DART+ Coastal North

FLOOD RISK ASSESSMENT

JULY 2024

NTA Údarás Náisiúnta Iompair National Transport Authority

Rialtas na hÉireann Government of Ireland | Tionscadal Éireann Project Ireland 2040

Iarnród Éireann Irish Rail

ARUP

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ACRONYMNS

Term	Definition
Annual Exceedance Probability	The probability, typically expressed as a percentage, of a flood event of a given magnitude being equalled or exceeded in any given year. For example, a 1% AEP flood event has a 1%, or 1 in a 100, chance of occurring or being exceeded in any given year
CFRAM	Catchment Flood Risk Assessment and Management
CIÉ	Córas Iompair Éireann
DART	Dublin Area Rapid Transit
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Environmental Impact Assessment Directive and Regulations, including the publication of an Environmental Impact Assessment Report.
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EPA	Environmental Protection Agency
EU	European Union
Flood Zone A	Where the 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	Where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 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)
Flood Zone C	Where the 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 of the plan which are not in zones A or B
Flooding – Fluvial (River)	Fluvial flooding occurs when rivers and streams break their banks and water flows out onto the adjacent low-lying areas (the natural floodplains)
Flooding - Groundwater	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

Term	Definition
Flooding – Pluvial	Pluvial flooding occurs when the capacity of the local urban drainage network is exceeded during period of intense rainfall. At these times, water can collect at low points in the topography and cause flooding
Flooding - Tidal / Coastal	The temporary inundation of low-lying areas, especially streets, during exceptionally high tide (i.e. tidal flood) events, such as at full and new moons
FRA	Flood Risk Assessment
IÉ	Iarnród Éireann
Justification Test	An assessment of whether a development proposal within an area at risk of flooding meets specific criteria for proper planning and sustainable development and demonstrates that it will not be subject to unacceptable risk nor increase flood risk elsewhere. The justification test should be applied only where development is within flood risk areas that would be defined as inappropriate under the screening test of the sequential risk-based approach adopted by the DOEHLG (2009) Flood Risk Management Planning Guidelines. There are two types of Justification Tests, the Plan-making Justification Test Justification Test (used at plan preparing stage) and the Development Management Justification Test (used at the planning application stage)
Mitigation Measures	Measures designed to avoid, prevent or reduce impacts (EPA, 2022)
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
Return Period	A term that is used to describe the probability of a flood event, expressed as the interval in the number of years that, on average over a long period of time, a certain magnitude of flood would be expected to occur. This term has been replaced by 'Annual Exceedance Probability, as Return Period can be misleading
RO	Railway Order
The Developer	Irish Rail / Iarnród Éireann
The Proposed Development	The DART+ Coastal North Project will deliver an improved and extended electrified rail network and will enable increased passenger capacity and an enhanced train service between Dublin City Centre and Drogheda, including the Howth Branch.

10. APPENDIX A10.1: SITE SPECIFIC FLOOD RISK ASSESSMENT

10.1 Introduction

Córas Iompair Éireann, hereafter referred to as CIÉ, is applying to An Bord Pleanála ("the Board") for a Railway Order ("RO") for the DART+ Coastal North project under the Transport (Railway Infrastructure) Act 2001 (as amended and substituted) hereafter referred to as 'the 2001 Act".

Iarnród Éireann (hereafter referred to as IÉ) has appointed Arup as multi-disciplinary consultants for the DART+ Coastal North project, referred as the "Proposed Development" in this Report. This Report, prepared by Arup, comprises a site-specific Flood Risk Assessment (FRA) Report which accompanies the Railway Order application to the Board. It is required to inform the design of the Proposed Development and support the RO application.

The report has been undertaken in accordance with the '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DoEHLG), and Circular PL 2/2014, herein referred to as 'the Guidelines'.

10.1.1 Project Background

The DART+ Coastal North project is the third infrastructure project to launch as part of the DART+ Programme.

The DART+ Coastal North project will deliver an improved and extended electrified rail network and will enable increased passenger capacity and an enhanced train service between Dublin City Centre and Drogheda, including the Howth Branch. The Proposed Development features modifications to the existing line, which are referred to as General Linear Works, as required across the entirety of the Proposed Development.

The Proposed Development will modify the current rail network between Dublin City Centre (north of Connolly Station) and Drogheda MacBride Station, inclusive of the Howth Branch. The Proposed Development extends across four administrative/local authority areas, including Louth, Meath and Fingal County Councils as well as Dublin City Council. The Proposed Development also includes the construction of 8no. substations along the course of the route. The total length of the Proposed Development is approximately 50km.

10.1.2 Study Area

The Study Area includes the DART rail network from Dublin City Centre (north of Connolly Station) and Drogheda. The rail network is entirely within the Eastern River Basin District (ERBD) traversing through the hydrometric areas of the Boyne (HA 07), the Nanny-Delvin (HA 08) and the Liffey (HA09). The risk of flooding is reviewed up to 250m radius either side of the railway track. The Proposed Development has been split into 5no. zones for ease of reference on a geographic basis using the local authority boundaries.

As Fingal County Council covers a large area of the Proposed Development this has been split into two zones. The zones are presented in Image 10-1 and described in Table 10-1.

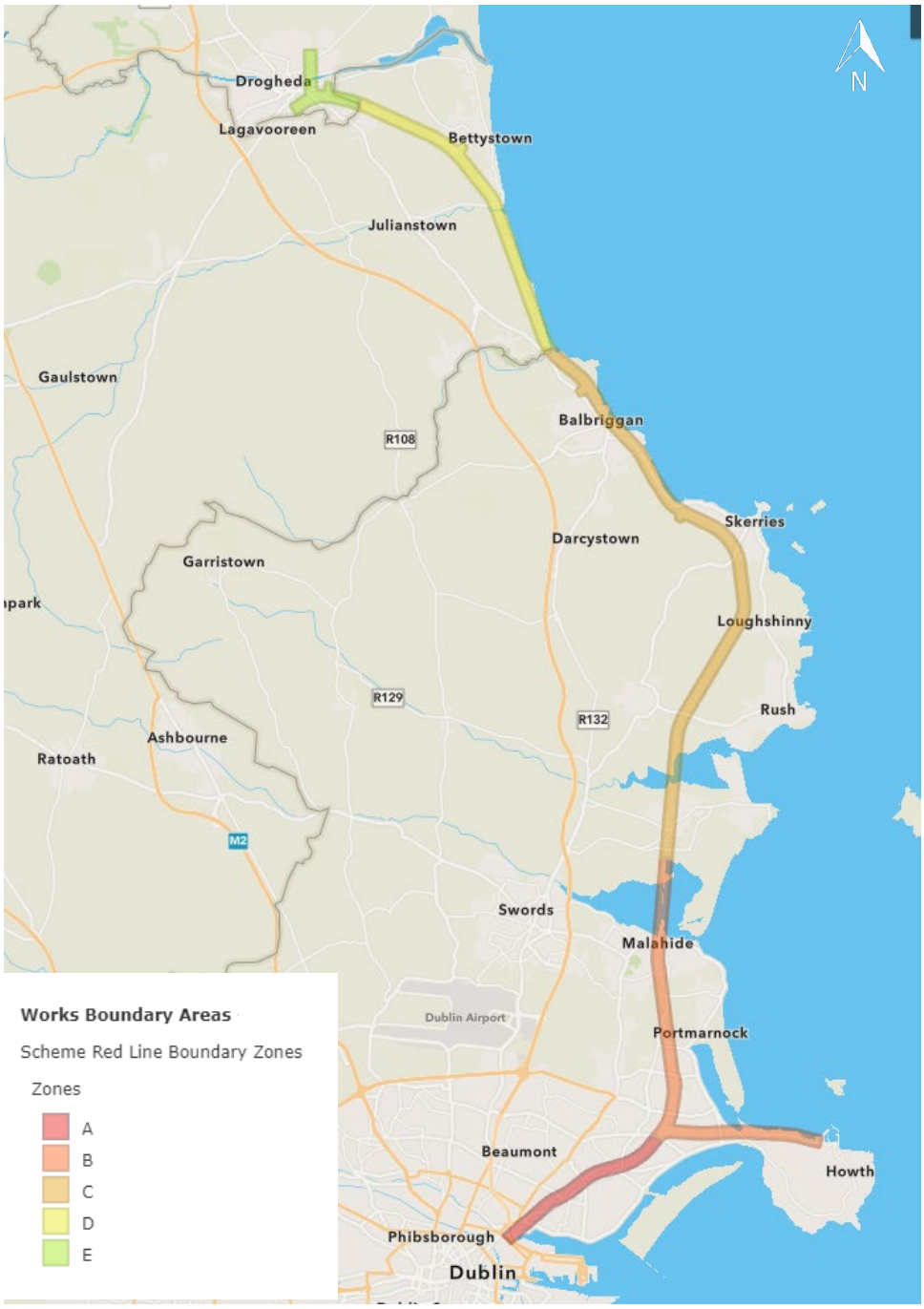


Image 10-1 DART+ Coastal North Proposed Development Extents and Zones

Table 10-1 DART+ Coastal North Geographical Zones

Zone	Location	Description	Local Authority
Zone A	North of Connolly Station to south of Howth Junction & Donaghmede Station	The area between north of Connolly Station to south of Howth Junction & Donaghmede Station, including Fairview Depot.	Dublin City Council
Zone B	South of Howth Junction & Donaghmede Station to north of Malahide Viaduct. (Including Howth Branch)	The area between Howth Junction & Donaghmede Station, and just north of Malahide Viaduct, plus the entire Howth Branch. Includes works within Howth Junction & Donaghmede Station, Clongriffin Station and the Malahide Viaduct.	Fingal County Council
Zone C	North of Malahide viaduct to south of Gormanston Station (Fingal boundary)	The area between south of Donabate Station to south of Gormanston Station. Area includes Donabate, Rush & Lusk, Skerries and Balbriggan Stations.	Fingal County Council
Zone D	South of Gormanston Station (Fingal border) to Louth/Meath border	The area between Gormanston Station (Fingal border) and the Louth/Meath border (boundary of Louth County 1.5km southeast of Drogheda MacBride Station). Includes Gormanston and Laytown Stations.	Meath County Council
Zone E	Drogheda MacBride Station and surrounds	Drogheda MacBride Station and surrounds including the area between the Dublin Road Bridge (UBK01) to the Louth/Meath border.	Louth County Council

10.1.3 Scope of Study

The scope of this FRA includes the following:

- Review the risk of tidal, fluvial, groundwater and pluvial flooding at or near the site;
- Review of the proposed buildings and stations layout and advise on a suitable finished floor level;
- Development of potential flood mitigation measures, if necessary; and
- Preparation of a site-specific FRA Report.

10.1.4 Summary of Data Sources

Data relating to flood risk relevant to the Proposed Development and surrounding area has been obtained from the following sources:

- Dublin City Development Plan 2022–2028 including its Strategic Flood Risk Assessment
- SFRA of the Fingal County Development Plan 2023-2029,
- SFRA of the Louth County Development Plan 2021-2027,
- SFRA of the Meath County Development Plan 2021-2027,
- Eastern CFRAM Hydrology and Hydraulics Reports and predictive flood mapping (https://www.floodinfo.ie/publications/);
- Western CFRAM Catchment Flood Risk Management Plan (https://www.floodinfo.ie/publications/);
- OPW National Flood Hazard Mapping Website (www.floodinfo.ie);

- Preliminary Flood Risk Assessment (PFRA) mapping produced by the OPW (https://www.floodinfo.ie/publications/);
- Topographical survey of the site; and
- Relevant Railway Order application drawings for the Proposed Development.

10.2 Stage 1 – Flood Risk Identification

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

- Fluvial (River) Flooding – fluvial flooding occurs when rivers and streams break their banks and water flows out onto the adjacent low-lying areas (the natural floodplains);
- Tidal/Coastal Flooding – is the temporary inundation of low-lying areas, especially streets, during exceptionally high tide (i.e. tidal flood) events, such as at full and new moons;
- Pluvial Flooding – pluvial flooding occurs when the capacity of the local urban drainage network is exceeded during periods of intense rainfall. At these times, water can collect at low points in the topography and cause flooding; and
- Groundwater Flooding – 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.

Each of these potential sources of flooding is considered in this FRA.

10.2.1 Historic Flood Maps

Records of historic floods were obtained from the OPW flood information website[1] and reports produced as part of the CFRAM Studies. A significant number of flood events have occurred in and around the Proposed Development site location.

Image 10-2 displays historic flood extents and flood points from floodmaps.ie. It can be noted that the DART line is in proximity to areas previously flooded.

[1] www.floodinfo.ie

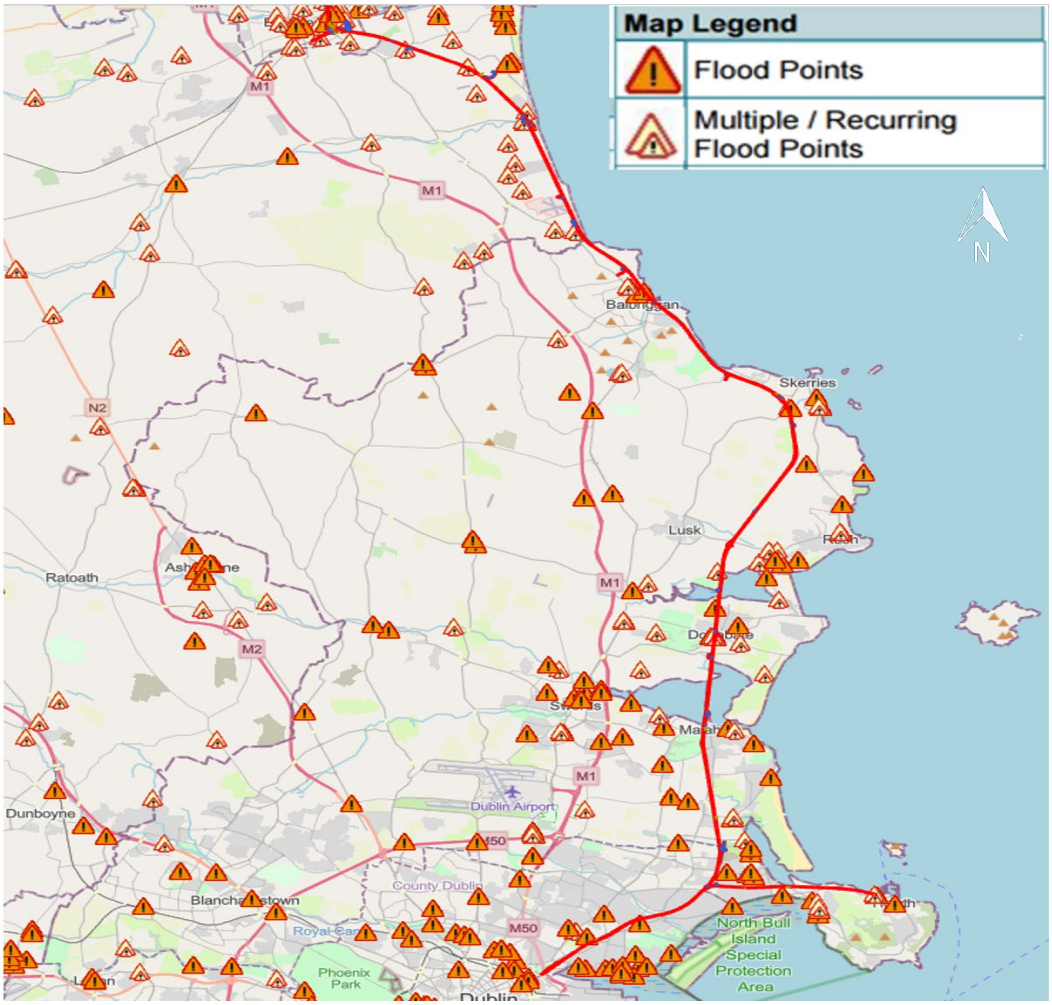


Image 10-2 Historic Flood Event locations

10.2.2 Past Flood Events

10.2.2.1 Zone A

Eleven historic flood events have been recorded across the existing railway line within Zone A. Among these flood events, the source of three flood events is riverine, one is coastal/estuarine, one other is because of low lying land and another one is due to surface runoff. The source of flooding for the remaining events is unknown or not stated.

Table 10-2 Historic Flood Events within Scheme Zone A

Location	Description	Source
ID-293	Single Flood event at Howth Road Harmonstown on 10 June 1963	Null
ID-665	Single Flood event at Naniken River Artane on 08 December 1954	River
ID-11566	Single Flood event at Clanmoyle Road, Donnycarney, Dublin 5 on 24 October 2011	Null
ID-292	Single Flood event at Donnycarney Wad on 10 June 1963	River
ID-10660	Single Flood event at Dublin Area on 02 July 2009	Other
ID-13534	Single Flood event at Clontarf on 02 February 2017	Coastal/Estuarine Waters
ID-2581	Single Flood event at Clontarf Rd Seaview Avenue on 23 August 2004	Runoff
ID-11655	Single Flood event at Shamrock Place, Cottages and Terrace, Dublin 3 on 24 October 2011	Null
ID-291	Single Flood event at North Strand Road June 1963	Null
ID-11945	Single Flood event at Jones Road, Dublin 3 on 26 July 2013	Null
ID-23	Single Flood event at Tolka on 25 November 1965	River

10.2.2.2 Zone B

Nineteen historic flood events have been recorded across the existing railway line within Zone B. Among these flood events, 14no. are single flood events with 5no. being recurring flood events. The source of seven flood events is riverine, 7no. are coastal/estuarine and 4no. are as a result of runoff. The source of one is unknown.

Table 10-3 Historic Flood Events Scheme Zone B

Location	Description	Source
ID-13023	Single Flood event at Malahide on 03 January 2014	Coastal/Estuarine Waters
ID-1617	Recurring Flooding at Seabank (Estate) Court Malahide	Coastal/Estuarine Waters
ID-1738	Single Flood event at Mill View Lawn Malahide 01 Feb 2002	Coastal/Estuarine Waters
ID-2165	Single Flood event at Biscayne Coast Road Malahide 19 October 2002	Runoff
ID-1652	Single Flood event at Streamstown to Malahide Road Dublin Undated	River
ID-1742	Single Flood event at Strand Road Malahide on 01 February 2002	Coastal/Estuarine Waters
ID-1262	Single Flood event at Sluice Kinsealy Hall on 24 August 1986	River
ID-1933	Recurring Flooding at Sluice River Kinsealy Lane	River
ID-1613	Recurring Flooding at Sluice River Strand Road Portmarnock	River
ID-677	Single Flood event at Mayne Balgriffin Park on 10 June 1993	River
ID-1463	Recurring Flooding at Mayne River Bridge Baldoyle	River
ID-1462	Recurring Flooding at Baldoyle Coastal	Coastal/Estuarine Waters
ID-13005	Single Flood event at Baldoyle on 03 January 2014	Coastal/Estuarine Waters
ID-2212	Single Flood event at Grange Road Donaghmede Nov 1982	Runoff
ID-1715	Single Flood event at The Grange Road Baldoyle 19 October 2002	Runoff
ID-14088	Single Flood event at Kilbarrack on 02 December 2021	Null
ID-1732	Single Flood event at Dublin Road Sutton 01 February 2002	Coastal/Estuarine Waters
ID-1714	Single Flood event at Bloody Stream Howth Area on 14 November 2002	Runoff
ID-13112	Single Flood event at Howth on 10 August 2014	River

10.2.2.3 Zone C

Sixteen historic flood events have been recorded across the existing railway line within Zone C. Among these flood events, 11no. are single flood events and 5no. are recurring flood events. The source of 1no. flood event is riverine, 6no. are coastal/estuarine, 2no. are because of low lying land and 4no. are due to runoff. The source of the remaining 3no. is unknown.

Table 10-4 Historic Flood Events Scheme Zone C

Location	Description	Source
ID-2183	Recurring flooding at Bremore Court Balbriggan 05 November 2000	Null
ID-1712	Single Flood event at Covetown Balbriggan 12 November 2002	Coastal/Estuarine Waters
ID-1713	Single Flood event at Bath Road 14 November 2002	Coastal/Estuarine Waters
ID-2131	Single Flood event at Mill Stream Skerries 05 November 1982	River
ID-2872	Single Flood event at Skerries South Beach Holmpatrick 01 February 2002	Coastal/Estuarine Waters
ID-1619	Recurring flooding at Holmpatrick Skerries	Coastal/Estuarine Waters
ID-2361	Single Flood event at Ballykea Lusk Autumn 31 August 2000	Null
ID-1709	Single Flood event at Ballisk Donabate 14 November 2002	Surface Runoff
ID-14068	Recurring Flooding at Donabate New Road/Distributor Road Junction on 12 November 2020	Surface Runoff
ID-14067	Single Flood event at The Links Donabate on 01 November 2019	Surface Runoff
ID-1711	Single Flood event at Beaverstown 14 November 2002	Surface Runoff
ID-1637	Recurring Flooding at Balleally Lane	Surface Runoff
ID-2361	Single Flood event at Ballykea Lusk Autumn 31 August 2000	Null
ID-1458	Recurring Flooding at Rogerstown Rush	Coastal/Estuarine Waters
ID-2173	Single Flood event at Spout Road Rogerstown/Rush 17 August 2004	Runoff
ID-14011	Single Flood event at Rogerstown Spout Road, Rush on 20 October 2020	Coastal/Estuarine Waters

10.2.2.4 Zone D

Fourteen historic flood events have been recorded across the existing railway line within Zone D. Among these flood events, 2no. are single flood events and 12no. are recurring flood events. The source of 2no. flood events is riverine, 3no. are coastal/estuarine and 8no. are because of surface runoff.

Table 10-5 Historic Flood Events Scheme Zone D

Location	Description	Source
ID-1713	Single Flood event at Bath Road 14 November 2002	Coastal/Estuarine Waters
ID-1712	Single Flood event at Covetown Balbriggan 14 November 2002	Coastal/Estuarine Waters
ID-2183	Recurring flooding at Bremore Court Balbriggan 11 November 2000	Null
ID-961	Recurring flooding at Station Road, Gormanston	River
ID-954	Recurring flooding at Martin's Road, Gormanston	Surface Runoff
ID-956	Recurring flooding at Irishtown, CR 438 A	Surface Runoff
ID-960	Recurring flooding at Mosney Road	Surface Runoff
ID-957	Recurring flooding at Irishtown CR 438 B	Surface Runoff
ID-1180	Recurring flooding at Irishtown CR 438 C	Surface Runoff
ID-5321	Recurring flooding at Laytown Feb 2002	Coastal/Estuarine Waters
ID-963	Recurring flooding at Alvera Heights, Laytown	Surface Runoff
ID-962	Recurring flooding at Minnistown	Surface Runoff
ID-941	Recurring flooding at Piltown Meath	River
ID-959	Recurring flooding at Colp West	Surface Runoff

10.2.2.5 Zone E

Eleven historic flood events have been recorded across the existing railway corridor within Zone E. Among these flood events, 7no. are single flood events and 4no. are recurring flood events. The source of 6no. flood events is riverine, 3no. are coastal/estuarine and 2no. are a result of surface runoff on low-lying land.

Table 10-6 Historic Flood Events Scheme Zone E

Location	Description	Source
ID-13687	Single Flood event recorded at R167 North Strand, Drogheda on 13 January 2020	Coastal/Estuarine Waters
ID-11642	Single Flood event recorded at North Strand and Newtown Rd, Drogheda, Co. Louth on 24 October 2011	River
ID-4600	Single Flood event recorded at North Quay Area Drogheda February 2002	River
ID-4732	Single Flood event recorded at Drogheda 26 October 2004	Coastal/Estuarine Waters
ID-12005	Single Flood event recorded at Marsh Road, Drogheda, Co. Louth on 03 January 2014	River
ID-12894	Single Flood event at Drogheda on 17 October 2012	Coastal/Estuarine Waters
ID-12003	Single Flood event in Ship Street, Drogheda, Co. Louth on 03 January 2014	River
ID-4606	Recurring flooding at Poorhouse Lane Drogheda	Surface Runoff
ID-4621	Recurring flooding at The Glen Drogheda	River
ID-4620	Recurring flooding at Greenmount and Boyne	River
ID-4611	Recurring flooding at Dublin Road Drogheda	Runoff

10.2.3 Fluvial Flood Risk Maps

The Eastern CFRAM was completed in 2017 and provided predicted fluvial and tidal flood maps for a range of return periods.

An extract from the Eastern CFRAMS fluvial flood extent map is presented in Image 10-3. The predicted extents for the 1 in 10-, 100- and 1000-year fluvial flood events are shown in Image 10-3.

The flood map indicates that a portion of each of the DART Zones A-E lie within the 1 in 10 and 1 in 100-year flood extents and are therefore considered to be within Flood Zone A.

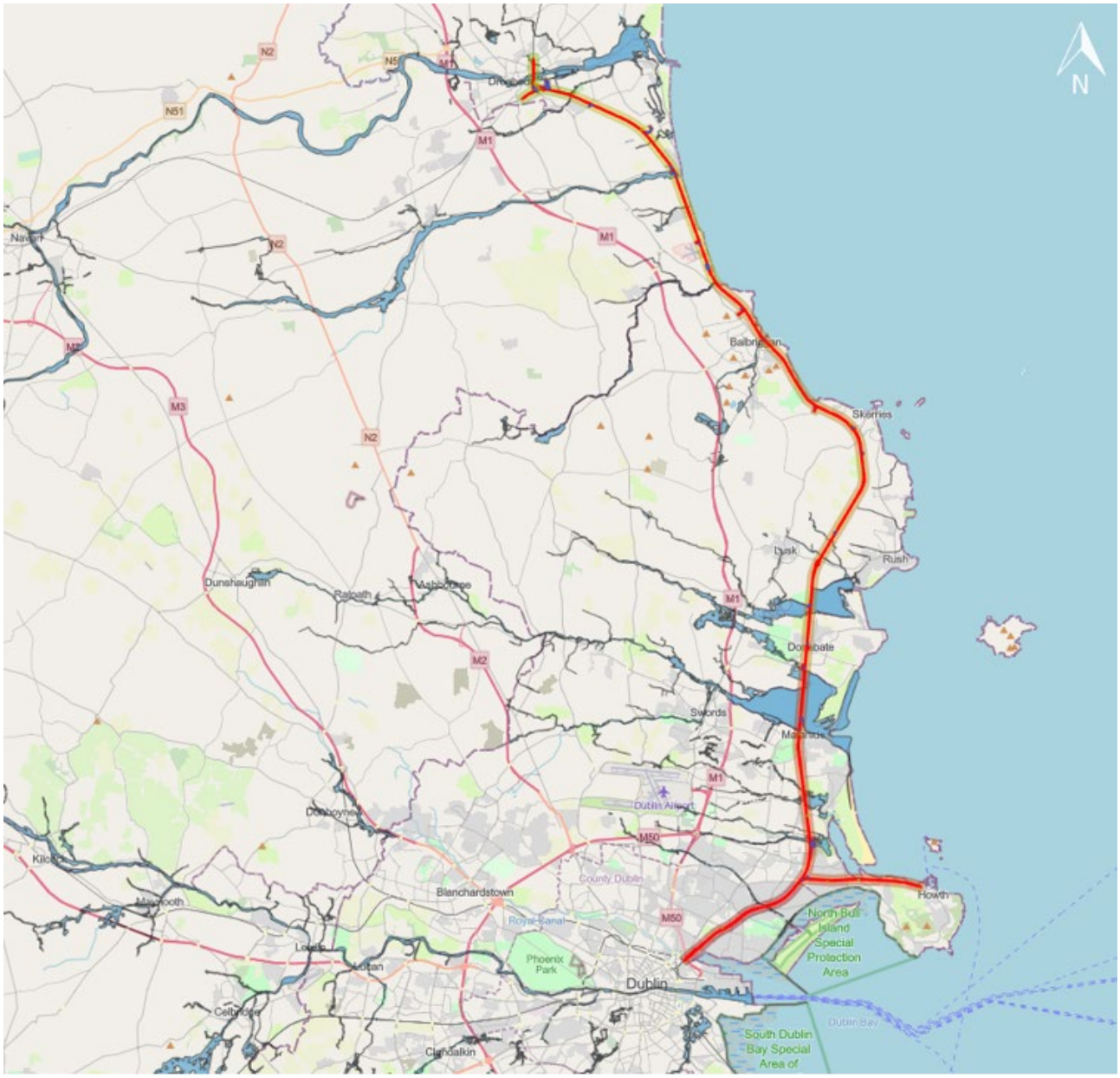


Image 10-3 1% AEP Fluvial Flood Extents

10.2.4 Tidal Flood Risk Maps

An extract from the Eastern CFRAMS tidal flood extent map is displayed in Image 10-4. The predicted extents for three separate return period events of the 1 in 10-, 200- and 1000-year tidal flood events are shown. Nodal points detailing the water level have not been included within the Eastern CFRAM Coastal study.

The flood map indicates that most of the site lies within areas outside the 1 in 1000-year tidal flood extent, categorised as Flood Zone C. However, some sections of the Proposed Development are within areas categorised as Flood Zone B and Flood Zone A.

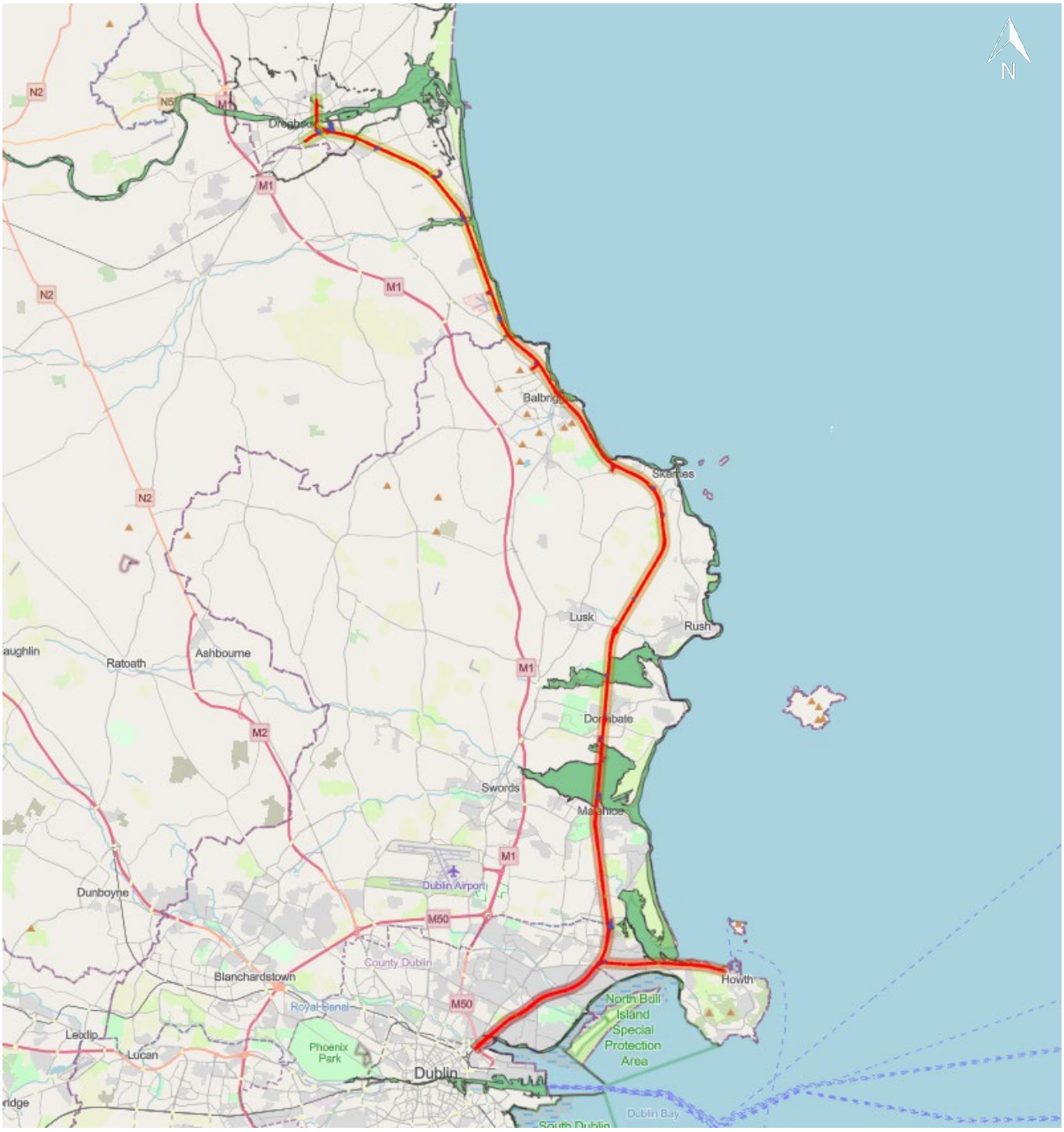


Image 10-4 0.5% AEP Tidal Flood Extents

10.2.5 Pluvial Flooding

Pluvial flooding occurs when extreme rainfall overwhelms drainage systems or soil infiltration capacity, causing excess rainwater to pond above ground at low points in the topography. For the purpose of Stage 1 FRA, the risk of pluvial flooding to the site, the PFRA undertaken by the OPW has been reviewed. These maps are not conclusive but were used to indicate if there is any potential for pluvial flooding event in the past or any potential for the future as predicted using a hydraulic model.

The PFRA maps are reproduced in the sections below and show that there is very low risk of pluvial flooding along the existing railway corridor. However, as noted above these maps are preliminary, and

the risk of pluvial flooding may not be ruled out as the risk can increase due to defective drainage system, leaking/displaced joints, broken/collapsed sections of pipes, blockage, etc. which can be addressed through maintenance activities.

10.2.5.1 Pluvial Vulnerability Zone A

Zone A is the area between north of Connolly Station to south of Howth Junction & Donaghmede Station, including Fairview Depot. The OPW has commissioned a higher level of detail pluvial study of Dublin city as can be seen in Image 10-5. It can be seen from this figure that Zone A is of moderate pluvial flood vulnerability with many small pockets of flood risk but no large ponding (indicating pluvial flood vulnerability).

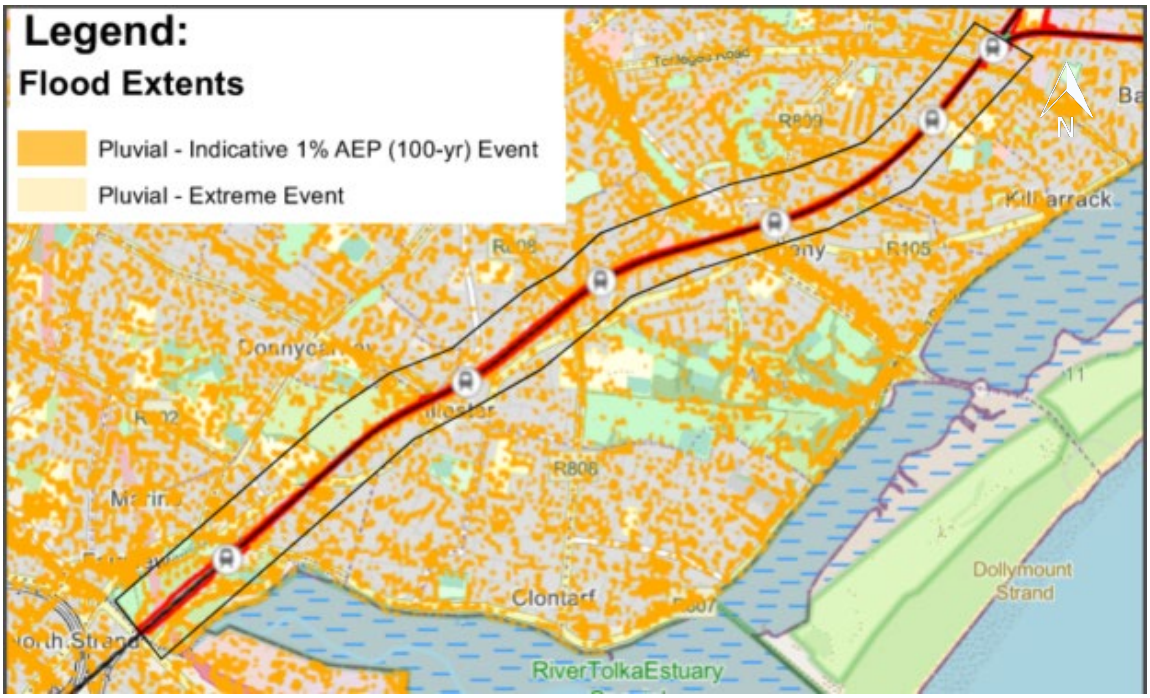


Image 10-5 Pluvial Flood Extent Scheme Zone A

10.2.5.2 Pluvial Vulnerability Zone B

Zone B is the area between Howth Junction & Donaghmede Station and just north of Malahide Viaduct, plus the entire Howth Branch including works around Howth Junction & Donaghmede Station, Clongriffin Station and the Malahide Viaduct. Zone B lies in an area of low pluvial flood vulnerability.

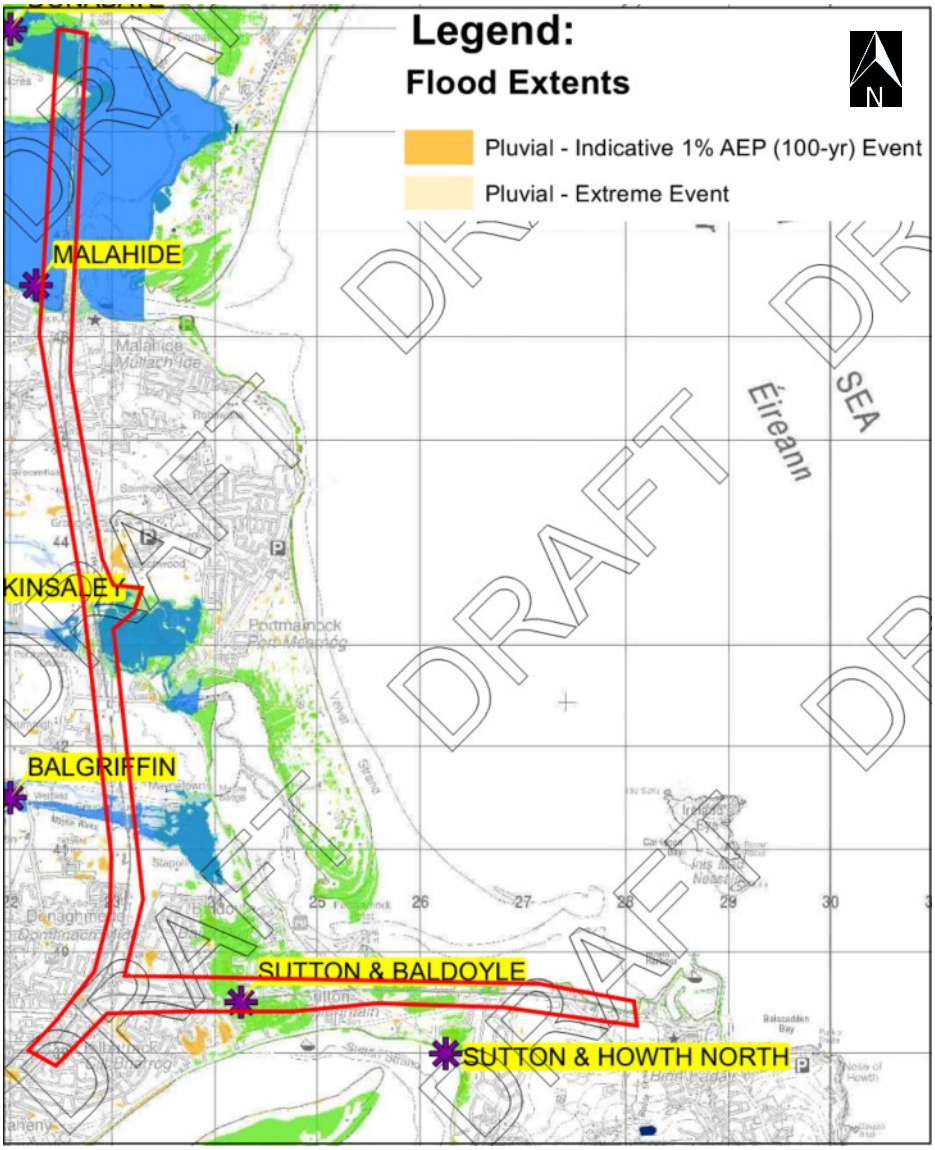


Image 10-6 Pluvial Flood Extent Scheme Zone B

10.2.5.3 Pluvial Vulnerability Zone C

Zone C covers the area between south of Donabate Station to south of Gormanston Station. This zone includes Donabate, Rush & Lusk, Skerries and Balbriggan Stations. The zone is of low pluvial flood vulnerability. Five substations are located within this Zone.

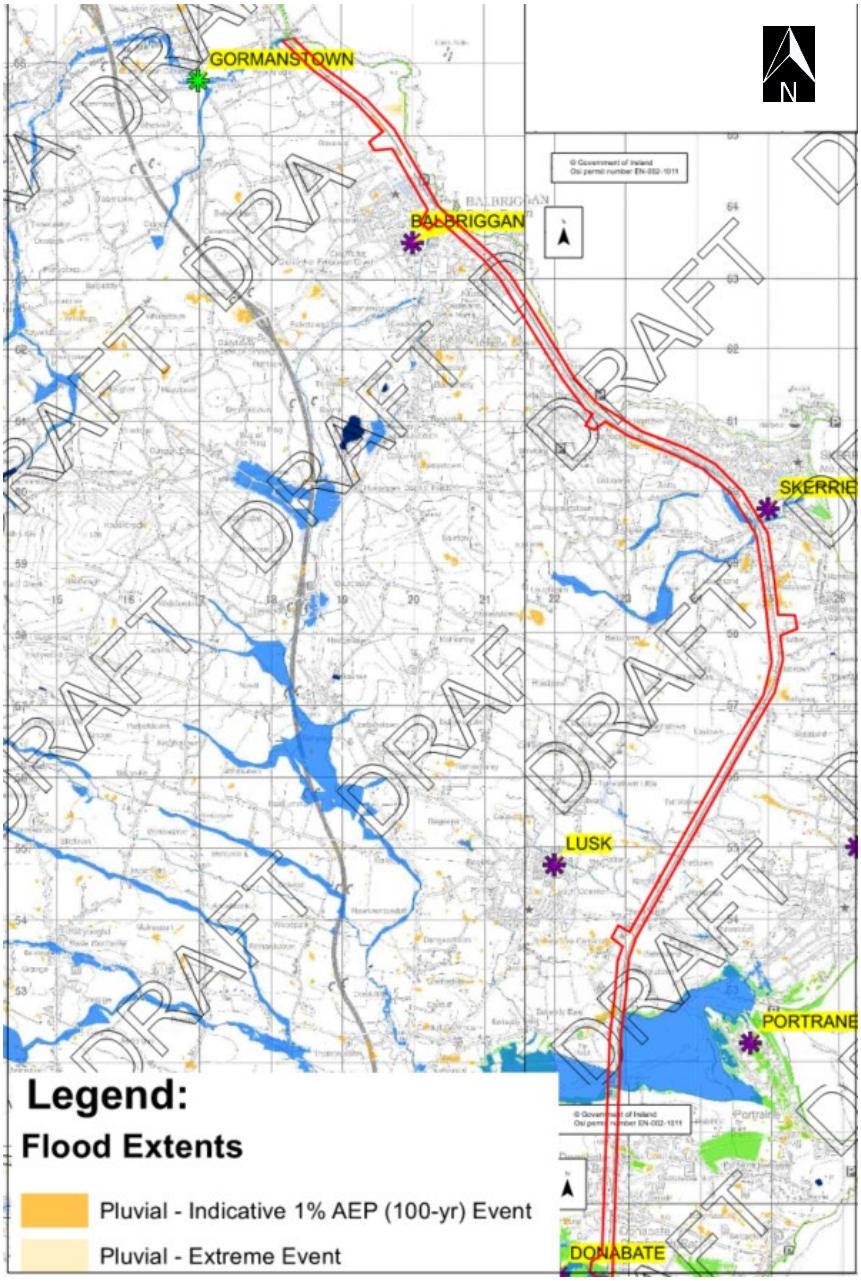


Image 10-7 Pluvial Flood Extent Scheme Zone C

10.2.5.4 Pluvial Vulnerability Zone D

Zone D extends from Gormanston Station (Fingal border) and the Louth/Meath border (1.5km southeast of Drogheda MacBride Station). This zone includes the proposed Gormanston and Laytown substations. Zone D is of low pluvial vulnerability as no area along the railway corridor within this zone lies in a pluvial flood risk zone. The Gormanston and Laytown Substations both lie within areas of low pluvial vulnerability.

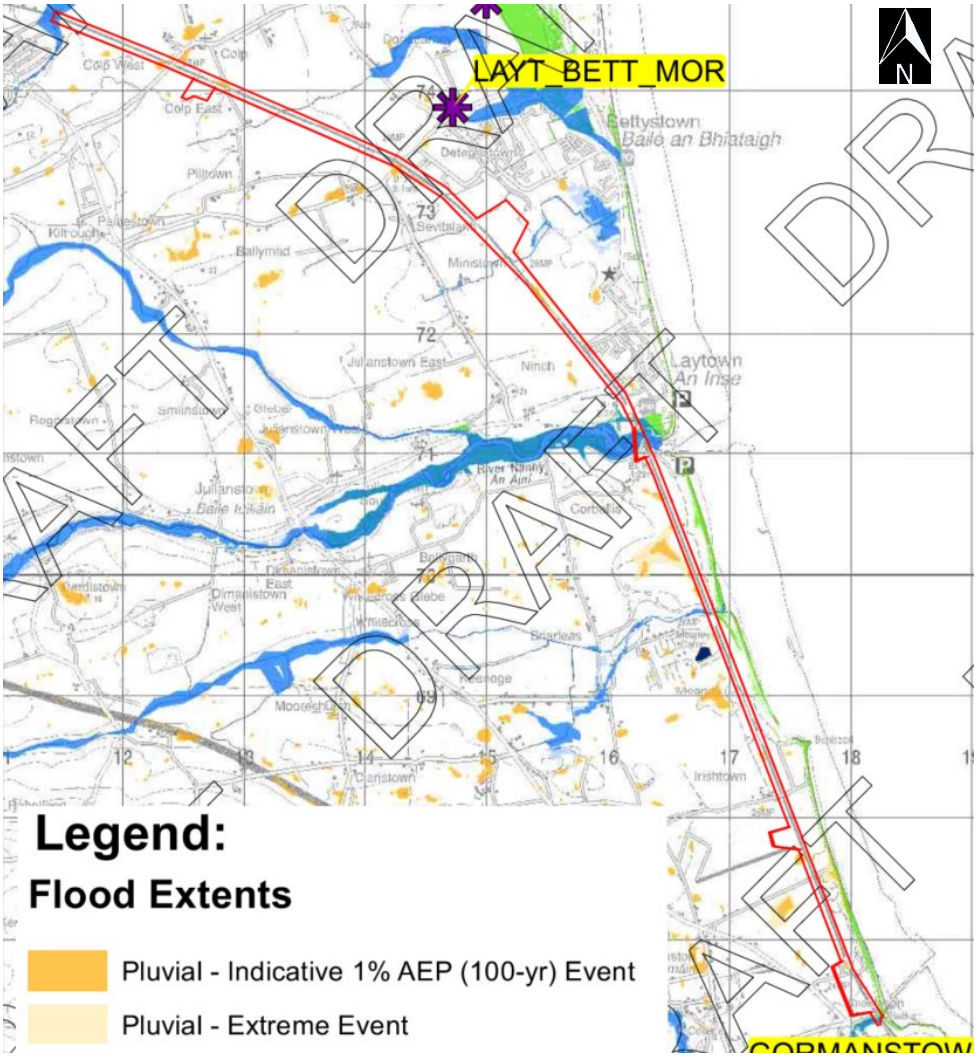


Image 10-8 Pluvial Flood Extent Scheme Zone D

10.2.5.5 Pluvial Vulnerability Zone E

Zone E extends from the Louth/Meath border to just north of Drogheda MacBride Station, in Drogheda town. The Drogheda Substation and works around Drogheda MacBride Station lie in this zone. Zone E is of low pluvial flood vulnerability and hence at low risk as only small pockets of ponding outside of the track are visible.

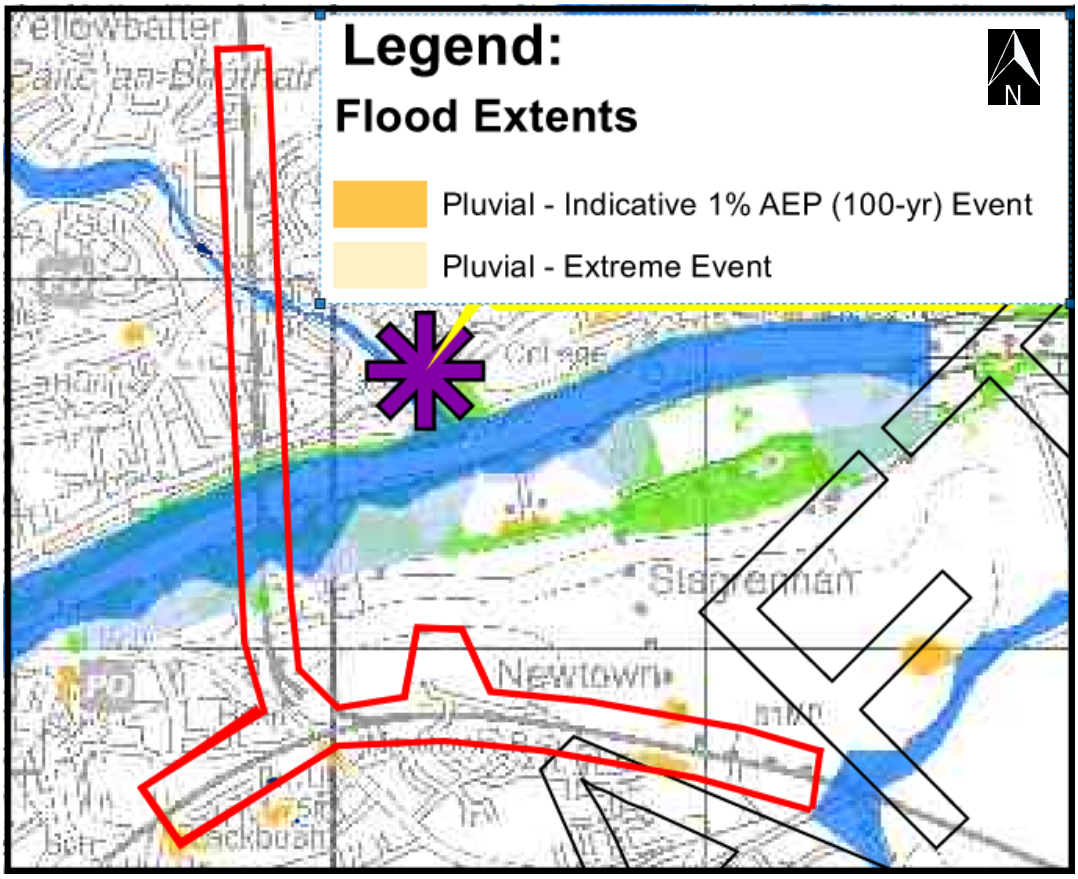


Image 10-9 Pluvial Flood Extent Scheme Zone E

10.2.6 Groundwater Flooding

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.

GSI ground water flooding data shows no risk of flooding along the tracks or at proximity to it.

10.2.7 Conclusion of Stage 1 – FRA

The various sources of flooding were assessed, and it was determined that the Proposed Development, at least in part, is at risk of flooding from fluvial and tidal sources. Therefore, the FRA is progressed to Stage 2: Initial Flood Risk Assessment.

10.3 Stage 2 – Initial Flood Risk Assessment

10.3.1 General

For Stage 2: Initial Flood Risk Assessment, the Proposed Development is assessed by subdividing the 5no. distinct geographic zones to better understand the risk of flooding from all sources and identify management options for each area. Flood risk to each of these zones is detailed below.

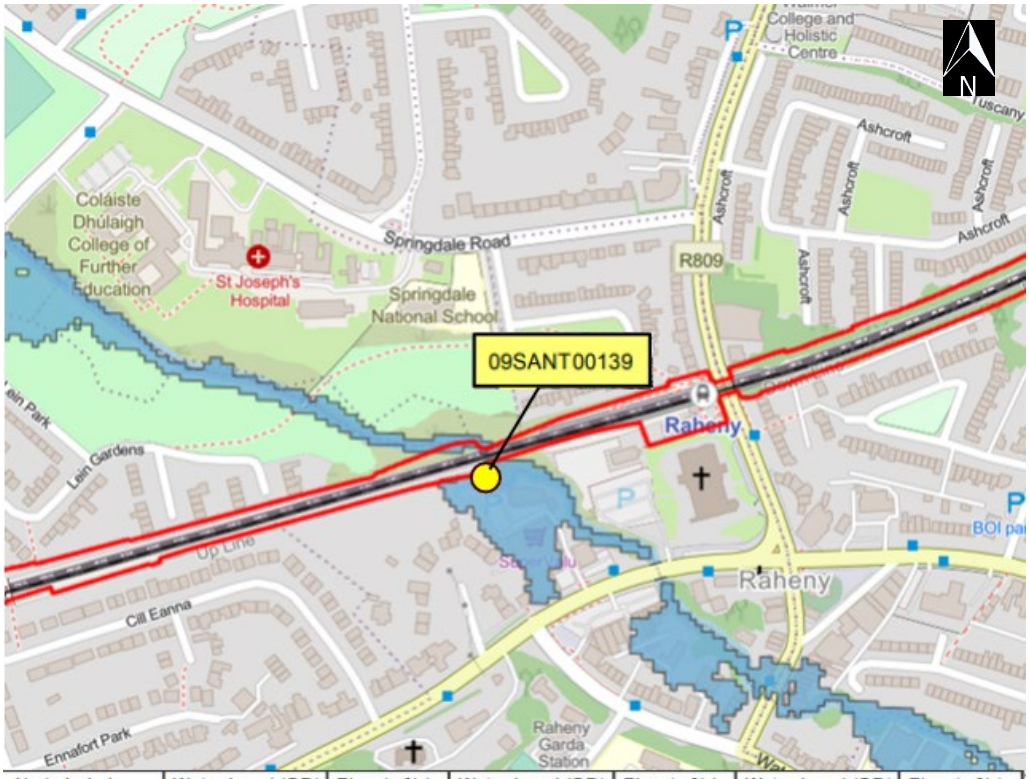
10.3.2 Zone A

Zone A is the area between north of Connolly Station to south of Howth Junction & Donaghmede Station and works within this zone are minimal, comprising mainly internal modifications to Fairview Depot.

Image 10-10 Scheme Zone A Extents

10.3.2.1 Fluvial Risk - River Santry

The existing railway corridor passes through Raheny and over the Santry River and its associated flood extents. The track line itself is above the 0.5% AEP tidal flood level, however the surroundings of the track are within the 0.5% (1 in 200 year) AEP tidal floodplain and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.



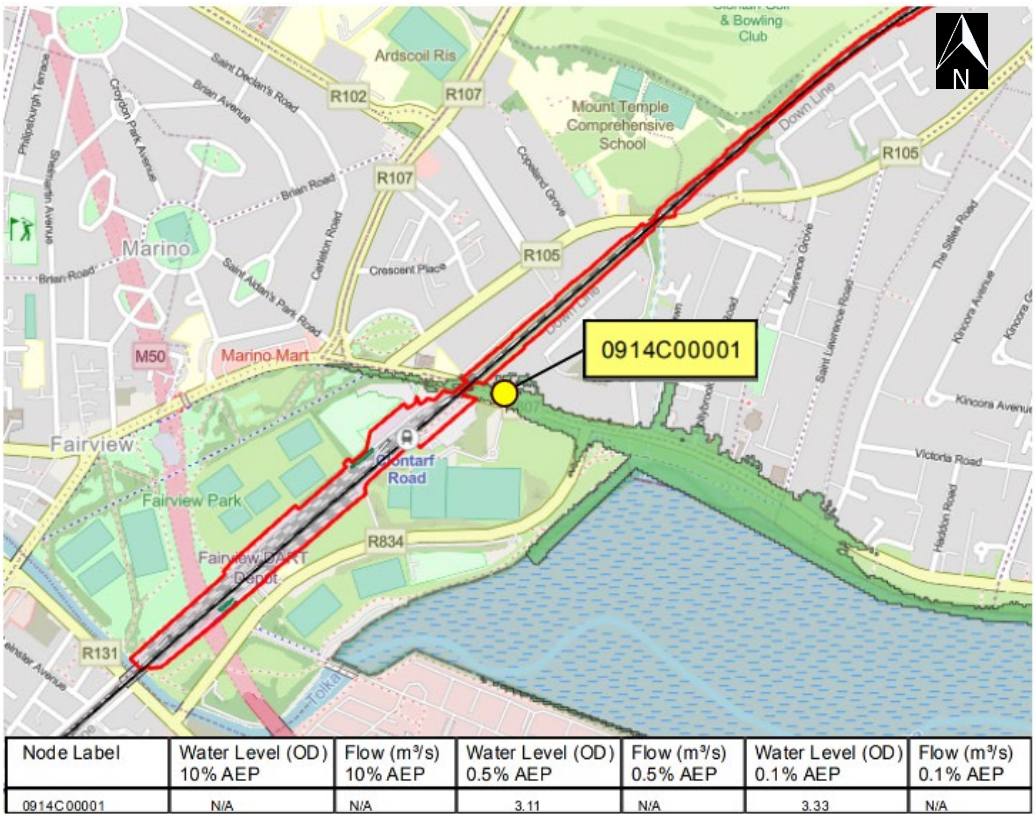
Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 1% AEP	Flow (m³/s) 1% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
09SANT00190D!	21.38	N/A	23.00	N/A	23.30	N/A
09SANT00139	15.90	7.45	16.56	13.28	17.87	21.90
09SANT00084W	12.30	8.08	12.79	14.43	13.15	23.98

Image 10-11 River Santry Fluvial Extent

The nodal point on the Santry River which interacts with the line is 09SANT00139. The 1% AEP fluvial water level at the node is 16.56mOD. The railway line at this location is at 21.7mOD and therefore not at risk. No further works are planned for outside of the boundaries of the track but risk to surrounding areas should be noted if plans change.

10.3.2.2 Tidal Risk - River Tolka Estuary

The railway corridor passes along a large flood extent at the River Tolka Estuary. Track Levels are assessed to be at >14mOD which is significantly higher than the 0.5% AEP tidal flood level. However, the surroundings of the existing railway line are within the 0.5% AEP extent and therefore classified as Flood Zone A and as a result, interaction with lands outside of the site boundary including access to site in flood events may be affected.



Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 0.5% AEP	Flow (m³/s) 0.5% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
0914C00001	N/A	N/A	3.11	N/A	3.33	N/A

Image 10-12 Tolka Estuary tidal extent

The nodal point on the Tolka River which interacts with the line is 0914C00001. The 0.5% AEP fluvial water level at the node is 3.11mOD. The railway line is at 14.3mOD in this location and therefore at low risk.

10.3.3 Zone B

Zone B is the area between Howth Junction & Donaghmede Station, and just north of Malahide Viaduct, including the Howth Branch. The zone includes the following works:

- Construction of the Howth Junction and Donaghmede station platform extension;
- Construction of a new crossover east of Howth Junction and Donaghmede Station;
- Construction of significant upgrades to the Howth Junction and Donaghmede Station;
- Clongriffin Station track works (Clongriffin Turnback);
- Construction of a secondary bridge adjacent to UBB19 over the Mayne River;
- Track works and railway embankment widening north of Malahide station (Malahide Turnback);
- Modification of UBB30 Malahide Viaduct (OHLE);
- XB001 (user worked) level crossing closure, and
- Temporary construction compounds associated with the above works.

Image 10-13 Zone B Extents

10.3.3.1 Fluvial Risk

10.3.3.1.1 Sluice River

The Proposed Development passes through Malahide and over the Sluice River and its associated flood extents. The track line is above the 1% AEP fluvial flood level; however, the surroundings of the track are not and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.

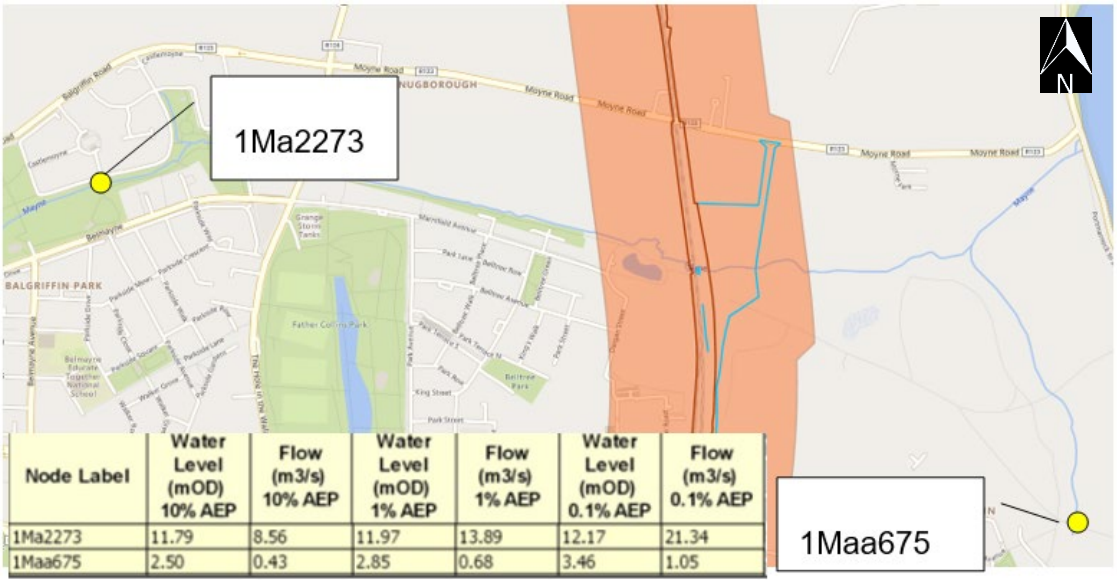
Node Label	Water Level (mOD) 10% AEP	Flow (m3/s) 10% AEP	Water Level (mOD) 1% AEP	Flow (m3/s) 1% AEP	Water Level (mOD) 0.1% AEP	Flow (m3/s) 0.1% AEP
2Saa687	3.28	2.03	3.77	3.83	4.14	5.98
2Sa2090	2.24	7.17	2.42	12.22	2.68	3.53

Image 10-14 Sluice River fluvial extent

The nodal point on the Sluice River with the highest level is 2Saa687. The 1% AEP fluvial water level at the node is 3.77mOD. The DART track line and proposed infrastructure is at 7.5mOD in this location and therefore not at risk. However, the surroundings of the track are within the 1% AEP tidal floodplain and therefore interaction with lands outside of the site boundary including access to site in flood events may be at risk.

10.3.3.1.2 Mayne River

The existing DART Line passes through Clongriffin and over Mayne River and its associated flood extents. The track line itself is above the 1% AEP flood level, however the surroundings of the track are not (see Image 10-15).



Node Label	Water Level (mOD) 10% AEP	Flow (m3/s) 10% AEP	Water Level (mOD) 1% AEP	Flow (m3/s) 1% AEP	Water Level (mOD) 0.1% AEP	Flow (m3/s) 0.1% AEP
1Ma2273	11.79	8.56	11.97	13.89	12.17	21.34
1Maa675	2.50	0.43	2.85	0.68	3.46	1.05

Image 10-15 Mayne River fluvial Levels

The nodal points on the Mayne River are quite distant and have significant variations in their flood levels. For this reason, the flood level at the proposed site has been interpolated between nodal points 1Ma2273 (721799E, 741394N) and 1Maa675 (733992E,740214N). The interpolated 1% AEP fluvial water level at the bridge is therefore 5.89mOD[2]. The track itself is at 9.5mOD and therefore not at risk. However, the surroundings of the track fall within the 1% AEP fluvial floodplain, which may impact interaction with lands outside the site boundary, including access during flood events.

The proposed temporary Construction Compound and proposed arch bridge adjacent to UBB19 are designed considering the 1% AEP flood level with appropriate allowance of freeboard and climate change. To assess the impact of the proposed arch bridge UBB19A (Image 10-16) on flood levels at the Mayne River crossing, a channel survey was conducted, and a 1D HEC RAS[3] 6.4.1 hydraulic model developed. The pre and post development flood levels derived from the hydraulic model for the reach, taking account of the proposed arch bridge, are tabulated in Table 10-7.

Based on the identified worst-case design event scenarios involving joint fluvial and tidal events, the most conservative combination for studying the impact of the new bridge on flood risk is the 0.1% (1 in 1000 year) AEP fluvial event combined with the 2% (1 in 50 year) tidal event. This scenario resulted in the highest flood level at the bridge section.

[2] This was later confirmed to be a conservative estimate by means of a hydraulic model developed for the proposed bridge widening at this crossing.

[3] US Army Corps of Engineers Hydraulic Engineering Centre River Analysis System Software, Version 6.4.1, June 2023.

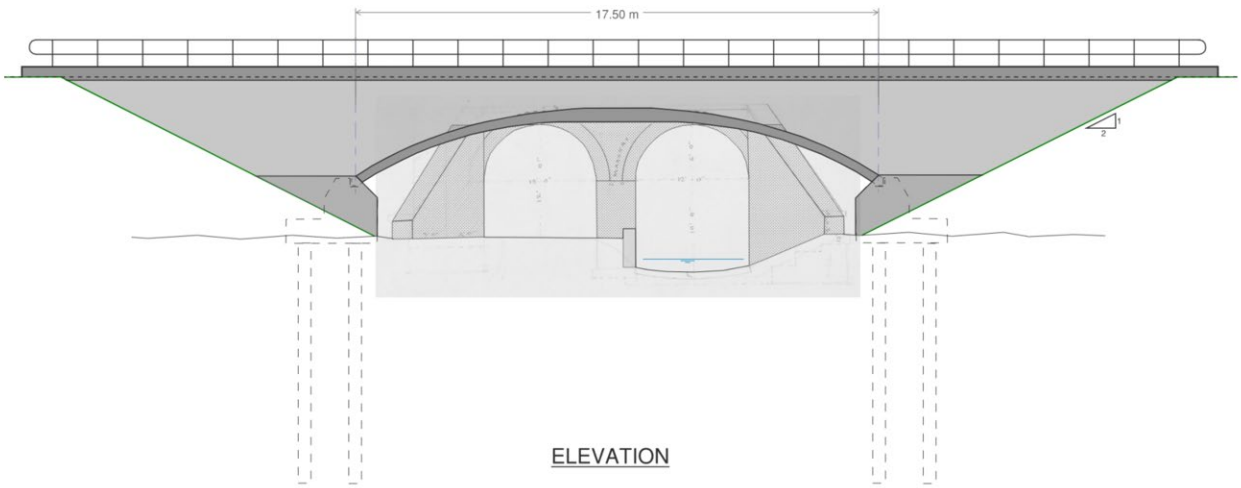


Image 10-16 Proposed Single Arch Bridge (UBB19A)

The hydraulic modelling results (Table 10-7) indicate that the maximum water level immediately upstream of the proposed arch bridge increases by approximately 18cm to 4.304m OD post development for the design event scenario. However, this increase remains localised and does not propagate further downstream as the level observed at the downstream face of the arch bridge is 4.227mOD.

The hydraulic regime change was also reviewed and no significant scour or deposition was predicted that would undermine the integrity of the existing and/or proposed bridge. Additionally, the sofit level of the proposed arch bridge at 7.75mOD provides a substantial freeboard of 3.24m at this location. This is much more than the minimum requirement of 300mm for bridges of a similar nature. Overall, this modelling exercise demonstrates that the bridge opening can convey the design event flow without altering the hydraulic characteristics of the watercourse and impacting on receptors elsewhere.

Table 10-7 Pre and Post Bridge Development Flood Levels at Mayne River Crossing

Design Event	Pre-development			Post-Development		
	Elevation at X-Section US of UBB19, m OD	Elevation at X-Section US of Proposed Arch Bridge, m OD	Elevation at X-Section DS of Proposed Arch Bridge, m OD	Elevation at X-Section US of UBB19, m OD	Elevation at X-Section US of Proposed Arch Bridge, m OD	Elevation at X-Section DS of Proposed Arch Bridge, m OD
Fluvial 1% + Tidal 5%	5.287	4.251	4.138	5.293	4.409	4.138
Fluvial 0.1% + 2% Tidal	5.557	4.338	4.227	5.557	4.518	4.227
Fluvial 10% + 0.5% Tidal	4.925	4.094	3.986	4.932	4.211	3.986

Design Event	Pre-development			Post-Development		
	Elevation at X-Section US of UBB19, m OD	Elevation at X-Section US of Proposed Arch Bridge, m OD	Elevation at X-Section DS of Proposed Arch Bridge, m OD	Elevation at X-Section US of UBB19, m OD	Elevation at X-Section US of Proposed Arch Bridge, m OD	Elevation at X-Section DS of Proposed Arch Bridge, m OD
Fluvial 2% + 0.1% Tidal	5.188	4.203	4.082	5.188	4.304	4.082

10.3.3.2 Tidal Risk

10.3.3.2.1 Malahide Estuary

The existing railway passes through a large flood extent through the Malahide Estuary. The existing railway line is outside of the 0.5% AEP extent and is therefore classified as Flood Zone C. However, the surroundings of the track are within the 0.5% AEP tidal floodplain and therefore interaction with lands outside of the site boundary including access to site and widening of the railway embankment for the turnback may be at risk.

Node Label	Water Level (mOD) 10% AEP	Water Level (mOD) 0.5% AEP	Water Level (mOD) 0.1% AEP
062	2.57	3.07	3.36
052	2.82	3.24	3.44
053	2.76	3.18	3.41

Image 10-17 Malahide Estuary tidal extent

As the northern nodal points have been previously assessed in Section 10.3.4.1.3, the nodal point 062 was evaluated for this waterbody. The 0.5% AEP fluvial water level at the node is 3.07 mOD. The DART Line is proposed at 7.76mOD and is therefore at low risk.

10.3.3.2.1.1 Malahide Turnback

The Malahide Turnback will be used to facilitate train services by allowing trains to be turned back clear of continuing services on separate tracks. To support the turnback, new retaining structures will be constructed west of the existing rail alignment. A 400-meter-long modular reinforced earth wall will be built. Its height will vary, with a 3-meter middle section and 1-meter ends. An embankment (1:2 slope) will top the wall to accommodate the remaining height difference. The wall and modified embankment will be completed before installing additional railway tracks, overhead line equipment (OHLE) and other infrastructure.

The wall will run along the eastern boundary of the proposed Broadmeadow Way Greenway along the length of the southern causeway. The wall and modified embankment will be completed prior to the installation of the additional railway tracks, OHLE and other equipment.

The Irish Coastal Wave and Water Level Modelling Study (ICWWS) node closest to the Malahide Estuary is NE16. The tidal level at NE16 is greater at 3.16m OD for the 0.5% AEP tidal and will be used to determine the maximum water level that should be used to analyse the stability of the embankment by taking account of the appropriate freeboard and climate change allowance. Assuming a Mid-range Future Scenario (MRFS) climate change allowance of 0.55 and a minimum freeboard of 300mm, the flood level that should be used for design purposes is approximately 4.0m. The track at this location is at approximately 4.95m OD and hence above the design flood level.

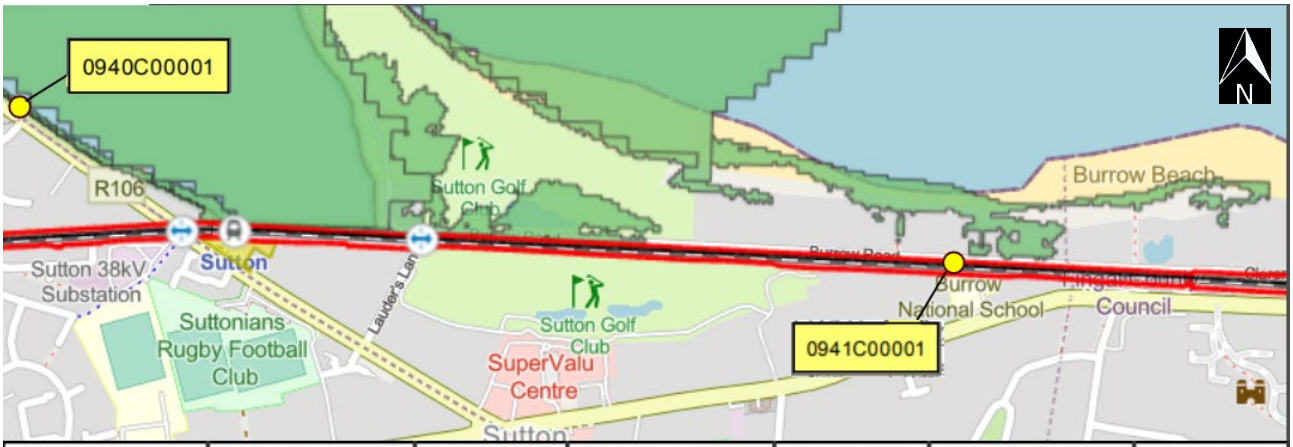
The works of the Broadmeadow Way Greenway will interface with the widening of the railway embankment and construction sequencing must be discussed and agreed to avoid the risk of flooding to the track as well as the greenway. It should be noted that the greenway may not be as vulnerable as the embankment when it comes to flooding.

Two of the proposed Construction Compounds needed for the construction of the Malahide turnback, being the proposed Construction Compound adjacent to Bissetts Strand and that south of Malahide Yacht club are at risk from the 20% AEP tidal flooding. To minimise risk, the following potential mitigation measures are proposed for the temporary construction compounds:

- They are accessed during the months of May – September (matching ecological constraints),
- Minimise or eliminate, if possible, any hard standing in the proposed construction compound,
- Use raised platforms for material storage, and
- in the event of a tidal flood warning, materials stored in the compound will be removed immediately to avoid the risk of flooding to neighbouring properties.

10.3.3.2.2 Baldoyle River/Estuary

The existing railway line passes along a large flood extent at the Baldoyle Estuary. Track Levels are assessed to be at >7mOD which is significantly higher than the footprint of the flood extent. The existing railway line therefore is above the 0.5% AEP extent and is classified as Flood Zone C. However, the surroundings of the track are within the 0.5% AEP tidal floodplain and any future works outside of the track must consider this and operate above this design level.



Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 0.5% AEP	Flow (m³/s) 0.5% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
0940C00001	N/A	N/A	3.16	N/A	3.39	N/A
0941C00001	N/A	N/A	3.18	N/A	3.41	N/A

a

Image 10-18 Baldoyle Estuary

The node closest to the Proposed Development in Baldoyle Estuary is 0940C0001. The 0.5% AEP fluvial water level at the node is 3.18mOD. The track at this location is proposed at 5.49mOD and is therefore at low risk.

10.3.4 Zone C

Zone C is the longest stretch of track at 20.8km and covers the area between south of Donabate Station to south of Gormanston Station and includes the following works:

- Donabate Substation;
- Modification of UBB36 Rogerstown Viaduct;
- Rush and Lusk Substation;
- Track lowering (by 88mm over 140m length) at OBB39 Station Road/R128 Bridge;
- Track lowering at OBB44 (by 380mm over 450m length) Tyrrelstown Bridge;
- Skerries South Substation;
- Skerries North Substation;
- Track lowering (by 325mm over 355m length) at OBB55 Lawless Terrace/R127 Bridge;
- Modification of UBB56 Balbriggan Viaduct;
- Balbriggan Substation;
- OHLE and SET line wide works including utility diversions;
- Road overbridge parapet modifications to:
    - OBB32A, OBB35, OBB38, OBB41, OBB46, OBB47, OBB49, OBB55 and OBB68
- Pedestrian overbridge parapet modifications to:
    - OBB33A, OBB38A, OBB51A, OBB54 and OBB57A.

Five substations are located within this Zone, as presented in Image 10-19.

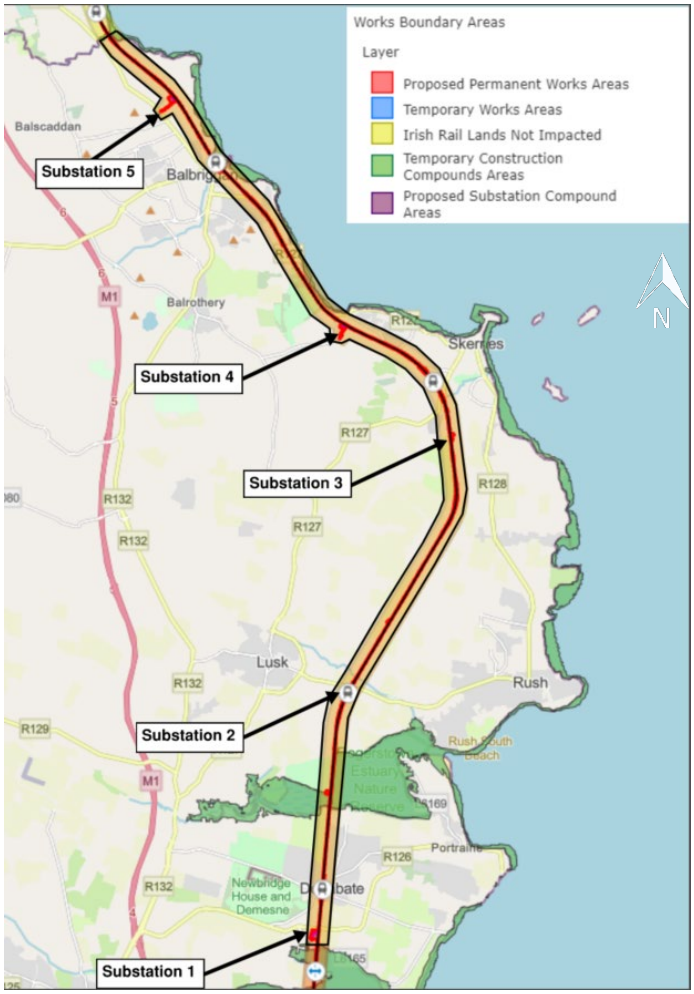


Image 10-19 Zone C layout

Table 10-8 Zone C Substations

Zone	Substation Number	Substation Name	Finished Floor Level
C	1	Donabate	6.5mOD
C	2	Rush and Lusk	19.5mOD
C	3	South Skerries	25.5mOD
C	4	North Skerries	18.75mOD
C	5	Balbriggan	12.00mOD

10.3.4.1 Fluvial Risk

10.3.4.1.1 Bracken River

The DART Line passes through Balbriggan and over the Bracken River and its associated flood extents. The track line itself is above the 1% AEP fluvial flood extent and is therefore classified as Flood Zone C. However, the surroundings of the track are within the 1% AEP fluvial floodplain and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.

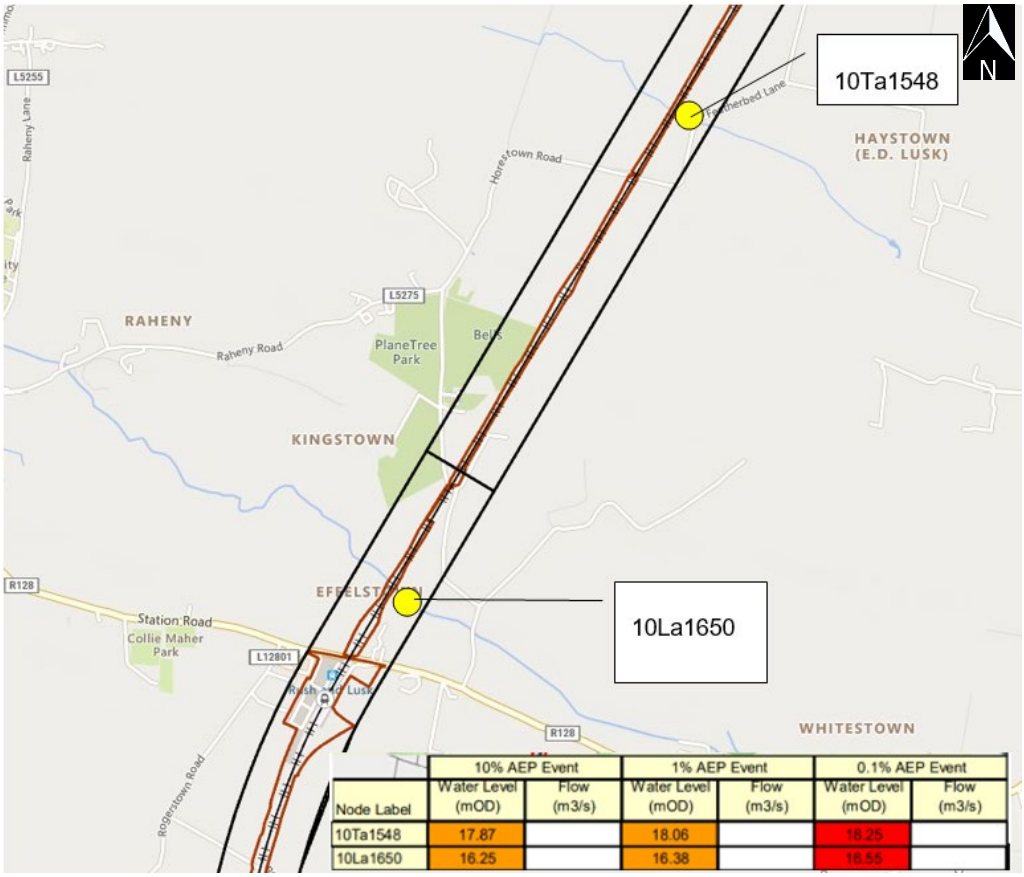
	10% AEP Event		1% AEP Event		0.1% AEP Event	
Node Label	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)
16Ma88	3.46		3.86		4.57	
16Ma0	2.80		2.94		3.30	

Image 10-20 Bracken River fluvial extent

The node within the site on the Bracken River with the highest levels is 16Ma88. The 1% AEP fluvial water level at the node is 3.86mOD. The DART Line and temporary Construction Compound in this location is proposed at 13.7mOD and is therefore at low risk.

10.3.4.1.2 Bride Stream

The DART Line passes through two watercourses north of the Rush and Lusk substation. Both watercourses have minor flood extents in the 1% AEP. The Bride Stream runs closer to Rush and Lusk substation and therefore is the examined watercourse.



Node Label	10% AEP Event		1% AEP Event		0.1% AEP Event	
	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)
10Ta1548	17.87		18.06		18.25	
10La1650	16.25		16.38		16.55	

Image 10-21 Bride Stream fluvial event

The nodal point on the Bride Stream with the highest levels is 10La1650. The 1% AEP fluvial water level at the node is 16.38mOD. The Rush & Lusk Substation and temporary Construction Compound in this location is proposed at 19.5mOD and is therefore not at risk.

10.3.4.1.3 River Pill

The DART Line passes through a large flood extent through the River Pill as the watercourse becomes estuarine. The existing DART Line itself is within Flood Zone C. However, the surroundings of the track are within the 1% AEP fluvial floodplain and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.

The Donabate Substation (location no. 1 in Table 10-8) is located on the northern boundary of this flood extent.

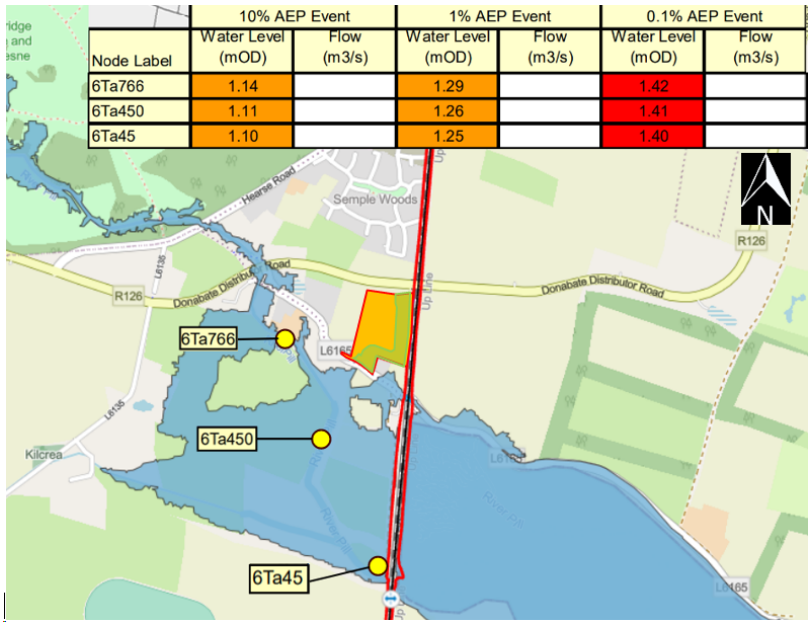


Image 10-22 River Pill/Estuary fluvial extent

The nodal point on the River Pill with the highest levels is 6Ta766. The 1% AEP fluvial water level at the node is 1.29mOD. The Donabate Substation is proposed at 6.5mOD and is therefore not at risk.

10.3.4.2 Tidal Risk

10.3.4.2.1 River Pill/Estuary

As outlined above, the Proposed Development passes through a large flood extent through the River Pill as the watercourse becomes estuarine. The existing railway corridor is above the 0.5% AEP extent and is therefore classified as Flood Zone C. However, the surroundings of the track are within the 0.5% AEP tidal floodplain and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.

The Donabate substation (Location no. 1 in Table 10-8) is located on the northern boundary of this flood extent.

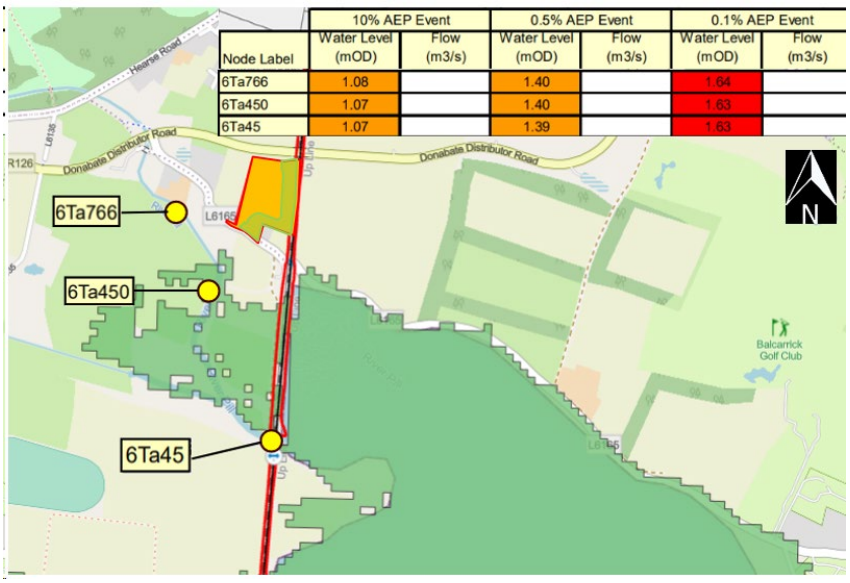


Image 10-23 River Pill/Estuary tidal extent

The nodal point on the River Pill with the highest levels is 6Ta766. The 0.5% AEP fluvial water level at the node is 1.40mOD. The Donabate Substation is proposed at 6.5mOD and is therefore at low risk.

10.3.4.2.2 Balbriggan Coastal

The coastal levels were examined along the outskirts of Balbriggan as the DART Line runs close to the shoreline with Balbriggan Substation located approximately 200m from the flood extent.

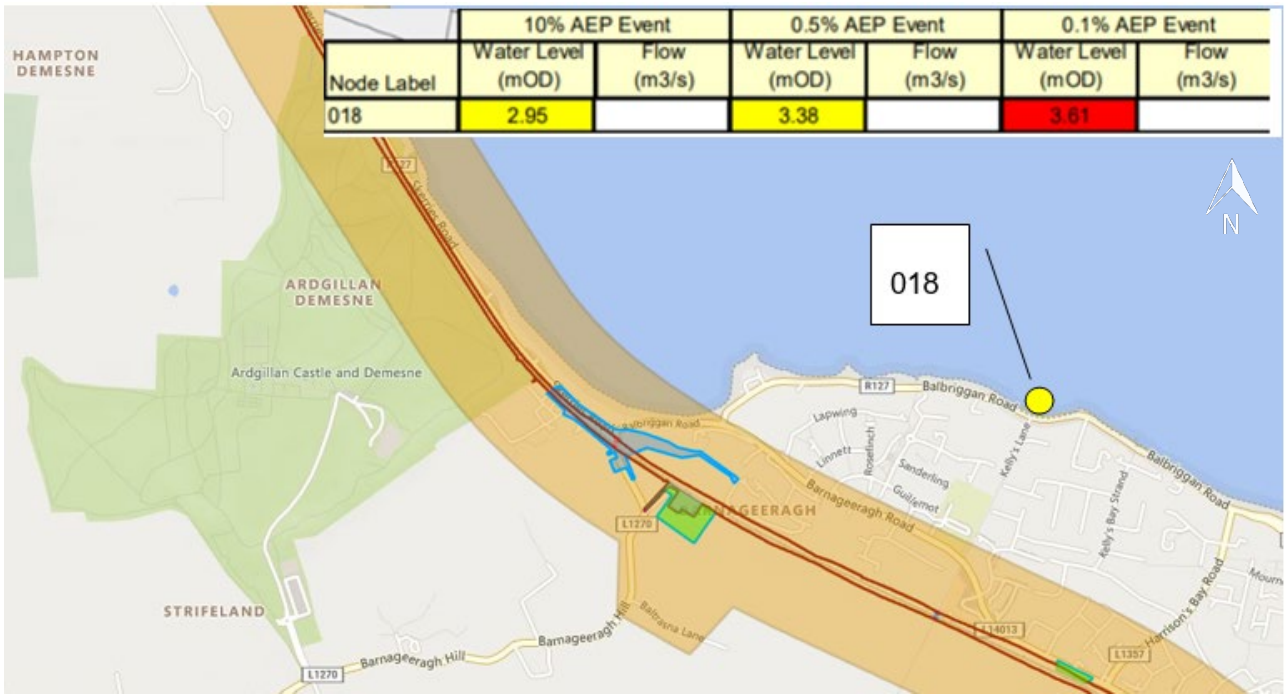
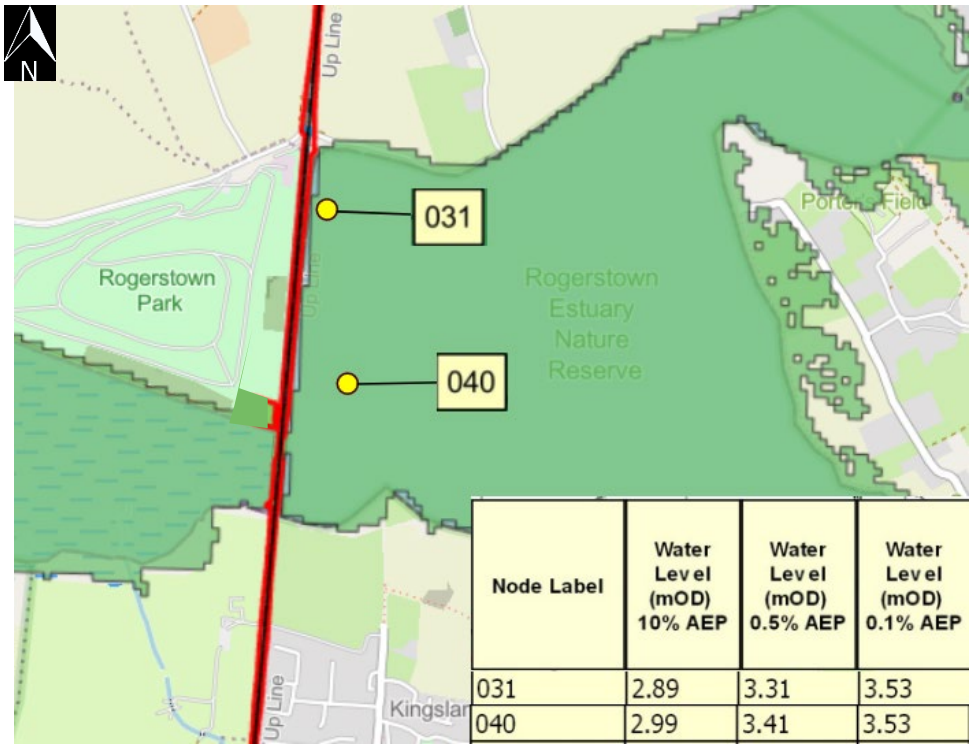


Image 10-24 Balbriggan Coastal tidal level

The node closest to the substation in the Balbriggan area is 018. The 0.5% AEP fluvial water level at the node is 3.38mOD. The substation is proposed at 12mOD and is therefore not at risk.

10.3.4.2.3 Rogerstown Estuary

The railway corridor passes through a large flood extent through the Rogerstown Estuary. The existing railway line itself is outside of the 0.5% AEP extent and is therefore classified as Flood Zone C. However, the surroundings of the track are within the 0.5% AEP tidal floodplain and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.



Node Label	Water Level (mOD) 10% AEP	Water Level (mOD) 0.5% AEP	Water Level (mOD) 0.1% AEP
031	2.89	3.31	3.53
040	2.99	3.41	3.53

Image 10-25 Rogerstown Estuary tidal extent

The node closest to the railway line in Rogerstown Estuary is 040. The 0.5% AEP fluvial water level at the node is 3.41mOD. A small temporary Construction Compound area is proposed along the border of the flood extent. The DART Line is proposed at 5.6mOD in this location and is therefore at low risk.

10.3.5 Zone D

Zone D extends from Gormanston Station (Fingal border) to the Louth/Meath border (1.5km southeast of Drogheda MacBride Station). This zone includes the following works:

The zone south of Gormanston Station (Fingal border) to Louth/Meath border includes the following works:

- Gormanston Substation;
- Modification of UBB72 Laytown Viaduct;
- Bettystown Substation;
- Track lowering at OBB78 (by 129mm over 220m length) Colpe Road Bridge;
- OHLE and SET line wide works including utility diversions;
- Road overbridge parapet modifications to OBB78; and
- Pedestrian overbridge modifications to OBB74A.

Two substations are contained within Zone D, as indicated in Table 10-9 and Image 10-26.

Table 10-9 Zone D Substations

Zone	Substation Number	Substation Name	Finished Floor Level
D	6	Gormanston	17.00mOD
D	7	Bettystown	18.00mOD

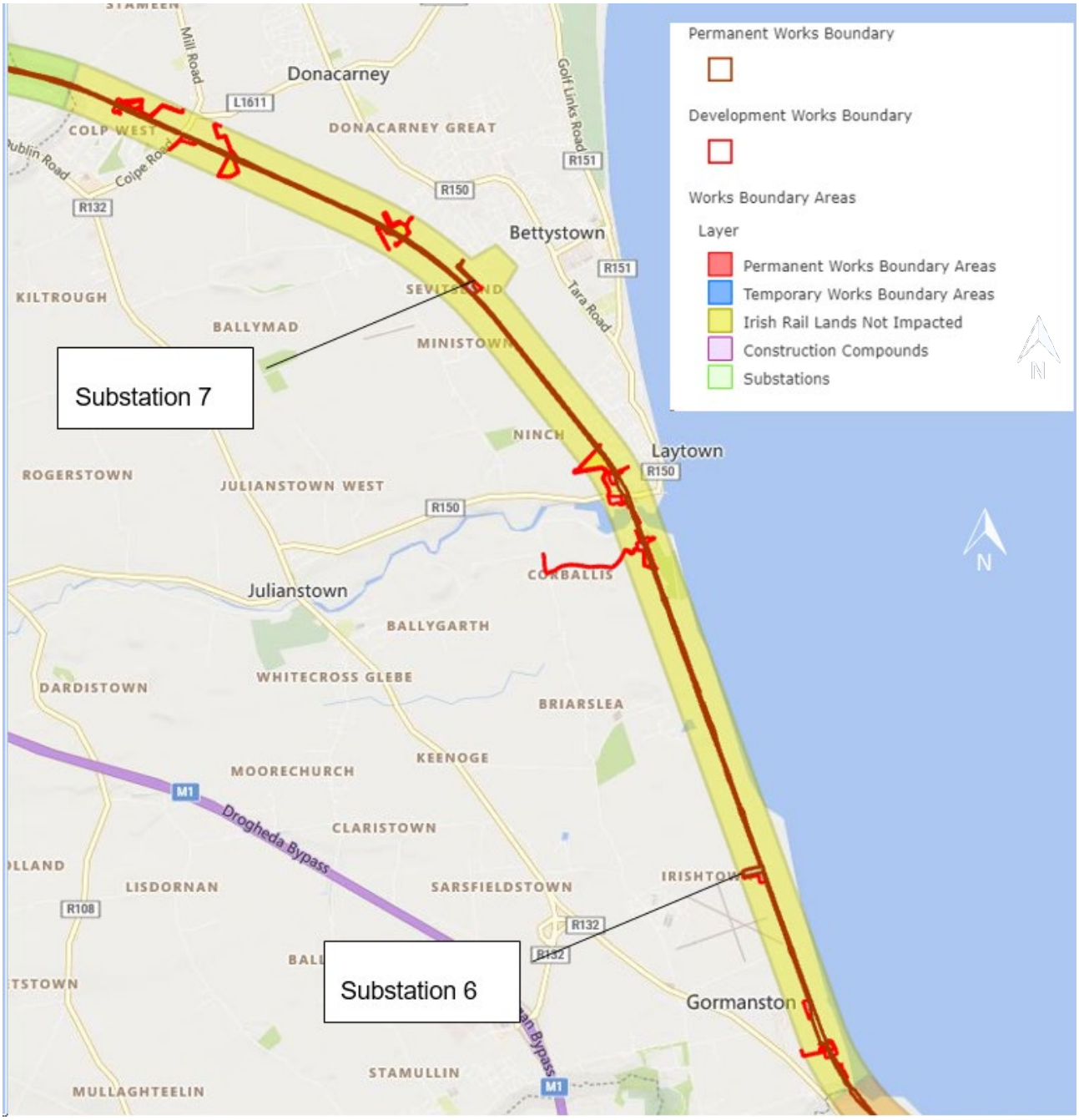


Image 10-26 Key Interventions in Zone D

10.3.5.1 Fluvial Risk

10.3.5.1.1 Brookside Stream

The railway corridor crosses Brookside Stream in Bettystown with no interaction with flood extents. The area of development is outside the 1% AEP extent and is therefore classified as Flood Zone C. Bettystown Substation is positioned 200m north of this watercourse.

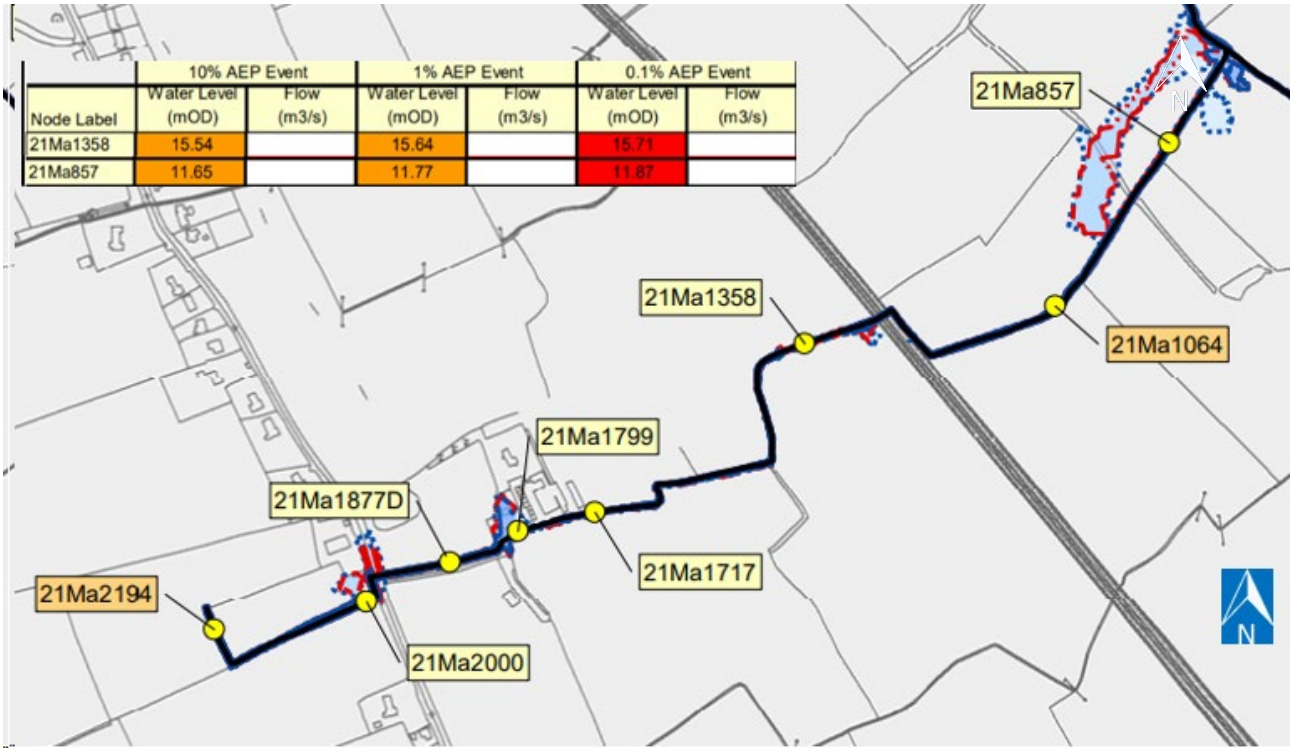


Image 10-27 Brookside Stream fluvial extent

The node within the site on the Brookside Stream with the highest levels is 21Ma1358. The 1% AEP fluvial water level at the node is 15.64mOD. The Bettystown Substation is proposed at 18mOD and is therefore not at risk.

10.3.5.1.2 River Nanny

Although the railway corridor passes through Laytown and over the River Nanny and its associated flood extents, the track line itself is not impacted. However, the area of development is within the 1% AEP extent and classified as Flood Zone A, and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.

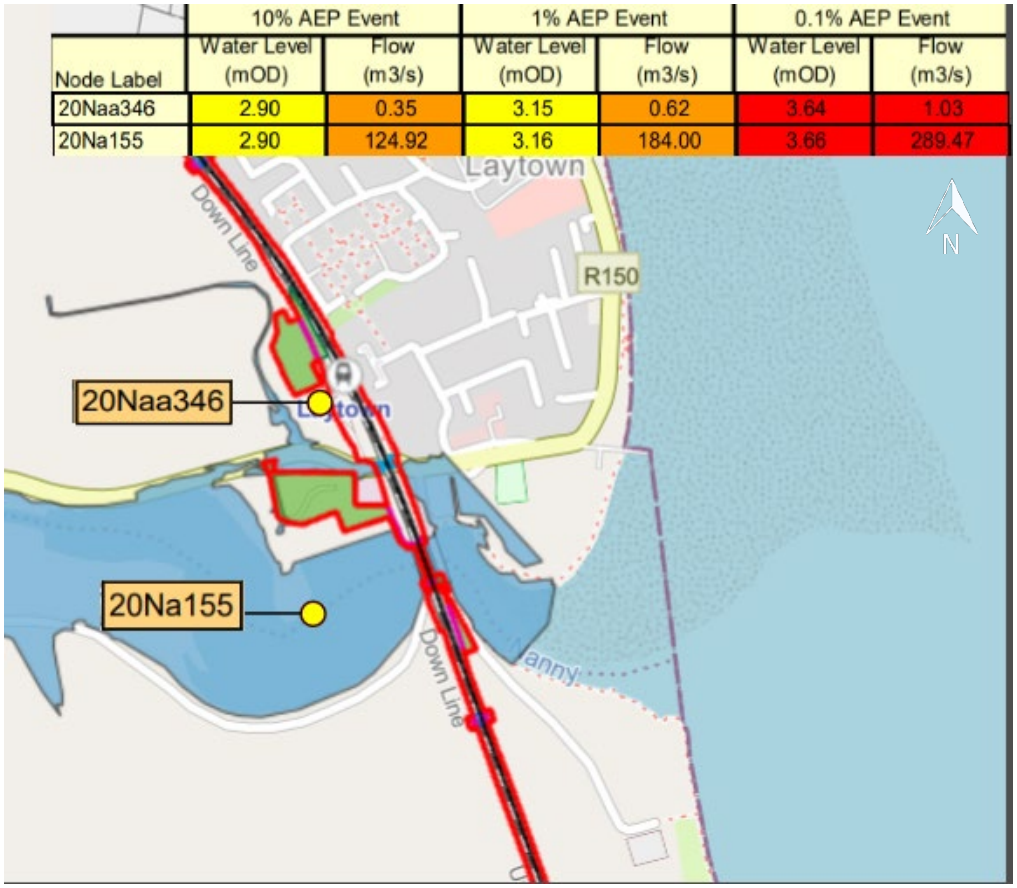
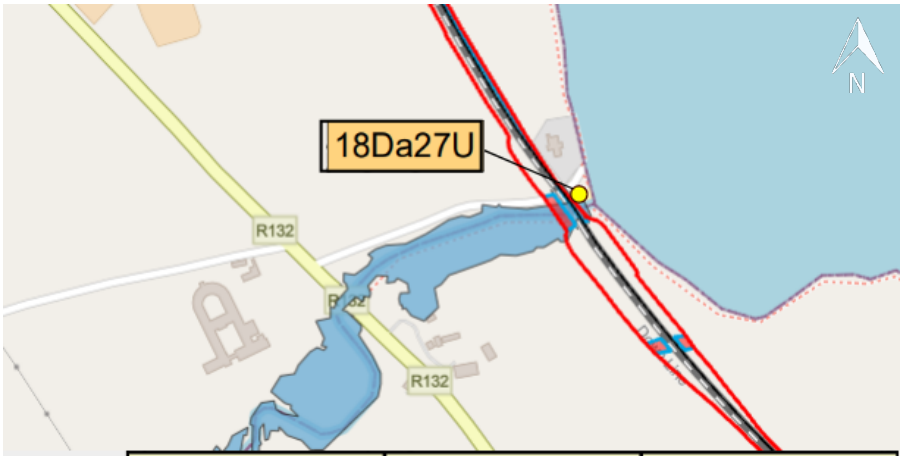


Image 10-28 River Nanny fluvial extent

The nodal point at the Nanny River with the highest levels is 20Na155. The 1% AEP fluvial water level at the node is 3.16mOD. The railway corridor and temporary Construction Compound is proposed at 8.2mOD and is therefore at low risk.

10.3.5.1.3 Delvin River

The railway corridor passes over the Delvin River and its associated flood extents, 300m south of Gormanston. The surrounding area outside of the existing railway track is within the 1% AEP extent and is therefore classified as Flood Zone A and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.



Node Label	10% AEP Event		1% AEP Event		0.1% AEP Event	
	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)
18Da27U	2.84	18.82	3.00	29.83	3.34	44.94

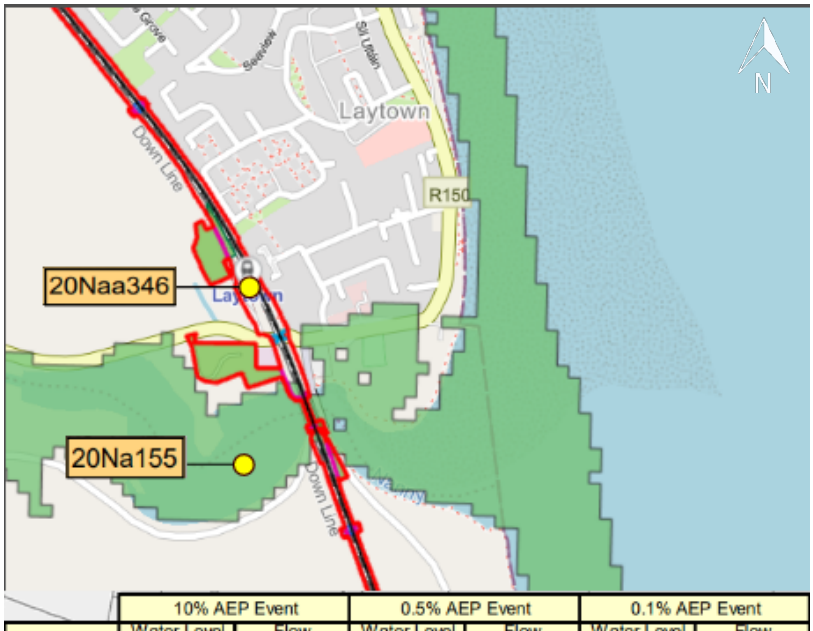
Image 10-29 Delvin River fluvial extent

The node within the site on the Delvin River with the highest levels is 18Da27U. The 1% AEP fluvial water level at the node is 3.00mOD. The Proposed Development and temporary Construction Compound at this location is proposed at 11.5mOD and is therefore at low risk.

10.3.5.2 Tidal Risk

10.3.5.2.1 River Nanny

The railway line passes through Laytown and over the River Nanny and its associated tidal flood extents. The area of development outside of the track line is within the 0.5% AEP tidal extent and is therefore classified as Flood Zone A and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.



as

Node Label	10% AEP Event		0.5% AEP Event		0.1% AEP Event	
	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)
20Naa346	3.08	0.20	3.51	0.35	3.75	0.53
20Na155	3.08	106.72	3.51	157.49	3.76	202.36

Image 10-30 River Nanny tidal extent

The node within the site on the River Nanny with the highest levels is 20Na155. The 0.5% AEP fluvial water level at the node is 3.51mOD. The Proposed Development and temporary Construction Compound are proposed at 8.2mOD and is therefore not at risk.

10.3.5.2.2 Delvin River

The railway line passes over the Delvin River and its associated flood extents, 300m south of Gormanston. The area of development is within the 0.5% AEP extent and is therefore classified as Flood Zone A and therefore interaction with lands outside of the site boundary including access to site in flood events may be affected.

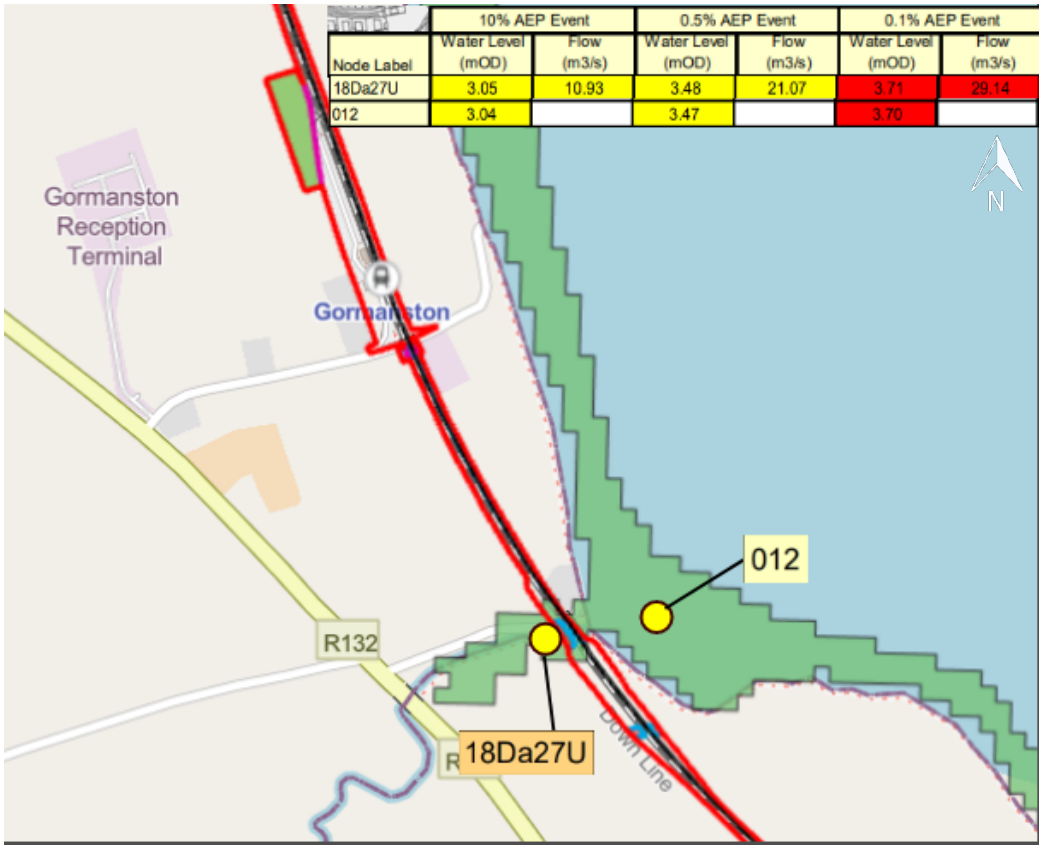
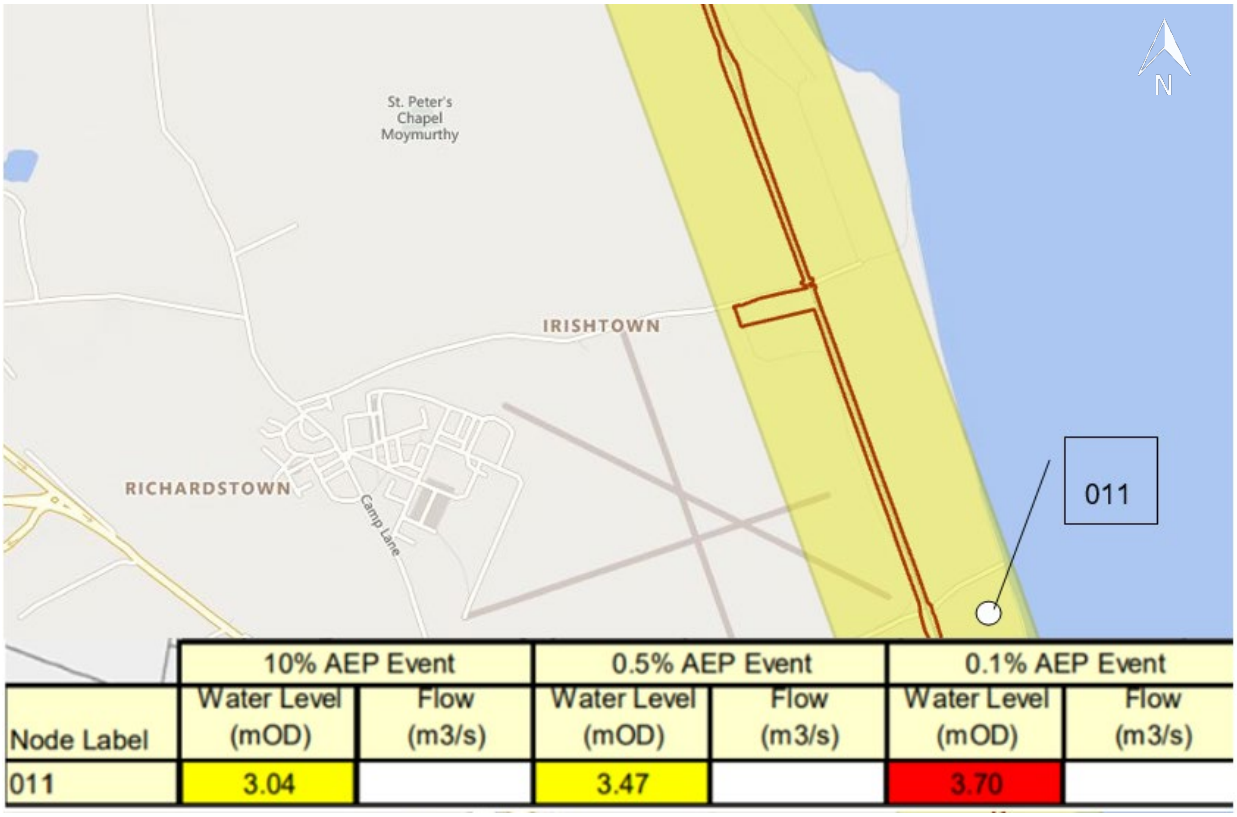


Image 10-31 Delvin River tidal extent

The node within the site on the Delvin River with the highest levels is 18Da27U. The 0.5% AEP fluvial water level at the node is 3.00mOD. The Proposed Development and temporary Construction Compound are proposed at 11.5mOD and is therefore not at risk.

10.3.5.2.3 Gormanston

The coastal levels were examined through Gormanston as the existing railway line is in close proximity to the shoreline with Gormanston Substation located approximately 150m from the flood extent.



	10% AEP Event		0.5% AEP Event		0.1% AEP Event	
Node Label	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)
011	3.04		3.47		3.70	

Image 10-32 Gormanston tidal extent

The node closest to the substation in the Gormanston area is 011. The 0.5% AEP fluvial water level at the node is 3.47mOD. The DART Line and temporary Construction Compound is proposed at 17mOD and is therefore not at risk.

10.3.6 Zone E

Zone E extends from the Louth/Meath border to just north of Drogheda MacBride Station and comprises the proposed works within the station and surrounds and includes the following works:

- Replacement of OBB80/80A/80B Railway Terrace Bridge (triple span);
- Reconstruction of UBK01 Dublin Road Bridge;
- Reconstruction of OBB81 Drogheda Station footbridge;
- Construction of Platform 4 (on Navan line) and associated trackwork (Drogheda Turnback);
- Installation of Drogheda Substation;
- Works on Light Maintenance Roads and Under Frame Cleaning (UFC) facility at Drogheda Deport;
- Works on Stabling Roads 7a and 7b;
- Works on Northern Headshunt; and
- OHLE and SET line wide works and utility diversions.

One substation is contained within Zone E as indicated in Image 10-33 and Table 10-10.

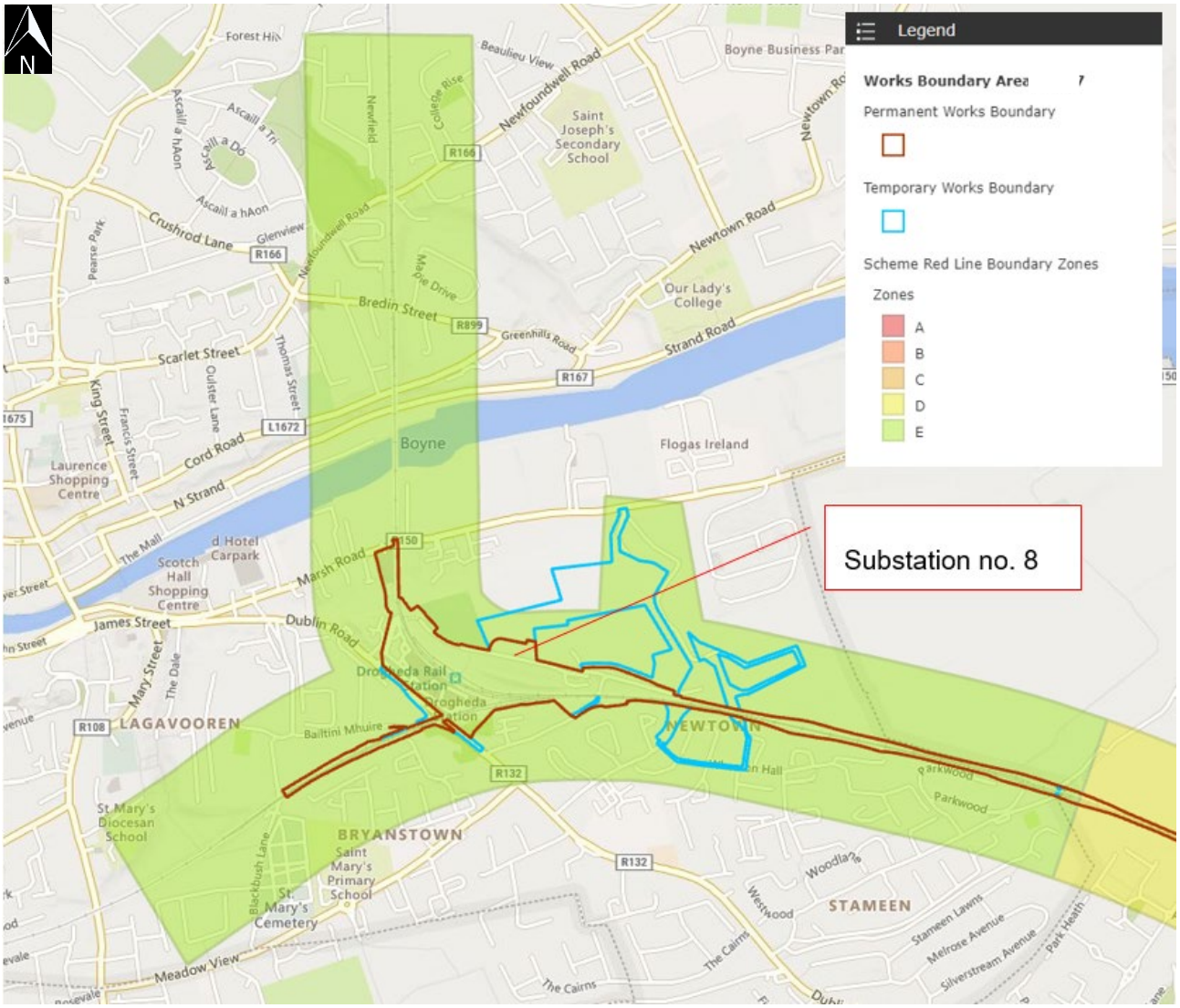


Image 10-33 Zone E Layout

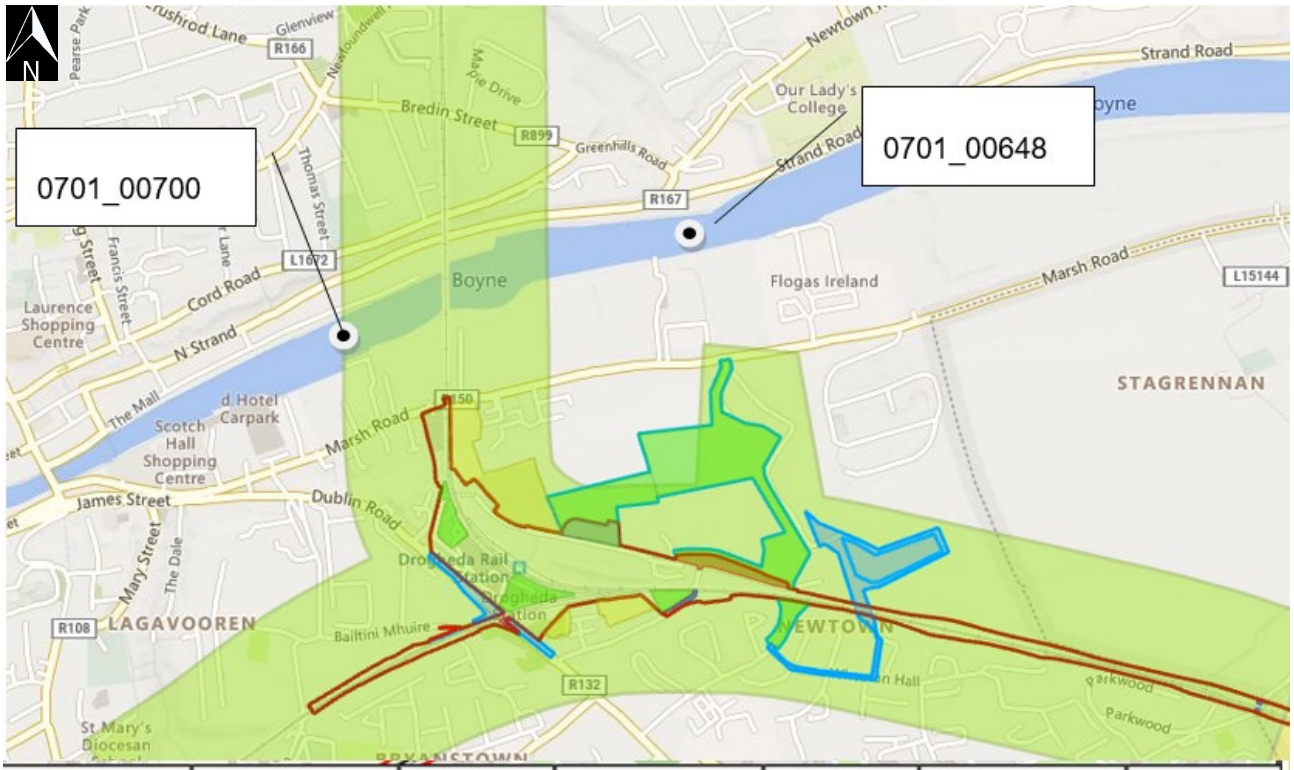
Table 10-10 Zone E Substations

Zone	Substation Number	Substation	Finished Floor Level
E	8	Drogheda	33.00mOD

10.3.6.1 Fluvial Extent

10.3.6.1.1 River Boyne

Zone E has a singular location of fluvial flood waters interfacing with the site boundary in Drogheda town centre. As the railway corridor passes over the River Boyne, the water levels upstream and downstream of the bridge for the 1:10, 1:100, 1:1000-year events as listed in Image 10-34.The proposed location of the Drogheda substation is outside of the flood extents and therefore is considered within Flood Zone C. Furthermore, all associated temporary works areas and Construction Compounds are also found to be within Flood Zone C.



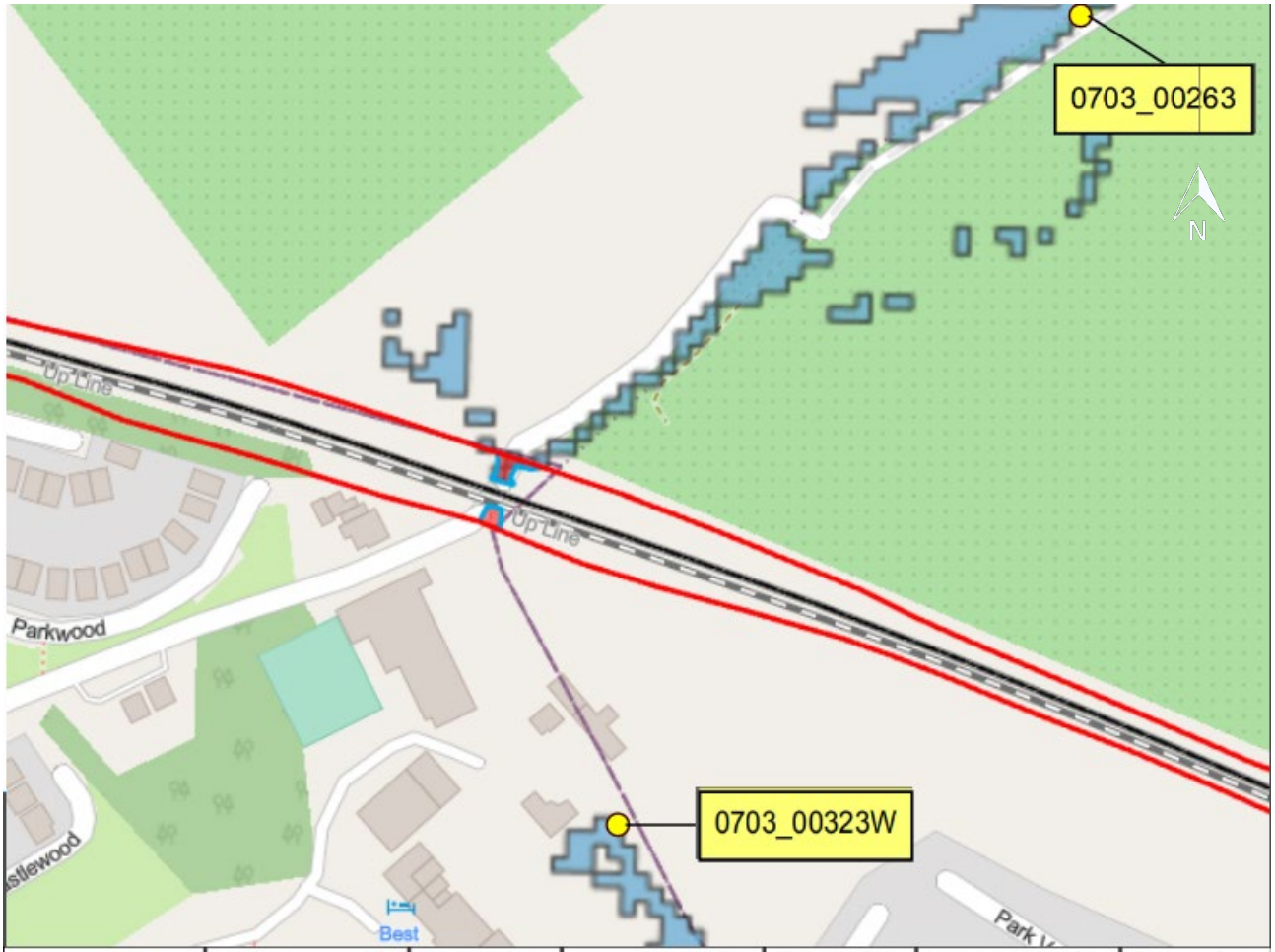
Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 1% AEP	Flow (m³/s) 1% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
0701_00700	3.025	N/A	3.168	N/A	3.413	N/A
0701_00648	2.985	459.60	3.086	603.34	3.262	801.10
0701_00588	2.978	N/A	3.074	N/A	3.245	N/A

Image 10-34 River Boyne fluvial extent

The node within the site on the River Boyne with the highest levels is 0701_00700. The 1% AEP fluvial water level at the node is 3.17mOD. The Drogheda Substation is proposed at 33mOD and is therefore not at risk. Ground levels at the existing station where further works are to be carried out are at a minimum of 29mOD and are therefore at low risk.

10.3.6.1.2 Stagrennan Stream

At the southern boundary of Zone E, the railway corridor crosses the Stagrennan Stream. Fluvial extents in the 1% AEP are minimal here. Two permanent works boundary areas are proposed at the watercourse crossing point.



Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 1% AEP	Flow (m³/s) 1% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
0703_00323W	25.157	N/A	25.19	N/A	25.223	N/A
0703_00263	19.491	N/A	19.773	N/A	19.859	N/A

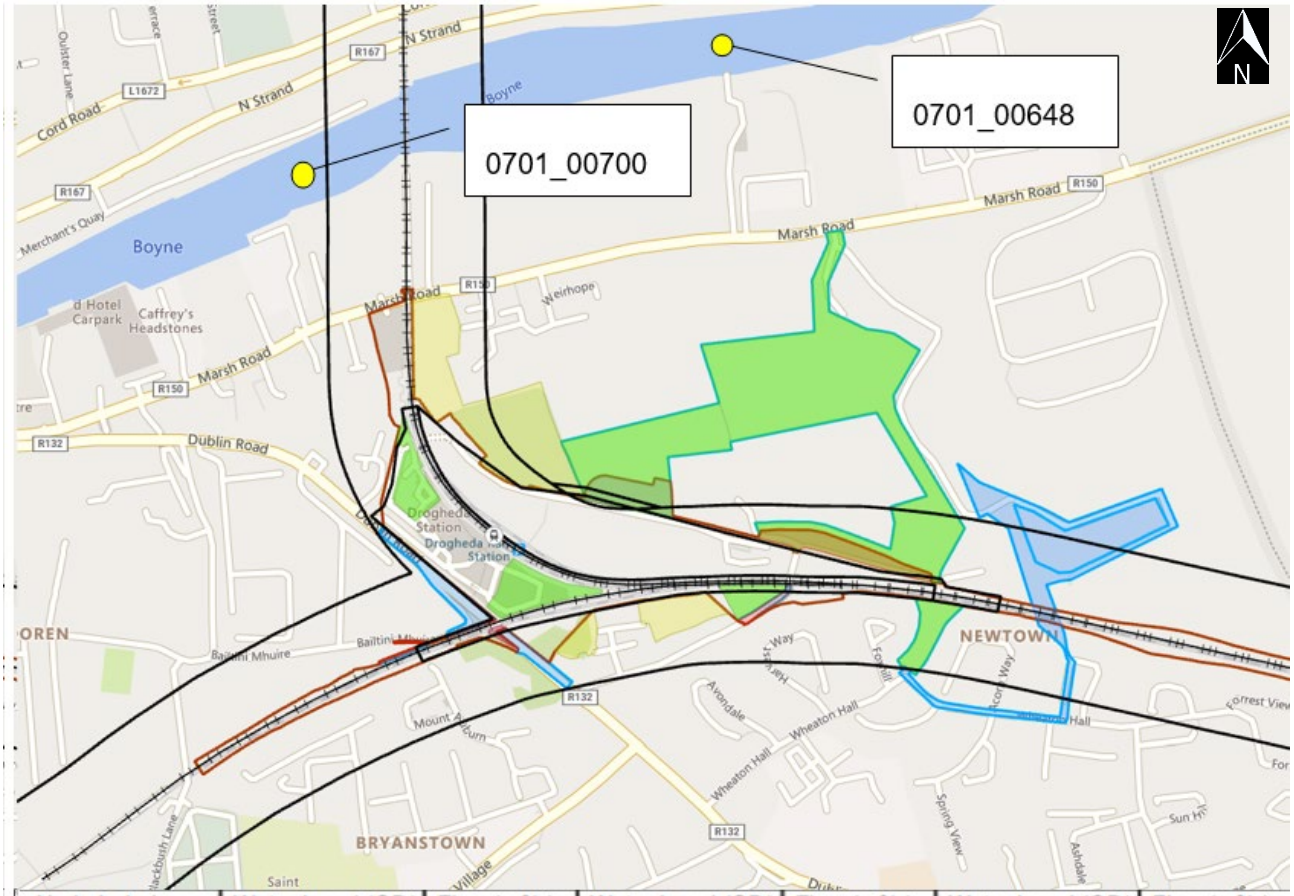
Image 10-35 Stagrennan Stream fluvial extent

The node within the site on the Stagrennan Stream with the highest levels is 0703_00323W as shown in Image 10-35. The 1% AEP fluvial water level at the node is 25.19mOD. The railway line at this location is at 28mOD and is therefore not at risk.

10.3.6.2 Tidal Extent

10.3.6.2.1 River Boyne

The River Boyne has additional significant tidal influence on Drogheda town. Similar to the fluvial extents noted in Section 10.1.1, as the railway corridor passes over the River Boyne it covers areas that fall within the 1:10, 1:100, 1:1000-year extents. The proposed location of the Drogheda substation and all other significant works within this zone are outside of these flood extents and therefore within Flood Zone C.



Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 0.5% AEP	Flow (m³/s) 0.5% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
0701_00700	3.16	N/A	3.55	N/A	3.76	N/A
0701_00648	3.15	N/A	3.54	N/A	3.75	N/A
0705_00015I	3.75	N/A	3.75	N/A	3.75	N/A

Image 10-36 River Boyne Tidal Extent

The node within the site on the River Boyne with the highest levels is 0701_00700. The 1% AEP fluvial water level at the node is 3.55mOD. The Drogheda Substation is proposed at 33mOD and is therefore not at risk. Furthermore, all associated areas of construction within this zone, including works within Drogheda MacBride Station are also at levels well above this fluvial water level and are therefore not at risk.

10.3.7 Conclusion of Stage 2 – FRA

There are 18no. watercourse crossings across the full area of the Proposed Development at moderate risk of flooding. The predominant sources of flooding across these areas are identified as tidal and fluvial. Although most of the existing track line is in Flood Zone C, sections of the Proposed Development partially encroach Flood Zones A and B. Assessment of the flood extents throughout the Proposed Development site demonstrated that at each location along the railway, at substations, compounds (except at the temporary Construction Compound at Bissetts Strand which will be utilised with the mitigation measures proposed) and ancillary features, the design level was set at least 2m above the 1% or 0.5% AEP level, making the risk of flooding at each location low. Therefore, as each of the flood levels at the proposed sites were determined without the need for additional hydraulic modelling, it is not necessary to carry out a detailed flood risk assessment.

However, as the development is considered "critical infrastructure" and partially within Flood Zones A and B, a development management Justification Test is completed as illustrated in Table 10-11.

Table 10-11 Justification Test Criteria

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

10.3.8 Development Management Justification Test

Table 10-12 outlines the development management justification criteria and how the Proposed Development satisfies each as per the Guidelines.

Table 10-12 Justification Test Table

No.	Item	Justification	Satisfied
1	The development has been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.	The International, European, national, regional, and local significance of the DART+ programme is discussed in Chapter 2 of the EIAR.	Yes
2	The proposal has been subject to a flood risk assessment that demonstrates that:		
2(i)	The mitigation option suggested will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;	The DART+ is subject to site specific flood risk assessment. The assessment determined that although the track line itself and proposed infrastructure are outside of Flood Zone A and B, interaction with the flood plain may not be avoided during construction. However, best practice construction methods will ensure that the interaction does not result in increased risk on site and elsewhere.	Yes
2(ii)	The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;	There is a significant difference (>2m) between the flood levels and the proposed design levels. Moreover, all track lowering proposals are in flood Zone C (low risk), and hence no mitigation measures are proposed.	Yes

No.	Item	Justification	Satisfied
2(iii)	The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access.	The development does not propose mitigation measures other than best practice construction methods that will ensure the flood risk is managed. No residual risk will remain on site as a result of the works.	Yes
2(iv)	The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.	The proposal will enhance the existing transport infrastructure in line with the city's planning objectives and facilitates the seamless connection with the surrounding environs	Yes

Therefore, it is concluded that the development proposal satisfies all the criteria of the Development Management Justification Test.

10.3.9 Establishment of Site Design Flood Levels

As established in the Stage 2 assessment, whilst 18no. crossing locations of the Proposed Development appear to fall within Flood Zone A and B, the levels of the DART line, substations, stations and all other critical infrastructure at all of these locations was found to be >2m above the flood level. This resulted in the reduction of severity of risk from high to low.

The design water level refers to the minimum finished floor level at which infrastructure should be developed to ensure low risk of flooding is maintained throughout the construction and operation of the Proposed Development. This is taken as either the 1 in 100-year fluvial or 1 in 200-year tidal, dependent on which results in higher levels.

10.3.9.1 Climate Change

Future climate change is predicted to result in several effects, including more extreme rainfall, more severe floods, and an increase in mean sea level.

In Ireland, current OPW draft guidance on climate change for flood risk management defines two possible future scenarios of varying severity:

- Mid-range future scenario (MRFS); and
- High-end future scenario (HEFS).

OPW's recommended allowances for both scenarios are given in Table 5-1 of OPW's Climate Change Sectoral Adaptation Plan (2019)[4].

[4] Office of Public Works: Flood Risk Management – Climate Change Sectoral Adaptation Plan, Government of Ireland, 2019.

The conclusions that can be taken from the predictions made on climate change include:

- Increases in sea levels may result in extreme tidal events, with tidal levels increasing by more than a metre in the next century.
  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.

The lower climate change allowance for the MRFS, as it represents a more "likely" future scenario based on the best predictions available, is incorporated to the proposed design level.

10.3.9.2 Freeboard

It is generally accepted that a minimum freeboard of 300mm above predicted flood levels is appropriate for establishing minimum floor levels. Therefore, a 300mm freeboard is proposed for this development.

10.3.9.3 Recommended Flood Defence Level

Based on the above, the following flood defence level is recommended:

- (1 in 100- or 200-year design flood level) + 0.55m (MRFS climate change allowance) + 0.3m (freeboard) = +0.85m

This additional defence level has been added to each of the flood levels in Table 10-13.

Table 10-13 Design Flood Defence Levels

Location	Watercourse Crossing	1% AEP Fluvial Level (mOD)	0.5% AEP Tidal Level (mOD)	Recommended Flood Defence Level (mOD)	Proposed Development Level (mOD)
Zone A	River Santry	16.56	-	17.41	21.7
Zone A	River Tolka Estuary	-	3.11	3.96	14.3
Zone B	Sluice River	3.77	-	4.62	7.5
Zone B	Mayne River	5.89	-	6.74	9.3
Zone B	Baldoyle River/Estuary	-	3.24	4.09	7.76
Zone B	Rogerstown Estuary	-	3.18	4.03	5.49
Zone B	Malahide Estuary	-	3.16	4.01	4.95
Zone C	Bracken River	3.86	3.44	4.71	13.7
Zone C	Bride Stream	16.38	-	17.23	19.5
Zone C	River Pill	1.25	1.63	2.48	7.00
Zone C	Balbriggan Coast	-	3.38	4.23	18.75
Zone C	Rogerstown Estuary	-	3.41	4.26	5.6
Zone D	Brookside Stream	15.64	-	16.49	18.00
Zone D	River Nanny	3.16	3.51	4.36	8.20
Zone D	Delvin River	3.00	3.48	4.33	11.5

Location	Watercourse Crossing	1% AEP Fluvial Level (mOD)	0.5% AEP Tidal Level (mOD)	Recommended Flood Defence Level (mOD)	Proposed Development Level (mOD)
Zone D	Gormanston	-	3.47	4.32	18.00
Zone E	River Boyne	3.17	3.55	4.40	33.00
Zone E	Stagrennan Stream	25.19	-	26.04	28.00

Each of the flood risk zones has been compared against a MRFS design flood level and it is observed that each location is at least 1.34m (@Rogerstown Estuary which is in Flood Zone C) above the recommended flood levels. This indicates that the fluvial and tidal risk to the Proposed Development is low.

10.4 Conclusion and Recommendations

This FRA has been carried out to accompany the Railway Order application for the proposed DART+ Coastal North project.

There are 18no. watercourses along the proposed scheme where there is a risk of fluvial and/or tidal flooding.

Whilst some of these sections fall within Flood Zones A or B, the railway line and substation levels within the Proposed Development boundary are >2m above the max flood level at each location.

Where areas of the scheme are identified as being within Flood Zone A and B, the proposed development levels at all crossing points are higher than the recommended flood defence levels, therefore, further investigation of the flood risk in the form of a Stage 3 FRA will not be necessary.

The temporary Construction Compound at Bissetts strand will be accessed only during the months of May to September, aligning with ecological constraints. Efforts will also be made to minimize or eliminate hard standing within the proposed construction compound. In the event of a tidal flood warning, materials stored in this compound will be promptly removed to prevent flooding of neighbouring properties.

The proposed single arch bridge at Clongriffin is shown to have insignificant impact on flood levels through a hydraulic modelling exercise. This bridge is subject to Section 50 Consent by the OPW.

As the scheme does not propose significant level changes, it is not proposed to mitigate flooding for the existing rail network in its entirety other than those proposed as best practice construction methods.

This FRA has demonstrated that the risks relating to flooding to the Proposed Development are moderate but acceptable and therefore comply with DoEHLG / OPW and Dublin City Council, Fingal County Council, Meath County Council and Louth County Council planning guidance.

10.5 References

OPW (2009). *The Planning System and Flood Risk Management. Guidelines for Planning Authorities.*, Environment, Heritage and Local Government, and Office of Public Works; Government of Ireland, Dublin.

OPW (2017). *Eastern CFRAM Study: Final Report*. Office of Public Works, Dublin, Ireland.

OPW (2019). *Flood Risk Management: Climate Change Sectoral Adaptation Plan*, The Office of Public Works, Government of Ireland.