Appendix 16

Flood Risk Assessment

Appendix 13.4

Flood Risk Assessment

Indaver

Ringaskiddy Resource Recovery Centre

Flood Risk Assessment

238129_REP/1_FRA

Issue 2 | 1 April 2019

This report takes into account the particular instructions and requirements of our client.

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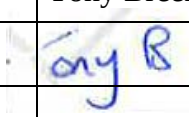
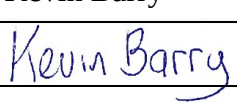
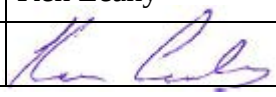
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Executive Summary

Indaver proposes to develop a resource recovery centre in Ringaskiddy in County Cork. The proposed development will include a waste-to-energy facility for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility.

In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby beach and an amenity walkway to the Ringaskiddy Martello tower

A flood risk assessment is required as part of the planning application of the project. This report details the flood risk assessment carried out by Arup. It has been undertaken in accordance with the Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

The site for the Ringaskiddy Resource Recovery Centre is located approximately 15km to the south-east of Cork City, in the townland of Ringaskiddy on the Ringaskiddy Peninsula in the lower part of Cork harbour. The site occupies an area of approximately 13.55 hectares and is approximately 800m east of the village of Ringaskiddy. The L2545, the main road from Ringaskiddy village to Haulbowline Island forms the northern boundary of the site. The eastern boundary of the site extends to the foreshore of Cork harbour along Gobby Beach. The lands to the immediate south and west are in agricultural use. The site surrounds the Hammond Lane Metal Recycling Co Ltd facility.

In broad terms, the potential sources of flooding to the site at Ringaskiddy can be categorised as follows Tidal/Coastal Flooding, Pluvial Flooding, Groundwater Flooding and Urban Drainage. Given the site's proximity to Cork Harbour, the main source of potential flooding at the site is tidal.

Given the absence of any significant watercourse from the site the risk of fluvial flooding is remote.

Based on a review of all available information, the predicted 1 in 200 year design tidal level for the site and adjacent L2545 has been estimated as 2.73mOD. Sections of the road close to the Gobby beach car park are below this level and are therefore at risk of tidal flooding during a 1 in 200 year tidal event.

There is a risk of pluvial flooding to the L2545 and the low lying areas of the site during periods of heavy rainfall due to an insufficient drainage network and tide locking of the existing drainage outfall.

Small areas of the site along the northern boundary are also below the predicted 1 in 200 year design tidal level (2.73mOD). The majority of the site is above 2.73mOD.

There is a low risk of groundwater flooding of the site.

The subject site is not indicated as being within the design 1000 year tidal floodplain. Consequently the site is classified as lying within Flood Zone C.

The minimum design flood defence level of the proposed development has been calculated as 3.8mOD Malin. Arup however has proposed a far more conservative flood defence level of 4.55mOD Malin for the site. This level offers a very high standard of flood protection to the site.

It is proposed to raise the footprint of the entire site to the proposed site flood defence level of 4.55mOD. This includes all internal roads, car parking area and all associated site works. This measure will ensure that the risk of flooding to the site is remote. The finished floor level of the buildings on the site will be set at even more conservative levels – the administration building and ESB substation will be set at 5.0mOD Malin while the floor level of the main process building varies from 5.0m to 7.0mOD Malin. The Turbine and Aero-Condenser buildings will be set at 11mOD Malin.

It is proposed to upgrade the L2545 to address the risk of flooding of the road. The upgrade works will include raising a 185m section of the road to a maximum height of 3.45mOD between the car park adjacent to Gobby Beach and the eastern end of the Hammond Lane Metal Company site. This is approximately 1.0m above the existing road level. This will elevate the road to above the 200 year design tidal water level plus an allowance for climate change. This will offer a high level of protection to the road from tidal flooding and ensure that access and egress routes are maintained during extreme flood events.

A new dedicated surface water drainage system will also be installed as part of the upgrade works to collect, convey and attenuate the runoff from the road before connecting back into the existing drainage to discharge to the foreshore.

These measures are sufficient to ensure that the risk of flooding of the site and the L2545 is extremely low.

It is considered that the proposed resource recovery centre at Ringaskiddy should be classified as a “Highly Vulnerable Development” as per the vulnerability classification. As the site is classified as Flood Zone C, a Justification Test is not required for the proposed development and it is necessary only to identify mitigation measures for any residual risks.

A wave modelling and erosion study of the area of the subject site was undertaken by Arup in 2015 and is detailed in the Coastal Erosion Report submitted as part of this planning application.

Based on the results from the modelling and the protected location of the site it was concluded that wave conditions in the nearshore area are sufficiently low to potentially allow for the use of an appropriate ‘soft’ coastal solution to protect the toe and base of the glacial till cliffs from wave action.

1 Introduction and background

1.1 Project background

Indaver proposes to develop a resource recovery centre in Ringaskiddy in County Cork. The proposed development will include a waste-to-energy facility (incinerator) for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility.

In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby beach and an amenity walkway to the Ringaskiddy Martello tower.

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1.2 Scope of study

Following best practice in undertaking flood risk, the study includes the following:

- Review of all relevant information and data, as outlined in Section 1.3 below;
- Review the risk of fluvial, tidal, groundwater and pluvial flooding;
- Review of access/egress routes to the site;
- Review of available Site Investigation data;
- Recommendations on a suitable site flood defence level, taking account of climate change and freeboard;
- Development of potential mitigation measures (if necessary);
- Commentary on any residual risk;
- Preparation of a Flood Risk Assessment Report.

1.3 Summary of data used and assumptions made

In preparing this report, the following data was collated and reviewed:

- Review and analysis of relevant reports from the Lee CFRAM Study, January 2014 (available to download from http://www.leecframs.ie/)
- Predicted extreme water levels and flood extent maps from the Irish Coastal Protection Strategy Study (ICPSS), May 2011. These are available from the website of the Office of Public Works (www.opw.ie);

- Flood history of the site from the OPW National Flood Hazard Mapping website (www.floodmaps.ie);
- Preliminary Flood Risk Assessment (PFRA) Mapping produced by the OPW, March 2012 (www.cfram.ie/pfra);
- Site Geological and hydrogeological data from the Geological Survey of Ireland website (www.gsi.ie) (note: datasets accessed on October 2015);
- Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG);
- Relevant information from the Ringaskiddy Waste to Energy Facility – EIS Coastal Recession and Sea Flooding Assessment (published in 2008);
- Coastal Erosion Report (Arup 2015) included in the Indaver Ringaskiddy Resource Recovery Centre EIS;
- Results from the Site Investigation carried out at the subject site in 2000 and 2001;
- Aerial photography and mapping from Google Maps (2015);
- Water level data from a number of periods from the gauge maintained at Cobh by the Port of Cork;
- Ringaskiddy Resource Recovery Centre planning application site layout drawings for the proposed development;
- The available topographical survey information for the site (2014).

All Ordnance Datum (OD) levels referred to in this report are to Malin Head Ordnance Datum unless otherwise stated.

1.4 Site description and proposed development

1.4.1 Site Description

The site for the Ringaskiddy Resource Recovery Centre is located approximately 15km to the south-east of Cork City, in the townland of Ringaskiddy on the Ringaskiddy Peninsula in the lower part of Cork harbour. The site occupies an area of approximately 13.55 hectares and is approximately 800m east of the village of Ringaskiddy. Refer to Figure 1 below.

The L2545, the main road from Ringaskiddy village to Haulbowline Island forms the northern boundary of the site. The eastern boundary of the site extends to the foreshore of Cork harbour along Gobby Beach. The site surrounds the Hammond Lane Metal Recycling Co Ltd facility. The site is relatively level to the immediate south of the L2545 road and rises up steeply to the south. At the top of this steep scarp the ground rises more gently to the southern site boundary along the top of the ridge.

The National Maritime College of Ireland and the Beaufort Research Laboratory (UCC) are located to the North of the site. Access to these premises is from the existing L2545 road.

Figure 2 presents an outline of the site.



Figure 1: Location of the existing Indaver site

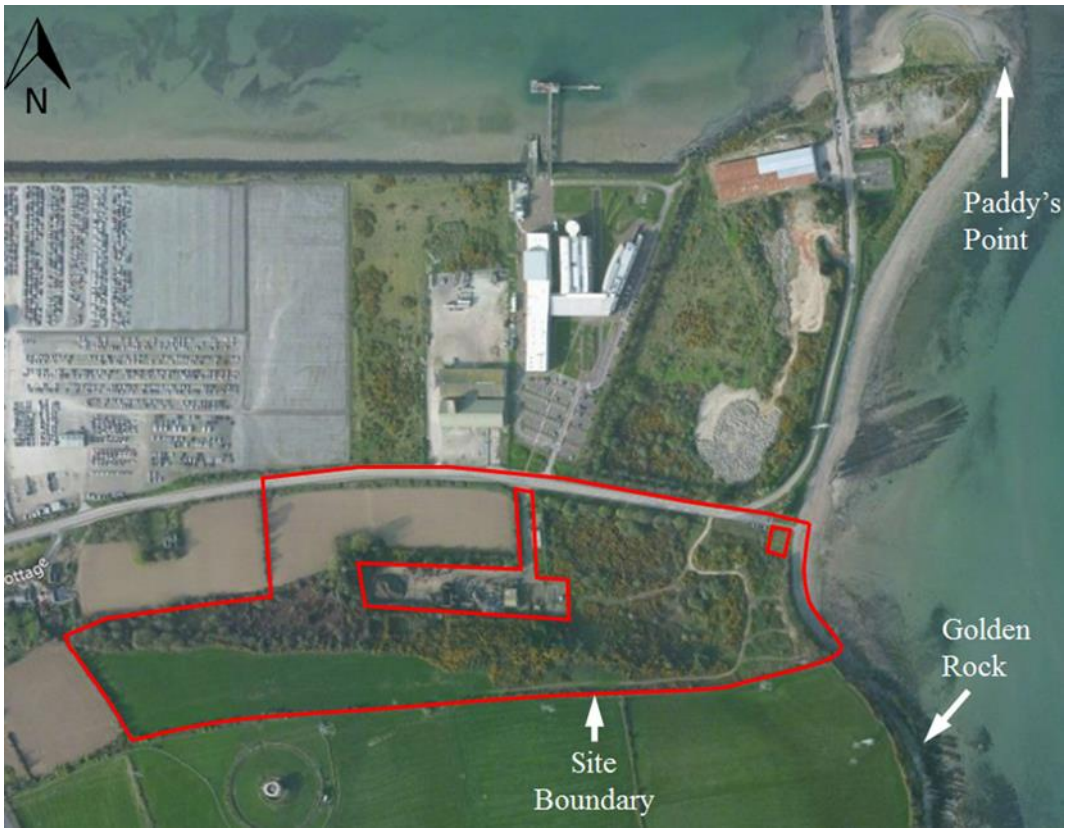


Figure 2: Outline of the existing Indaver site

The ground levels of the site vary considerably in both the North-South direction and the East-West direction. In the South of the site the levels vary from circa 10m OD to circa 41mOD. In the North of the site the ground levels vary from circa 2.05mOD to circa 4.0mOD. The level at the eastern end of the side bordering Gobby Beach is circa 3.25m OD. The level of the existing access road (L2545) to the North of the site is set at circa 2.6m to 2.95mOD.

Figure 3 presents the ground contours of the site. The image has been annotated with spot heights which present the existing ground levels.

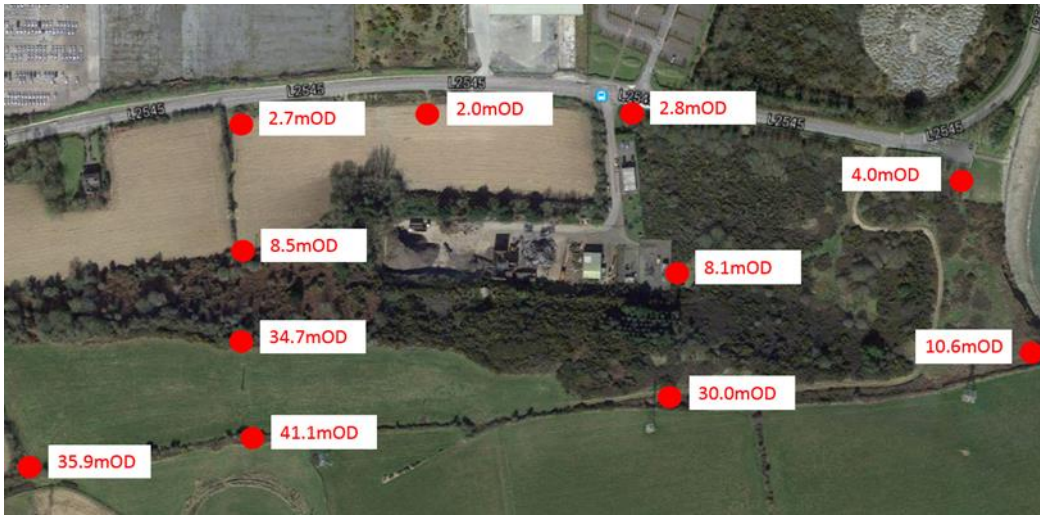


Figure 3: Existing ground contours and ground levels of the site

1.4.2 Proposed development

The proposed development will include a waste-to-energy facility (incinerator) for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility. In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby beach and an amenity walkway to the Ringaskiddy Martello tower.

The coastal protection measures proposed along the eastern boundary of the Indaver site will consist of the placement of shingle above the foreshore along the section of Gobby beach within Indaver ownership. This shingle will act as beach nourishment on the beach and will slow the retreat rate of the glacial till cliff.

Further details on the coastal protection measures are provided in Section 7.7 of this report and the Environmental Impact Statement which accompanies the planning application. The main elements of the proposed development include:

- Main process building;
- Turbine hall and aero-condenser structure;
- Security building/gate house;
- Administration building;
- Firewater storage and pump house;
- Firewater retention tank and storm water retention tank;
- Weigh bridges;
- Electricity substation, compound and grid connection;
- Light fuel oil storage tank;
- Emergency access;

- Public amenity footpath;
- Increase in ground levels
- L2545 road upgrade;
- Coastal protection measures;
- Diversion of services;
- Grid connection;



Figure 4: Outline of the proposed development

2 Planning context

The following planning policy documents are relevant to the assessment of this proposed development:

- The national planning guidelines published by the OPW and the Department of the Environment, Heritage and Local Government in November 2009 entitled 'The Planning System and Flood Risk Management: Guidelines for Planning Authorities' are particularly pertinent and are discussed in Section 2.1.1 below.
- In terms of planning policy context, the provisions contained in the following document are relevant:
  - Cork County Development Plan 2014 - 2020;
  - Ballincollig Carrigaline Municipal District Local Area Plan, August 2017

2.1 The planning system and flood risk management guidelines

2.1.1 Introduction

In November 2009, the Department of Environment, Heritage and Local Government and the Office of Public works jointly published a Guidance Document for Planning Authorities entitled "the Planning System and Flood Risk Management".

The guidelines are issued under Section 28 of the Planning and Development Act 2000. Planning Authorities and An Bord Pleanála are therefore required to implement these Guidelines in carrying out their functions under the Planning Acts.

The aim of the guidelines is to ensure that flood risk is neither created nor increased by inappropriate development.

The guidelines require the planning system to avoid development in areas at risk of flooding, unless they can be justified on wider sustainability grounds, where the risk can be reduced or managed to an acceptable level.

They require the adoption of a Sequential Approach (to Flood Risk Management) of Avoidance, Reduction, Justification and Mitigation and they require the incorporation of Flood Risk Assessment into the process of making decisions on planning applications and planning appeals.

Fundamental to the guidelines is the introduction of flood risk zoning and the classifications of different types of development having regard to their vulnerability.

The management of flood risk is now a key element of any development proposal in an area of potential flood risk and should therefore be addressed as early as possible in the site master planning stage.

2.1.2 Definition of flood zones

Flood Zones are geographical areas within which the likelihood of flooding is in a particular range.

There are three types of flood zones defined in the Guidelines as follows:

Flood Zone A	Probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding).
Flood Zone B	Probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 year and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding); and
Flood Zone C	Probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas which are not in zones A or B.

2.1.3 Definition of vulnerability classes

The following table summarises the Vulnerability Classes defined in the Guidelines and provides a sample of the most common type of development applicable to each.

Highly vulnerable development	Includes Garda, ambulance and fire stations, hospitals, schools, residential dwellings, residential institutions, essential infrastructure, such as primary transport and utilities distribution and SEVESO and IPPC sites, etc.
Less vulnerable development	Includes retail, leisure, warehousing, commercial, industrial and non-residential institutions, etc.
Water compatible development	Includes Flood Control Infrastructure, docks, marinas, wharves, navigation facilities, water based recreation facilities, amenity open spaces and outdoor sport and recreation facilities

2.1.4 Types of vulnerability class appropriate to each zone

The following table illustrates the different types of Vulnerability Class appropriate to each Zone and indicates where a Justification Test will be required.

	Flood Zone A	**Flood Zone B**	**Flood Zone C**
Highly vulnerable	Justification test	Justification test	Appropriate
Less vulnerable	Justification test	Appropriate	Appropriate
Water compatible	Appropriate	Appropriate	Appropriate

2.2 The Cork County Development Plan 2014 - 2020

The Cork County Council Development Plan 2014 - 2020 sets out Cork County Council's overall strategy for the proper planning and sustainable development of Cork County over a 6 year period.

The plan seeks to secure the development and improvement in a sustainable manner of the economic, environmental, cultural and social assets of the County. The plan governs the functional area of Cork County Council excluding the areas governed by the City Council.

A County wide Strategic Flood Risk Assessment (SFRA) was undertaken as part of the Development Plan and was prepared in accordance with 'The Planning System and Flood Risk Management Guidelines (OPW, 2009).

The plan makes specific reference to the Lee CFRAM Study and how its findings will be used to identify areas at risk of flooding (Flood Zone A, Flood Zone B and Flood Zone C) in the County in additional to the findings of the PFRA mapping.

The Cork County Development plan's flood risk objectives are reproduced in the following figure.

County Development Plan Objective
WS 6-1: Flood Risks – Overall Approach

Take the following approach in order to reduce the risk of new development being affected by possible future flooding:

- Avoid development in areas at risk of flooding; and
- Where development in floodplains cannot be avoided, to take a sequential approach to flood risk management based on avoidance, reduction and mitigation of risk.

In areas where there is a high probability of flooding - 'Zone A' - it is an objective of this plan to avoid development other than 'water compatible development' as described in Section 3 of 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' issued in November 2009 by DoEHLG.

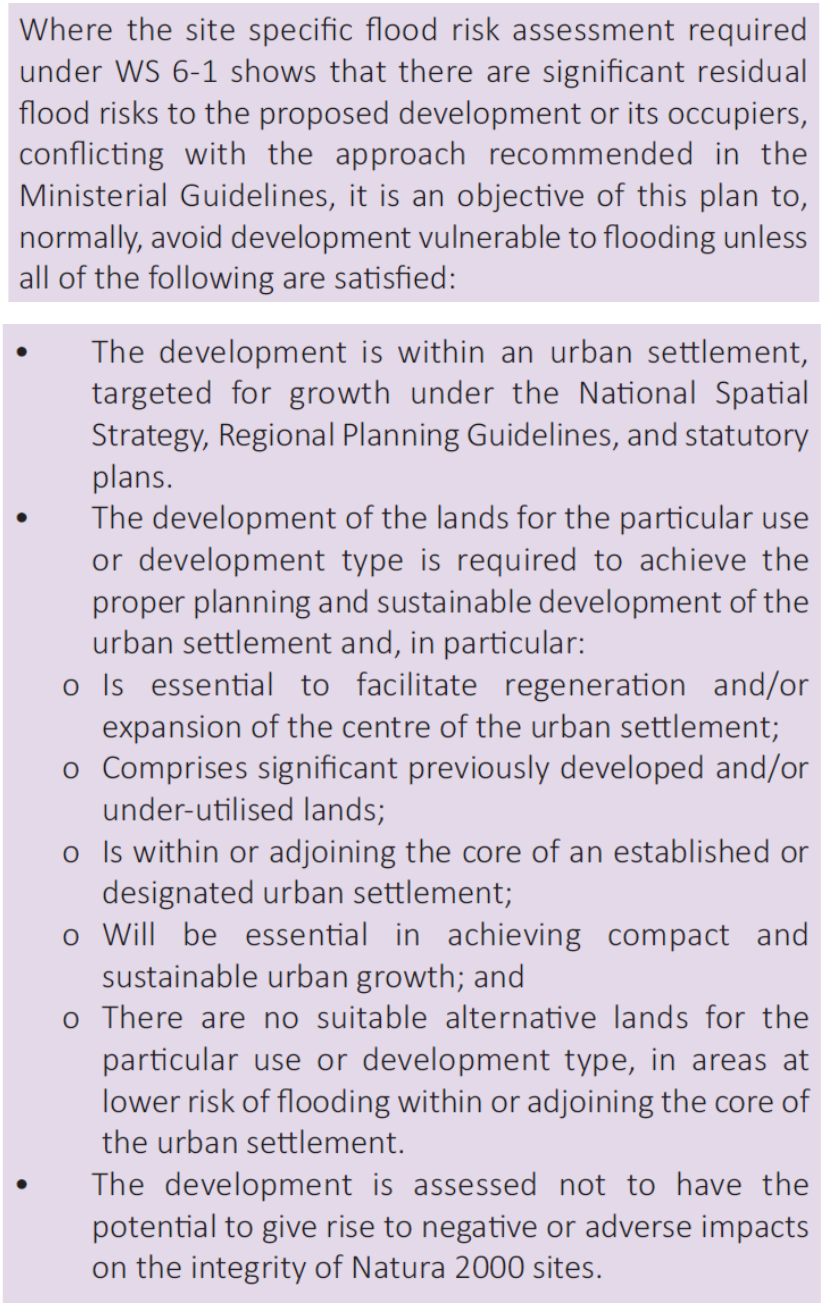
In areas where there is a moderate probability of flooding - 'Zone B' - it is an objective of this plan to avoid 'highly vulnerable development' described in section 3 of 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' issued in November 2009 by DoEHLG.

Implement the recommendations of the South Western CFRAM study.

County Development Plan Objective
WS 6-2: Development in Flood Risk Areas

Ensure that all proposals for development falling within flood zones 'A' or 'B' are consistent with the Ministerial Guidelines – 'The Planning System and Flood Risk Management. In order to achieve this, proposals for development identified as being at risk from flooding will need to be supported by a site-specific flood risk assessment prepared in line with Paragraph 11.6.16 of this plan.

Where the planning authority is satisfied that it can be satisfactorily shown in the site-specific flood risk assessment required under objective WS 6-1 that the proposed development, and its infrastructure, will avoid significant risks of flooding in line with the priciples set out in the Ministerial Guidelines, then, subject to other relevant proper planning considerations, permission may be granted for the development.


Where the site specific flood risk assessment required under WS 6-1 shows that there are significant residual flood risks to the proposed development or its occupiers, conflicting with the approach recommended in the Ministerial Guidelines, it is an objective of this plan to, normally, avoid development vulnerable to flooding unless all of the following are satisfied:

- The development is within an urban settlement, targeted for growth under the National Spatial Strategy, Regional Planning Guidelines, and statutory plans.
- The development of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in particular:
  - Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement;
  - Comprises significant previously developed and/or under-utilised lands;
  - Is within or adjoining the core of an established or designated urban settlement;
  - Will be essential in achieving compact and sustainable urban growth; and
  - There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.
- The development is assessed not to have the potential to give rise to negative or adverse impacts on the integrity of Natura 2000 sites.

Figure 5 Extract From Cork County Council's Development Plan 2014-2020

2.3 Ballincollig Carrigaline Municipal District Local Area Plan, August 2017

The Ballincollig Carrigaline Municipal District Local Area Plan (August 2017) sets out a detailed planning framework to ensure sustainable development of the environs of Carrigaline which includes Ringaskiddy. It details proposals for the delivery of the physical, social and environmental infrastructure necessary to sustain the communities of the area in the future. A strategic flood risk assessment is included as part of the development plan.

The plan states:

"Ringaskiddy is designated as a Strategic Employment Centre within the County Metropolitan Strategic Planning Area and has developed into one of the most significant employment areas in the Country. The objective for Ringaskiddy is set out in EE 4-1 of the County Development Plan 2014 where the stated aim is to promote the development of Ringaskiddy as Strategic Employment Area suitable for large scale industrial developments which is compatible with relevant environment, nature and landscape protection policies as they apply around Cork Harbour.

Figure 6 presents the planning zones for the Carrigaline area as set out in the LAP. It can be seen that the site is zoned for industry. The specific zoning objective for the site (RY-I-15) is detailed in the LAP as:

"Suitable for large standalone industry with suitable provision for landscaping and access points from the R613 and provision for appropriate landscape buffering to all residential areas".

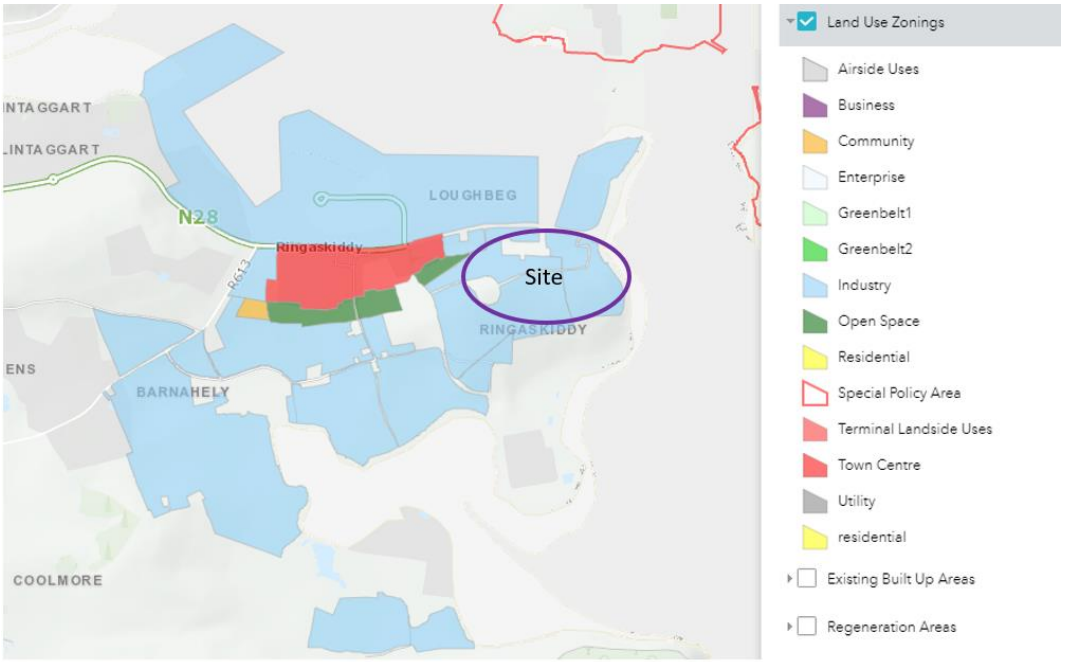


Figure 6: Planning zones for the Carrigaline area as set out in the LAP

A strategic flood risk assessment (SFRA) was carried out as part of the Cork County Development Plan. The SFRA amalgamated flood extent information from three separate sources into a single 'Indicative Flood Extent Map' of the area:

- Floodmaps produced by the Lee CFRAM Study;
- Data presented on OPW's National Flood Hazard Mapping website floodmaps.ie;

- Flood Hazard Mapping – Flood extent mapping undertaken by Cork County Council for areas where the more detailed Lee CFRAM Study maps are not available;

The 'Indicative Flood Extent Map' was used to derive the Flood Zone Classifications for the area and is presented in with the Planning Zones. It can be seen from Figure 7 that the subject site is not indicated as lying within Flood Zone A or B. It is therefore classified in the LAP as lying within Flood Zone C. The implications of this are discussed later in this report in Section 8.



Figure 7: Indicative Flood Extent Map

3 Overview of flood hazard and historic flooding

3.1 Overview

In broad terms, the potential sources of flooding to the site at Ringaskiddy can be categorised as follows:

- Tidal/Coastal Flooding;
- Pluvial Flooding;
- Groundwater Flooding; and
- Urban Drainage.

Given the site's proximity to Cork Harbour, the main source of potential flooding at the site is tidal which is considered in the following section of the report.

Other sources of flood risk are discussed in Section 5.

The risk of flooding from wave overtopping is considered to be very low for the site given the relatively small design wave heights incident on the site. The reader is referred to the Coastal Erosion Report that forms part of this planning application for a detailed description of the wave modelling work undertaken by Arup. Flooding from wave overtopping is therefore not considered as part of this FRA.

3.2 Historic flooding of the site and access road

3.2.1 Review of data from OPW's 'floodmaps.ie' website

Reports and maps from the OPW website www.floodmaps.ie have been examined at the time of writing of this report (2015) as part of this flood risk assessment. Given the absence of any flood defences or arterial drainage schemes at the subject site, the Land Commission Maps, Benefitting Land Maps and Drainage District Maps presented on the website are not relevant to this FRA.

There is however a number of post-flood event reports which detail some of the flood events in the area. Reports from two tidal flood events are presented as follows:

1. February 2014 surge event
2. October 2004 surge event

These are discussed in more detail below.

3.2.2 February 2014 event

On the 3rd and 4th of February 2014, a surge event occurred around the Irish coast leading to coastal flooding at a number of locations.

A short description of the flooding experiened in Ringaskiddy is provided in one of the post flood event reports. It states:

"Floodwater extended approx. 60m from the car park at end of local road (L2545) and was approximately 13 – 15 inches deep. No properties were flooded as part of this event. Access to Haulbowline was shut off."

It is noted that the report does not indicate the likely return period of the event.

A map highlighting the location of the flood event is also provided in the flood report and it is reproduced in Figure 8 below. It is noted that the figure has a label stating "Extents of Flood Waters" but there is no actual flood extent presented on the figure.



Figure 8: Flood location map for the February 2014 event extracted from the Flood maps website.

The flood report does not explicitly state that the southern end of the Indaver site was flooded in this event.

To determine the magnitude of this event Arup obtained data from the water level gauge at Cobh which is maintained by the Port of Cork. Recordings from this gauge are presented in Figure 9 below. It can be seen from the plot that the maximum water level for the event was 2.42mOD and it was recorded at 07:09am on 03 February 2014.

It is noted that the lowest level of the road in the vicinity of the Gobby Beach car park is approximately 2.4mOD and the level of the car park is between 2.7mOD and 2.8mOD

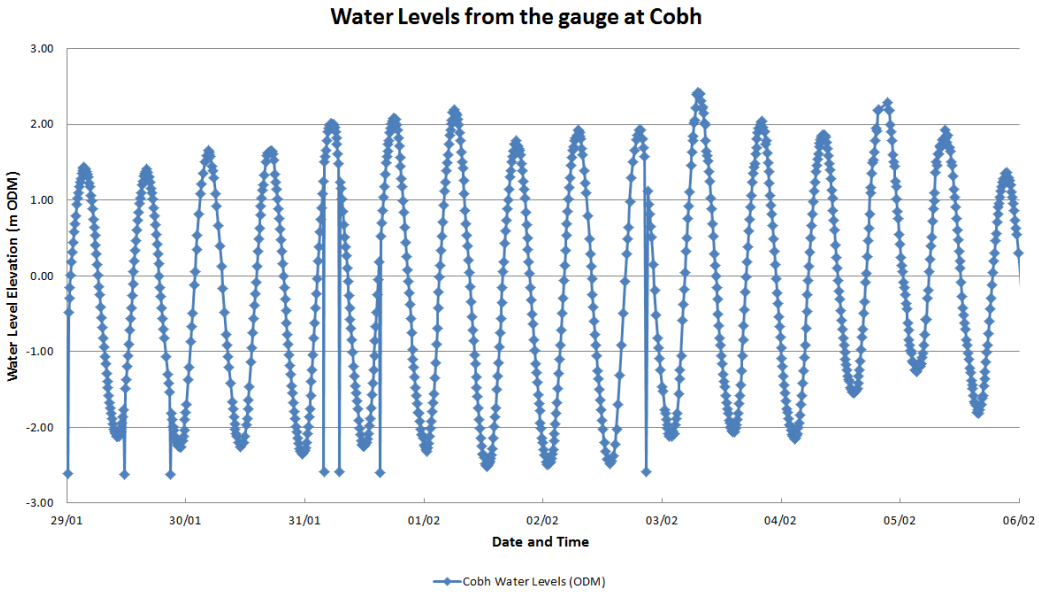


Figure 9: Water level data from the gauge at Cobh. This data was provided by the Port of Cork in 2014.

3.2.3 October 2004 event

A surge event also occurred around the Irish coast on the 27 October 2004. The impact of this event on the Ringaskiddy area is provided in one of the post flood event reports. It states:

"The surface of the car park has been significantly damaged, and part of the sea wall has been washed away."

This car park corresponds to the area that experienced flooding in the February 2014 coastal flood event as detailed in the previous section.

It was stated that the recorded water level at Cobh for the event was 2.66m ODM. It was also stated that the Nautical Almanac suggests that the tide in Ringaskiddy is 0.1m above the level of the tide in Cobh giving an approximate value of 2.76m ODM at Ringaskiddy for the October 2004 event. It is noted that the lowest level of the road in the vicinity of the Gobby Beach car park is approximately 2.4mOD and the level of the car park is between 2.7mOD and 2.8mOD

A number of photographs of the aftermath of the event are also provided in the flood reports available from floodmaps.ie and are reproduced in the following figures:

- Figure 10 shows the local road (L2545) flooded;
- Figure 11 shows part of the subject site to the west of Hammond Lane flooded. This area is indicated on plan view in Figure 12.

It is not stated at what time these photographs were taken, so it is not possible to determine the maximum extent of flooding at the peak of the tidal event.

It is noted that only photos from the 2004 event are provided on floodmaps.ie. There are no photos provided of the 2014 event.



Figure 10: L2545 road adjacent to Indaver site shown as flooded after the 2004 event



Figure 11: Part of the Indaver site (western fields) to the west of Hammond Lane shown flooded after the 2004 event



Figure 12: Location of the flood extent in western fields area (blue shading) presented in **Figure 11**.

3.2.4 Other historic flooding events at the site

In addition to the recorded flood events as presented on floodmaps.ie, Arup have obtained information on two other flood events in the vicinity of the site:

- A tidal flood event in the Cork area in 1994 caused pluvial flooding to the site and the L2545 roadway. No further information is available on this storm event.
- The site was subject to flooding in December 2015 as a consequence of Storm Frank passing over Ireland. A high tide level of 2.09m was recorded at Ringaskiddy. This is approximately 1.2m below the level that would result in direct tidal flooding of the road. It is evident therefore that the flooding arose due to the extreme rainfall and is pluvial in nature.

4 Tidal flood risk

4.1 Lee CFRAM study

The final hydraulics report and final predictive flood maps from the Lee CFRAM study were made available on the project website in early 2014.

As the subject site in Ringaskiddy was studied as part of the Lee CFRAM Arup has consulted the report and the maps to determine the flood risk at the site.

The design tidal flood extent map for Ringaskiddy from the Lee CFRAM Study is reproduced in the figure (Figure 13) below. Three separate return period events are presented on the map:

- 1 in 10 year;
- 1 in 200 year;
- 1 in 1000 year;

The site of the proposed development is highlighted in red. As can be seen from the figure, the subject site is not indicated as being within any of the three modelled floodplains. Consequently the site is not located within Flood Zone A or B. It is therefore classified as lying within Flood Zone C. (Probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). It is noted that any area that is not within Flood Zone A or Flood Zone B is automatically designated as Flood Zone C as per OPW guidelines.

It can be seen from the figure that the site boundary extends along Gobby Beach which borders the 1 in 200 year design tidal flood extent. Given that the beach is subject to tidal inundation (as it is set at a lower elevation than the main area of the site) its flood zoning has been discounted for the purpose of flood zone classification.

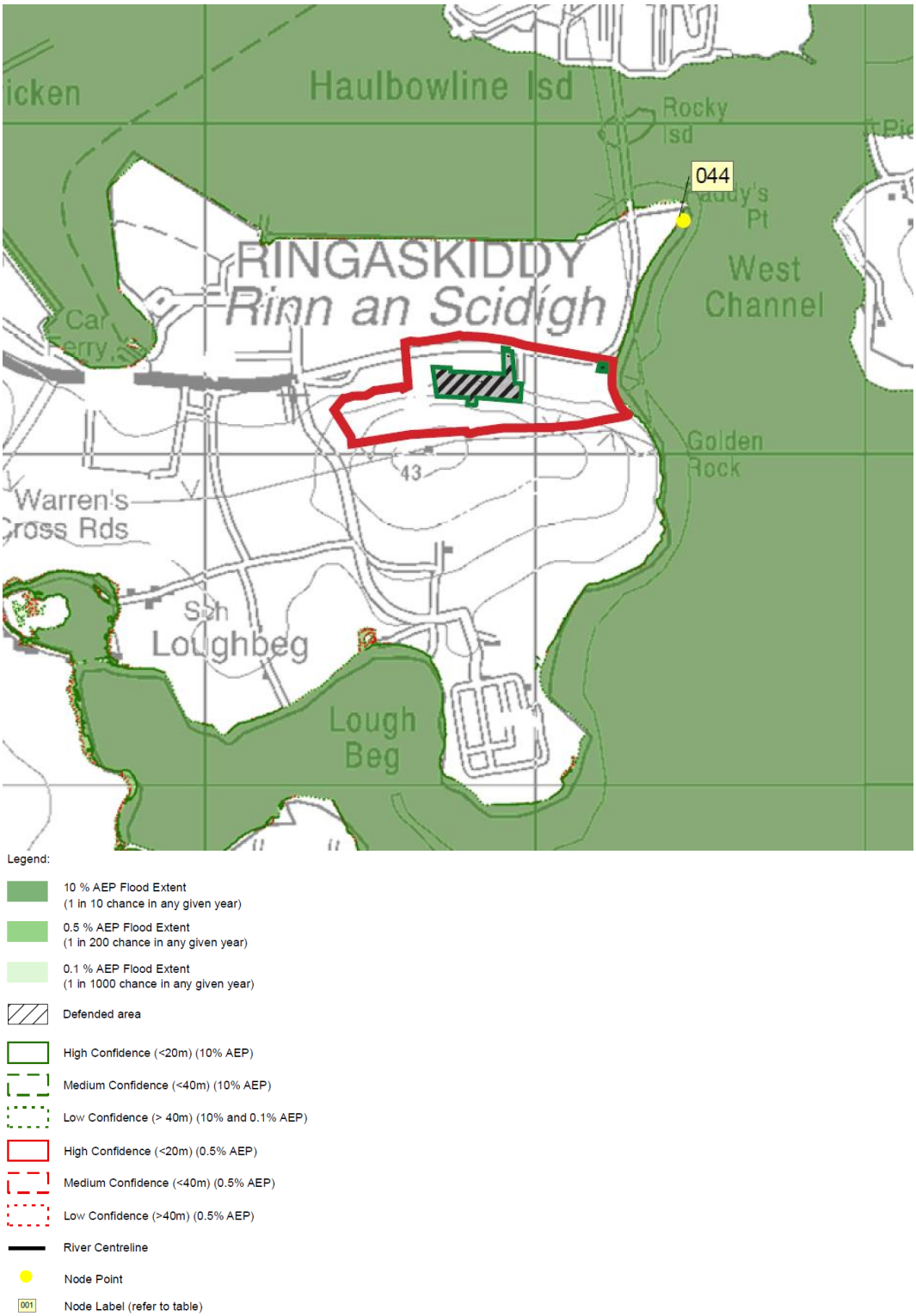


Figure 13: Predictive tidal flood extent map in the area of the Indaver site at Ringaskiddy. The subject site is highlighted in red. It is noted that the two hatched areas indicated within the site boundary are not within Indaver ownership.

The 10, 200 and 1000 year design tidal water levels as estimated by the Lee CFRAM study for a number of location nodes within Cork Harbour are presented in Figure 14 below. The node located closest to the subject site is the node labelled “044”.

The location of node 044 is indicated in the flood extent map shown above (Figure 13). (Note 10% AEP is 1 in 10 year design tidal water level, 0.5% AEP is 1 in 200 year design tidal water level and 0.1% AEP is 1 in 1000 year design tidal water level.).

It can be seen that the 200 year design tidal flood level according to the Lee CFRAM study for the current climate scenario for node 044 is estimated as 2.66m AOD. The majority of the ground levels within the Indaver site are above 2.66m AOD. Small sections along the northern boundary and in the western fields area are lower than 2.66m AOD (Refer to Figure 3 above).

	Water Level (mOD) per AEP		
Node Label	WL 10%	WL 0.5%	WL 0.1%
033	2.41	2.71	2.87
034	2.38	2.69	2.84
035	2.37	2.67	2.82
036	2.36	2.66	2.82
037	2.37	2.67	2.82
038	2.37	2.67	2.82
039	2.36	2.66	2.82
040	2.35	2.66	2.81
041	2.34	2.64	2.8
042	2.35	2.65	2.81
043	2.36	2.66	2.81
044	2.36	2.66	2.81
045	2.35	2.66	2.81

Figure 14: Design tidal water levels as estimated by Lee CFRAM study

4.2 Irish Coastal Protection Strategy Study (2011)

Output from the Irish Coastal Protection Strategy Study (ICPSS) is available from the OPW's website and was consulted as part of this FRA to determine the extent tidal flooding as predicted by the study. Two datasets from the ICPSS for Cork Harbour were examined as part of this FRA:

- Predicted extreme water levels for a range of return periods for a location close to the site of interest;
- Predicted flood extent maps for the design 200 year tidal flood event.

The 1 in 200 year predicted tidal floodplain for the Indaver site in Ringaskiddy is presented in Figure 15 below. As with the Lee CFRAM 1 in 200 year flood extent map, it is evident from the figure that the Indaver site (highlighted in red) is not located within the predicted floodplain.

It is noted that unlike the Lee CFRAM maps presented in the previous section, the ICPSS maps do not include the area of the harbour in the flood extent i.e. the harbour area is not indicated as shaded in the map.

The predicted extreme water levels for a number of points within Cork Harbour are given below in Figure 16. The point located nearest to the Indaver site is C_2 and for ease of reference is plotted in Figure 15.

The extreme water levels for this point are assumed to approximate to the extreme water levels of the subject site given its close proximity.

It can be seen that the predicted 200 year current scenario design tidal water level for the subject site is 2.73mOD. This value is marginally higher (0.08m) than the level predicted by the Lee CFRAM Study (2.66mOD). As mentioned previously, the majority of the ground levels within the Indaver site are above 2.73mOD. Small sections along the northern boundary and in the western fields area are lower than 2.73mOD (Refer to Figure 3 above)

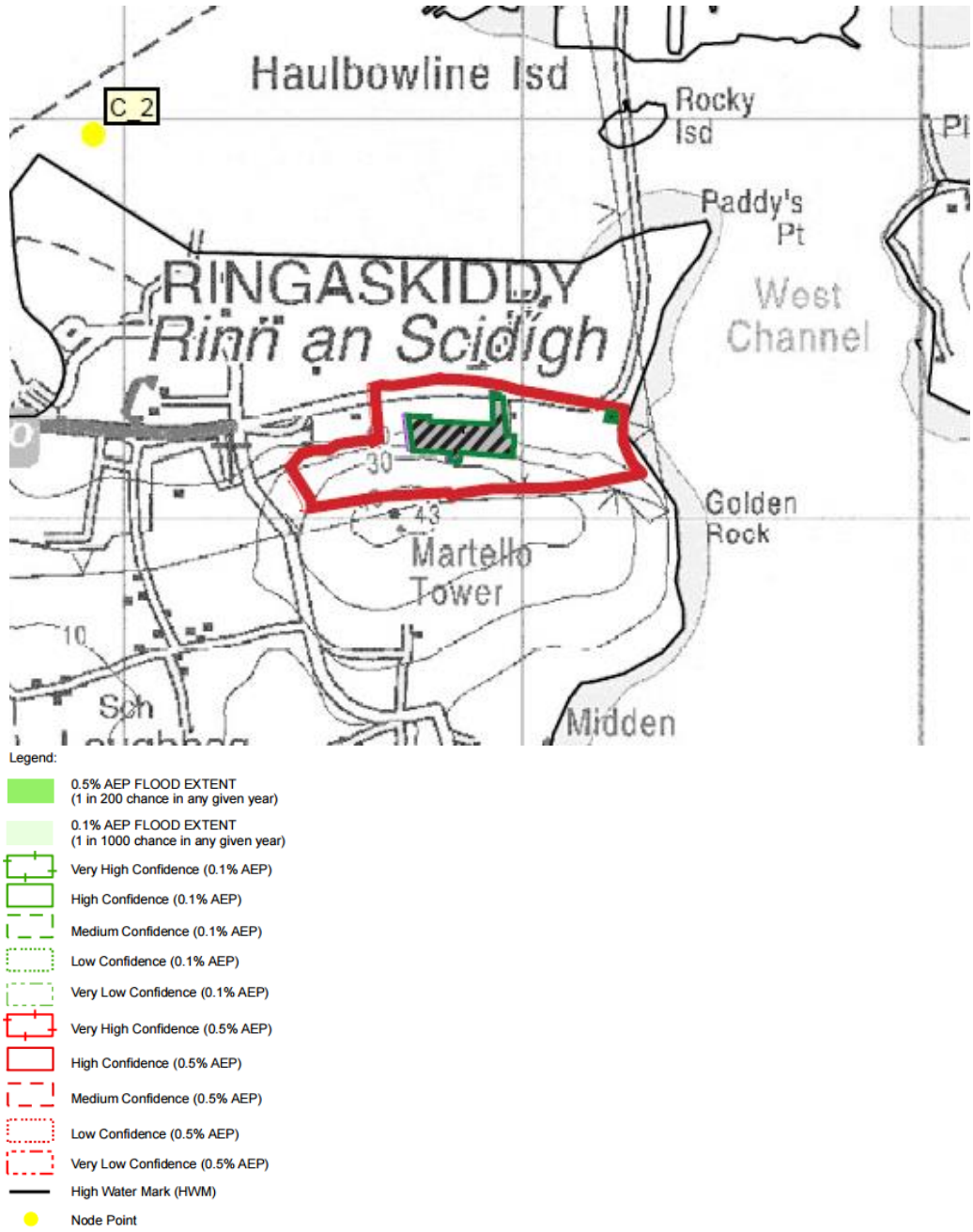


Figure 15: ICPSS 1 in 200 year tidal floodplain. The subject site is highlighted in red.

		Point C_1	Point C_2	Point C_3	Point C_4	Point C_5	Point C_6
Coord-inate	Longitude	-8.30	-8.32	-8.37	-8.26	-8.20	-8.25
	Latitude	51.82	51.84	51.88	51.85	51.85	51.83
Height to mean sea level for different AEP	50%	2.29	2.34	2.44	2.32	2.34	2.32
	20%	2.39	2.44	2.54	2.42	2.44	2.41
	10%	2.45	2.50	2.61	2.48	2.50	2.48
	5%	2.52	2.57	2.68	2.55	2.57	2.54
	2%	2.61	2.65	2.77	2.63	2.65	2.63
	1.00%	2.67	2.72	2.83	2.70	2.72	2.69
	0.50%	2.74	2.78	2.90	2.76	2.78	2.75
	0.10%	2.89	2.93	3.05	2.91	2.93	2.90
MSL to OD Malin		-0.207	-0.207	-0.209	-0.204	-0.202	-0.204
seich / set-up allowance		0.100	0.150	0.200	0.150	0.150	0.100
Height to OD Malin for different AEP	50%	2.19	2.28	2.43	2.27	2.29	2.21
	20%	2.28	2.38	2.53	2.36	2.38	2.31
	10%	2.35	2.45	2.60	2.43	2.45	2.37
	5%	2.41	2.51	2.67	2.49	2.52	2.44
	2%	2.50	2.60	2.76	2.58	2.60	2.52
	1.00%	2.56	2.66	2.82	2.64	2.66	2.59
	0.50%	2.63	2.73	2.89	2.70	2.73	2.65
	0.10%	2.78	2.88	3.04	2.85	2.87	2.80

Figure 16: Predicted extreme water levels from the ICPSS for a number of points within Cork Harbour. It can be seen that the predicted 200 year current scenario design tidal water level (0.5%) for the subject site is 2.73m OD

4.3 Previous Arup studies

Arup undertook an Environmental Impact Assessment in 2008 for a similar development on behalf of Indaver at the same site. The EIS included an investigation of the effects of coastal erosion and coastal flooding along the Eastern boundary of the Indaver site. As part of the EIA, design tidal water levels for a number of return period events were estimated through statistical analysis of historic water levels in Cork and subsequently translating these levels to Ringaskiddy.

The 200 year design tidal level at Ringaskiddy however was not estimated as part of the study. The level was instead taken from what was at the time provisional findings of the Lee CFRAM study.

The design tidal levels for a range of return periods from the 2008 EIS study are reproduced in Figure **17** below.

Return period [years]	Level in RK [m ODMalin]
200	3.04
100	2.86
50	2.70
20	2.49
5	2.15
2	1.94

Figure 17: Design Tidal Levels from the EIS study. RK corresponds to Ringaskiddy.

There is a difference of 0.38m between the finalised Lee CFRAM 200 year design tidal water level of 2.66mOD (which was published in 2014) and the value quoted in the EIS study of 3.04OD (which was published in 2008). As the Lee CFRAM was only in draft format at the time of writing the EIS in 2008, the data was provisional and has now been superseded in the final CFRAM report.

The final Lee CFRAM 1:200 year design tidal level figure for Ringaskiddy is 2.66mOD. The ICPSS 1:200 year design tidal level figure for Ringaskiddy is 2.73mOD. Therefore it can be concluded that the 1:200 year design tidal level figure of 3.04mOD for Ringaskiddy quoted in the 2008 EIS was a very conservative estimate.

Regarding a possible rise in water level owing to Climate Change, the 2008 EIS refers to an "unofficial" assessment of the predicted rise by the OPW as being equal to 0.55m. This value was subsequently adopted by the OPW but at the time of the EIS it was not published in any official documentation and was therefore discounted from the study.

Instead, the EIS followed a more conservative recommendation included in a 2006 report entitled "Flood and Coastal Defence Appraisal Guidance", published by the UK Department for Environment, Food and Rural Affairs (Defra). Following the recommendations in this report the climate change allowance for the site at Ringaskiddy was estimated to be 1m.

Utilising a free board value of 0.5m, the flood defence level in the 2008 EIS was recommended as:

3.04m (200yr tidal level) + 1.0m (climate change) + 0.5m (freeboard)

= 4.55mOD

The October 2004 flood event was also reviewed as part of the EIS. It was stated that the recorded water level at Cobh for the event was 2.66mOD. It was also stated that the Nautical Almanac suggests that the tide in Ringaskiddy is 0.1m above the level of the tide in Cobh giving an approximate value of 2.76mOD at Ringaskiddy for the October 2004 event.

The results of the Lee CFRAM Study suggest that a design water level of 2.76m OD at Ringaskiddy has a return period in excess of the 1 in 200 year event (2.66mOD).

In 2011, Arup prepared a report for UCC which outlined the engineering aspects of what was then the proposed UCC research facility at Ringaskiddy (and what is now known as the Beaufort building). The report considered the structural, geotechnical and environmental aspects of the building.

A flood risk assessment was also carried out as part of the study in 2011 and it recommended a site flood defence level of 4.55mOD. This conservative value was subsequently adopted as the finished floor level of the Beaufort building.

5 Other potential sources of flooding

5.1 Fluvial risk

The nearest identified watercourse (based both on EPA mapping of watercourses and OPW's mapping of watercourses) is the Glounatouig Stream which discharges at Rafeen Creek some 4 km to the west-northwest of the Indaver site. There is no risk of the resource recovery centre site flooding from the Glounatuoig Stream because of both given the wide expanse of its floodplain and the elevation of the topography between the watercourse and the site.

5.2 Pluvial risk to the site

OPW's PFRA mapping (Figure 18) indicates that there is a risk of pluvial flooding (orange shading) along the Northern boundary of the site. Flooding of this type has been experienced previously and was in fact presented earlier in this report in Section 3.2 when the field to the access road was shown as being flooded in a post flood event photograph from the 2004 event.



Figure 18: PFRA mapping for the area of the subject site.

5.3 Pluvial risk to the road

Based on a review of the historic flooding of the road, discussions with Cork County Council, and the PFRA mapping presented in Section 5.2, there is a significant risk of pluvial flooding of the road during periods of heavy rainfall combined with high tide.

The existing storm water drainage system along the road consists of a 450mm diameter pipe and has insufficient capacity to cater for the volume of water falling on the road during periods of heavy rainfall which can lead flooding of the road.

There are a minimal number of gullies along the road to accept water and transfer it to the storm water sewer. The dominant drainage mechanism for the road is "over the edge" drainage to the Indaver site on the south side of the road.

A number of channels have been cut in the berm on the southern side of the road which allow surface water drain from the road and into the western field area of the Indaver site. As a section of this field is lower than the adjacent road level, flooding of the road will lead to flooding of this area of the site.

This outfall of the local drainage network discharges into the sea at Gobby Beach. The invert level of the outfall is set at -0.28mOD. Once the level of the tide rises above this elevation the drainage system can become tide locked if there is insufficient differential head at the outfall. When this occurs the surface water is unable to discharge through the outfall and collects in the drainage pipe which can cause it to become surcharged. Any subsequent rain water falling on that area of the road normally drained by the existing gullies cannot drain away and causes the road to flood. This area of the road is located adjacent to the entrance to the public car park at Gobby beach.

Therefore, it can be concluded that the existing formal drainage system on the L2545 is inadequate. Measures to address this risk as part of the proposed development are detailed in Section 7.

5.4 Groundwater risk

Groundwater flooding can occur during lengthy periods of heavy rainfall, typically during late winter/early spring when the groundwater table is already high. If the groundwater level rises above ground level, it can pond at local low points and cause periods of flooding.

Geological and groundwater maps of the site at Ringaskiddy and surrounding areas have been obtained from the Geological Survey of Ireland (GSI) website (www.gsi.ie).

According to the GSI sub soils maps, the subsoil surrounding the site at Ringaskiddy is predominantly Till derived chiefly from Devonian sandstones.The site is underlain by Lower Carboniferous marine interbedded grey/brown sandstone, siltstone and mudstone referred to as the Cuskinny formation of the Kinsale group

The groundwater vulnerability is indicated as extreme.

Site investigations were carried out on the site in 2000 and 2001. These investigations consisted of both trial pits and borehole investigations from across the site as indicated in Figure 20. A stratigraphic profile of topsoil over orange/brown clay/silt was recorded. Interbedded lenses of silty gravelly sand were encountered in TP7, 13, 16 and 17 below the clay/silt stratum. Made ground was noted in BH2 towards the eastern end of the site. Clay deposits were recorded in BH1 to BH5 to depths of 0.3m to 8.5mBGL.

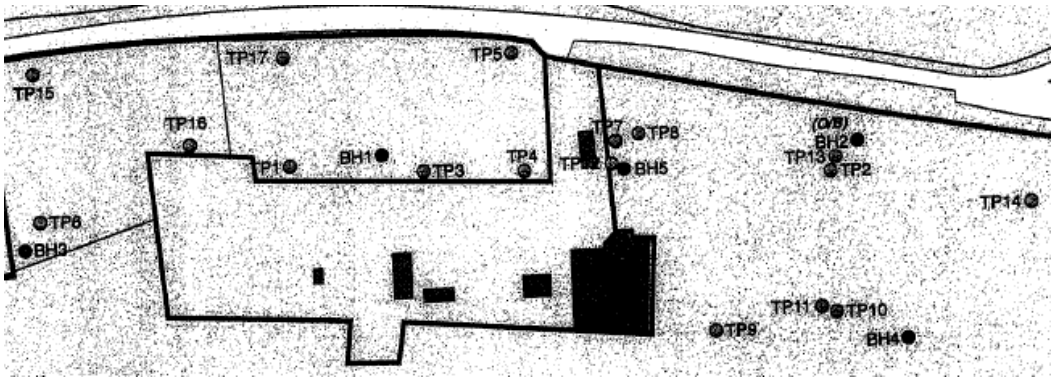


Figure 19: Location of Borehole data

Stratum	Depth to top of Stratum (m)	Thickness of Stratum (m)
Topsoil	ground level	0.1 – 0.3
MADE GROUND	ground level	0- 0.70
orange/brown gravelly SILT/CLAY	0.1 – 0.3	0.2 – 0.80
brown, gravelly SILT/CLAY with cobbles	ground level - 0.50	0.80 – 3.8
grey/brown sandy gravelly SILT/CLAY	ground level – 4.0	0.80 – 5.3
brown clayey/silty, gravelly SAND with cobbles	0.5 – 3.20	0.6 – 2.4
silty GRAVEL	3.80	>1.10
Pale green mudstone bedrock	0.30 - 5.5	

Figure 20 Summary of overburden from Trial pits and boreholes

Groundwater data from the site investigations is presented in Figure 21.

Exploratory Hole No	Depth (mbgl)	Elevation (mOD)	Water Strike Rose (m)
TP1 (2000)	1.8	1.45	0.8
TP2 (2000)	5	-0.75	0.5
TP4 (2000)	3.4	1.35	
TP5 (2000)	1	1.5	
TP5 (2000)	2.5	0	
TP7 (2000)	3	1.25	
TP11 (2001)	2.1	4.9	
TP13 (2001)	3.4	-0.3	
TP14 (2001)	3	1.95	
TP16 (2001)	2.5	0.75	1
TP17 (2001)	1.5	0.73	0.5
BH1 (2001)	4.5	-1.25	
BH2 (2001)	6	-3	
BH3 (2001)	12	-4.5	
BH4 (2001)	8	-1	
BH5 (2001)	8.5	-3.75	

Figure 21: Borehole data from the subject site

For the 2000 survey it can be seen that the ground water level varied across the Northerly area of the site from -0.75mOD to 1.45mOD. These levels correspond to depths below ground of 5mBGL to 1.8mBGL.

For the 2001 survey, it can be seen see that the ground water level varied across the site from -4.5mOD to 4.9mOD. These levels correspond to depths below ground of 12mBGL to 2.1mbBGL.

These groundwater levels are low relative to existing ground levels.

Given the proximity of the site to the sea however it is likely that the groundwater regime is in some hydraulic continuity with the tide. Groundwater levels may therefore be high at times of high tide. Monitoring of groundwater levels over a tidal cycle has been undertaken as part of site investigation for this planning application on a limited number of boreholes. The results of this monitoring show that fluctuation in groundwater levels around the tidal cycle is very small, circa 0.1m to 0.2m.The lowest point on the existing site is set at circa 2.0mOD. Given that this level is lower than the predicted 1 in 200year tidal level (2.73mOD), there is a minor risk of groundwater flooding to the site as this extreme tidal event may elevate ground water levels above the lowest point of the site.

6 Establishment of design flood levels

6.1 Predicted 1 in 200 year design tidal level at subject site

Based on a review of all available information, the 1 in 200 year design tidal level at the subject site has been estimated as 2.73mOD Malin.

6.2 Climate change

The OPW has issued Draft Guidance on the "Assessment of potential future scenarios for Flood Risk Management" which suggests the use of two scenarios: a mid-range future scenario (MRFS) and a high end future scenario (HEFS). The MRFS represents a likely future scenario which is within the bounds of the widely accepted projections. The HEFS is a more extreme event and is within the upper bounds of the widely accepted projections. These are detailed within the table below.

Table 1: Allowances for future scenarios

	MRFS	**HEFS**
Extreme rainfall events	+20%	+30%
Flood flows	+20%	+30%
Mean sea level rise	+500mm	+1000mm
Land movement	-0.5mm/year*	-0.5mm/year*
Urbanisation	No general allowance-review on a case by case basis	No general allowance-review on a case by case basis
Forestation	-1/6 Tp#	-1/3 Tp# +10% SPR^

*Applicable to the southern part of the country only (Dublin – Galway and south of this)

Reduce the time to peak (Tp) by a third: This allows for potential accelerated runoff that may arise as a result of drainage of afforested land

^ Add 10% to the Standard Percentage Runoff (SPR) rate: This allows for increased runoff rates that may arise following felling of forestry.

There are a number of conclusions that can be taken from the predictions made on climate change implications:

Increases in sea levels may result in extreme tidal events, with tidal levels increasing by more than a metre in the next century (HEFS). This would result in a greater risk of tidal flooding to the subject site at Ringaskiddy.

Increase in the frequency of extreme events, particularly hydrological extremes, storms and droughts may cause an increase in rainfall intensity, duration and amount, resulting in increased surface water runoff.

Based on this, it is proposed to account for climate change by considering a 550mm increase in the water levels in the estuary as per the Mid-Range Future Scenario as this represents the most likely future scenario and conforms to current standard practice in tidal flood risk assessments.

6.3 Freeboard

It is generally recognised and accepted in Ireland, that a minimum freeboard of 300mm is adopted with a higher freeboard where this is justified.

Arup has recommended that a 500mm freeboard be used as a conservative approach for this flood risk assessment.

6.4 Proposed minimum site flood defence level

From the analysis of the available reports and data, the 200 year design tidal level at the Indaver site was estimated to be 2.73m OD Malin.

Allowing for climate change and freeboard the minimum design flood defence level of the proposed development can be calculated as:

2.73m (200 year tidal level) + 0.55m (climate change) + 0.5m (freeboard) =

3.8mOD Malin

6.5 More conservative site flood defence levels

It is noted that the site flood defence level of 3.8m OD calculated in the previous section represents a minimum value of the site flood defence level. Higher defence levels can be used.

There are a number of reasons as to why a more conservative site flood level is merited for the proposed development:

- Given the nature of the proposed development, flooding of the site may lead to negative impacts on the environment – utilising a very conservative site flood defence level will greatly minimise this risk;
- A number of recent developments close the subject site in Ringaskiddy (Beaufort Research Lab, iMerc Development) have utilised a site flood defence level of 4.55m OD which have set a precedent for a more conservative approach to addressing the risk of tidal flooding in the area;
- The previous planning application for the same development in 2008 proposed a more conservative site defence level (4.55mOD) than the minimum 3.8m OD level.

A more conservative site flood defence level which considers the High-End Future Scenario could therefore be adopted:

2.73m (200 year tidal level) + 1.05m (climate change) + 0.5m (freeboard) =

4.28mOD Malin

Given that there is a precedent set by the Beaufort Research Lab and iMerc Development, a site flood defence level of 4.55mOD could also be adopted for the development.

The 4.55mOD would offer a very high standard of protection to the site and would ensure the risk of tidal inundation of the site is very remote.

Arup therefore proposes to use a site flood defence level of **4.55mOD**.

6.6 Proposed flood defence level for the L2545 road

From the analysis of the available reports and data, the 200 year design tidal level at the Indaver site was estimated to be 2.73mOD Malin.

Allowing for climate change the minimum design flood defence level of the proposed L2545 road upgrade can be calculated as:

2.73m (200 year tidal level) + 0.55m (climate change) =

3.28mOD Malin

7 Management of flood risk at the site

7.1 Increase in ground levels above 1 in 200 year design tidal level

As stated previously, some areas of the site (along the northern boundary and in the western fields) are below the 1 in 200 year design tidal flood level. It is proposed to increase the ground levels throughout the site to the proposed site flood defence level of 4.55m OD. This measure will ensure that the risk of flooding to the site is remote.

7.2 Floor levels of the buildings

The minimum site flood defence level was estimated as 3.8mOD. Arup has instead however adopted a far more conservative level of 4.55mOD for the site. The finished floor level of the buildings on the site however will be set at an even more conservative levels:

- The administration building and ESB substation will be set at 5.0mOD;
- The floor level of the main process building varies from 5.0m to 7.0mOD Malin.
- The Turbine and Aero-Condenser buildings will be set at 11mOD Malin.

The risk of flooding to all the buildings on the site is therefore very remote.

7.3 Roads and car parks

The internal roads and car parks within the site will also be raised to the proposed site flood defence level of 4.55mOD. This will ensure that the risk of flooding to the area of the site outside the building is also very remote.

It is noted that a small area at the entrance to the site will fall below the 4.55mOD level to facilitate a gradient for vehicles from the access road to the site. As detailed in Section 7.5, this area be flush with the access road which will be elevated to above the 200 year design tidal water level plus an allowance for climate change. This small area of the site will therefore still have a high level of protection from flooding.

7.4 Access and egress routes to the site

The subject site at Ringaskiddy is accessed by the L2545 road as highlighted in Figure 22 below. This road runs along the Northern boundary of the site. It is set at circa 2.40m to 2.80m ODM to the South and set at circa 2.8m to 4.9mOD Malin to the East. At the proposed entrance to site the existing road level is set at 2.61mOD Malin.



Figure 22: L2545 – Site access road (highlighted in red)

The L2545 road is prone to flooding as demonstrated during the February 2014 and October 2004 flood events and described in Section 3.2.1 and 5.2 of this report. Access and egress routes to the site are therefore at risk of being cut off during extreme rainfall and/or tidal events. Measures to address this risk of flooding are therefore required. These are detailed in the following section.

7.5 Proposed upgrade of the L2545

It is proposed to upgrade the L2545 to address the risk of flooding of the road. The proposed L2545 upgrade works will include raising a 185m section of the road to above the design flood level of 3.28mOD. This is approximately 1.0m above the existing road level. This will elevate the road to above the 200 year design tidal water level plus an allowance for climate change. The actual maximum proposed level of the road is 3.45mOD at its centreline (3.35mOD at the kerblines) which is approximately 1m above existing road level, this is a result from design iteration to comply with vertical road alignment standards. This will offer a high level of protection to the road and the access to the proposed site from tidal flooding.

The ground to the south of the road will rise to meet the proposed waste to energy site level of 4.55mOD. The levels of the existing ground to the north of the road have been checked and there no continuous route below this level which would act as a flow path around the raised road.

It is not proposed to raise the 260m of existing road from the western boundary of the Indaver site to the start of the road raising as it will be protected from tidal flooding by the proposed elevated road to the east. A new dedicated surface water drainage system will also be installed as part of the upgrade works to collect, convey and store the runoff from the road before connecting back into the existing drainage to discharge to the foreshore.

7.6 Proposed surface water drainage along the L2545

Currently the existing surface water drainage network consists of two separate systems which both discharge to the harbour via the 450mm diameter outfall on Gobby Beach:

- 450mm diameter surface water sewer which runs from approximately 200m west of the Hammond & Lane entrance eastwards through the public carpark before discharging to the foreshore on Gobby Beach.
- Combination of 225mm and 300mm diameter pipes which run from the bridge on the Haulbowline Road down to the junction of the Haulbowline Road and the L2545 at the public carpark

The majority of the L2545 road runoff does not drain to the 450mm sewer, but instead drains to western fields area within Indaver lands on the south side of the road where it infiltrates to the ground.

Arup's design of the proposed drainage network is based on the more critical of the following two scenarios:

- 100 year return period storm event occurring with a Mean High Water Spring (MHWS) tidal event (1.72mOD)
- 30 year return period storm event occurring with a 200 year tidal event (2.73mOD)

The most severe scenario is the 30 year rainfall event combined with the 200 year tidal event.

As part of the proposed Indaver development all surface water runoff from the L2545 road which currently discharges to the western fields south of the road will be collected in a series of road gullies and conveyed to the outfall for discharge to the foreshore via a new surface water attenuation structure.

Due to the high water level of the 200 year design tide, 2.73mO.D., the outfall to Gobby Beach will be submerged for approximately 7 hours during the tidal event (the invert level of the outfall is set at -0.28mOD). It is proposed to construct a new surface water attenuation structure under the upgraded road to attenuate all runoff generated from the drainage catchment while the submerged outfall is restricted due to the 200 year tide level.

During this scenario of the 30 year rainfall event coinciding with the 200 year tidal event 660m³ of attenuation volume will be required to store the runoff from the catchment while the outfall is submerged.

It is proposed to provide the required storage in 2 no. 1500mm∅ pipes approximately 190m in length which will be located under the raised section of the L2545.

The proposed L2545 road drainage upgrade will consist of approximately 260m of surface water channel on the section not being raised, which will discharge at regular intervals to the existing 450mm diameter surface water carrier pipe, and a kerb and gully system on the proposed raised section of the road. The gullies will discharge into the new surface water drainage system.

It is not proposed to construct a new outfall to the foreshore as the new drainage system will connect back into the existing 450mm diameter sewer in the vicinity of the public carpark prior to the discharge to the foreshore.

All of the above works will be within Indaver ownership, apart from a small area in Hammond Lane ownership. Consent has been given by Hammond Lane to undertake these works.

7.7 Coastal protection study

A wave modelling and erosion study of the area of the subject site was undertaken by Arup in 2015 and is detailed in the Coastal Erosion Report submitted as part of this planning application.

Based on the results from the modelling and the protected location of the site it was concluded that wave conditions in the nearshore area are sufficiently low to potentially allow for the use of an appropriate ‘soft’ coastal solution to protect the toe and base of the glacial till cliffs from wave action.

Erosion rates are low and there are no signs of potential accelerated erosion processes in the future potential scenarios assessed, other than natural variation and the possible acceleration of sea level rise due to climate change. The existence of the beach bedrock may also limit the maximum coastline and cliff retreat if the overlying beach sediment is eroded to the bedrock level. Arup recommended that the erosion tendency and status of the beach and cliffs are monitored in future in order to identify any changes in erosion rates.

The reader is referred to the report for a detailed description of this work.

8 Application of 'Flood Risk Management Guidelines'

8.1 Vulnerability classification

It is considered that the proposed resource recovery centre at Ringaskiddy should be classified as a "Highly Vulnerable Development" as per the vulnerability classification below given that it will be a waste treatment facility which treats both non-hazardous and hazardous waste and will require an Industrial Emissions Licence from the Environmental Protection Agency.

Vulnerability class	Land uses and types of development which include*:
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water-compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).
*Uses not listed here should be considered on their own merits	

Figure 23: Vulnerability classification

8.2 Flood zones

As indicated in Chapter 3 of this report, the site of the proposed development is not within the 1 in 200 year or 1 in 1000 year design tidal floodplain. Consequently, in accordance with the November 2009 OPW Guidelines for Planning Authorities, the site is within Flood Zone C.

As all types of development are acceptable within Flood Zone C, a Justification Test is not required for the proposed development.

8.3 Sequential approach

The figure below illustrates the sequential approach to be adopted under the 'Planning System and Flood Risk Management' guidelines.

As the proposed development lies within Flood Zone C, a Justification Test is not required and it is necessary only to identify mitigation measures for any residual risks.

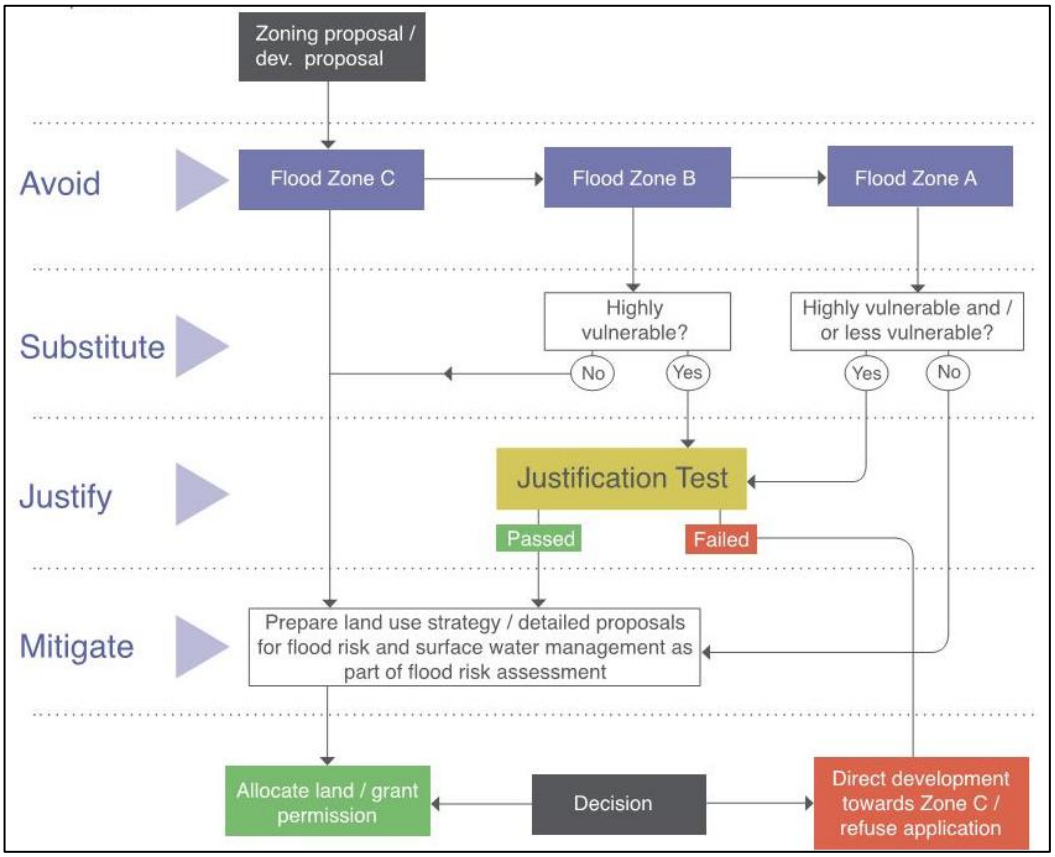


Figure 24: Sequential approach

9 Conclusions

Indaver proposes to develop a resource recovery centre in Ringaskiddy in County Cork. The proposed development will include a waste-to-energy facility for the treatment of up to 240,000 tonnes per annum of hazardous and non-hazardous residual household, commercial and industrial waste.

It was shown that the site is located in Flood Zone C as it outside the 1 in 1000 year design tidal floodplain.

The minimum design flood defence level of the proposed development was calculated as 3.8mOD Malin. Arup however have proposed a far more conservative flood defence level of 4.55mOD Malin for the site.

It is proposed to raise the footprint of the entire site to the proposed site flood defence level of 4.55mOD. This includes all the buildings, internal roads, car parking area and all associated site works. This measure will ensure that the risk of flooding to the site is remote.

It is proposed to upgrade the L2445 to address the risk of flooding of the road. The upgrade works will include raising a 185m section of the road to a maximum height of 3.45mOD between the car park adjacent to Gobby Beach and the Eastern end of the Hammond Lane Metal Company site. This is approximately 1.0m above the existing road level. This will elevate the road to above the 200 year design tidal water level plus an allowance for climate change. This will offer a high level of protection to the road from tidal flooding and ensure that access and egress routes are maintained during extreme flood events.

A new dedicated surface water drainage system will also be installed as part of the upgrade works to collect, convey and attenuate the runoff from the road before connecting back into the existing drainage to discharge to the foreshore.

These measures are sufficient to ensure that the risk of flooding of the site and its access road is extremely low.

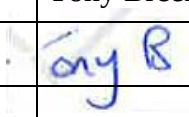
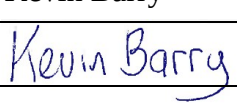
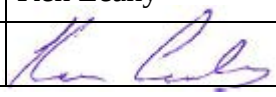
It is considered that the proposed resource recovery centre at Ringaskiddy should be classified as a “Highly Vulnerable Development” as per the vulnerability classification. As the site is classified as Flood Zone C, a Justification Test is not required for the proposed development and it is necessary only to identify mitigation measures for any residual risks.

Document Verification

ARUP

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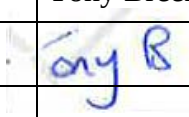
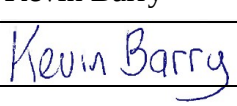
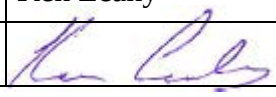
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Executive Summary

Indaver proposes to develop a resource recovery centre in Ringaskiddy in County Cork. The proposed development will include a waste-to-energy facility for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility.

In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby beach and an amenity walkway to the Ringaskiddy Martello tower

A flood risk assessment is required as part of the planning application of the project. This report details the flood risk assessment carried out by Arup. It has been undertaken in accordance with the Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

The site for the Ringaskiddy Resource Recovery Centre is located approximately 15km to the south-east of Cork City, in the townland of Ringaskiddy on the Ringaskiddy Peninsula in the lower part of Cork harbour. The site occupies an area of approximately 13.55 hectares and is approximately 800m east of the village of Ringaskiddy. The L2545, the main road from Ringaskiddy village to Haulbowline Island forms the northern boundary of the site. The eastern boundary of the site extends to the foreshore of Cork harbour along Gobby Beach. The lands to the immediate south and west are in agricultural use. The site surrounds the Hammond Lane Metal Recycling Co Ltd facility.

In broad terms, the potential sources of flooding to the site at Ringaskiddy can be categorised as follows Tidal/Coastal Flooding, Pluvial Flooding, Groundwater Flooding and Urban Drainage. Given the site's proximity to Cork Harbour, the main source of potential flooding at the site is tidal.

Given the absence of any significant watercourse from the site the risk of fluvial flooding is remote.

Based on a review of all available information, the predicted 1 in 200 year design tidal level for the site and adjacent L2545 has been estimated as 2.73mOD. Sections of the road close to the Gobby beach car park are below this level and are therefore at risk of tidal flooding during a 1 in 200 year tidal event.

There is a risk of pluvial flooding to the L2545 and the low lying areas of the site during periods of heavy rainfall due to an insufficient drainage network and tide locking of the existing drainage outfall.

Small areas of the site along the northern boundary are also below the predicted 1 in 200 year design tidal level (2.73mOD). The majority of the site is above 2.73mOD.

There is a low risk of groundwater flooding of the site.

The subject site is not indicated as being within the design 1000 year tidal floodplain. Consequently the site is classified as lying within Flood Zone C.

The minimum design flood defence level of the proposed development has been calculated as 3.8mOD Malin. Arup however has proposed a far more conservative flood defence level of 4.55mOD Malin for the site. This level offers a very high standard of flood protection to the site.

It is proposed to raise the footprint of the entire site to the proposed site flood defence level of 4.55mOD. This includes all internal roads, car parking area and all associated site works. This measure will ensure that the risk of flooding to the site is remote. The finished floor level of the buildings on the site will be set at even more conservative levels – the administration building and ESB substation will be set at 5.0mOD Malin while the floor level of the main process building varies from 5.0m to 7.0mOD Malin. The Turbine and Aero-Condenser buildings will be set at 11mOD Malin.

It is proposed to upgrade the L2545 to address the risk of flooding of the road. The upgrade works will include raising a 185m section of the road to a maximum height of 3.45mOD between the car park adjacent to Gobby Beach and the eastern end of the Hammond Lane Metal Company site. This is approximately 1.0m above the existing road level. This will elevate the road to above the 200 year design tidal water level plus an allowance for climate change. This will offer a high level of protection to the road from tidal flooding and ensure that access and egress routes are maintained during extreme flood events.

A new dedicated surface water drainage system will also be installed as part of the upgrade works to collect, convey and attenuate the runoff from the road before connecting back into the existing drainage to discharge to the foreshore.

These measures are sufficient to ensure that the risk of flooding of the site and the L2545 is extremely low.

It is considered that the proposed resource recovery centre at Ringaskiddy should be classified as a “Highly Vulnerable Development” as per the vulnerability classification. As the site is classified as Flood Zone C, a Justification Test is not required for the proposed development and it is necessary only to identify mitigation measures for any residual risks.

A wave modelling and erosion study of the area of the subject site was undertaken by Arup in 2015 and is detailed in the Coastal Erosion Report submitted as part of this planning application.

Based on the results from the modelling and the protected location of the site it was concluded that wave conditions in the nearshore area are sufficiently low to potentially allow for the use of an appropriate ‘soft’ coastal solution to protect the toe and base of the glacial till cliffs from wave action.

1 Introduction and background

1.1 Project background

Indaver proposes to develop a resource recovery centre in Ringaskiddy in County Cork. The proposed development will include a waste-to-energy facility (incinerator) for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility.

In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby beach and an amenity walkway to the Ringaskiddy Martello tower.

A flood risk assessment is required as part of the planning application of the project. This report details the flood risk assessment carried out by Arup. It has been undertaken in accordance with the Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

1.2 Scope of study

Following best practice in undertaking flood risk, the study includes the following:

- Review of all relevant information and data, as outlined in Section 1.3 below;
- Review the risk of fluvial, tidal, groundwater and pluvial flooding;
- Review of access/egress routes to the site;
- Review of available Site Investigation data;
- Recommendations on a suitable site flood defence level, taking account of climate change and freeboard;
- Development of potential mitigation measures (if necessary);
- Commentary on any residual risk;
- Preparation of a Flood Risk Assessment Report.

1.3 Summary of data used and assumptions made

In preparing this report, the following data was collated and reviewed:

- Review and analysis of relevant reports from the Lee CFRAM Study, January 2014 (available to download from http://www.leecframs.ie/)
- Predicted extreme water levels and flood extent maps from the Irish Coastal Protection Strategy Study (ICPSS), May 2011. These are available from the website of the Office of Public Works (www.opw.ie);

- Flood history of the site from the OPW National Flood Hazard Mapping website (www.floodmaps.ie);
- Preliminary Flood Risk Assessment (PFRA) Mapping produced by the OPW, March 2012 (www.cfram.ie/pfra);
- Site Geological and hydrogeological data from the Geological Survey of Ireland website (www.gsi.ie) (note: datasets accessed on October 2015);
- Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG);
- Relevant information from the Ringaskiddy Waste to Energy Facility – EIS Coastal Recession and Sea Flooding Assessment (published in 2008);
- Coastal Erosion Report (Arup 2015) included in the Indaver Ringaskiddy Resource Recovery Centre EIS;
- Results from the Site Investigation carried out at the subject site in 2000 and 2001;
- Aerial photography and mapping from Google Maps (2015);
- Water level data from a number of periods from the gauge maintained at Cobh by the Port of Cork;
- Ringaskiddy Resource Recovery Centre planning application site layout drawings for the proposed development;
- The available topographical survey information for the site (2014).

All Ordnance Datum (OD) levels referred to in this report are to Malin Head Ordnance Datum unless otherwise stated.

1.4 Site description and proposed development

1.4.1 Site Description

The site for the Ringaskiddy Resource Recovery Centre is located approximately 15km to the south-east of Cork City, in the townland of Ringaskiddy on the Ringaskiddy Peninsula in the lower part of Cork harbour. The site occupies an area of approximately 13.55 hectares and is approximately 800m east of the village of Ringaskiddy. Refer to Figure 1 below.

The L2545, the main road from Ringaskiddy village to Haulbowline Island forms the northern boundary of the site. The eastern boundary of the site extends to the foreshore of Cork harbour along Gobby Beach. The site surrounds the Hammond Lane Metal Recycling Co Ltd facility. The site is relatively level to the immediate south of the L2545 road and rises up steeply to the south. At the top of this steep scarp the ground rises more gently to the southern site boundary along the top of the ridge.

The National Maritime College of Ireland and the Beaufort Research Laboratory (UCC) are located to the North of the site. Access to these premises is from the existing L2545 road.

Figure 2 presents an outline of the site.



Figure 1: Location of the existing Indaver site

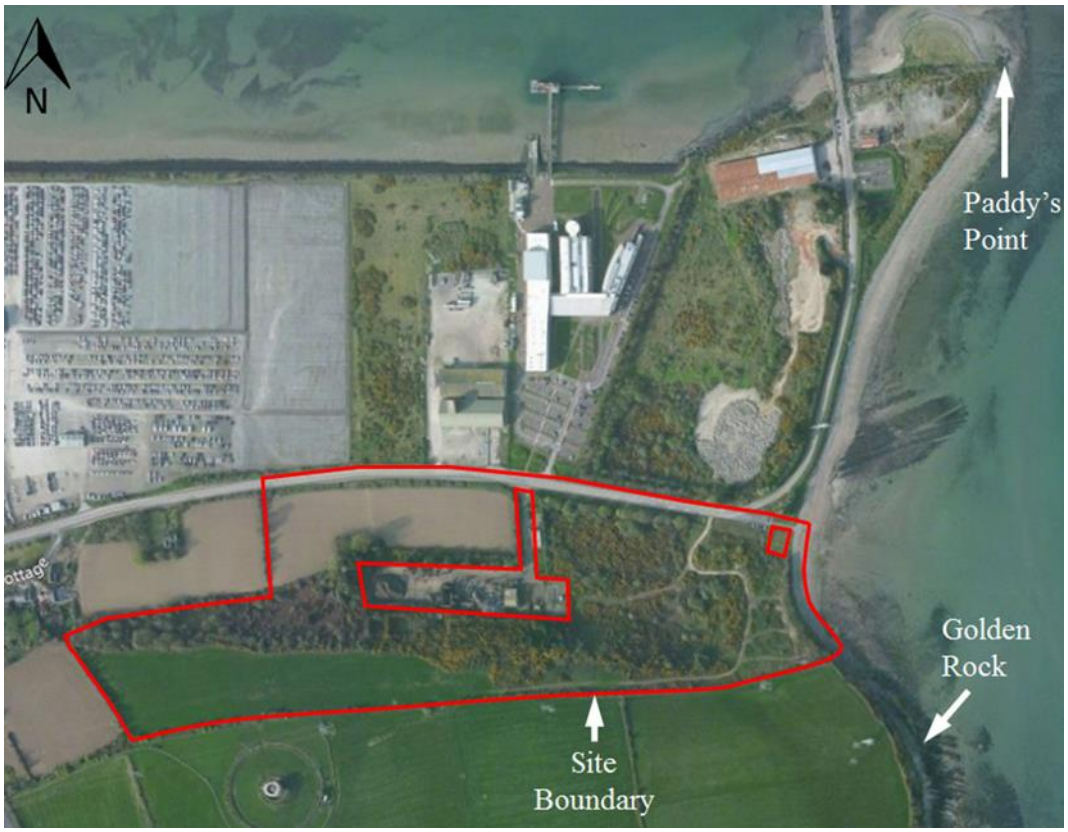


Figure 2: Outline of the existing Indaver site

The ground levels of the site vary considerably in both the North-South direction and the East-West direction. In the South of the site the levels vary from circa 10m OD to circa 41mOD. In the North of the site the ground levels vary from circa 2.05mOD to circa 4.0mOD. The level at the eastern end of the side bordering Gobby Beach is circa 3.25m OD. The level of the existing access road (L2545) to the North of the site is set at circa 2.6m to 2.95mOD.

Figure 3 presents the ground contours of the site. The image has been annotated with spot heights which present the existing ground levels.

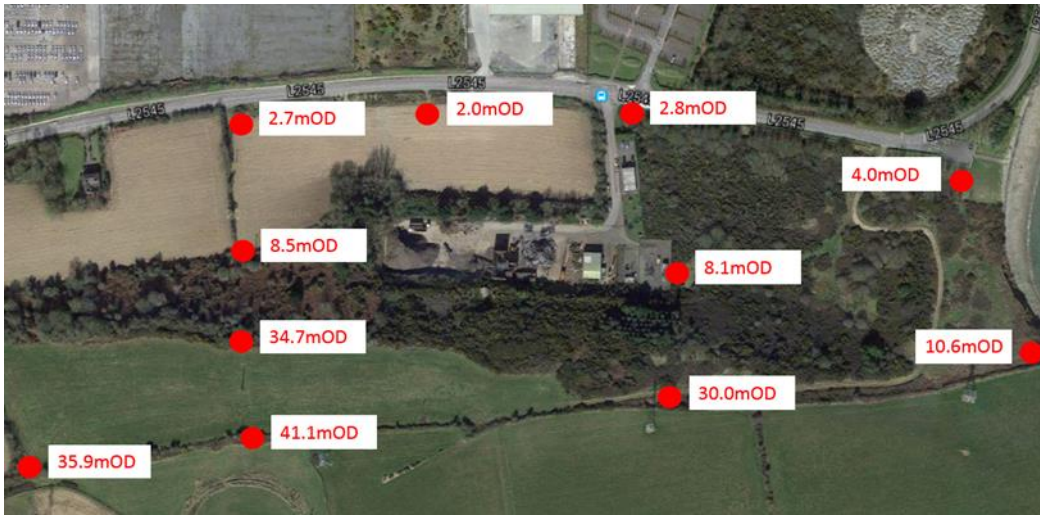


Figure 3: Existing ground contours and ground levels of the site

1.4.2 Proposed development

The proposed development will include a waste-to-energy facility (incinerator) for the treatment of up to 240,000 tonnes per annum of residual household, commercial and industrial non-hazardous and hazardous waste. Of the 240,000 tonnes of waste, up to 24,000 tonnes per annum of suitable hazardous waste will be treated at the facility. In addition to the provision of the waste-to-energy facility, the proposed development will include an upgrade of a section of the L2545 road, a connection to the national electrical grid, an increase in ground levels in part of the site, coastal protection measures above the foreshore on Gobby beach and an amenity walkway to the Ringaskiddy Martello tower.

The coastal protection measures proposed along the eastern boundary of the Indaver site will consist of the placement of shingle above the foreshore along the section of Gobby beach within Indaver ownership. This shingle will act as beach nourishment on the beach and will slow the retreat rate of the glacial till cliff.

Further details on the coastal protection measures are provided in Section 7.7 of this report and the Environmental Impact Statement which accompanies the planning application. The main elements of the proposed development include:

- Main process building;
- Turbine hall and aero-condenser structure;
- Security building/gate house;
- Administration building;
- Firewater storage and pump house;
- Firewater retention tank and storm water retention tank;
- Weigh bridges;
- Electricity substation, compound and grid connection;
- Light fuel oil storage tank;
- Emergency access;

- Public amenity footpath;
- Increase in ground levels
- L2545 road upgrade;
- Coastal protection measures;
- Diversion of services;
- Grid connection;



Figure 4: Outline of the proposed development

2 Planning context

The following planning policy documents are relevant to the assessment of this proposed development:

- The national planning guidelines published by the OPW and the Department of the Environment, Heritage and Local Government in November 2009 entitled 'The Planning System and Flood Risk Management: Guidelines for Planning Authorities' are particularly pertinent and are discussed in Section 2.1.1 below.
- In terms of planning policy context, the provisions contained in the following document are relevant:
  - Cork County Development Plan 2014 - 2020;
  - Ballincollig Carrigaline Municipal District Local Area Plan, August 2017

2.1 The planning system and flood risk management guidelines

2.1.1 Introduction

In November 2009, the Department of Environment, Heritage and Local Government and the Office of Public works jointly published a Guidance Document for Planning Authorities entitled "the Planning System and Flood Risk Management".

The guidelines are issued under Section 28 of the Planning and Development Act 2000. Planning Authorities and An Bord Pleanála are therefore required to implement these Guidelines in carrying out their functions under the Planning Acts.

The aim of the guidelines is to ensure that flood risk is neither created nor increased by inappropriate development.

The guidelines require the planning system to avoid development in areas at risk of flooding, unless they can be justified on wider sustainability grounds, where the risk can be reduced or managed to an acceptable level.

They require the adoption of a Sequential Approach (to Flood Risk Management) of Avoidance, Reduction, Justification and Mitigation and they require the incorporation of Flood Risk Assessment into the process of making decisions on planning applications and planning appeals.

Fundamental to the guidelines is the introduction of flood risk zoning and the classifications of different types of development having regard to their vulnerability.

The management of flood risk is now a key element of any development proposal in an area of potential flood risk and should therefore be addressed as early as possible in the site master planning stage.

2.1.2 Definition of flood zones

Flood Zones are geographical areas within which the likelihood of flooding is in a particular range.

There are three types of flood zones defined in the Guidelines as follows:

Flood Zone A	Probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding).
Flood Zone B	Probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 year and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding); and
Flood Zone C	Probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas which are not in zones A or B.

2.1.3 Definition of vulnerability classes

The following table summarises the Vulnerability Classes defined in the Guidelines and provides a sample of the most common type of development applicable to each.

Highly vulnerable development	Includes Garda, ambulance and fire stations, hospitals, schools, residential dwellings, residential institutions, essential infrastructure, such as primary transport and utilities distribution and SEVESO and IPPC sites, etc.
Less vulnerable development	Includes retail, leisure, warehousing, commercial, industrial and non-residential institutions, etc.
Water compatible development	Includes Flood Control Infrastructure, docks, marinas, wharves, navigation facilities, water based recreation facilities, amenity open spaces and outdoor sport and recreation facilities

2.1.4 Types of vulnerability class appropriate to each zone

The following table illustrates the different types of Vulnerability Class appropriate to each Zone and indicates where a Justification Test will be required.

	Flood Zone A	**Flood Zone B**	**Flood Zone C**
Highly vulnerable	Justification test	Justification test	Appropriate
Less vulnerable	Justification test	Appropriate	Appropriate
Water compatible	Appropriate	Appropriate	Appropriate

2.2 The Cork County Development Plan 2014 - 2020

The Cork County Council Development Plan 2014 - 2020 sets out Cork County Council's overall strategy for the proper planning and sustainable development of Cork County over a 6 year period.

The plan seeks to secure the development and improvement in a sustainable manner of the economic, environmental, cultural and social assets of the County. The plan governs the functional area of Cork County Council excluding the areas governed by the City Council.

A County wide Strategic Flood Risk Assessment (SFRA) was undertaken as part of the Development Plan and was prepared in accordance with 'The Planning System and Flood Risk Management Guidelines (OPW, 2009).

The plan makes specific reference to the Lee CFRAM Study and how its findings will be used to identify areas at risk of flooding (Flood Zone A, Flood Zone B and Flood Zone C) in the County in additional to the findings of the PFRA mapping.

The Cork County Development plan's flood risk objectives are reproduced in the following figure.

County Development Plan Objective
WS 6-1: Flood Risks – Overall Approach

Take the following approach in order to reduce the risk of new development being affected by possible future flooding:

- Avoid development in areas at risk of flooding; and
- Where development in floodplains cannot be avoided, to take a sequential approach to flood risk management based on avoidance, reduction and mitigation of risk.

In areas where there is a high probability of flooding - 'Zone A' - it is an objective of this plan to avoid development other than 'water compatible development' as described in Section 3 of 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' issued in November 2009 by DoEHLG.

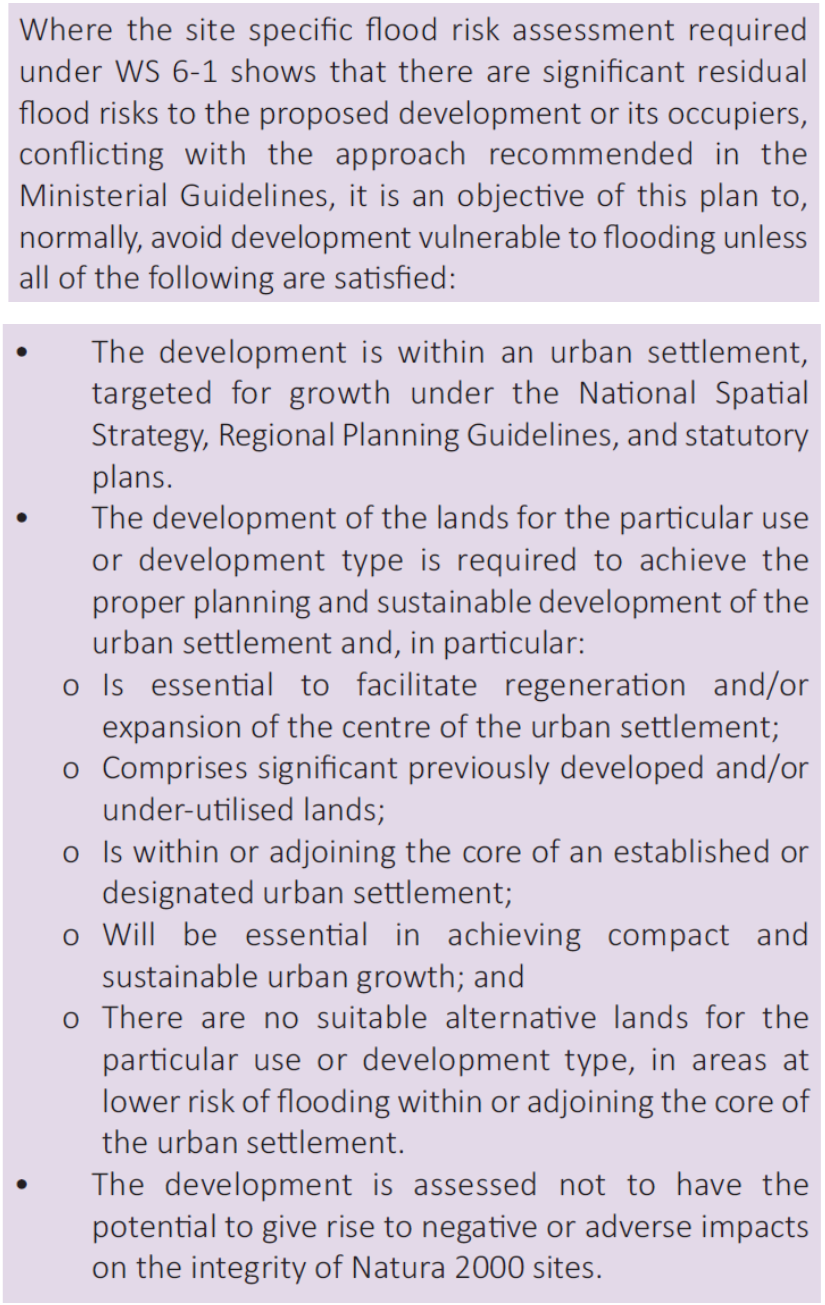
In areas where there is a moderate probability of flooding - 'Zone B' - it is an objective of this plan to avoid 'highly vulnerable development' described in section 3 of 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' issued in November 2009 by DoEHLG.

Implement the recommendations of the South Western CFRAM study.

County Development Plan Objective
WS 6-2: Development in Flood Risk Areas

Ensure that all proposals for development falling within flood zones 'A' or 'B' are consistent with the Ministerial Guidelines – 'The Planning System and Flood Risk Management. In order to achieve this, proposals for development identified as being at risk from flooding will need to be supported by a site-specific flood risk assessment prepared in line with Paragraph 11.6.16 of this plan.

Where the planning authority is satisfied that it can be satisfactorily shown in the site-specific flood risk assessment required under objective WS 6-1 that the proposed development, and its infrastructure, will avoid significant risks of flooding in line with the priciples set out in the Ministerial Guidelines, then, subject to other relevant proper planning considerations, permission may be granted for the development.


Where the site specific flood risk assessment required under WS 6-1 shows that there are significant residual flood risks to the proposed development or its occupiers, conflicting with the approach recommended in the Ministerial Guidelines, it is an objective of this plan to, normally, avoid development vulnerable to flooding unless all of the following are satisfied:

- The development is within an urban settlement, targeted for growth under the National Spatial Strategy, Regional Planning Guidelines, and statutory plans.
- The development of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in particular:
  - Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement;
  - Comprises significant previously developed and/or under-utilised lands;
  - Is within or adjoining the core of an established or designated urban settlement;
  - Will be essential in achieving compact and sustainable urban growth; and
  - There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.
- The development is assessed not to have the potential to give rise to negative or adverse impacts on the integrity of Natura 2000 sites.

Figure 5 Extract From Cork County Council's Development Plan 2014-2020

2.3 Ballincollig Carrigaline Municipal District Local Area Plan, August 2017

The Ballincollig Carrigaline Municipal District Local Area Plan (August 2017) sets out a detailed planning framework to ensure sustainable development of the environs of Carrigaline which includes Ringaskiddy. It details proposals for the delivery of the physical, social and environmental infrastructure necessary to sustain the communities of the area in the future. A strategic flood risk assessment is included as part of the development plan.

The plan states:

"Ringaskiddy is designated as a Strategic Employment Centre within the County Metropolitan Strategic Planning Area and has developed into one of the most significant employment areas in the Country. The objective for Ringaskiddy is set out in EE 4-1 of the County Development Plan 2014 where the stated aim is to promote the development of Ringaskiddy as Strategic Employment Area suitable for large scale industrial developments which is compatible with relevant environment, nature and landscape protection policies as they apply around Cork Harbour.

Figure 6 presents the planning zones for the Carrigaline area as set out in the LAP. It can be seen that the site is zoned for industry. The specific zoning objective for the site (RY-I-15) is detailed in the LAP as:

"Suitable for large standalone industry with suitable provision for landscaping and access points from the R613 and provision for appropriate landscape buffering to all residential areas".

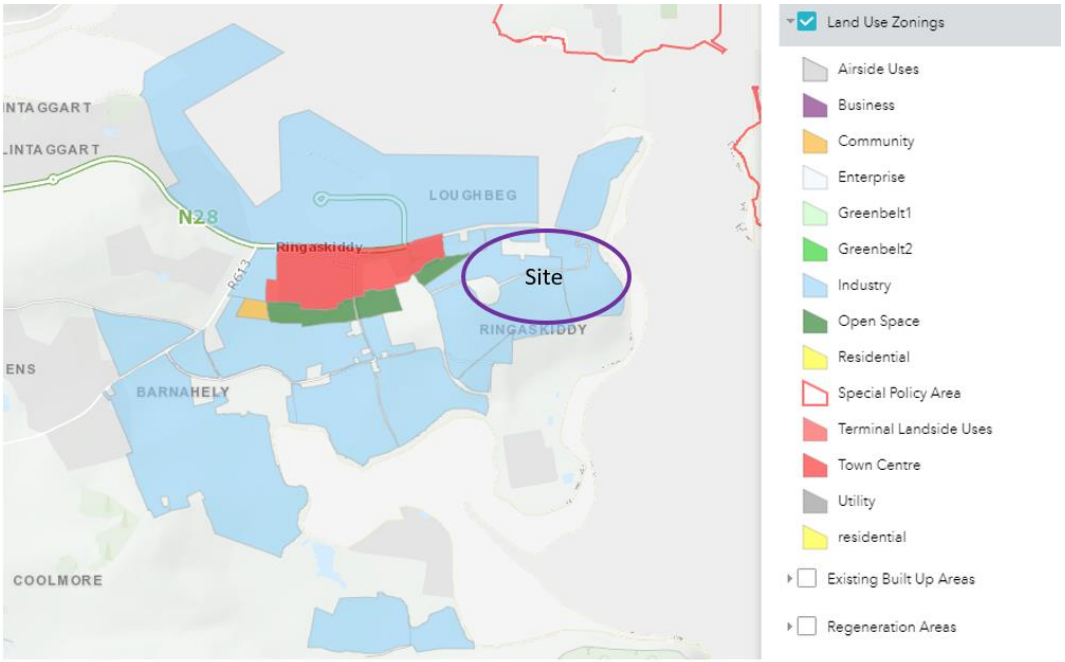


Figure 6: Planning zones for the Carrigaline area as set out in the LAP

A strategic flood risk assessment (SFRA) was carried out as part of the Cork County Development Plan. The SFRA amalgamated flood extent information from three separate sources into a single 'Indicative Flood Extent Map' of the area:

- Floodmaps produced by the Lee CFRAM Study;
- Data presented on OPW's National Flood Hazard Mapping website floodmaps.ie;

- Flood Hazard Mapping – Flood extent mapping undertaken by Cork County Council for areas where the more detailed Lee CFRAM Study maps are not available;

The 'Indicative Flood Extent Map' was used to derive the Flood Zone Classifications for the area and is presented in with the Planning Zones. It can be seen from Figure 7 that the subject site is not indicated as lying within Flood Zone A or B. It is therefore classified in the LAP as lying within Flood Zone C. The implications of this are discussed later in this report in Section 8.



Figure 7: Indicative Flood Extent Map

3 Overview of flood hazard and historic flooding

3.1 Overview

In broad terms, the potential sources of flooding to the site at Ringaskiddy can be categorised as follows:

- Tidal/Coastal Flooding;
- Pluvial Flooding;
- Groundwater Flooding; and
- Urban Drainage.

Given the site's proximity to Cork Harbour, the main source of potential flooding at the site is tidal which is considered in the following section of the report.

Other sources of flood risk are discussed in Section 5.

The risk of flooding from wave overtopping is considered to be very low for the site given the relatively small design wave heights incident on the site. The reader is referred to the Coastal Erosion Report that forms part of this planning application for a detailed description of the wave modelling work undertaken by Arup. Flooding from wave overtopping is therefore not considered as part of this FRA.

3.2 Historic flooding of the site and access road

3.2.1 Review of data from OPW's 'floodmaps.ie' website

Reports and maps from the OPW website www.floodmaps.ie have been examined at the time of writing of this report (2015) as part of this flood risk assessment. Given the absence of any flood defences or arterial drainage schemes at the subject site, the Land Commission Maps, Benefitting Land Maps and Drainage District Maps presented on the website are not relevant to this FRA.

There is however a number of post-flood event reports which detail some of the flood events in the area. Reports from two tidal flood events are presented as follows:

1. February 2014 surge event
2. October 2004 surge event

These are discussed in more detail below.

3.2.2 February 2014 event

On the 3rd and 4th of February 2014, a surge event occurred around the Irish coast leading to coastal flooding at a number of locations.

A short description of the flooding experienced in Ringaskiddy is provided in one of the post flood event reports. It states:

"Floodwater extended approx. 60m from the car park at end of local road (L2545) and was approximately 13 – 15 inches deep. No properties were flooded as part of this event. Access to Haulbowline was shut off."

It is noted that the report does not indicate the likely return period of the event.

A map highlighting the location of the flood event is also provided in the flood report and it is reproduced in Figure 8 below. It is noted that the figure has a label stating "Extents of Flood Waters" but there is no actual flood extent presented on the figure.



Figure 8: Flood location map for the February 2014 event extracted from the Flood maps website.

The flood report does not explicitly state that the southern end of the Indaver site was flooded in this event.

To determine the magnitude of this event Arup obtained data from the water level gauge at Cobh which is maintained by the Port of Cork. Recordings from this gauge are presented in Figure 9 below. It can be seen from the plot that the maximum water level for the event was 2.42mOD and it was recorded at 07:09am on 03 February 2014.

It is noted that the lowest level of the road in the vicinity of the Gobby Beach car park is approximately 2.4mOD and the level of the car park is between 2.7mOD and 2.8mOD

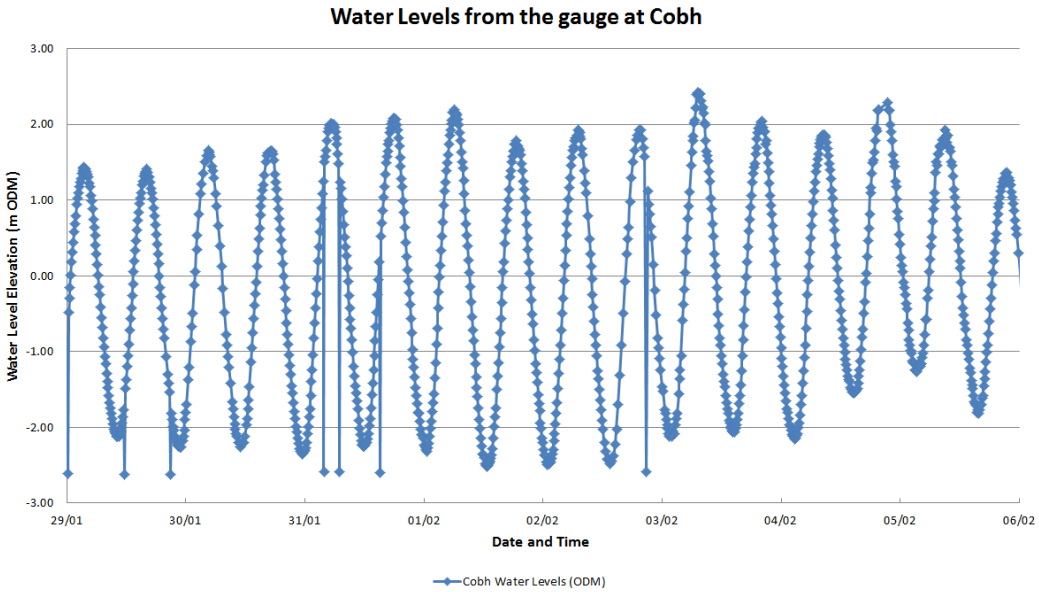


Figure 9: Water level data from the gauge at Cobh. This data was provided by the Port of Cork in 2014.

3.2.3 October 2004 event

A surge event also occurred around the Irish coast on the 27 October 2004. The impact of this event on the Ringaskiddy area is provided in one of the post flood event reports. It states:

"The surface of the car park has been significantly damaged, and part of the sea wall has been washed away."

This car park corresponds to the area that experienced flooding in the February 2014 coastal flood event as detailed in the previous section.

It was stated that the recorded water level at Cobh for the event was 2.66m ODM. It was also stated that the Nautical Almanac suggests that the tide in Ringaskiddy is 0.1m above the level of the tide in Cobh giving an approximate value of 2.76m ODM at Ringaskiddy for the October 2004 event. It is noted that the lowest level of the road in the vicinity of the Gobby Beach car park is approximately 2.4mOD and the level of the car park is between 2.7mOD and 2.8mOD

A number of photographs of the aftermath of the event are also provided in the flood reports available from floodmaps.ie and are reproduced in the following figures:

- Figure 10 shows the local road (L2545) flooded;
- Figure 11 shows part of the subject site to the west of Hammond Lane flooded. This area is indicated on plan view in Figure 12.

It is not stated at what time these photographs were taken, so it is not possible to determine the maximum extent of flooding at the peak of the tidal event.

It is noted that only photos from the 2004 event are provided on floodmaps.ie. There are no photos provided of the 2014 event.



Figure 10: L2545 road adjacent to Indaver site shown as flooded after the 2004 event



Figure 11: Part of the Indaver site (western fields) to the west of Hammond Lane shown flooded after the 2004 event



Figure 12: Location of the flood extent in western fields area (blue shading) presented in **Figure 11**.

3.2.4 Other historic flooding events at the site

In addition to the recorded flood events as presented on floodmaps.ie, Arup have obtained information on two other flood events in the vicinity of the site:

- A tidal flood event in the Cork area in 1994 caused pluvial flooding to the site and the L2545 roadway. No further information is available on this storm event.
- The site was subject to flooding in December 2015 as a consequence of Storm Frank passing over Ireland. A high tide level of 2.09m was recorded at Ringaskiddy. This is approximately 1.2m below the level that would result in direct tidal flooding of the road. It is evident therefore that the flooding arose due to the extreme rainfall and is pluvial in nature.

4 Tidal flood risk

4.1 Lee CFRAM study

The final hydraulics report and final predictive flood maps from the Lee CFRAM study were made available on the project website in early 2014.

As the subject site in Ringaskiddy was studied as part of the Lee CFRAM Arup has consulted the report and the maps to determine the flood risk at the site.

The design tidal flood extent map for Ringaskiddy from the Lee CFRAM Study is reproduced in the figure (Figure 13) below. Three separate return period events are presented on the map:

- 1 in 10 year;
- 1 in 200 year;
- 1 in 1000 year;

The site of the proposed development is highlighted in red. As can be seen from the figure, the subject site is not indicated as being within any of the three modelled floodplains. Consequently the site is not located within Flood Zone A or B. It is therefore classified as lying within Flood Zone C. (Probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). It is noted that any area that is not within Flood Zone A or Flood Zone B is automatically designated as Flood Zone C as per OPW guidelines.

It can be seen from the figure that the site boundary extends along Gobby Beach which borders the 1 in 200 year design tidal flood extent. Given that the beach is subject to tidal inundation (as it is set at a lower elevation than the main area of the site) its flood zoning has been discounted for the purpose of flood zone classification.

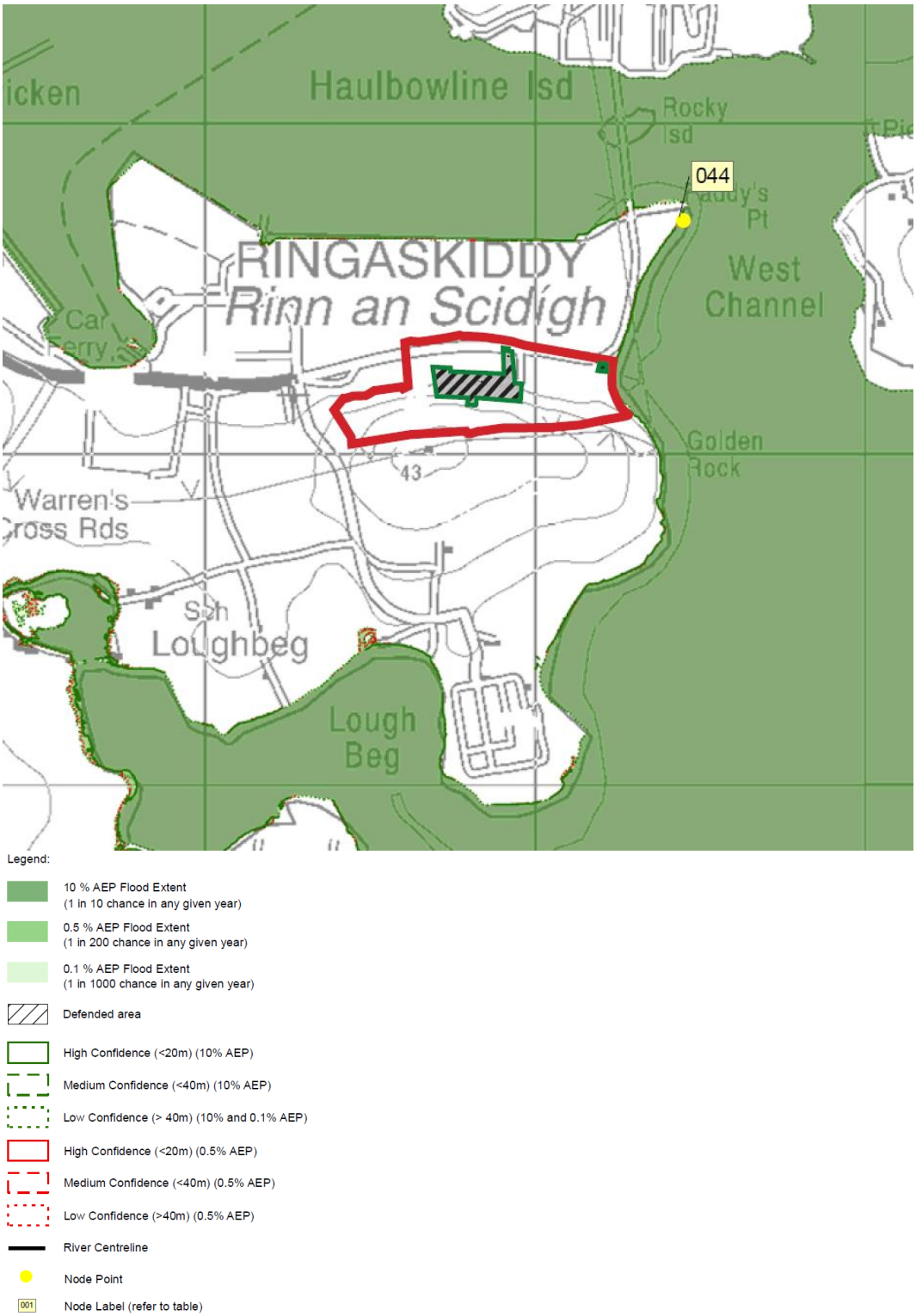


Figure 13: Predictive tidal flood extent map in the area of the Indaver site at Ringaskiddy. The subject site is highlighted in red. It is noted that the two hatched areas indicated within the site boundary are not within Indaver ownership.

The 10, 200 and 1000 year design tidal water levels as estimated by the Lee CFRAM study for a number of location nodes within Cork Harbour are presented in Figure 14 below. The node located closest to the subject site is the node labelled “044”.

The location of node 044 is indicated in the flood extent map shown above (Figure 13). (Note 10% AEP is 1 in 10 year design tidal water level, 0.5% AEP is 1 in 200 year design tidal water level and 0.1% AEP is 1 in 1000 year design tidal water level.).

It can be seen that the 200 year design tidal flood level according to the Lee CFRAM study for the current climate scenario for node 044 is estimated as 2.66m AOD. The majority of the ground levels within the Indaver site are above 2.66m AOD. Small sections along the northern boundary and in the western fields area are lower than 2.66m AOD (Refer to Figure 3 above).

	Water Level (mOD) per AEP		
Node Label	WL 10%	WL 0.5%	WL 0.1%
033	2.41	2.71	2.87
034	2.38	2.69	2.84
035	2.37	2.67	2.82
036	2.36	2.66	2.82
037	2.37	2.67	2.82
038	2.37	2.67	2.82
039	2.36	2.66	2.82
040	2.35	2.66	2.81
041	2.34	2.64	2.8
042	2.35	2.65	2.81
043	2.36	2.66	2.81
044	2.36	2.66	2.81
045	2.35	2.66	2.81

Figure 14: Design tidal water levels as estimated by Lee CFRAM study

4.2 Irish Coastal Protection Strategy Study (2011)

Output from the Irish Coastal Protection Strategy Study (ICPSS) is available from the OPW's website and was consulted as part of this FRA to determine the extent tidal flooding as predicted by the study. Two datasets from the ICPSS for Cork Harbour were examined as part of this FRA:

- Predicted extreme water levels for a range of return periods for a location close to the site of interest;
- Predicted flood extent maps for the design 200 year tidal flood event.

The 1 in 200 year predicted tidal floodplain for the Indaver site in Ringaskiddy is presented in Figure 15 below. As with the Lee CFRAM 1 in 200 year flood extent map, it is evident from the figure that the Indaver site (highlighted in red) is not located within the predicted floodplain.

It is noted that unlike the Lee CFRAM maps presented in the previous section, the ICPSS maps do not include the area of the harbour in the flood extent i.e. the harbour area is not indicated as shaded in the map.

The predicted extreme water levels for a number of points within Cork Harbour are given below in Figure 16. The point located nearest to the Indaver site is C_2 and for ease of reference is plotted in Figure 15.

The extreme water levels for this point are assumed to approximate to the extreme water levels of the subject site given its close proximity.

It can be seen that the predicted 200 year current scenario design tidal water level for the subject site is 2.73mOD. This value is marginally higher (0.08m) than the level predicted by the Lee CFRAM Study (2.66mOD). As mentioned previously, the majority of the ground levels within the Indaver site are above 2.73mOD. Small sections along the northern boundary and in the western fields area are lower than 2.73mOD (Refer to Figure 3 above)

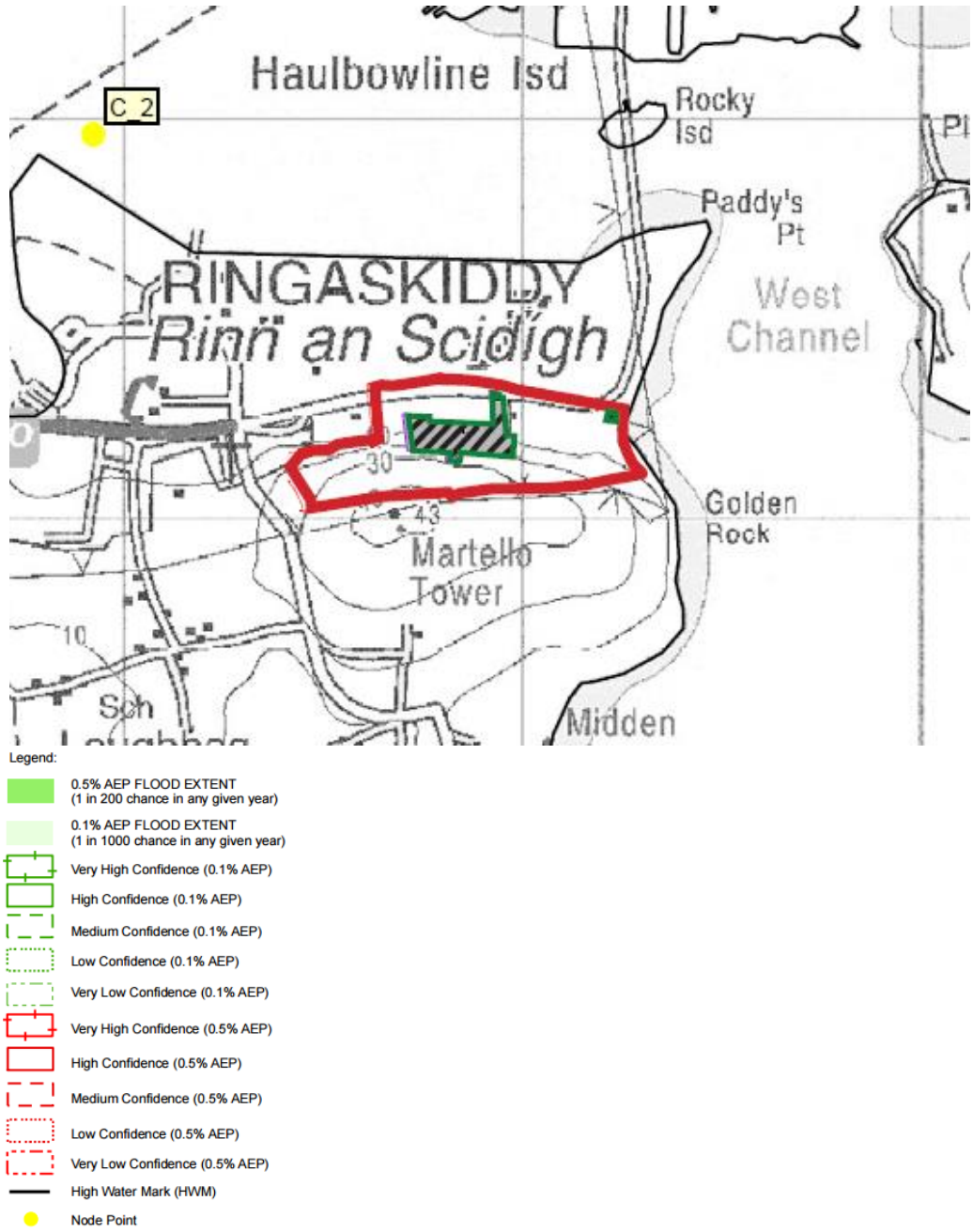


Figure 15: ICPSS 1 in 200 year tidal floodplain. The subject site is highlighted in red.

		Point C_1	Point C_2	Point C_3	Point C_4	Point C_5	Point C_6
Coord-inate	Longitude	-8.30	-8.32	-8.37	-8.26	-8.20	-8.25
	Latitude	51.82	51.84	51.88	51.85	51.85	51.83
Height to mean sea level for different AEP	50%	2.29	2.34	2.44	2.32	2.34	2.32
	20%	2.39	2.44	2.54	2.42	2.44	2.41
	10%	2.45	2.50	2.61	2.48	2.50	2.48
	5%	2.52	2.57	2.68	2.55	2.57	2.54
	2%	2.61	2.65	2.77	2.63	2.65	2.63
	1.00%	2.67	2.72	2.83	2.70	2.72	2.69
	0.50%	2.74	2.78	2.90	2.76	2.78	2.75
	0.10%	2.89	2.93	3.05	2.91	2.93	2.90
MSL to OD Malin		-0.207	-0.207	-0.209	-0.204	-0.202	-0.204
seich / set-up allowance		0.100	0.150	0.200	0.150	0.150	0.100
Height to OD Malin for different AEP	50%	2.19	2.28	2.43	2.27	2.29	2.21
	20%	2.28	2.38	2.53	2.36	2.38	2.31
	10%	2.35	2.45	2.60	2.43	2.45	2.37
	5%	2.41	2.51	2.67	2.49	2.52	2.44
	2%	2.50	2.60	2.76	2.58	2.60	2.52
	1.00%	2.56	2.66	2.82	2.64	2.66	2.59
	0.50%	2.63	2.73	2.89	2.70	2.73	2.65
	0.10%	2.78	2.88	3.04	2.85	2.87	2.80

Figure 16: Predicted extreme water levels from the ICPSS for a number of points within Cork Harbour. It can be seen that the predicted 200 year current scenario design tidal water level (0.5%) for the subject site is 2.73m OD

4.3 Previous Arup studies

Arup undertook an Environmental Impact Assessment in 2008 for a similar development on behalf of Indaver at the same site. The EIS included an investigation of the effects of coastal erosion and coastal flooding along the Eastern boundary of the Indaver site. As part of the EIA, design tidal water levels for a number of return period events were estimated through statistical analysis of historic water levels in Cork and subsequently translating these levels to Ringaskiddy.

The 200 year design tidal level at Ringaskiddy however was not estimated as part of the study. The level was instead taken from what was at the time provisional findings of the Lee CFRAM study.

The design tidal levels for a range of return periods from the 2008 EIS study are reproduced in Figure **17** below.

Return period [years]	Level in RK [m ODMalin]
200	3.04
100	2.86
50	2.70
20	2.49
5	2.15
2	1.94

Figure 17: Design Tidal Levels from the EIS study. RK corresponds to Ringaskiddy.

There is a difference of 0.38m between the finalised Lee CFRAM 200 year design tidal water level of 2.66mOD (which was published in 2014) and the value quoted in the EIS study of 3.04OD (which was published in 2008). As the Lee CFRAM was only in draft format at the time of writing the EIS in 2008, the data was provisional and has now been superseded in the final CFRAM report.

The final Lee CFRAM 1:200 year design tidal level figure for Ringaskiddy is 2.66mOD. The ICPSS 1:200 year design tidal level figure for Ringaskiddy is 2.73mOD. Therefore it can be concluded that the 1:200 year design tidal level figure of 3.04mOD for Ringaskiddy quoted in the 2008 EIS was a very conservative estimate.

Regarding a possible rise in water level owing to Climate Change, the 2008 EIS refers to an "unofficial" assessment of the predicted rise by the OPW as being equal to 0.55m. This value was subsequently adopted by the OPW but at the time of the EIS it was not published in any official documentation and was therefore discounted from the study.

Instead, the EIS followed a more conservative recommendation included in a 2006 report entitled "Flood and Coastal Defence Appraisal Guidance", published by the UK Department for Environment, Food and Rural Affairs (Defra). Following the recommendations in this report the climate change allowance for the site at Ringaskiddy was estimated to be 1m.

Utilising a free board value of 0.5m, the flood defence level in the 2008 EIS was recommended as:

3.04m (200yr tidal level) + 1.0m (climate change) + 0.5m (freeboard)

= 4.55mOD

The October 2004 flood event was also reviewed as part of the EIS. It was stated that the recorded water level at Cobh for the event was 2.66mOD. It was also stated that the Nautical Almanac suggests that the tide in Ringaskiddy is 0.1m above the level of the tide in Cobh giving an approximate value of 2.76mOD at Ringaskiddy for the October 2004 event.

The results of the Lee CFRAM Study suggest that a design water level of 2.76m OD at Ringaskiddy has a return period in excess of the 1 in 200 year event (2.66mOD).

In 2011, Arup prepared a report for UCC which outlined the engineering aspects of what was then the proposed UCC research facility at Ringaskiddy (and what is now known as the Beaufort building). The report considered the structural, geotechnical and environmental aspects of the building.

A flood risk assessment was also carried out as part of the study in 2011 and it recommended a site flood defence level of 4.55mOD. This conservative value was subsequently adopted as the finished floor level of the Beaufort building.

5 Other potential sources of flooding

5.1 Fluvial risk

The nearest identified watercourse (based both on EPA mapping of watercourses and OPW's mapping of watercourses) is the Glounatouig Stream which discharges at Rafeen Creek some 3 km to the west-northwest of the Indaver site. There is no risk of the resource recovery centre site flooding from the Glounatuoig Stream because of both given the wide expanse of its floodplain and the elevation of the topography between the watercourse and the site.

5.2 Pluvial risk to the site

OPW's PFRA mapping (Figure 18) indicates that there is a risk of pluvial flooding (orange shading) along the Northern boundary of the site. Flooding of this type has been experienced previously and was in fact presented earlier in this report in Section 3.2 when the field to the access road was shown as being flooded in a post flood event photograph from the 2004 event.



Figure 18: PFRA mapping for the area of the subject site.

5.3 Pluvial risk to the road

Based on a review of the historic flooding of the road, discussions with Cork County Council, and the PFRA mapping presented in Section 5.2, there is a significant risk of pluvial flooding of the road during periods of heavy rainfall combined with high tide.

The existing storm water drainage system along the road consists of a 450mm diameter pipe and has insufficient capacity to cater for the volume of water falling on the road during periods of heavy rainfall which can lead flooding of the road.

There are a minimal number of gullies along the road to accept water and transfer it to the storm water sewer. The dominant drainage mechanism for the road is "over the edge" drainage to the Indaver site on the south side of the road.

A number of channels have been cut in the berm on the southern side of the road which allow surface water drain from the road and into the western field area of the Indaver site. As a section of this field is lower than the adjacent road level, flooding of the road will lead to flooding of this area of the site.

This outfall of the local drainage network discharges into the sea at Gobby Beach. The invert level of the outfall is set at -0.28mOD. Once the level of the tide rises above this elevation the drainage system can become tide locked if there is insufficient differential head at the outfall. When this occurs the surface water is unable to discharge through the outfall and collects in the drainage pipe which can cause it to become surcharged. Any subsequent rain water falling on that area of the road normally drained by the existing gullies cannot drain away and causes the road to flood. This area of the road is located adjacent to the entrance to the public car park at Gobby beach.

Therefore, it can be concluded that the existing formal drainage system on the L2545 is inadequate. Measures to address this risk as part of the proposed development are detailed in Section 7.

5.4 Groundwater risk

Groundwater flooding can occur during lengthy periods of heavy rainfall, typically during late winter/early spring when the groundwater table is already high. If the groundwater level rises above ground level, it can pond at local low points and cause periods of flooding.

Geological and groundwater maps of the site at Ringaskiddy and surrounding areas have been obtained from the Geological Survey of Ireland (GSI) website (www.gsi.ie).

According to the GSI sub soils maps, the subsoil surrounding the site at Ringaskiddy is predominantly Till derived chiefly from Devonian sandstones.The site is underlain by Lower Carboniferous marine interbedded grey/brown sandstone, siltstone and mudstone referred to as the Cuskinny formation of the Kinsale group

The groundwater vulnerability is indicated as extreme.

Site investigations were carried out on the site in 2000 and 2001. These investigations consisted of both trial pits and borehole investigations from across the site as indicated in Figure 20. A stratigraphic profile of topsoil over orange/brown clay/silt was recorded. Interbedded lenses of silty gravelly sand were encountered in TP7, 13, 16 and 17 below the clay/silt stratum. Made ground was noted in BH2 towards the eastern end of the site. Clay deposits were recorded in BH1 to BH5 to depths of 0.3m to 8.5mBGL.

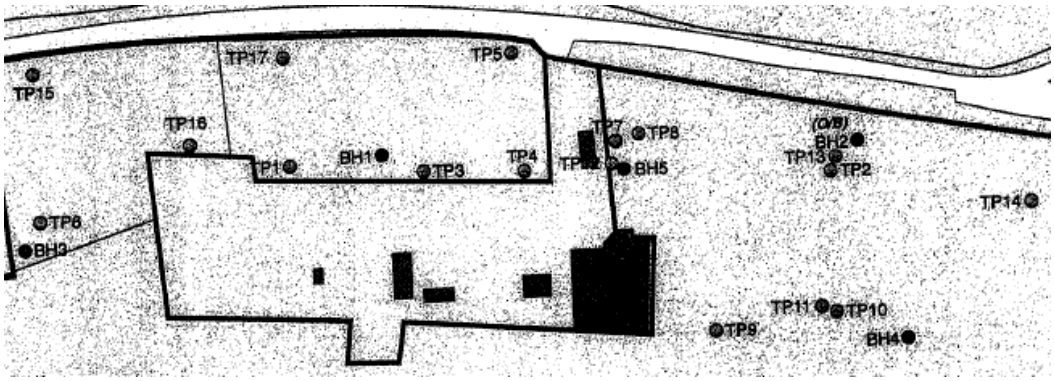


Figure 19: Location of Borehole data

Stratum	Depth to top of Stratum (m)	Thickness of Stratum (m)
Topsoil	ground level	0.1 – 0.3
MADE GROUND	ground level	0- 0.70
orange/brown gravelly SILT/CLAY	0.1 – 0.3	0.2 – 0.80
brown, gravelly SILT/CLAY with cobbles	ground level - 0.50	0.80 – 3.8
grey/brown sandy gravelly SILT/CLAY	ground level – 4.0	0.80 – 5.3
brown clayey/silty, gravelly SAND with cobbles	0.5 – 3.20	0.6 – 2.4
silty GRAVEL	3.80	>1.10
Pale green mudstone bedrock	0.30 - 5.5	

Figure 20 Summary of overburden from Trial pits and boreholes

Groundwater data from the site investigations is presented in Figure 21.

Exploratory Hole No	Depth (mbgl)	Elevation (mOD)	Water Strike Rose (m)
TP1 (2000)	1.8	1.45	0.8
TP2 (2000)	5	-0.75	0.5
TP4 (2000)	3.4	1.35	
TP5 (2000)	1	1.5	
TP5 (2000)	2.5	0	
TP7 (2000)	3	1.25	
TP11 (2001)	2.1	4.9	
TP13 (2001)	3.4	-0.3	
TP14 (2001)	3	1.95	
TP16 (2001)	2.5	0.75	1
TP17 (2001)	1.5	0.73	0.5
BH1 (2001)	4.5	-1.25	
BH2 (2001)	6	-3	
BH3 (2001)	12	-4.5	
BH4 (2001)	8	-1	
BH5 (2001)	8.5	-3.75	

Figure 21: Borehole data from the subject site

For the 2000 survey it can be seen that the ground water level varied across the Northerly area of the site from -0.75mOD to 1.45mOD. These levels correspond to depths below ground of 5mBGL to 1.8mBGL.

For the 2001 survey, it can be seen see that the ground water level varied across the site from -4.5mOD to 4.9mOD. These levels correspond to depths below ground of 12mBGL to 2.1mbBGL.

These groundwater levels are low relative to existing ground levels.

Given the proximity of the site to the sea however it is likely that the groundwater regime is in some hydraulic continuity with the tide. Groundwater levels may therefore be high at times of high tide. Monitoring of groundwater levels over a tidal cycle has been undertaken as part of site investigation for this planning application on a limited number of boreholes. The results of this monitoring show that fluctuation in groundwater levels around the tidal cycle is very small, circa 0.1m to 0.2m.The lowest point on the existing site is set at circa 2.0mOD. Given that this level is lower than the predicted 1 in 200year tidal level (2.73mOD), there is a minor risk of groundwater flooding to the site as this extreme tidal event may elevate ground water levels above the lowest point of the site.

6 Establishment of design flood levels

6.1 Predicted 1 in 200 year design tidal level at subject site

Based on a review of all available information, the 1 in 200 year design tidal level at the subject site has been estimated as 2.73mOD Malin.

6.2 Climate change

The OPW has issued Draft Guidance on the "Assessment of potential future scenarios for Flood Risk Management" which suggests the use of two scenarios: a mid-range future scenario (MRFS) and a high end future scenario (HEFS). The MRFS represents a likely future scenario which is within the bounds of the widely accepted projections. The HEFS is a more extreme event and is within the upper bounds of the widely accepted projections. These are detailed within the table below.

Table 1: Allowances for future scenarios

	MRFS	**HEFS**
Extreme rainfall events	+20%	+30%
Flood flows	+20%	+30%
Mean sea level rise	+500mm	+1000mm
Land movement	-0.5mm/year*	-0.5mm/year*
Urbanisation	No general allowance-review on a case by case basis	No general allowance-review on a case by case basis
Forestation	-1/6 Tp#	-1/3 Tp# +10% SPR^

*Applicable to the southern part of the country only (Dublin – Galway and south of this)

Reduce the time to peak (Tp) by a third: This allows for potential accelerated runoff that may arise as a result of drainage of afforested land

^ Add 10% to the Standard Percentage Runoff (SPR) rate: This allows for increased runoff rates that may arise following felling of forestry.

There are a number of conclusions that can be taken from the predictions made on climate change implications:

Increases in sea levels may result in extreme tidal events, with tidal levels increasing by more than a metre in the next century (HEFS). This would result in a greater risk of tidal flooding to the subject site at Ringaskiddy.

Increase in the frequency of extreme events, particularly hydrological extremes, storms and droughts may cause an increase in rainfall intensity, duration and amount, resulting in increased surface water runoff.

Based on this, it is proposed to account for climate change by considering a 550mm increase in the water levels in the estuary as per the Mid-Range Future Scenario as this represents the most likely future scenario and conforms to current standard practice in tidal flood risk assessments.

6.3 Freeboard

It is generally recognised and accepted in Ireland, that a minimum freeboard of 300mm is adopted with a higher freeboard where this is justified.

Arup has recommended that a 500mm freeboard be used as a conservative approach for this flood risk assessment.

6.4 Proposed minimum site flood defence level

From the analysis of the available reports and data, the 200 year design tidal level at the Indaver site was estimated to be 2.73m OD Malin.

Allowing for climate change and freeboard the minimum design flood defence level of the proposed development can be calculated as:

2.73m (200 year tidal level) + 0.55m (climate change) + 0.5m (freeboard) =

3.8mOD Malin

6.5 More conservative site flood defence levels

It is noted that the site flood defence level of 3.8m OD calculated in the previous section represents a minimum value of the site flood defence level. Higher defence levels can be used.

There are a number of reasons as to why a more conservative site flood level is merited for the proposed development:

- Given the nature of the proposed development, flooding of the site may lead to negative impacts on the environment – utilising a very conservative site flood defence level will greatly minimise this risk;
- A number of recent developments close the subject site in Ringaskiddy (Beaufort Research Lab, iMerc Development) have utilised a site flood defence level of 4.55m OD which have set a precedent for a more conservative approach to addressing the risk of tidal flooding in the area;
- The previous planning application for the same development in 2008 proposed a more conservative site defence level (4.55mOD) than the minimum 3.8m OD level.

A more conservative site flood defence level which considers the High-End Future Scenario could therefore be adopted:

2.73m (200 year tidal level) + 1.05m (climate change) + 0.5m (freeboard) =

4.28mOD Malin

Given that there is a precedent set by the Beaufort Research Lab and iMerc Development, a site flood defence level of 4.55mOD could also be adopted for the development.

The 4.55mOD would offer a very high standard of protection to the site and would ensure the risk of tidal inundation of the site is very remote.

Arup therefore proposes to use a site flood defence level of **4.55mOD**.

6.6 Proposed flood defence level for the L2545 road

From the analysis of the available reports and data, the 200 year design tidal level at the Indaver site was estimated to be 2.73mOD Malin.

Allowing for climate change the minimum design flood defence level of the proposed L2545 road upgrade can be calculated as:

2.73m (200 year tidal level) + 0.55m (climate change) =

3.28mOD Malin

7 Management of flood risk at the site

7.1 Increase in ground levels above 1 in 200 year design tidal level

As stated previously, some areas of the site (along the northern boundary and in the western fields) are below the 1 in 200 year design tidal flood level. It is proposed to increase the ground levels throughout the site to the proposed site flood defence level of 4.55m OD. This measure will ensure that the risk of flooding to the site is remote.

7.2 Floor levels of the buildings

The minimum site flood defence level was estimated as 3.8mOD. Arup has instead however adopted a far more conservative level of 4.55mOD for the site. The finished floor level of the buildings on the site however will be set at an even more conservative levels:

- The administration building and ESB substation will be set at 5.0mOD;
- The floor level of the main process building varies from 5.0m to 7.0mOD Malin.
- The Turbine and Aero-Condenser buildings will be set at 11mOD Malin.

The risk of flooding to all the buildings on the site is therefore very remote.

7.3 Roads and car parks

The internal roads and car parks within the site will also be raised to the proposed site flood defence level of 4.55mOD. This will ensure that the risk of flooding to the area of the site outside the building is also very remote.

It is noted that a small area at the entrance to the site will fall below the 4.55mOD level to facilitate a gradient for vehicles from the access road to the site. As detailed in Section 7.5, this area be flush with the access road which will be elevated to above the 200 year design tidal water level plus an allowance for climate change. This small area of the site will therefore still have a high level of protection from flooding.

7.4 Access and egress routes to the site

The subject site at Ringaskiddy is accessed by the L2545 road as highlighted in Figure 22 below. This road runs along the Northern boundary of the site. It is set at circa 2.40m to 2.80m ODM to the South and set at circa 2.8m to 4.9mOD Malin to the East. At the proposed entrance to site the existing road level is set at 2.61mOD Malin.



Figure 22: L2545 – Site access road (highlighted in red)

The L2545 road is prone to flooding as demonstrated during the February 2014 and October 2004 flood events and described in Section 3.2.1 and 5.2 of this report. Access and egress routes to the site are therefore at risk of being cut off during extreme rainfall and/or tidal events. Measures to address this risk of flooding are therefore required. These are detailed in the following section.

7.5 Proposed upgrade of the L2545

It is proposed to upgrade the L2545 to address the risk of flooding of the road. The proposed L2545 upgrade works will include raising a 185m section of the road to above the design flood level of 3.28mOD. This is approximately 1.0m above the existing road level. This will elevate the road to above the 200 year design tidal water level plus an allowance for climate change. The actual maximum proposed level of the road is 3.45mOD at its centreline (3.35mOD at the kerblines) which is approximately 1m above existing road level, this is a result from design iteration to comply with vertical road alignment standards. This will offer a high level of protection to the road and the access to the proposed site from tidal flooding.

The ground to the south of the road will rise to meet the proposed waste to energy site level of 4.55mOD. The levels of the existing ground to the north of the road have been checked and there no continuous route below this level which would act as a flow path around the raised road.

It is not proposed to raise the 260m of existing road from the western boundary of the Indaver site to the start of the road raising as it will be protected from tidal flooding by the proposed elevated road to the east. A new dedicated surface water drainage system will also be installed as part of the upgrade works to collect, convey and store the runoff from the road before connecting back into the existing drainage to discharge to the foreshore.

7.6 Proposed surface water drainage along the L2545

Currently the existing surface water drainage network consists of two separate systems which both discharge to the harbour via the 450mm diameter outfall on Gobby Beach:

- 450mm diameter surface water sewer which runs from approximately 200m west of the Hammond & Lane entrance eastwards through the public carpark before discharging to the foreshore on Gobby Beach.
- Combination of 225mm and 300mm diameter pipes which run from the bridge on the Haulbowline Road down to the junction of the Haulbowline Road and the L2545 at the public carpark

The majority of the L2545 road runoff does not drain to the 450mm sewer, but instead drains to western fields area within Indaver lands on the south side of the road where it infiltrates to the ground.

Arup's design of the proposed drainage network is based on the more critical of the following two scenarios:

- 100 year return period storm event occurring with a Mean High Water Spring (MHWS) tidal event (1.72mOD)
- 30 year return period storm event occurring with a 200 year tidal event (2.73mOD)

The most severe scenario is the 30 year rainfall event combined with the 200 year tidal event.

As part of the proposed Indaver development all surface water runoff from the L2545 road which currently discharges to the western fields south of the road will be collected in a series of road gullies and conveyed to the outfall for discharge to the foreshore via a new surface water attenuation structure.

Due to the high water level of the 200 year design tide, 2.73mO.D., the outfall to Gobby Beach will be submerged for approximately 7 hours during the tidal event (the invert level of the outfall is set at -0.28mOD). It is proposed to construct a new surface water attenuation structure under the upgraded road to attenuate all runoff generated from the drainage catchment while the submerged outfall is restricted due to the 200 year tide level.

During this scenario of the 30 year rainfall event coinciding with the 200 year tidal event 660m³ of attenuation volume will be required to store the runoff from the catchment while the outfall is submerged.

It is proposed to provide the required storage in 2 no. 1500mm∅ pipes approximately 190m in length which will be located under the raised section of the L2545.

The proposed L2545 road drainage upgrade will consist of approximately 260m of surface water channel on the section not being raised, which will discharge at regular intervals to the existing 450mm diameter surface water carrier pipe, and a kerb and gully system on the proposed raised section of the road. The gullies will discharge into the new surface water drainage system.

It is not proposed to construct a new outfall to the foreshore as the new drainage system will connect back into the existing 450mm diameter sewer in the vicinity of the public carpark prior to the discharge to the foreshore.

All of the above works will be within Indaver ownership, apart from a small area in Hammond Lane ownership. Consent has been given by Hammond Lane to undertake these works.

7.7 Coastal protection study

A wave modelling and erosion study of the area of the subject site was undertaken by Arup in 2015 and is detailed in the Coastal Erosion Report submitted as part of this planning application.

Based on the results from the modelling and the protected location of the site it was concluded that wave conditions in the nearshore area are sufficiently low to potentially allow for the use of an appropriate ‘soft’ coastal solution to protect the toe and base of the glacial till cliffs from wave action.

Erosion rates are low and there are no signs of potential accelerated erosion processes in the future potential scenarios assessed, other than natural variation and the possible acceleration of sea level rise due to climate change. The existence of the beach bedrock may also limit the maximum coastline and cliff retreat if the overlying beach sediment is eroded to the bedrock level. Arup recommended that the erosion tendency and status of the beach and cliffs are monitored in future in order to identify any changes in erosion rates.

The reader is referred to the report for a detailed description of this work.

8 Application of 'Flood Risk Management Guidelines'

8.1 Vulnerability classification

It is considered that the proposed resource recovery centre at Ringaskiddy should be classified as a "Highly Vulnerable Development" as per the vulnerability classification below given that it will be a waste treatment facility which treats both non-hazardous and hazardous waste and will require an Industrial Emissions Licence from the Environmental Protection Agency.

Vulnerability class	Land uses and types of development which include*:
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water-compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).
*Uses not listed here should be considered on their own merits	

Figure 23: Vulnerability classification

8.2 Flood zones

As indicated in Chapter 3 of this report, the site of the proposed development is not within the 1 in 200 year or 1 in 1000 year design tidal floodplain. Consequently, in accordance with the November 2009 OPW Guidelines for Planning Authorities, the site is within Flood Zone C.

As all types of development are acceptable within Flood Zone C, a Justification Test is not required for the proposed development.

8.3 Sequential approach

The figure below illustrates the sequential approach to be adopted under the 'Planning System and Flood Risk Management' guidelines.

As the proposed development lies within Flood Zone C, a Justification Test is not required and it is necessary only to identify mitigation measures for any residual risks.

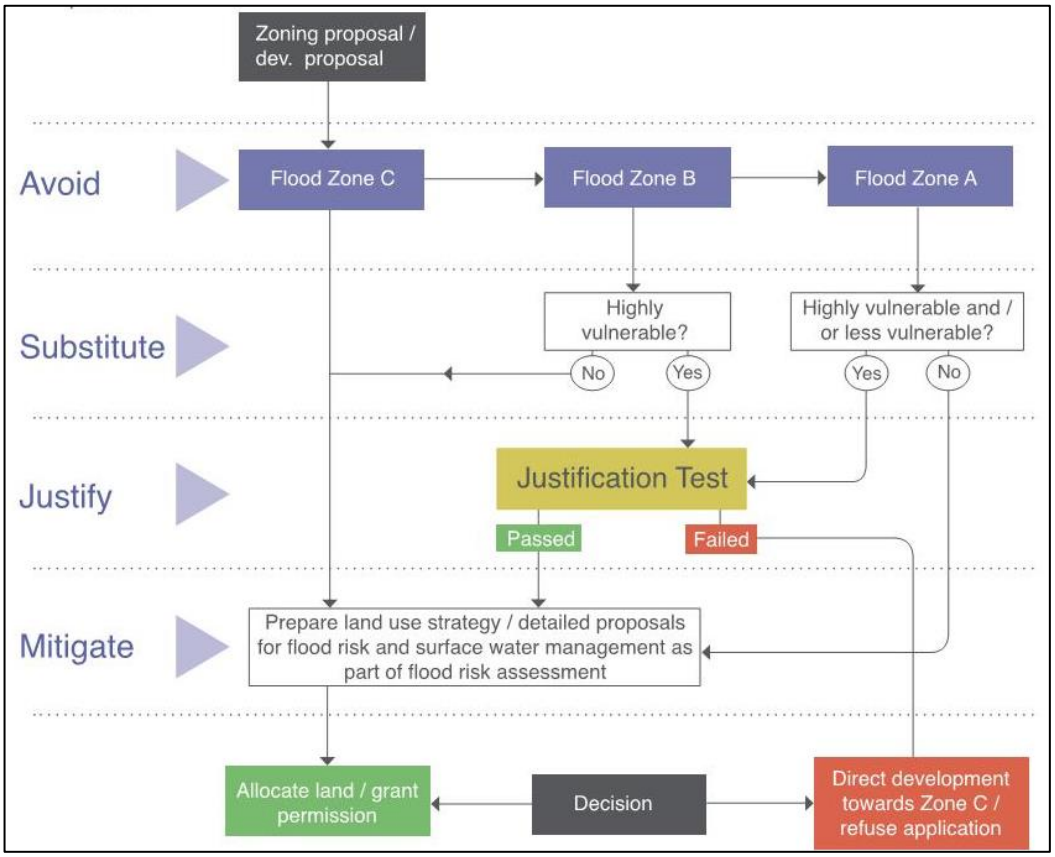


Figure 24: Sequential approach

9 Conclusions

Indaver proposes to develop a resource recovery centre in Ringaskiddy in County Cork. The proposed development will include a waste-to-energy facility for the treatment of up to 240,000 tonnes per annum of hazardous and non-hazardous residual household, commercial and industrial waste.

It was shown that the site is located in Flood Zone C as it outside the 1 in 1000 year design tidal floodplain.

The minimum design flood defence level of the proposed development was calculated as 3.8mOD Malin. Arup however have proposed a far more conservative flood defence level of 4.55mOD Malin for the site.

It is proposed to raise the footprint of the entire site to the proposed site flood defence level of 4.55mOD. This includes all the buildings, internal roads, car parking area and all associated site works. This measure will ensure that the risk of flooding to the site is remote.

It is proposed to upgrade the L2445 to address the risk of flooding of the road. The upgrade works will include raising a 185m section of the road to a maximum height of 3.45mOD between the car park adjacent to Gobby Beach and the Eastern end of the Hammond Lane Metal Company site. This is approximately 1.0m above the existing road level. This will elevate the road to above the 200 year design tidal water level plus an allowance for climate change. This will offer a high level of protection to the road from tidal flooding and ensure that access and egress routes are maintained during extreme flood events.

A new dedicated surface water drainage system will also be installed as part of the upgrade works to collect, convey and attenuate the runoff from the road before connecting back into the existing drainage to discharge to the foreshore.

These measures are sufficient to ensure that the risk of flooding of the site and its access road is extremely low.

It is considered that the proposed resource recovery centre at Ringaskiddy should be classified as a “Highly Vulnerable Development” as per the vulnerability classification. As the site is classified as Flood Zone C, a Justification Test is not required for the proposed development and it is necessary only to identify mitigation measures for any residual risks.