_2S level at the site boundary of 5 ppb which, if it had been achieved, would certainly have eliminated any odour problems in the Greater Ringsend Area.

8.3 The Contract Documents

Although the EIS for Ringsend Treatment Works contained many of the aims of the Contract, the EIS itself was not given primacy in the listings of the Contract Documents. Sub-Clause 1.6 of Volume 1 of the Tender Documents lists the documents purporting to form the Contract but does not include the EIS. The Employer's Requirements, Volume 2, is listed as Item (c) in the list after the Contract Agreement and the Letter of Acceptance.

In the Employer's Requirements, the question of odours is dealt with in Section 2.7.1. Sub-Clause 2.7.1.1 states "the works shall operate such that the concentration of hydrogen sulphide in atmosphere at any works site boundary does not exceed 100 ul/m^3 (micro litres per m^3) at any time". This value is equivalent to 100 ppb and is repeated in paragraph 5.1.2.3.4 and paragraph 6.9.4.6 of the Employer's Requirements. It is 20 times the limit value for odour quoted in the EIS.

It is difficult to see why such a limit was stated in the Contract. One can only assume that the very positive results provided by the odour modelling in the EIS created a false sense of security with regard to potential odour problems from the new works. Otherwise, it has to be regarded as a serious error of judgement.

8.4 Odour Provisions in Original Design

Provisions for odour treatment in the original design for Contract 2 consisted of the following:

1. an Odour Control Unit (OCU) consisting of a twin-tower chemical scrubber was provided in duplicate as a duty/stand-by arrangement to treat all ventilated air from the following:
    - the inlet works
    - the Fat, Oil and Grease (FOG) plant and grit tanks
    - mixed sludge holding tanks and sludge thickeners

- belt presses and cake hopper (located in the THP Building)

2. a smaller OCU consisting of another chemical scrubber installed with the sludge drying plant to treat odiferous air from the following:
   - centrifuges
   - cake transfer screw conveyors
   - associated sumps and buffer storage tanks
3. Thermal Oxidisers (TO) in the THP plant room to treat all foul air streams from the process vessels in the Cambi System.
4. A small biofilter at the storm return pumping station

8.5 Odour Incidents

Historically, odour complaints at Ringsend arose mainly from the operations involved in loading the ship which carried sludge to be dumped in the Irish Sea. When Contract No. 1 was commissioned, the primary sludge which hitherto had been dumped at sea was now thermally dried. The exhaust air from the dryers was treated in an OCU and, generally speaking, no serious odour problems were known to have occurred.

The first serious odour problem began with the commissioning of Contract 2 i.e. the Contract which was to provide secondary treatment for Dublin City and the Greater Suburbs including North County Dublin, Dun Laoghaire and South County Dublin.

This Contract began commissioning in May/June 2003. In August 2003 flows from North Dublin were introduced to Ringsend for the first time through a sub-marine pipeline running from Sutton to Ringsend. Due to the long length of pipeline from Sutton, the sewage discharged at Ringsend was already septic on arrival and was a rich source of hydrogen sulphide (H_2S).

Whenever effluent containing large amounts of H_2S is passed over a weir, the H_2S volatilises and is released to the atmosphere. There are several points throughout the treatment process where the liquid passes over weirs and discharges to another area for further treatment. At each of these points there is considerable release of H_2S.

As the works were being commissioned, many odour problems became manifest over a short period of time. Firstly, levels of H_2S generated at the inlet to the works exceeded expectations causing severe odour problems in the screen room. Fugitive emissions from covered areas and buildings also caused problems.

The sludge treatment system known as the Cambi System consists of a process whereby the incoming sludge is super-heated with steam up to 150^0C in enclosed vessels. This process, known as hydrolysis, breaks down the cell structure of the sludge so that extra biogas is released during the subsequent process of anaerobic digestion. The heating of the sludge to such high temperatures inevitably releases high levels of odiferous gases such as sulphides, mercaptans, Volatile Organic Compounds (VOCs) and ammonia which, if not contained, will cause serious odours on and off site.

Considerable problems were encountered in the commissioning of the Cambi System because of leaking valves and fugitive emissions from the Thermal Hydrolysis Plant (THP) building which was vented at eaves level with extractor fans on which there was no form of odour treatment.

Further problems were experienced with fugitive emissions from covered areas and buildings causing widespread odour on and off site. At one time, the main biogas storage tank was leaking and contributed in a significant way to odour releases on site.

In addition to these teething problems, it became apparent that there were significant omissions from the odour treatment system such as:

- Odour emissions from the primary lamellae tanks (settling tanks) were untreated
- There was no individual odour extraction from the sludge presses which are highly odiferous
- High levels of ammonia were being released from the treated sludge
- There was no individual odour control on the extraction fans from the THP Building (as already stated above).

Faced with mounting problems, DCC had some difficult choices. On the one hand, the Contractor was reluctant to incur extra costs in rectifying problems which, he maintained, were not of his making while, on the other hand, DCC were responsible for the protection of Dublin Bay and ensuring that the treatment plant continued to operate at the front end, maintaining a good quality effluent to Dublin Bay which undoubtedly the new works was achieving.

After difficult negotiations with the Contractor, a range of improvement works to combat odour was agreed in August 2004 costing €1.2 M, the cost to be shared between DCC and the Contractor. The improvement works consisted of the following:

- Repairs and improved sealing of all containment areas
- Modification of the main OCU to duty/assist i.e. both air scrubbers could work simultaneously when required

- Modification to the OCU for the dryers to cater for increased load and addition of an ammonia scrubber
- Containment of the collection culverts from the lamellae tanks and provision of 2 no. Bord na Mona bio-filters to treat the extracted air from these sources.
- Addition of containment screens and improved extraction rates from the sludge press area
- Modification and improvement to the extractor ducts and ventilation rates (fans).
- Increased chemical storage to store spare chemicals for the OCU's.

Two significant areas were not dealt with in the first tranche of remedial works, namely, the complete covering over of the lamellae tanks and the elimination of odiferous air being extracted from the THP building via the extractor fans at eaves level.

8.6 Odour Surveys

Between the Summer of 2003 and 2005 several odour studies were commissioned by DCC to determine the gravity of the odour problems and the steps necessary to remedy them.

Following the odour incidents in the Summer of 2003 an odour audit was carried out by Hyder Consulting on behalf of MACL Consultants acting on instructions from DCC. The audit highlighted the following problems:

- The septicity of the sewage discharge from Sutton was causing major problems at the inlet and in the lamellae settling tanks.
- The Thermal Hydrolysis Plant (THP) building was a major source of odour particularly from the four extractor fans venting air from the building at eaves level.
- The thermal oxidisers associated with the Cambi process were not functioning adequately and residual odour was coming from the discharge stacks.
- The dryer odour control unit was not functioning properly and significant discharges of hydrogen sulphide were measured at the outlet.
- Chemical for the main odour control unit had run out for several days during which time there was no odour treatment.

The principal reason for the high odour emissions from the THP building was the inability of the Contractor to manage foul gases due to extensive leakage from defective valves and inadequate cooling resulting in regular discharges of odiferous gas.

Also the waste gas burner malfunctioned repeatedly causing regular release of biogas which had a high H_2S content and was therefore very odiferous. It was later discovered that the burner was fitted with an incorrect fitting and when this was replaced, the problem ceased.

A further report on odour control was prepared by MACL in November 2004 for DCC. This report listed the improvements which had been carried out on foot of the November 2003 audit including the following:

- Additional scrubbers were provided at the Contract 1 Odour Control Unit and at the lamellae primary settling tanks. The main OCU was modified into an acid scrubber.
- The containment of odour within the sludge treatment building was improved.
- The Main OCU's were upgraded to permit operation as duty/assist when peak loads are experienced.
- Modifications were carried out to the process control and the thermal oxidisers in the THP building.

All of the above modifications were completed by November 2004. Around about this time, an explosion occurred in dryer no. 3 which was an additional dryer provided under Contract 2. The explosion meant that the dryer was out of action for at least 18 months while repairs were carried out and explosion prevention measures were being installed.

As a result of the explosion in Dryer No. 3, and the introduction of new Health & Safety measures (ATEX) in relation to explosion prevention (S.I. 258, 2003), all three dryers were retro-fitted with explosion prevention equipment between 2004 and 2006.

In spite of the additional odour control works sanctioned by DCC and completed by the end of 2004, odour problems persisted throughout 2005. In a final effort to resolve the odour issue, Dublin City Council contracted with Odour Ireland to complete a comprehensive odour survey of the Ringsend Site. This survey was carried out between February and November 2005 with the bulk of the sampling done between Mid-September and early November. The results of the sampling were provided to an independent consultant CDM, not previously employed in connection with the Ringsend Works. DCC requested the consultant to make clear recommendations that would result in Ringsend Facility being among the elite of wastewater treatment plants in the world with regard to odour goals.

The consultant made the following recommendations in January 2006:

- Cover lamellas and all channels leading to and from them and treat the odours in a new odour control unit.
- Enclose the belt filter presses within the THP building and treat the odours from within the enclosures in a new multi-stage odour control unit.
- Repair leaks in biogas storage bag.
- Increase extraction rate in head spaces of head works channels and processes and improve sealing of covers.
- Install a sulphur removing process to treat the digester gas upstream of the CHP engines.
- Increase capacity and efficiency of the drier building OCU.

At the time of writing, the above recommendations are 95% complete and will be fully complete before the end of 2008.

8.7 Other Remedial Works

Independent of the recommendations listed above, other variations and improvements to the treatment plant have been agreed from time to time with the Main Contractor, which have contributed significantly to the reduction of odour. These may be listed as follows:

- A complete replacement and enclosure of the main screens at the inlet works.
- The complete overhaul and replacement of the equipment for the treatment of fats, oils, grease and grit.
- The retrofitting of combustion chambers on each of the sludge dryers.
- The redirection of foul gases from the Cambi vessels through the digesters.

8.8 Contractual Difficulties

It is important to note that contractual difficulties with the Main Contractor began at an early date during construction and continued right through the commissioning period and up to 2006. Many of the major odour incidences during that period took place against a background of plant malfunction or failure and disputes between the Contractor and DCC as to liability for such failures. In this regard, the fact that the pollution loads reaching the works were on occasions in excess of the 2020 design load together with the lenient odour standard expressed in the Contract Documents of 100 PPB at the site boundary were unhelpful to DCC in their protracted negotiations.

There is no doubt that problems with the Cambi System also lead to serious odour problems over the period. This process is relatively new, and the Dublin plant was the biggest plant of its kind to be built anywhere in the world. The first Cambi plant was built in Norway in 1996 and had only one-tenth the capacity of the Dublin plant. As with all new processes, teething problems arise, particularly, when there is a ten-fold increase in plant size. At different times, defective pressure valves had to be removed and replaced.

The thermal oxidisers which were designed to deal with the foul gases from the Cambi pressure vessels never functioned properly and have been replaced with a new foul gas system.

The sludge belt presses which were the cause of so much odour release have been replaced by totally enclosed centrifuges. The belt presses now can only be used in stand-by mode.

8.9 Comment and Summary

The treatment plant at Ringsend is not alone in the problems it has experienced with odour. Odour has become an important issue at many treatment plants in the UK, for example, Mogden (Thameswater), Liverpool (United Utilities) and Edinburgh (Seafield Sewage Works) where remedial actions similar to those at Ringsend have been, or are scheduled to be, carried out. Odour issues with wastewater and sludge treatment plants are also very prevalent in the United States.

The odour problems at Ringsend have been serious and prolonged, and the resolution difficult and costly. Nevertheless, DCC has stuck to its task and now appears to have finally overcome all major difficulties. Constant vigilance and good management will still be required to ensure that odour nuisance will no longer be a concern of the local population at Ringsend.

The performance of the treatment plant itself should also be acknowledged. Since 2004, the effluent standard to Dublin bay has been quite good apart from some poor results in early 2006 when some of the aeration equipment in the main treatment tanks (SBRs) failed and had to be replaced.

There are two-tier limits on the discharge for BOD as follows:

- Low Limit: < 25 mg/l BOD
- High Limit: > 25 < 50 mg/l BOD

In spite of all the teething troubles and overloading of the Works, the lower limit has been achieved over 80% of the time (excluding 2006 when it was 72%) and the higher limit achieved over 95% of the time (85% in 2006). So far in 2008 the works is compliant with the low limit (i.e. >95%).

As a consequence, the quality of water in Dublin Bay has improved to such an extent that Dollymount Strand has achieved Blue Flag status in 2007 and 2008, and will also enjoy Blue Flag status in 2009.

The positive side of the Cambi process should not be discounted. The process of hydrolysis renders the sludge more amenable to anaerobic digestion and increases the biogas yield significantly. The digester feed occurs at a much higher solids content than conventional digesters, thereby, reducing the size of the digester by 50%. The resultant sludge is considerably reduced in volume by virtue of conversion to biogas and is much more easily dewatered. It is also highly pasteurised.

Biogas on site feeds to a Combined Heat and Power (CHP) unit which provides 3 MW of power from gas generators and also provides heat which is used to generate steam for the hydrolysis process.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

1. The population projections made in connection with the design of Ringsend Wastewater Treatment Plant have been shown to be on target up to the Census year of 2006.

2. The decision to take 60% of the licensed flows and loads of industry as the design load at Ringsend has proved to be correct up to the present.

3. Pollution loads arising from commercial sources such as shops, offices, restaurants, public houses and public buildings etc. were underestimated in the design. It is estimated that commercial sources could be contributing an equivalent population of **190,000** or more to the population load arriving at Ringsend.

4. Increases in prosperity and tourism may account for an extra **12,000** population equivalent from same-day visits to Dublin from the rest of the country.

5. Commuter journeys into Dublin have increased significantly. The design allowed for 20,000 commuters each having the effect of one third of a person, making the total population equivalent contribution 6,700 in the design. The CSO estimated from the 2006 Census that over 90,000 commuters come into the Greater Dublin Area every week-day i.e. a population equivalent of 30,000 or an increase of **23,300** over the design load.

6. The cumulative additional loads estimated from commuters, tourism and the commercial sector could amount to **225,300 PE.**

7. The monitoring of existing trade licences in all the local authority areas needs to be improved so that measurement of the actual loads being discharged are readily quantifiable.

8. Certain anomalies in the measurement of flow and load arriving at Ringsend WWTP need to be investigated.

9. The odour control equipment now installed at Ringsend is fit for purpose and should eliminate the odour nuisance experienced in the nearby residential areas since 2003.

9.2 Recommendations

1. The Consultants Brief for the final upgrading of Ringsend WWTP to its maximum capacity should be extended to include a comprehensive review of the measurement of the existing flow/load entering the works from the following sources:

    - Sutton Pumping Station
    - Dun Laoghaire Pumping Station
    - Middle-level Pumping Station
    - Dodder Valley Siphon

2. The adequacy of the flow/load recording equipment currently in use should be carefully checked and modified/upgraded as necessary.

3. The monitoring, control and measurement of all licensed trade discharges in each constituent local authority area contributing to the Ringsend Works should be significantly improved so that actual load versus allowable load can be readily quantifiable in terms of kg of BOD per day.

4. Trade licences should incorporate requirements for continuous review and improvement in a similar manner to IPPC licences.

5. All discharges from commercial premises should be licensed and routinely monitored.

6. The monitoring, control and measurement of transboundary flows/loads from one local authority area to another should be improved and adequate measures installed to achieve credible results.

7. Additional random spot-checks should be carried out on tanker loads of liquid waste being discharged on site at the inlet to Ringsend Wastewater Treatment Plant.

Terms of Reference for Independent Examination and Report to the Minister for the Environment, Heritage and Local Government, in relation to the Determination of the Phase 1 Design Capacity of Ringsend Waste Water Treatment Works and Related Matters

The Department of Environment, Heritage and Local Government, plans, manages and finances the Water Services Investment Programme (WSIP) under which capital funding is provided for all major public water supply and wastewater infrastructural schemes undertaken by local authorities.

The design, procurement and supervision of individual projects is the responsibility of the local authorities, subject to Departmental approval at specific stages of each project. Local authorities engage consulting engineers to design the works, prepare contract documents, advise on tenders and to supervise the construction phase. The Department reviews the scale and scope of projects proposed for funding under the WSIP and advises local authorities on issues that may arise from time to time in relation to individual schemes.

The Preliminary design Report for the Ringsend Waste Water Treatment Plant, the major component of the Dublin Bay Project, was approved by the Department in November 1997 following certification of the Environmental Impact Statement. The objective was to provide full secondary treatment for domestic, industrial and commercial waste water arisings in Dublin City and County and parts of County Meath. At the time:

- Approximately two thirds of the Dublin region's waste water received only primary treatment in an overloaded works in Ringsend, and
- Untreated sewage from the North Dublin Drainage System was discharge to the Irish Sea at Howth.

The Environmental Impact Statement (EIS) for the Dublin Bay Project was certified in 1997 setting final effluent standards to meet the water quality objectives of the Dublin Bay Water Quality Management Plan and the requirements of the EU Urban Waste Water Treatment and Bathing Water Directives and of the 'Blue Flag' scheme for bathing areas.

The tender documents for the new Ringsend waste water treatment plant were approved by the Department on 1 July 1998 and required the contractor to design and construct the works to treat an average load of a 1.64 m population equivalent (p.e.). The domestic design load prescribed in the tender documents was based on projections (made in 1995/6) of the anticipated growth and expansion of the catchment up to the year 2020. The non-domestic design load specified was set at 60% of the prevailing licensed load at the time. This was based on European experience, which indicated that non-domestic loads reduced significantly when users faced volumetric charges.

Commissioning of the Ringsend plant commenced in 2002. Data from Dublin City Council indicates that the influent load to the plant exceeds the design load.

The Greater Dublin Strategic Drainage Study (GDSDS) published in late 2005 has assessed the future wastewater capacity requirements throughout the Dublin region and the infrastructural responses needed, including the scale of the capacity expansion required in Ringsend. The expandability of the plant is site constrained, but the GDSDS suggest that an average capacity of 2.16 m population equivalent could be provided. The Study also envisages additional treatment capacity up to 880,000 PE elsewhere in the Region to cater for growth in the period to 2031.

There were protracted delays at commissioning and testing of the new plant which experienced difficulties in achieving the required performance standards. In addition, odour problems were experienced beyond the site boundary within a short time of the plant coming into operation. Works currently underway to resolved this issue are due for completion in November 2008.

The Minister has requested an independent examination of the design parameters of the works to determine whether they adequately addressed existing and project loads at the time they were approved. The Minister requires the person carrying out the examination to review and report to him on the following matters in particular:

- The basis for, and timing of, the determination of the design capacity of the treatment works;
- The volume and timing of actual loads arising (domestic and non-domestic) by comparison to the load projections when the design capacity was determined;
- A comparison of the IPC licensed discharge loads and the actual discharge loads from those licensees to the treatment works;
- The appropriateness of the design capacity determined having regard to the information available at that time;
- The consideration given to nutrient reduction requirements in the context of the water quality standards applying to the receiving waters (both prior to and after the designation of the Liffey Estuary as sensitive under the Urban Wastewater Treatment Directive in 2001); and
- The factors that contributed to the odour problems and the effectiveness of the actions taken to deal with such odours prior to October 2007 when the City Council, on foot of a contractual agreement with the contractor, issued instructions for additional works to resolve the odour issue.

The person appointed is required to complete the examination and to report to the Minister within 40 working days of the appointment. The remuneration would reflect that timescale.

It will be necessary for the appointed person, in compliance with public procurement requirements, to furnish the Department with a Tax Clearance Certificate. The payment of VAT, if appropriate, will be additional to the consideration determined,

Mr. Terry Allen, Principal Officer, Water Services Section, Department of Environment, Heritage and Local Government, will liaise on behalf of the Department with the person conducting the examination.

Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

8.2

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

8.2

INITIAL REVIEW OF FINAL STRATEGY REPORT & DRAFT SCOPING REPORT FOR STRATEGIC ENVIRONMENTAL ASSESSMENT

Greater Dublin Strategic Drainage Study

for

Fairshare

19 April 2007

Architects
Consulting Engineers
Project Managers
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CONTENTS

1.0 INTRODUCTION 1
1.1 Instructions 1
1.2 Documents Reviewed 1
1.3 Overview 1

2.0 SEWER SYSTEMS 2
2.1 Modelling 2
2.2 Misconnections 2
2.3 Infiltration 3
2.4 Sustainability 5

3.0 POPULATION GROWTH 5
3.1 Population Prediction 5

4.0 INFLOWS 5
4.1 Per Capita Consumption 5
4.2 Non-Domestic 6

5.0 TREATMENT TECHNOLOGIES 6

6.0 COSTS 6

7.0 REVIEW OF OPTIONS 7

8.0 CONFIRMATION OF FLOWS AND PE 7

9.0 DRAFT SCOPING REPORT (DSR) FOR THE STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) .. 7

10.0 SUMMARY 9

Checked by: ..... **Date:** .....

1.0 INTRODUCTION

1.1 Instructions

Pick Everard have been instructed by Fairshare to undertake a brief technical review of the Greater Dublin Strategic Drainage Study (GDSDS) Final Strategy Report (FSR), and to offer comment on the conclusions drawn.

1.2 Documents Reviewed

Final Strategy Report Volume 1 Main Report ref GDSDS/NE02057/035C

Regional Drainage Policies Technical Document Volume 4 Inflow, Infiltration & Exfiltration (I/I/E)

Draft Scoping Report for the SEA of the GDSDS

1.3 Overview

It is clear from our review of the GDSDS and associated documents, as listed above, that a thorough and comprehensive study has been undertaken for the Greater Dublin catchments, and we would support the vast majority of the principles which have been developed for the deficiencies of the existing sewerage networks, and the principles of the solution development which has been carried out.

However, the outcomes of the GDSDS result in the recommendation of important and large scale schemes which have a significant impact upon the residents of Greater Dublin and direct impacts on particular centres of population. These impacts are both environmental and financial with high associated costs to be funded from the public purse.

It is therefore appropriate that the recommendations are subject to challenge to ensure that the solutions are robust and fully justified.

Our review has identified three principal reservations concerning the approach and recommendations, contained within the GDSDS, as follows:

- **Infiltration** – the recommendations contained within the GDSDS, if adopted, will result in the construction of new waste water treatment works (WwTW) the capacity of which will effectively equate to the volume of ground and surface water entering the sewerage systems. The high capital and revenue costs of this proposal cannot be justified and the environmental sustainability of this approach should be challenged.

- **Regulation** – Ireland has adopted Public Private Partnership (PPP) for many government funded schemes, yet the lessons learnt from other regulated water industries in the UK and Europe have not been considered in the GDSDS. The experience elsewhere has been that the high population growth, and demand increase predicted at privatisation have not been realised. Metering of domestic and non-domestic water supplies and the optimisation of sewerage systems has been a major factor in minimising the need for additional waste water treatment.

- **Population** – there should be a staged approach to population increase, and a cautionary approach to reliance on population forecasts. Schemes which propose high front-end capital expenditure based upon forecasts of high population increase and growth in demand should be challenged to ensure that they are fully justified.

2.0 SEWER SYSTEMS

2.1 Modelling

Section 5: Data Collection and Processing and *Section 6: Hydraulic Modelling*, set out the extent of the work undertaken to model and verify the performance of the existing drainage systems. These sections of the FSR do not provide sufficient detail of the coverage of the surveys and the degree of success achieved in verifying the hydraulic performance of the existing networks to enable us to confirm whether the use of these models in predicting future performance would provide a sufficient degree of accuracy. Typically, this could be compared to UK industry standards (Wastewater Planning Users Group (WaPUG) criteria). The inclusion of Figures 6.1, 6.2 and 6.4 are simply a very small selection of examples that are insufficient to convey a true picture of the success of the verification exercise.

2.2 Misconnections

From the descriptions of the sewerage systems contained in Section 7 of the FSR, it is clear that the level of misconnections to the foul system is highly significant for the Greater Dublin Catchments. Many of the systems appear to have been installed as separate systems, but roof and paved areas, particularly from industrial land has been allowed to be connected to the foul drainage system.

The flow monitoring surveys indicated significant increases in flow within the foul trunk sewers following storms. Surface water runoff up to 5 times the Dry Weather Flow (DWF) is entering the separate Blanchardstown foul system, and up to 8 times DWF for the Lucan Clondalkin 9B system. Failure to fully implement the policy of separate sewer systems has therefore allowed a high proportion of surface water (rather than foul sewage) to be directed to the treatment facilities where it receives expensive and unnecessary treatment. Strict maintenance of separate drainage systems directs rainwater runoff which does not require treatment at a wastewater plant via the surface water drainage systems to the watercourses within the catchment.

The control of inflow is also referred to in the regional drainage policies where "illegal stormwater connections due to poor supervision of construction and local modifications to accommodate drainage of extensions, patios and driveways" is acknowledged.

Clause 3.4.2 of the FSR: Overall Approach Needed states "It must be recognised that I/I/E is difficult and expensive to identify and locate and reduce. It is therefore far more cost-effective to minimise its occurrence in the first place."

Whilst we accept that to eliminate misconnections and infiltration is best achieved at the time the sewer is laid or receives a new connection, we do not accept that the removal of existing misconnections from the system should not be undertaken. Indeed, we consider that it should be rigorously pursued in preference to expensive and potentially unnecessary treatment options. It would appear that the pursuit of a rigorous environmental policy to properly eliminate surface water from the foul sewerage system, with the capital, revenue and environmental benefits that would result has been discounted.

Furthermore, a rigorous approach to trade discharges through a polluter pays principle will not only act to reduce clean water entering the foul sewer, but also serve to attract funding for the solutions to be adopted. The design horizon of 2031 offers a considerable time period to achieve such environmentally sustainable goals. *Clause 4.2: 2002 (Existing) Development* of the FSR indicates that there is currently little information on actual trade discharges, which would imply that there is little regulation.

Clause 10.3.1 Load Management for Ringsend WwTW for Scenario 2 states "This scenario is based on reducing 2002 non-domestic loads by 25%, and allowing for residential growth related to regional planning guidelines, and for regulation of future non-domestic discharges to domestic strength". We consider that this approach should be rigorously pursued in preference to simply providing large additional treatment capacities.

Clause 10.3.1 further states "Existing licences should be reviewed in respect of both flow and other load parameters." The clause also states "Currently these discharges are considered to be largely uncontrolled". We consider that the existing non-domestic discharge licences should be restricted, not merely reviewed. It is unacceptable to expend public money on very large treatment works, as a result of the failure to enforce discharge regulation upon non-domestic customers.

Clause 10.3.1 further states "the only practical option to make capacity available for new development in the short term is to achieve a reduction in existing non-domestic loads through a systematic load management programme. Given the cost of new wastewater treatment infrastructure, it is essential that a rigorous load management strategy be put in place". There is no evidence that this proposal has been carried through to the final recommendations. We consider that doing so will have a considerable affect upon the best options for the Greater Dublin catchments.

Clause 10.4: Intermittent Discharges recommends that new capacity be provided "by removing storm flows from the system", and "that budgets be provided to facilitate disconnection of storm water discharges to foul and combined sewers where this is practical and for reduction in infiltration". Again, there is no evidence that this proposal has been carried through to the final recommendations. We consider that doing so will have a considerable affect upon the best options for the Greater Dublin catchments.

Clause 10.9: Foul Sewerage Strategy states "In the newer developments in Dublin, the sewers were designed as separate foul sewers, whose capacity is less than Formula A. Due to the expedient stormwater connections, many of these sewers can experience flows in excess of their design capacity during severe rainfall". It is clearly not reasonable to expend public money on large additional treatment when such issues have not been resolved.

2.3 Infiltration

We have not been able to gain access to the Phase 1, 2 and 3 Hydraulic Modelling Reports referred to in Clause 6.1 of the FSR.

Section 7: Sewerage Systems summarises details of the existing sewerage catchment drainage systems. It is clear from this section that infiltration is a major issue for Greater Dublin. Where infiltration has been assessed through the modelling exercise, the quantities are in many areas significant. For example,

- 43% of dry weather flow for the Trunk Sewer catchments is infiltration
- 57% DWF for the City Centre/Docklands Sewerage System is infiltration
- Greater than 50% in Quarryvale, Rowlagh, Kilmacud, Yellow Meadows, Clondalkin Village, Ballymount, Walkinstown Park and Robinhood is infiltration

Many of the descriptions of sewerage systems contained within *Section 7: Sewerage Systems* do not refer to the level of infiltration. We consider that this may be indicative of a lack of information derived from the modelling and verification exercise such that

infiltration rates could not be quoted. Major decisions and recommendations made by the FSR should be based upon adequate knowledge of the performance of the existing sewerage systems such that the flows delivered to the treatment facilities can be confidently predicted. We suspect that this may not be entirely the case for the Greater Dublin catchment.

We would disagree with the statement in *Section 7.2.2.3: Future Needs* that reduction of infiltration would only marginally affect future flows. The total infiltration flows are summarised in the FSR *Clause 3.4.1: Evidence of Inflow and Infiltration* summarises the infiltration for the Ringsend WwTW catchment as 2011 litres/sec. This document further notes that most catchments for the Greater Dublin catchment have infiltration in the order of 30% to 40% of DWF. That is, between a third and a half of the flow in the foul sewer which arrives at the waste water treatment plant does not require treatment.

The documents further notes that at a daily sewage discharge per household of 650 litres equates to 267,300 households. At the current household size of 2.92, as noted in Table 1.1 of the FSR, the infiltration equates to 780,516 persons. This therefore represents over 90% of the population equivalent figure for the new works.

A key principle underlying the development of options within the FSR is that Ringsend WwTW cannot be expanded to meet the ultimate requirements of the Greater Dublin catchment. However, based upon Table 8.6 of the FSR, the consequences of removing the need to treat this level of infiltration from the sewerage systems are demonstrated in Table 1 below:

WwTW	PE 2031 from FSR	Infiltration PE equivalent	Net PE required at 2031	WwTW Design Capacity	Additional Capacity Required
Ringsend	2,813,901	780,516	2,033,385	2,160,000	NIL

Table 1 Removal of Infiltration

It is clear therefore that addressing the infiltration problem within the existing sewer systems would have the potential to eliminate the need for a new large works (as has been recommended for Portrane). We consider that directing the planned expenditure towards rehabilitation of sewers through a variety of available techniques would reduce the hydraulic load on the Ringsend works, and reduce the need for additional new works. This would also be in line with the sustainable approach set out in the Strategy Principles and Drivers for the Drainage Study, referred to below.

The Regional Drainage Policy document - Volume 4 also notes that there is widespread pollution of aquifers from sewage exfiltration to the groundwater. This in turn has the potential to pollute drinking water supplies taken from these aquifers, posing risks to health and the potential for unnecessary water treatment costs. The rehabilitation of existing sewers would also address these issues, and should be made a priority over additional and potentially unnecessary treatment.

Clause 3.4.2: Overall Approach Needed of the FSR notes that reductions of inflow, infiltration and exfiltration of between 50 and 80% are typically achievable, but that 25% is recommended for Great Dublin. This appears to be unnecessarily conservative. Significant expenditure in this area is clearly justified to maximise the capacity of existing works, and also from an environmental perspective. Maximising the capacity of existing works will produce benefits of cost savings for the taxpayers of the region, and should be prioritised ahead of building new works on a major scale, which may not ultimately be needed.

Clause 3.4.1: Evidence of Inflow and Infiltration recommends a pilot study into I/I/E reduction, but it is not immediately apparent from the report whether even the 25% allowance has been included in the final options. From the descriptions of work included for each option under *Section 11: STRATEGY SCENARIOS AND RESULTING OPTIONS* of the FSR, it would appear that even this allowance has not been included.

As discussed above, the impact of infiltration on the scheme is massive, and the position on infiltration must be clearly stated in the FSR.

2.4 Sustainability

Clause 10.6: Strategy Principles and Drivers of the FSR sets out the Strategy Principles and Drivers for the Drainage Study. Bullet point 4 states "In addition, environmental sustainability requires load minimisation at source as a priority ahead of 'end of pipe' treatment and disposal". We consider that the recommendations put forward by the study do not achieve this goal.

Clause 10.5: Overview of Current System Status of the FSR states "The city centre trunk sewers cater for combined flows and they overflow regularly to the River Liffey and to the Estuary. These overflows are well outside appropriate environmental standards and are unacceptable. Measures are needed to reduce loads on the sewers and reduce spill occurrences to acceptable levels." This proposal does not appear to have been carried forward to the recommendations of the FSR, and the recommendations of the FSR are therefore not environmentally sustainable.

The recommended options propose the construction of large-scale treatment facilities without addressing the minimisation of hydraulic load at source.

3.0 POPULATION GROWTH

3.1 Population Prediction

Clause 4.4: 2031 Development notes the difficulty of the task of predicting the population growth over a long timescale up to 2031, with the only published data providing estimates varying between 1.9m and 2.6m for the GDA.

Clause 4.4 further notes that the "Exact siting and timing of new works will depend on the out-turn development realised".

We consider that the experience in the UK is a good comparator for any developing water industry. The growth predictions made for population and demand were never realised. If it is considered that the Irish water industry will develop in the same way as the UK and other regulated industries in Europe then the high predictions of growth made for the Greater Dublin catchment should be reviewed.

Clearly, if the recommended option of a new works were to be adopted, such uncertainty and variation in the base data would have a significant impact.

4.0 INFLOWS

4.1 Per Capita Consumption

At a daily sewage discharge per household of 650 litres and a current household size of 2.92, the per capita consumption that appears to have been adopted for the GDSDS is 222.6 litres per head per day.

This figure far exceeds that which is typical for the UK, and we consider that it is an over-estimate leading to excessive treatment capacity and excessive cost. The experience of the UK water industry since privatisation, as discussed above should be considered.

The UK industry average water consumption unmeasured household consumption is 150 litres per head per day (ref. Ofwat). Adopting a per capita consumption of this level would clearly have a significant impact on the required hydraulic capacity of the future treatment facilities. It is difficult, however, to quantify the impact since the technical data contained within the FSR is limited. It is interesting to note that Tables 4.2 and 4.3 are missing from the report, although referred to in the text. From the text, it would appear that these tables would have provided some data that would have allowed more understanding of the flows to be treated.

Over the longer term to the design horizon to 2031, water consumption levels can be reduced through environmentally sustainable policies that encourage lower domestic water usage. The principal tool that has reduced consumption in the UK is to incentivise the use of water metering. The UK average measured water per capita consumption is 138 litres. This is only one of a number of measures that could be utilised, including the requirement to use water efficient devices and education of the customer.

4.2 Non-Domestic

Clause 4.3: 2011 Development of the FSR sets out the basis for estimating future flows and loads from industrial lands areas, and notes the difficulties of estimation. It is stated that "By applying loadings to all employment land, there may be some over-estimate of total catchment loads but this is considered preferable to an under-estimate".

This approach is not preferable for the public purse and the local residents who may end up with a larger works than is necessary under the recommended option.

Clause 10.8: Wastewater Treatment Strategy for Fingal County Plants states "There is little practical constraint on the capacity of a coastal plant discharging to the Irish Sea, with appropriate treatment", and further, "The level of success in implementing non-domestic load management and achieving the targets will not impact upon the ultimate strategy adopted". We would disagree with both these statements, as the environmental damage to the local environment should also be taken into account, and reduction of hydraulic load to the existing works will clearly reduce the need for additional capacity.

5.0 TREATMENT TECHNOLOGIES

The FSR does not contain any detail as to the waste treatment technologies being considered for the expansion of the existing works at Ringsend. It is therefore not clear whether the best available technologies including low footprint and high rate technologies have been fully considered, to maximise use of land which may be available at this location.

6.0 COSTS

The capital cost difference between Options 2B and 2C is €168m in favour of Option 2B. This difference is then dismissed given the inaccuracies in calculation. We consider that the sum is significant and the calculations should be sufficiently accurate that the lowest Net Present Value (NPV) solution can be confidently identified. However, we also consider that when a more realistic per capita consumption is used, and misconnections and infiltration issues are addressed, neither of these options will offer the lowest NPV.

As set out in clause 13.2.2 of the FSR, the recommended option will require a high level of front-end investment, since the full orbital sewer will be required together with the initial phase of the proposed works at Portrane, both at an early stage. This will require a high level of early capital funding from the Authorities involved.

We would anticipate difficulties in securing investment for any Design Build Operate and Finance (DBOF) scheme due to the high level of front-end investment required with the long-term revenue profile and associated risk of anticipated development not materialising.

7.0 REVIEW OF OPTIONS

Section 11: STRATEGY SCENARIOS AND RESULTING OPTIONS of the FSR undertakes a review of the strategy scenarios and resulting options. All options are dismissed on technical grounds, other than Options 2B and 2C.

We do not consider that it is valid to dismiss all of the other options on technical grounds when the total flow in the catchments has been significantly over-estimated through the per-capita consumption, and the reduction of very high levels of misconnection and infiltration have not been considered. We consider that were this assessment to be made, the capacity at Ringsend could be maximised, and there is a likelihood that the additional large works proposed for Portrane will not be required, and the range of options for a smaller additional provision will change. As set out in Table 1 above, removal of infiltration may enable Ringsend to cater for the wastewater treatment needs of the catchment at 2031. This is in line with Strategy Approach 1 set out in the FSR, and in our opinion presents a viable option which should be considered further.

Clause 13.2: Feasible Strategy Options undertakes a review of the two options apparently deemed feasible. For Option 2B, a stated advantage is that "The South Dublin plant could be designed and operated on a fixed term operational contract for a defined period (say 20years), following which it could be eventually made redundant when the western orbital sewer is in place and South Dublin can be connected". This would indicate that the options are not stand-alone, and indeed, that the outcome of the FSR has been pre-determined.

8.0 CONFIRMATION OF FLOWS AND PE

There is some ambiguity within the FSR concerning the required PE for the proposed treatment works.

The table contained within *Clause 12.3: Option 2B Capital Cost Estimate* lists an expansion of Portrane to 300,000PE in association with an additional works in South Dublin with a capacity of 300,000PE. These capacities are not consistent with those in *Clause 11.2.3* for Scenario 2B, which state 450,000PE and 350,000PE, respectively.

Clause 15.2: Summary of Proposed Works refers to the capacity of the proposed works at Portrane being 400,000PE in 2013, expanding to 880,000PE in 2024. Again, this is not consistent with the capacity of 850,000PE stated in Table 11.5.

Clause 8.5: Receiving Waters indicates a capacity considered for Portrane of 625,000PE, noting this as an extreme combination of loading.

We are also unclear as to why Tables 4.2 and 4.3 are missing from the published FSR.

9.0 DRAFT SCOPING REPORT (DSR) FOR THE STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

The SEA is intended to be a systematic evaluation of the likely significant environmental effects of implementing the options and recommendations produced by the GDSDS.

Clause 4.1: Introduction of the DSR sets out reasons why regional policy recommendations including inflow, infiltration and exfiltration are excluded from the SEA. Similarly, the results of the drainage modelling exercises are specifically excluded. It is noted that in Clause 10.1, the first key environmental issue listed is the limited drainage capacity in the Greater Dublin Region. It is our opinion that the limited drainage capacity cannot be properly considered without reference to the assessment of and the reasons for the lack of capacity.

We consider that without due consideration of the environmental benefits of dealing with the lack of capacity of the existing sewerage systems, a balanced and properly evaluated assessment of environmental impact cannot be made.

As identified above, we consider that addressing the I/I/E issues will have significant environmental benefits including the reduction of additional treatment capacity and the elimination of groundwater contamination. Reducing the industrial and per capita consumptions, maximising the capacity of the existing drainage through the separation of misconnections and infiltration, and minimising the requirement for additional treatment capacity is clearly the more environmentally sustainable approach, as compared to the provision of very large additional treatment works.

As demonstrated in Table 1 above, if the infiltration is dealt with, the expansion of Ringsend WwTW may be sufficient to cater for the future needs of the catchments without the need for an additional large-scale works. The treatment of vast quantities of ground and surface water cannot be justified.

Table 6.12 of the DSR sets out the proposed Environmental Objectives for the GDSDS SEA Environmental Report.

The comments contained in the table relating to population note that it is generally preferable to locate major waste water treatment plants close to small centres of population. We consider it sensible to locate a major treatment plant away from any population to eliminate the adverse environmental impacts upon the residents, particularly where it is already proposed to transfer the sewage over long distances. Currently, it is proposed that there is a new large works located at Portrane.

It is also of note that Table 6.1 does not mention environmental issues which are key to Portrane.

- Rogerstown Estuary is a National Heritage area
- Rogerstown Estuary is an internationally significant Special Protection Area and a Wetland Site of International Importance under the RAMSAR Convention.
- The beaches of Portrane, Donabate and Malahide have achieved Blue Flag status.

In our opinion, all of these factors must be carefully considered.

These environmental classifications would be at severe risk by a major works located at Portrane. It is essential that such issues are given proper consideration.

Furthermore, no consideration has been given to the principal production of a Waste Water Treatment Plant, namely sludge. The treatment processes for the sludge, the handling, transport and odour control measures for any works must all be carefully

considered, and the impacts on the local environment addressed. Modern technologies may be able to address odour nuisance to some degree, but other aspects of sludge production such as transport of thickened sludge remain.

The DSR also make no mention of the environmental risks associated with existing exfiltration for the existing sewer systems in the Greater Dublin catchments. Aquifers are at risk of contamination.

10.0 SUMMARY

In summary, the key points are, as follows:

- The GDSDS is a detailed and comprehensive study, but fails to adequately deal with the aspect of infiltration.
- There is insufficient data provided within the FSR to be confident that the existing sewerage systems have been adequately modelled and verified.

- Many expedient stormwater connections have been made to separate foul sewers due to a failure to fully implement the policy of separate sewer systems. It is clear that discharges from non-domestic land are largely uncontrolled. It is not justifiable to expend such large quantities of the public purse when the case is unproven. The removal of stormwater from the foul system must be given priority over the provision of additional treatment.

- Infiltration is a major factor for the sewer systems within the Greater Dublin catchment. This must be reduced through a programme of sewer rehabilitation in preference to the provision of additional treatment capacity at the end of the systems. It is not clear that any allowance for reduction has been included within the recommended options. The estimate of infiltration to the system as a whole equates to over 90% of the hydraulic capacity proposed for the new works at Portrane. A works one tenth the size of the proposed works would be required if the infiltration were to be eliminated.

- Reduction of the infiltration into the foul sewers will enable Ringsend WwTW to cater for a much larger proportion of the future load and no additional large-scale treatment plants may be required. In general terms any reduction in the infiltration to the sewerage system will generate spare capacity in the existing treatment facilities to help accommodate future growth.

- The per capita consumption which appears to have been used for the calculations is over 222 litres per head per day. This compares to a more typical figure for the UK of 150 litres per head per day. Adoption of a lower per capita consumption will further reduce the size of the total treatment plant capacity required to deal with future needs.

- No information is contained within the FSR regarding the treatment technologies which have been considered for the Ringsend treatment plant. It is therefore not clear whether the best available technologies including low footprint and high rate technologies have been fully considered to maximise use of land which may be available.

- We do not consider that it is valid to dismiss all of the other options on technical grounds when the total flow in the catchments has been significantly over-estimated through the per-capita consumption, and the reduction of very high levels of misconnection and infiltration have not been considered. We consider that were this assessment to be made, the capacity at Ringsend could be maximised, and there is a likelihood that the additional large works (currently

proposed for Portrane) will not be required, and the range of options for a smaller additional provision will change.

- Addressing the I/I/E issues will have significant environmental benefits including the reduction of additional treatment capacity and the elimination of groundwater contamination. Reducing the industrial and per capita consumptions, maximising the capacity of the existing drainage through the separation of misconnections and infiltration, and minimising the requirement for additional treatment capacity is clearly the more environmentally sustainable approach, as compared to the provision of very large additional treatment works.

- We consider that all of the above factors should be carefully reviewed to ensure that the future needs for the Greater Dublin catchments are justified, and environmentally sustainable.

Greater Dublin Drainage Project

SID Application

ABP Case file 312131

Appendix Reference:

Appendix Description:

Sabrina Joyce-Kemper submission 7th June 2024

Iarnród Éireann
Irish Rail
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An Bord Pleanála
Strategic Housing Unit
64 Marlborough Street
Dublin 1
D01 V902

Date: 24 December 2021
Our ref: 3237/21/8
Your ref: TA06F.312112

Re: Portmarnock South Phase 1D - Station Road, Portmarnock, Townlands of Drumnigh, Maynetown and Portmarnock, Co. Dublin. 172 No. residential units (150 No. houses, 22 No. apartments) and associated site works.

Dear Sirs,

In relation to the above proposed Strategic Housing Development, I wish to advise that on behalf of the Board of Iarnród Éireann, a Prescribed Body under the Planning & Development Regulations 2006, Article 28.(1).(j & w), we would like to make the following observations:

1) The Railway Safety Act 2005 places an obligation on all persons carrying out any works on or near the railway to ensure that there is no increase in risk to the railway as a consequence of these works. Because of the proximity of the site to the Railway, the Developer must take into account this obligation in Design, Construction and Operation of the development. The proposed development has the potential to significantly impact the safety of the operational railway. The Applicant must engage with Iarnród Éireann seeking advice on technical requirements for mitigating impacts on railway infrastructure and operations.

2) The proposed development lies directly adjacent to, and east of, the Dublin - Belfast Railway line over a linear length of approximately 200 metres between overbridge UBB20 to the South and Portmarnock Station to the North. The site boundary shown on the plan drawings assumes that the property boundary to railway lands corresponds with OSi mapping. This approach is unreliable and does not take account of the historical drainage channels running parallel to the railway at the crest of the cutting which fall within the original land take for the railway corridor. It is therefore probable that the proposed development encroaches onto CIÉ/Iarnród Éireann lands. It is noted that the drawings provided by the applicant under the heading of Architectural Drawings do not specify a dimension between any new boundary wall and the track, or alternatively GPS coordinates for the line of the wall that would allow for comparison with the Railway's records for the boundary line along this section. The Applicant should engage with Iarnród Éireann and provide detailed cross sections with a view to agreeing the line of the proposed boundary treatment

Cathaoirleach Chairman - F Allen, **Stiúrthóirí** Directors: S Byrne, C Griffiths (UK), D Guinan, V Little, M McGreevy (UK), Dr. P Mulholland, S Roarty, T Wynne; **Príomh Fheidhmeannach** Chief Executive: J Meade
Iarnród Éireann – Irish Rail, cuideachta ghníomhaíochta ainmnithe, faoi theorainn scaireanna, cláraithe in Éirinn ag Stáisiún Uí Chonghaile, Baile Átha Cliath 1, Ur. 119571 Ur. CBL: IE 4812851 O
Iarnród Éireann – Irish Rail, a designated activity company, limited by shares, registered in Ireland at Connolly Station, Dublin 1, No. 119571 VAT No. IE 4812851 O

3) The DART+ Coastal Project (Northern Line) is underway and is currently at Phase 2 Project Concept, Feasibility & Option Selection. The works will involve track modifications to improve capacity, the installation of trackside overhead line equipment, construction of electrical substations including access roads, modifications to rail bridges, and any other modifications required to existing permanent way or railway systems infrastructure. An optioneering study to determine those works is on-going and this may determine the requirement for railway infrastructure additions or modifications in the vicinity of this proposed development. As a consequence of the estimated land take required to facilitate a works corridor for the track and bridge upgrade, no development is to take place within an area 25m East of the nearest running edge of the rail without the written permission of Iarnród Éireann. This also includes the positioning of any access road, Soakholes / Percolation areas. The Developer should consult with IÉ in relation to the output of this option selection study together with all other aspects of the DART+ Coastal Project.

4) The planning documentation makes no reference to how the ground levels of the development may alter the existing ground levels adjacent to the track boundary. Iarnród Éireann will require a detailed submission of the proposed new topography including an engineering assessment of the proposed drainage provisions. This will need to be approved by Iarnród Éireann prior to commencement of works.

5) The integrity and functionality of the existing historical drainage channel running parallel to the railway at the crest of the cutting must not be affected by any temporary or permanent works or landscaping. Iarnród Éireann have had serious instances of slope failure in the past due to third party works at the crest of cuttings. Photo 1. below shows an example of a derailment in Co. Wicklow caused by third party works at the crest of a cutting.



Photo 1 - Derailment in Co. Wicklow caused by third party works at the crest of a cutting.

6) The development may not undermine the integrity of the embankment supporting the structure UBB20A (a culvert) and Overbridge OBB21, for which Iarnrod Eireann has a statutory obligation to maintain. It must be noted that the approach and embankments to OBB21 are in full ownership of CIE. This is clearly set out in Section 46 of the Railway Clauses Consolidation Act 1845. Any works proposed to the approach road and embankments adjacent to the bridge including resurfacing, landscaping, laying of ducts or services etc will require written consent from CIE/Irish Rail.

7) In keeping with a residential development of this scale and density a 2.4m high appropriately designed, solid block/concrete boundary treatment, should be erected by the applicant on the applicants' side of the boundary to the Railway. The maintenance of this boundary treatment rests with the Applicant and Successor-in-Title. It is noted that the planning documentation refers to the existing boundary fence being retained, this is not in keeping with the access and security issues associated with a development of this scale and type. As mentioned previously the exact location and details of the boundary treatment are to be identified on site in co-operation with this office.

8) The landscaping plan should avoid locating deciduous trees along the railway boundary. This is to reduce the risk of low rail adhesion during leaf fall season which can have a detrimental impact on the breaking performance of trains on approach to signals and station platforms. Trees placed close to the boundary can also block sight lines to signals. The Applicant must engage with Iarnród Éireann to agree on the landscaping plan for this portion of the development.

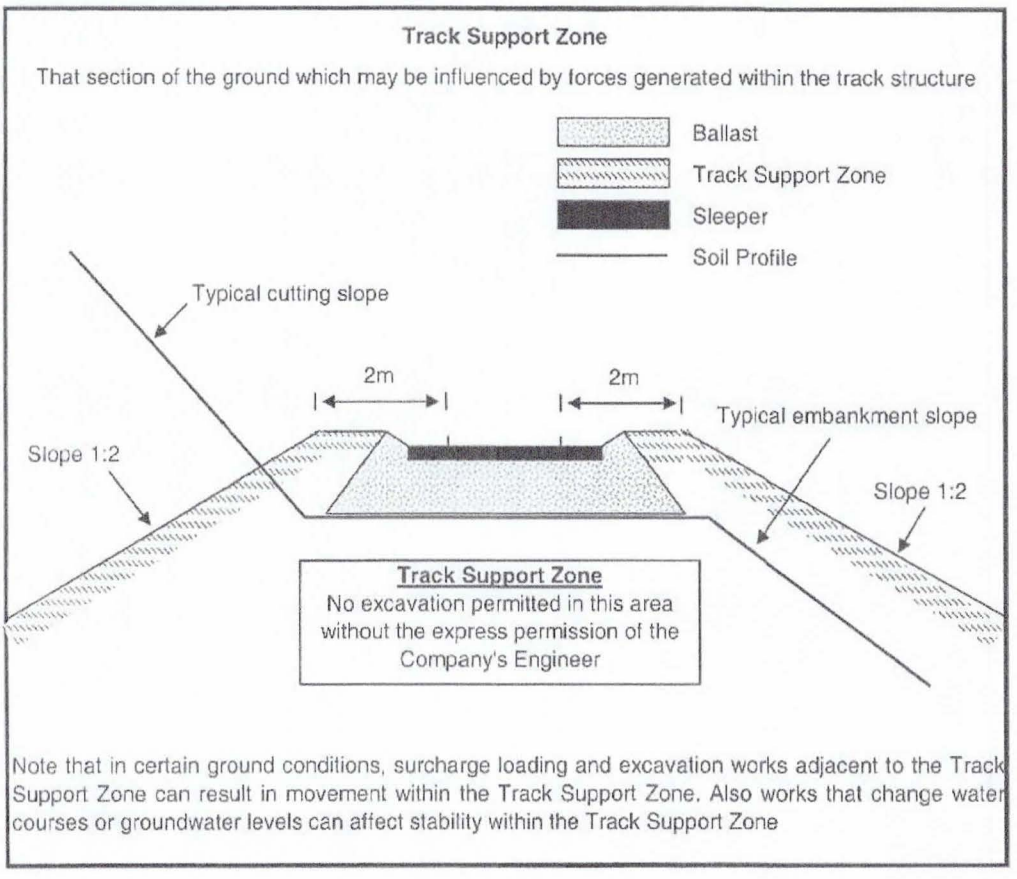
9) Provision must be made for maintaining the security of the railway boundary during the construction phase and the agreed permanent boundary treatment should be completed during the early stages of the development.

10) Access for Iarnród Éireann staff to culverts / bridges under the Railway should not be hindered.

11) Railway mounds and drainage ditches are to be preserved except where the written consent of Senior Track & Structures Engineer, Iarnród Eireann, Pearse Stn, Westland Row, Dublin 2, has been sought and received. Refer to observation 2 & 7 above with regard to the property line.

12) No additional liquid, either surface water or effluent shall be discharged to, or allow to seep onto, the railway property or into railway drains / ditches.

13) Any excavations which infringe upon the Track Support Zone will require permission and approval from the Senior Track & Structures Engineer. This relates to all excavations along the railway boundary for this development.



14) No building shall be constructed within 4m of the Boundary Treatment on the applicants' side. This is to allow for the applicant to maintain his / her building, without the need to enter Board Property. Refer to observation 5 above.

15) Should the development require the use of a crane that could swing over the railway property, then the Applicant must enter into an agreement with Iarnród Éireann / C.I.É. regarding this issue.

16) Any proposed services that are required to cross along, over or under the railway property must be the subject of a wayleave agreement with Iarnród Éireann / C.I.É

17) No overhang of any part of the development over the railway property is to be allowed.

18) Lights from the proposed development, either during the construction phase or when the development is completed, should not cause glint or glare or in any way impair the vision of train drivers or personnel operating on track machines. A glint and glare survey should be carried out to confirm this is the case.

19) The railway operates 24 hours a day with maintenance activity taking place at night and during shutdowns of passenger services. The development is in close proximity to the live railway and therefore must take account of the potential noise and vibration impact that an operational railway may have on sensitive receptors. Residential units should be designed, orientated and located to limit the impacts of noise and vibration from transportation traffic and maintenance activities. It is recommended that the Applicant incorporates best practice principles in the design using BS8233 - Guidance on Sound Insulation and Noise Reduction for Buildings. The Applicant must refer to the local authority's Noise Action Plan regarding development adjacent railways and where appropriate carry out a noise risk assessment to inform an Acoustic Design Statement (ADS). The detail of the ADS should be commensurate with the level of risk identified in the noise risk assessment. The Applicant must take responsibility for specifying necessary mitigation measures where noise thresholds are expected to be exceeded. The noise assessment should consider a number of scenarios, including the following:

- within the development with windows closed;
- within the development with windows open; and
- exterior of development within private or communal gardens.

20) It should also be noted by the Applicant that a height restricted bridge under the railway exists on the R123 (Mayne Road). The clearance beneath underbridge UBB20 is approximately 3.85m. During the construction phase of the project, a proper traffic management plan should be drawn up to prevent construction traffic from having to traverse under bridge UBB20. The Applicant must ensure that no over-height vehicles attempt to pass under this bridge and that the routes for all high vehicle movements are planned. A fuller listing of our bridges can be found at the following web site http://www.irishrail.ie/about-us/infrastructure.

21) Prior to any works that could disrupt road traffic being carried out in the vicinity of railway underbridge UBB20, the Roads Authority of Fingal County Council shall comply with its statutory duty under Sections 113, part 1, 2 and 3 of the Railway Safety Act 2005 and provide Iarnród Éireann with 21 days written notice of intended works. Accordingly, the Developer will have to provide sufficient notice to the Roads Authority in order to do this.

Therefore, the Planning Authority may decide to condition the developer to provide sufficient notice as contravention of this section of the Act could lead to prosecution of any person in the Roads Authority who is found to be in breach of this statutory requirement. Section 113 refers to fines and offences under the Act.

22) There is increased potential for vehicular impact at Underbridge UBB20 on the R123 due to the proposed increase in trips generated by the applicant's development and adjacent developments. The Traffic Impact Assessment does not comment on what impact the proposals will have for traffic passing through the narrow bridge. The Applicant must engage with Iarnród Éireann and Fingal County Council to agree on possible traffic easing measures to mitigate the collision potential at the bridge.

These observations are made in the interests of safety in operation of the railway, and we recommend that the above points be made to the applicant and be a condition of planning should the planning application succeed.

Yours faithfully,

pp

D. Gannon

Senior Track & Structures Engineer