Kingsbridge Consultancy Ltd.

Proposed Strategic Housing Development

@

Haggardstown, Blackrock, Dundalk, Co. Louth

Flood Risk Assessment

DOCUMENT CONTROL SHEET

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1.0 Introduction

1.01 Proposed Development

Finn Design Partnership have been commissioned by Kingsbridge Consultancy Ltd to complete a Site-specific Flood Risk Assessment in support of a planning application to An Bord Planeála for a Strategic Housing Development on a site that extends to 17.55 ha at Haggardstown, Blackrock, Dundalk, Co. Louth.

The FRA has been carried out in full compliance with the requirements of "The Planning System & Flood Risk Management Guidelines" published by the Department of the Environment in November 2009.

The site is located off the R172 coastal roadway linking the village of Blackrock to the South and the town of Dundalk to the North. (refer to Figure 1). The site is bounded by Dundalk Golf Club to the West, residential dwellings to the North and East where there is residentially zoned land and the practice area of the adjoining Golf Club to the South.

The entrance to the site is from the R172 from where there will be a new service roadway extending circa 250 m in a westerly direction to the main part of the development site where the new units will be constructed. The existing ground levels within the developable area are within the range of 7.0 m in the north-east corner and up to 23.0m in the south west corner. (All levels relate to the Malin Head datum).

The site is located within the Neagh Bann River Basin District and the Fane Water Management Unit. Dundalk Bay coastline is circa 250.00 m from the development site.

Figure 1 Site Location

1.02 Nature of Proposed Development

Planning permission is being sought for the construction of 483 number residential units, that will be made up of detached, semi-detached, terraced, duplex and apartment dwellings. (refer to Figure 2 for proposed site plan).

The development will also include a crèche facility together with associated access roads, cycle paths, footways and infrastructure/services. The main entrance and service roadway for the development will be taken from the R172. There will be full pedestrian and cycle links between both areas where vehicular access between the two areas will be limited to times of emergency.

Figure 2 Proposed Site Plan

2.0 The Planning System and Flood Risk Management Guidelines

2.01 General

In September 2008 "The Planning System and Flood Risk Management" Guidelines were published by the Department of the Environment, Heritage and Local Government in Draft format. In November 2009 the adopted version of the document was published.

2.02 Flood Risk Assessment Stages

A three staged approach will be applied to undertaking the Flood Risk Assessment

Flood Risk Identification (Stage 1) - Identification of any issues relating to the site that will need further investigation through a Flood Risk Assessment.

Initial Flood Risk Assessment (Stage 2) - Involves establishment of the sources of flooding, the extent of the flood risk, potential impacts of the development and mitigation measures.

Detailed Flood Risk Assessment (Stage 3) - Assess flood risk issues in sufficient detail to provide quantitative appraisal of potential flood risk of the development, impacts of the flooding elsewhere and the effectiveness of any proposed mitigation measures.

This report addresses the requirements for all 3 stages.

This site-specific flood risk assessment will initially use existing flood risk information to determine the flood zone category of the Site i.e. to check if the Guidelines Sequential Approach has been applied, see Figure 3 below for details.

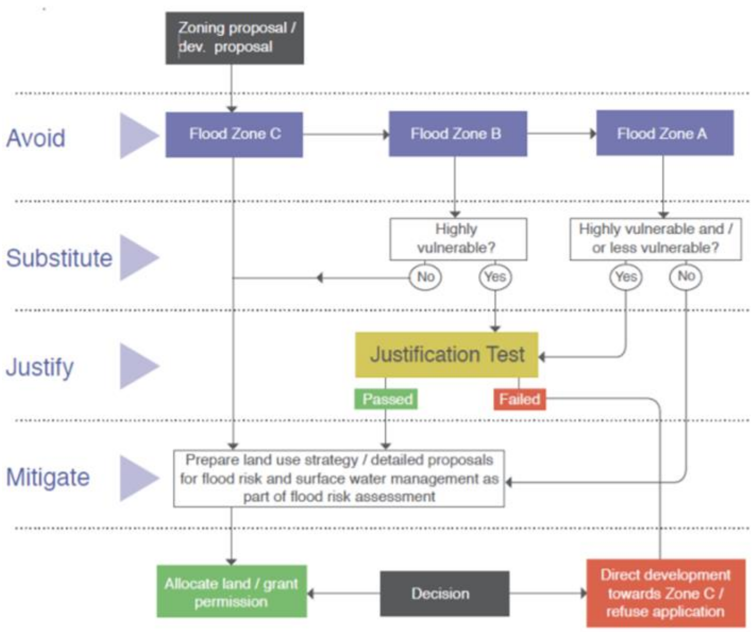


Figure 3 Sequential Approach mechanism in the Planning Process

2.03 Level of Service

The risk of a flood event is a function of the probability of occurrence in any given year. Traditionally, this has been expressed as a return period (e.g. 1-in-100-year return period). However, this has led to misconceptions about the likelihood of repeat occurrences. A less ambiguous expression of probability is the Annual Exceedance Probability (AEP), which may be defined as the probability of a flood event being exceeded in any given year. A 1- in-100-year return period flood event is therefore expressed as a 1% AEP flood event. Likewise, a 1-in-1-year return period flood event is expressed as a 100% AEP flood event.

Flooding Source	Drainage	Fluvial (River)	Tidal Costal
Residential	1% AEP	0.1% AEP	0.1% AEP
Commercial	1% AEP	1% AEP	0.5% AEP
Water-Compatible	-	>1% AEP	>0.5% AEP

Table 1: Summary of Level of Service

In addition, the Greater Dublin Strategic Drainage Study (GDSDS) requires that ground floor levels of houses be provided with a 500mm freeboard over the 1% fluvial flood level.

Both the GDSDS, the Planning System and the Flood Risk Guidelines for Planning Authorities require that account be taken for the effects of climate change over the design life of the development, normally 100 years. The design parameters given in the GDSDS are included in the following table 2

Design Category	Impact of Climate Change
Drainage	10% increase in rainfall.
Fluvial (River)	20% increase in flood flow.
Tidal (Coastal)	Minimum Floor Level of 4.0m AOD

Table 2: Climate Change

2.04 Proposed Development in the Context of the Guidelines

In the context of the 'Planning System and Flood Risk Management Guidelines, DOEHLG, 2009' three flood zones are designated in consideration of flood risk to a particular development site.

Flood Zone 'A' – where the probability of flooding from rivers and watercourses is the highest (greater than 1% or 1 in 100 year for river and watercourse flooding and 0.5% or 1 on 200 for coastal or tidal flooding).

Flood Zone 'B' – where the probability of flooding from rivers and watercourses is moderate (between 0.1% or 1 in 1000 year for river and watercourse flooding and 0.5% or 1 on 200 for coastal or tidal flooding).

Flood Zone 'C' – where the probability of flooding from rivers and watercourses is low or negligible (less than 0.1% of 1 in 1000 year for both river and watercourse and coastal flooding). Flood Zone 'C' covers all areas that are not in Zones 'A' or 'B'.

The 'Planning System and Flood Risk Management Guidelines' list the planning implications for each flood zone, as summarised below:-

Zone A – High Probability of Flooding. Most types of development would not be considered in this zone. Development in this zone should be only be considered in exceptional circumstances, such as in city and town centres, or in the case of essential infrastructure that cannot be located elsewhere, and where the 'Planning System and Flood Risk Management Guidelines' justification test has been applied. Only water-compatible development, such as docks and marinas, dockside activities that require a waterside location, amenity open space and outdoor sports and reaction would be considered appropriate in this zone.

Zone B – Moderate Probability of Flooding. Highly vulnerable development such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses, strategic transport and essential utilities infrastructure would generally be considered inappropriate in this zone, unless the requirements of the justification test can be met. Less vulnerable development such as retail, commercial and industrial uses and recreational facilities might be considered appropriate in this zone. In general however, less vulnerable development should only be considered in this zone if adequate lands or sites are not available in Zone 'C' and subject to a flood risk assessment to the appropriate level of detail to demonstrate that flood risk to the development can be adequately managed and that development in this zone will not adversely affect adjacent lands and properties.

<u>Zone C – Low to Negligible Probability of Flooding</u>. Development in this zone is appropriate from a flood risk perspective. Developments in this zone are generally not considered at risk of fluvial flooding and would not adversely affect adjacent lands and properties from a flood risk perspective.

Exceptions to the restriction of development due to potential flood risks are provided for through the use of the Justification Test, where the planning needed and the sustainable management of flood risk to an acceptable level must be demonstrated. This recognises that there will be a need for future development in existing towns and urban centres that lie within flood risk zones, and that the avoidance of all future development in these areas would be unsustainable. Table 4 taken from the Guidelines provide a justification test, which establishes the criteria under which the development of a site in a floodplain may be warranted.

	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

Table 4: "Appropriateness" Matrix

3.0 Stage 1 Flood Risk Identification

3.01 Initial Assessment of Potential Sources of Flooding

The flood risk identification uses existing information to identify and confirm whether there may be flooding or surface water management issues for the lands that require further investigations.

3.02 Information Sources

The following information sources were reviewed as part of the identification process.

Information	Source	Assessment
Predictive and historic flood maps, and benefiting lands maps which are available for review on http://www.floods.ie	OPW www.floodmaps.ie were reviewed.	There are no OPW land commission schemes or benefitting land zones within the subject site's boundary. The map provides no evidence of any recorded historical flood events occurring at or within the immediate vicinity of the site.
Predictive fluvial, coastal, pluvial, and ground water maps.	Neagh Bann CFRAMS	The existing road level of the R172 in the general vicinity of the proposed entrance to the site 3.34 m AOD where the predicted flood level for 0.5% or 1 in 200 is 3.74 m AOD and for 0.1% or 1 in 1000 is 3.94 m AOD. The portion of the site upon which the residential units will be constructed will not be at risk from flooding given the AOD level of the lowest dwelling floor will be 8.20 m which will be 4.2 m above highest predicted sea level and where the elevation of the site rises to 23.00 m AOD).
Previous Flood Risk Assessments	Neagh Bann CFRAMS	There are no recorded previous risk assessments for the area. Whilst the proposed scheme is located near the Dundalk Bay Estuary the site is not indicated to be in a tidal flood risk area.
Topographical maps, and surveys.	OSI Maps consulted and site topographic survey reviewed.	The OSI maps of the area show that that the HWM for the coastal water is located within the Dundalk Bay Estuary to the East of the R172. The topographical survey shows that the AOD levels for entire area where the new residential units will be constructed are significantly above any predicted coastal flood event.

Information on flood defence condition and performance;	No defences are present within the subject site or in the vicinity of the site.	-
Information on existing public sewerage condition and performance;	IW drawings for existing foul and storm drainage services in the vicinity of the subject site examined.	There are no existing significant surface water or foul sewers along the R172 or passing through the site.

Table 4 Information Sources Consulted

3.03 OPW Predictive, Historic & Benefiting Lands Maps & Flood Hazard Information

The OPW website www.floods.ie indicates that there were no OPW land commission schemes or benefitting land zones within the boundary of the subject site. The website does not indicate any flood events near or within the site. Refer to report included in **Appendix A**

3.04 Predictive fluvial, coastal, pluvial and ground water maps.

3.04.1 Fluvial Flood Predictive Maps

Fluvial flooding refers to the channel capacity of a watercourse being exceeded during higher flows and generally relates to Rivers and Streams. Flooding occurs when the capacity of a watercourse is exceeded, or the channel is blocked, or restricted, and excess water spills out from the channel onto adjacent low-lying areas. Fluvial Flooding is not relevant to this location, given that there are no streams or rivers passing through or near the site and in considering the size of the adjacent estuary.

The available Neagh Bann CFRAM fluvial flooding maps do not identify any risk for this area and therefore fluvial flooding is not a concern for this site.

3.04.2 Coastal Flooding

Coastal flooding results from sea levels which are higher than normal and result in sea water overflowing onto the land. Coastal flooding is influenced by the following three factors which often work in combination, high tide level, storm surges and wave action.

The extract included as Appendix B taken from the CFRAM Coastal Flood Map N06BRK_EXCCD_F0_02 shows the predicted coastal flooding for the 10%, 1% and 0.1% AEP events.

3.04.3 Pluvial Flooding

Pluvial or surface water flooding is the result of rainfall generated flows that arise before runoff can enter a watercourse or sewer. In undeveloped land overland flow occurs when the amount of rainfall exceeds the infiltration capacity of the ground to absorb it. This excess water flows overland forming ponds in natural hollows.

Generally, in order for a site to be considered at risk from overland flooding, it would require steep gradients within or surrounding the site and a reasonably large catchment area. Given the topography of the site and the fact the surrounding areas are relatively flat and to a large extent fall away from the site, Pluvial Flooding is not seen as a risk for the development.

3.04.4 Groundwater Flows

Groundwater flooding occurs when the level of water stored in the ground rises as a result of prolonged rainfall to meet the ground surface and flows out over it. Groundwater flooding tends to be very local and result from site specific factors such as tidal variations.

The development will be serviced by surface water network that discharges into the Dundalk Bay Estuary following on-site attenuation/infiltration. The site levels around the dwellings have been designed so that sufficient falls exist that ensure that the storm water discharges by gravity to gulley's and drainage channels and on into below ground gravity pipe network prior to connecting to the attenuation system for the development.

3.04.5 Historical Maps

Neither the historic 6" nor the historic 25" OS Map give any indication of the site or any of the surrounding lands being 'liable to flooding' or to comprise of wetlands as shown in Appendix C.

3.04.6 Flood Risk from Surface Water Network

We have analysed the surface water network to assess for flood risk arising from potential blockages in the proposed network. This analysis was undertaken using the MicroDrainage computer modelling software, for a scenario in which the HydroBrake (within manhole SMH71 immediately downstream of the attenuation/infiltration basin) would become blocked. This approach was considered as the most critical scenario for blockage risk within the proposed surface water network. The methodology of applying a 50% blockage at this HydroBrake gave a restricted flow of 40.3 l/s i.e. 50% of the allowable runoff rate of 80.6 l/s. The resultant TWL within the basin for a 1 in 100 yr storm event in this case was 8.63 m where there were no resultant flood volumes on any of the manholes in either network 1 or 2.

To fully mitigate for a potential flood event of 50% blockage to the HydroBrake, we have oversized the attenuation/infiltration basin to contain an additional volume of 711 m3 (combined total for 1 in 100 yr storm event and 50% blockage of Hydrobrake) within the structure. This additional storage will safeguard the proposed development and the neighbouring properties in the immediate vicinity of the attenuation/infiltration basin. The table included in Appendix D details the additional storage applied to the attenuation tank to fully contain potential flood water for the scenario described above:

This approach will provide sufficient protection to the proposed development buildings by preventing flood waters getting to a level where they create a risk for the new dwellings. The floor levels of the new dwellings within the vicinity of the attenuation/infiltration structure will be set at a level where there will be at least 500 mm of freeboard between the maximum top water level in the attenuation/infiltration basin to any dwelling floor level. These measures will safeguard the proposed development from potential flood risk associated with blockage within the proposed surface water network. In the unlikely event of a 50% blockage of the HydroBrake, overland flow will follow a safe route and will discharge to the local estuary/sea.

3.05 Other Sources

- Topographical surveys of the area – no evidence based on topography.
- Flood defence information – there are no flood defences in the vicinity of the site.
- Existing Local Authority Drainage Records - There are no existing surface water pipes within the site.
- There is a wetlands area to the east of the development site which serves as a stormwater greenfield runoff area and which is also has tidal influences. Following a site inspection, it was confirmed that this area does not create a flood risk to the development.

3.06 Conclusion of the Stage 1 Assessment

In the context of the 'Planning System and Flood Risk Management Guidelines, DOEHLG, 2009' this initial flood risk assessment has determined that a large portion of the development site (in excess of 98% of the site area) does not fall within Flood Zone 'A' and Flood Zone 'B' and therefore no further consideration is required for this area of the development site. There is that area of the site that is immediately west of the R172 where the proposed new entrance to the development will be constructed that will be subject to tidal/coastal flooding during extreme events. In accordance with the 'Planning System & Flood Risk Management Guidelines, DOEGLG, 2009' this flood risk assessment has determined that this area of the proposed development site may fall within Flood Zone 'A' and Flood Zone' B'. In accordance with the 'Planning System & Flood Risk Management Guidelines, DOEGLG, 2009' development proposals for this part of the site are subject to the requirements of 'The Justification Test'.

4.0 Stage 2 Assessment (Scoping Stage) Initial Flood Risk Assessment

The Stage 1 Assessment has identified Coastal Flooding as the most likely source of flooding within the wetland area that is immediately West of the R172 in the area where the new site access to the development will be constructed.

4.01 Sources of Flooding

4.01.1 Coastal Flooding

The information available on the following sources is considered to be sufficiently detailed to allow a well-informed assessment of the extent and depth of any coastal flooding that would occur at the site:

a) CFRAM Coastal Flood Map. See attached map N06BRK_EXCCD_F0_02 incl in Appendix B

b) The topographical survey of the site.

The current coastal tidal map represents the most definitive information currently available on the predicted level of flooding where the topographical survey of the site provides an accurate record of the ground levels throughout the site, the adjoining lands and public roadways. The extent of flooding associated with a flood level is dependent on the level of the surrounding lands relative to the flood level. The topographical survey therefore represents an important site-specific data set which shall complement and supplement the 3D digital Coastal Tidal Map. The CFRAM Maps are based on the calculation of the flood depth at certain key node points along the coastline. One of these nodes (0622C00010) is located within the estuary East of the site where the dataset provided indicates that the predicted high tide levels at this node location are as follows:

Event	Water Level (OD) m
10% AEP	3.38
1% AEP	3.72
0.1% AEP	3.94

The CFRAM Map included in Appendix B shows the extent of the predicted flooding within the lower level areas of the site where the new priority junction entrance from the R172 will be located and where the initial section of the new service roadway will be constructed.

4.01.2 Impact of Post Development Runoff

An assessment of the site including the overland flows concludes that the current greenfield runoff enters the estuary through a number of different paths and open channels. Therefore, there is a requirement to determine the impact of discharging the greenfield runoff rate to the existing open channel and wetland areas.

Surface water runoff rates for the proposed development will be limited to the predevelopment greenfield run-off rates of 50.40 l/s for the larger portion of the site (Part A incl. Network 1, 2 & 3) and a rate of 1.0 l/s for the area where the new access roadway (Part B - Network 4) will be constructed. The attenuated greenfield run-off from Part A of the development will discharge to a new outfall at the existing open channel north east of the site (which drains naturally to Dundalk SAC), via network 3 and which is shown on drawing 1703-ENG-114-Zone 4 - Surface Drainage Layout. The attenuated flows from Part B (Network 4) will discharge to the existing wetlands area North of the proposed new access roadway and west of the R172 as shown on 1703-ENG-110-Entrance Road - Surface Drainage Layout.

The impact of these discharges has been assessed through the completion of Stage 2/3 Flood Risk Assessment (FRA). This has been completed by IE Consulting Water-Environmental-Civil where a copy of their final report is included in Appendix E.

The synopsis of the FRA was that with the input of attenuated surface water discharge from the proposed development site at a maximum discharge rate of 106.0lts/s from network 3 into the existing open channel that there is the potential to increase 1% AEP and 0.1% AEP flood levels to between 0.03m (30mm) and 0.04m (40mm) within a short length downstream of the discharge point. The assessment also found that the small predictive increases in flood levels within the receiving channel were imperceptible and immeasurable and would not result in an adverse impact to the existing hydrological regime or result in an increased flood risk to adjacent lands or properties. It is also noted that the model is based on a worst case scenario where the maximum discharge rate (106.0lts/s) of attenuated stormwater from the proposed development site would discharge into the channel with the occurrence of a 1% AEP or a 0.1% AEP fluvial flood event where the probability of both of these events occurring at the same time is extremely low.

In the case of Part B (Network 4) the assessment established the attenuated surface water flow of 2.1lts/sec would not result in any measurable increase in current scenario fluvial flood levels within these drainage channel or the existing wetland areas.

4.01.3 Impact of Proposed New Access Roadway

The assessment also considered the effect of constructing the proposed new access roadway through part of the existing wetlands area west of the R172. The hydraulic modelling found that while there will be a small displacement of tidal/coastal flood waters, that it is imperceptible in consideration of the occurrence of a 0.1% AEP mid-range future climate change scenario tidal/coastal flood event in Dundalk Bay Estuary and the wholly massive volume of flood waters associated with this tidal/coastal flood event. In conclusion the development of the access road as proposed is not predicted to result in any adverse impact to the existing hydrological regime of the area or to result in an increased flood risk elsewhere where it is considered to be appropriate from a hydrological and flood risk perspective.

4.02 Conclusion of the Stage 2 Assessment

4.02.1 The small increases in flood levels associated with discharging the greenfield runoff rate to the existing open channel on the periphery of the Dundalk Bay Estuary are imperceptible and immeasurable and would not result in an adverse impact to the existing hydrological regime or result in an increased flood risk to adjacent properties.

4.02.2 There are no negative impacts of discharging attenuated flows to the wetland area that is located to the West of the R172 nor constructing the proposed new access roadway through the same area.

4.02.3 On the information that is available, it is concluded that the eastern portion of the site where the new entrance and a section of the service roadway will be constructed is susceptible to coastal flooding under extreme conditions.

In this case it is deemed that the site is located within a Flood Zone A as defined in the Flood Risk Management Guidelines. Therefore, a justification test is required to check that the development satisfies all of the criteria applicable in terms of flood risk management. It is considered that the information sources are of sufficient quality to make a conclusion on the extent and level of any flooding without the need to advance to a more detailed Stage 3 Assessment for this element of the assessment.

5.0 Stage 3 Detailed Flood Risk Assessment

The highest coastal flood level for the predicted 0.1% AEP Water Level for Node No. 0622C00010 is 3.94 m AOD as shown on the CFRAM Coastal Flood Map (N06BRK_EXCCD_F0_02) incl in Appendix B

5.01 Existing Situation

The existing levels of the public roadway along the site frontage where the new entrance to the development is proposed range from 3.30 m AOD to the North and 3.52 m to the South.

The vertical alignment of the public roadway continues to rise when travelling along the route in a southerly direction. In fact, the centreline of the public roadway rises to 4.50 m AOD some 38.00 m beyond the site boundary. See figure 3 below.

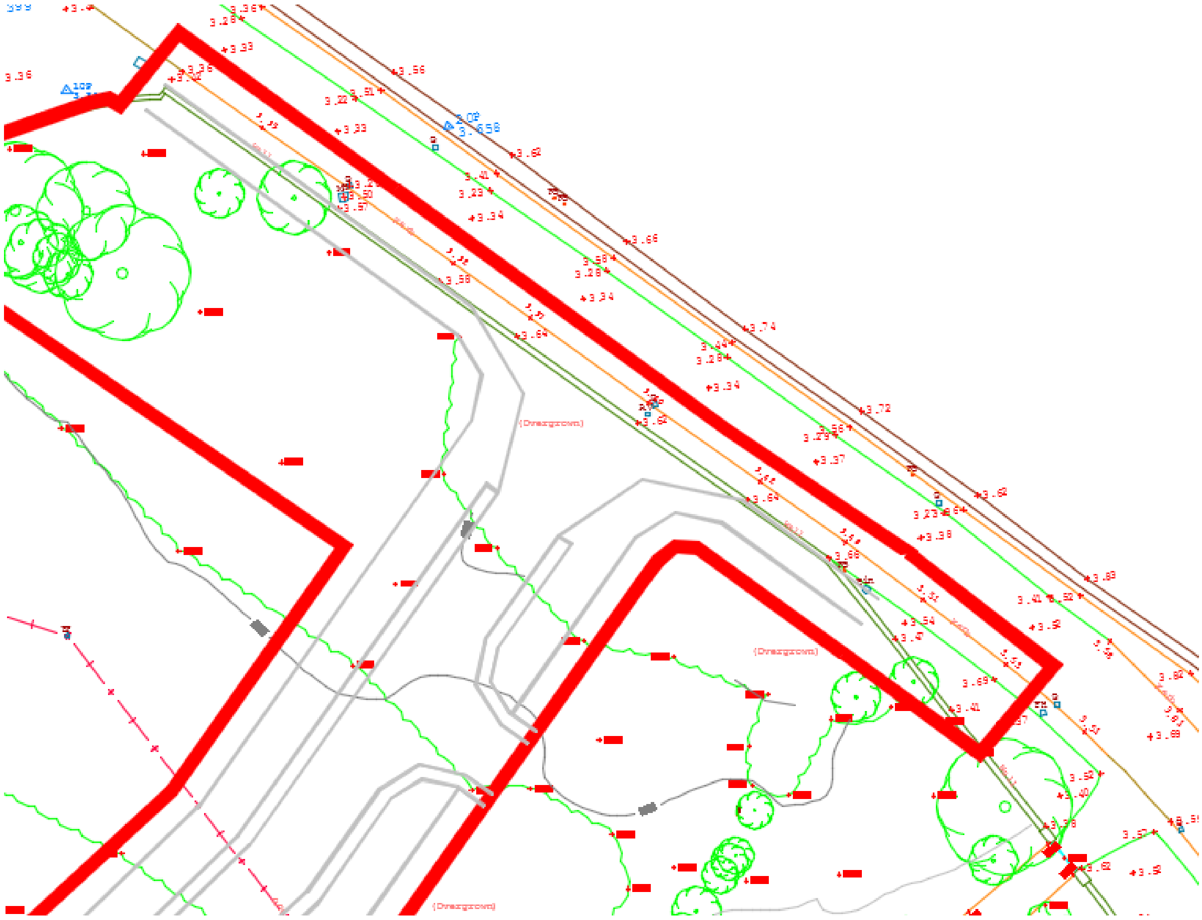


Figure 3 Existing Ground Levels at Proposed New Entrance

The existing edge of the public road carriageway at the vehicular entrance to the adjoining residential property to the south of the proposed entrance is 3.60 m AOD where the floor level of the dwelling itself is 4.35 m AOD.

The existing edge of the public road carriageway at the vehicular entrance to the adjoining residential property to the northwest of the proposed entrance is 3.40 m AOD where the floor level of the dwelling is circa 6.00 m AOD.

5.02 Proposed Mitigation Measures

It is proposed to raise the vertical alignment of the R172 along the site frontage from a point that is 53.50 m along the north arm of R172 from the intersection of the centrelines of the proposed new entrance roadway and R172. The level of this existing point is 3.36 m AOD. The gradient (.88%) of the new vertically aligned R172 from this point will be such that its centreline level at the intersection with the new entrance roadway will be 3.83 m AOD where the centerline gradient (.175%) will continue to rise along the south arm of the R172 until it ties back into the existing carriageway at a level of 3.94 m AOD some 63.00 m beyond the centreline of the new entrance roadway. Refer to Longitudinal Section – Public Roadway R172 as included in drawing 1703-ENG-108 for details

Construct the new entrance and the service roadway for the development at a level that ties in with the new vertical alignment of the public roadway. Refer to Longitudinal Section - Road 1 as included in drawing 1703-ENG-105 for details.

Under this arrangement vehicular access will be available to and from the development in a southerly direction for a 10% AEP, 1 in 10yr and 1% AEP, 1 in 200yr coastal flood event.
In the case of a 0.1% AEP, 1 in 1000yr event it is likely that there will be circa 110 mm of water along a section of the southern leg of public roadway, the entrance to the development and a section of the service roadway. Most vehicles can pass safely through 200 mm of standing water where larger vehicles can safely pass through 300 mm of standing water.

Pedestrian access will be available to and from the development through the provision of a new footpath that will be constructed as shown on drawing 1703-ENG-105 Service Roadways & Pavings – Entrance Roadway. The existing public footpath that extends along the frontage of the site will be replaced and tied in to the new development footpath as shown. The levels of the new footpaths within the development site and that section extending along the south arm of the R172 will be such so that they will be above the a 0.1% AEP, 1 in 1000yr predicted flood level of 3.94 m AOD. This will ensure that pedestrian access will be available to and from the development during the extreme coastal weather event.

6.0 Application of the justification test

It has been concluded that part of the proposed development site is located within a Flood Zone A.

The proposed development of 500 no. residential units, is classified as 'a highly vulnerable development' in the Flood Guidelines.

The Flood Guidelines permit development within a flood zone in cases where an appropriate 'Justification Test' can be satisfied and with the proviso that 'the risk should be mitigated and managed through the location, layout and design of the development to reduce such risks to an acceptable level'.

The appropriate test in this particular case is considered to be the Justification Test for Development Management (Box 5.1 of the Flood Guidelines) given that the subject site is zoned as 'Residential' in the Dundalk Development Plan which has been incorporated into the Louth Development Plan of 2015 to 2021 as shown on Figure 4

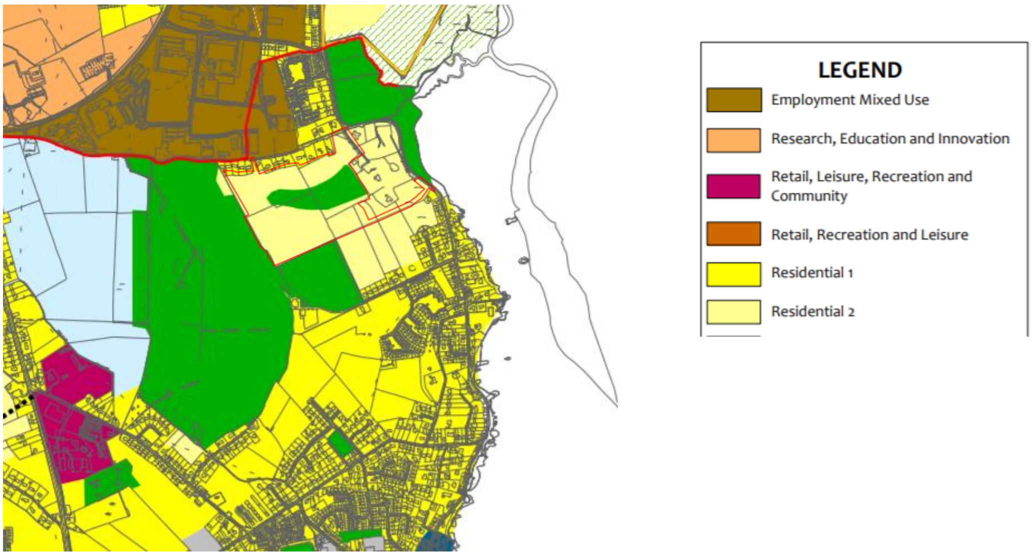


Figure 4 – Extract from Land Use Zoning Map – Dundalk Development Plan

6.01 Criterion No.1

The subject lands have 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 into account these Guidelines.

6.01.1 The site is zoned as 'Residential' in the Dundalk Development Plan and can be defined as an in-fill development located within the Urban Core and therefore supports the continued renewal and development of the compact urban form in accordance with the key planning objectives.

6.02 Criterion No.2

(i) *The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk.*

6.02.1 As the surface water run-off from the proposed development will be restricted to green-field levels in accordance with SuDS principles the proposed development shall not contribute to flooding elsewhere through an increase in the rate of discharge into Dundalk Bay.

6.02.2 The proposed development shall not adversely impact upon or block on existing flow paths.

(ii) *The development proposed includes measures to minimize flood risk to people, property, the economy and the environment as far as is reasonably possible.*

6.02.3 The floor levels of all the residential units will be significantly above the highest predicted coastal flood event of 3.94 m AOD where the proposed lowest ground floor level for a unit shall be 8.10 m. of the . No part of the site should be subject to flooding under the design flood scenario.

6.02.4 The floor levels of all the residential units shall have the minimum freeboard of 0.5m between the highest predicted coastal flood level of 3.94 m AOD in accordance with the recommendations of the Greater Dublin Strategic Drainage Scheme (GDSDS). Similarly, no residential unit has a floor level at or below the minimum level of 4.0m AOD for coastal regions as stated in the GDSDS

6.02.5 Residents remaining within their dwelling shall be safe from flooding while no material damage shall be caused to any residential unit.

6.02.6 While some level of flooding of the R172 will take place at the entrance to the development during an extreme coastal weather event the predicted depth (110mm depth) will be such that vehicles can still safely enter and leave the site. Pedestrian access will be provided through the provision of footpaths where their levels will be above the predicted flood level.

6.02.7 All houses shall be connected to the public sewer and public water supply. Any Coastal flooding shall have no adverse environmental impact on the operation of on-site wastewater pumping station or contamination a drinking water supply well.

(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.*

6.02.8 The proposed measure to raise the level of the R172 carriageway on either side of the proposed new entrance to the site and where the new entrance and service roadway will tie in with such levels will mean that access will be available to and from the site at all times albeit that vehicles may have to pass through a section of the public roadway and service roadway that will be under a maximum depth of 110 mm of water in the case of a 0.1% or 1 in 1000 coastal flood event The proposed flood management measures reduce the residual risk to the development by incorporating an allowance for climate change and provide provisions for emergency services access.

6.02.9 The proposed mitigated measures are site specific and not dependent on any existing or future communal flood protection system being in place.

6.02.10 Nonetheless any future local flood risk management measures that may be provided to prevent coastal flooding eastern side of the R172 will further reduce the residual risk of flooding at the site.

(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.*

6.02.11 The proposed development supports the achievement of a sustainable living environment by locating a residential development where the necessary infrastructure is available together with supporting social and community facilities.

7.0 Summary & Conclusion

7.01.1 It is concluded, that the eastern portion of the site where the new site entrance from the R172 is proposed would be susceptible to coastal flooding during extreme events.

7.01.2 The raising of the existing R172 carriageway on either side of the new entrance by on average 395 mm will ensure that the site can be accessed during extreme coastal flood events.

7.01.3 No proposed dwellings are at risk from flooding at their floor level will be significantly above the highest predicted level for the most extreme coastal flood event.

7.01.4 It has been demonstrated, in Section 6.0, that the proposed development satisfies all of the criteria of the Justification Test for Development Management (Box. 5.1 of the Flood Risk Management Guidelines).

7.01.5 It is the overall conclusion of this assessment that the proposed development does not represent an unacceptable flooding risk nor shall it exacerbate flooding in the immediate vicinity or wider area. The proposed development is therefore deemed to be in compliance with both The Planning System and Flood Risk Management Guidelines for Planning Authorities Dundalk Development Plan and Louth County Development Plan with respect to flood risk.

.

Appendix A

OPW *National Flood Hazard Mapping*

Summary Local Area Report

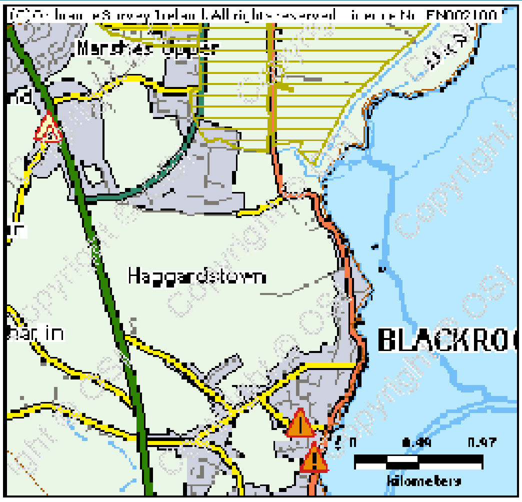
This Flood Report summarises all flood events within 2.5 kilometres of the map centre.

The map centre is in:

County: Louth

NGR: J 068 041

This Flood Report has been downloaded from the Web site www.floodmaps.ie. The users should take account of the restrictions and limitations relating to the content and use of this Web site that are explained in the Disclaimer box when entering the site. It is a condition of use of the Web site that you accept the User Declaration and the Disclaimer.



Map Scale 1:40,300

Map Legend
Flood Points
Multiple / Recurring Flood Points
Areas Flooded
Hydrometric Stations
Rivers
Lakes
River Catchment Areas
Land Commission *
Drainage Districts *
Benefiting Lands *

* Important: These maps do not indicate flood hazard or flood extent. Thier purpose and scope is explained in the Glossary.

4 Results

1. Blackrock, Co. Louth February 2002 — Start Date: 01/Feb/2002
County:Louth — Flood Quality Code:3
Additional Information: Reports (4) Press Archive (13) More Mapped Information

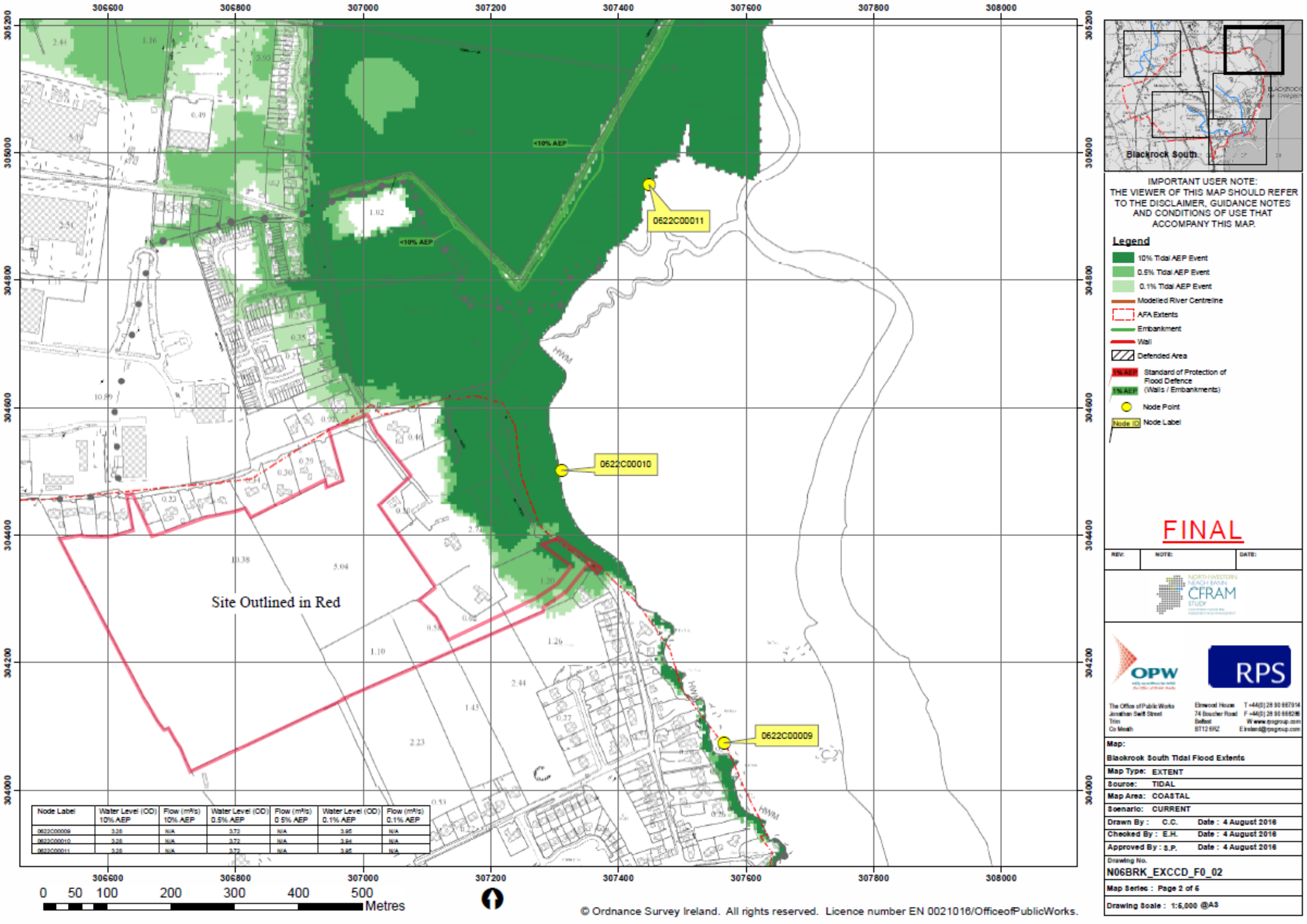
2. Blackrock Promenade February 2002 — Start Date: 01/Feb/2002
County:Louth — Flood Quality Code:4
Additional Information: Reports (1) Press Archive (10) More Mapped Information

3. Mullaharlin Road, Dundalk Recurring — Start Date:
County:Louth — Flood Quality Code:3
Additional Information: Reports (2) More Mapped Information

4. Lismore, Dundalk, Co Louth Recurring — Start Date:
County:Louth — Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

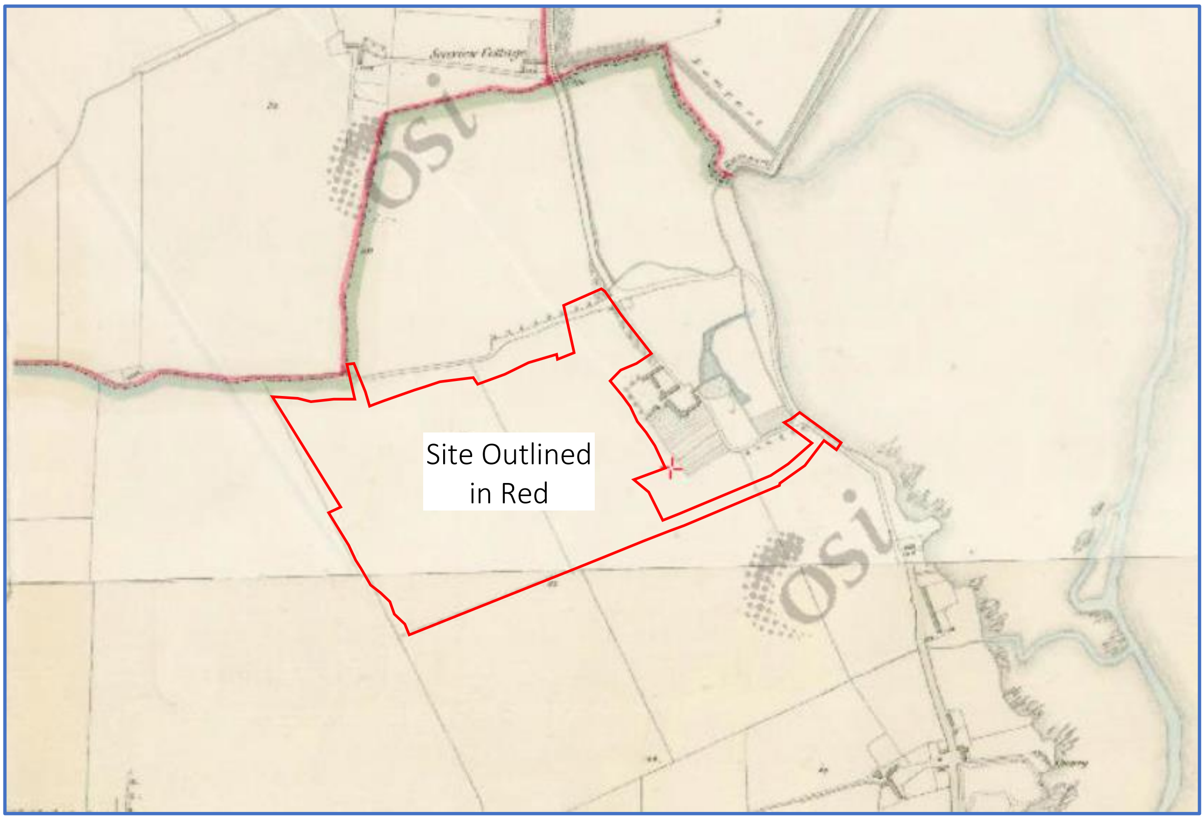
Report Produced: 18-Aug-2018 13:19

Appendix B



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
0622C00009	3.26	N/A	3.72	N/A	3.95	N/A
0622C00010	3.26	N/A	3.72	N/A	3.94	N/A
0622C00011	3.26	N/A	3.72	N/A	3.95	N/A

Appendix C


Site Outlined in Red


Soldier's Pt
Red Barn
C.G.S.
R.C.C.
25
18
Priorland Ho.
Seaview Catt.
Site
R.C.C.
65
Sch.
98
Black Rock
Ch.
Clermont Park
Sch

Appendix D

Summary of Results for 100 year Return Period (+10%)

Half Drain Time : 497 minutes

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Overflow (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Overflow Volume (m³)	Maximum Volume (m³)	Status
15 Summer	31.7	16.1	0.0	47.6	7.7893	0.7893	0.0	1310.5	O K
30 Summer	33.1	18.5	0.0	51.6	8.0028	1.0028	0.0	1771.5	O K
60 Summer	35.1	20.7	0.0	55.8	8.1853	1.1853	0.0	2215.9	O K
120 Summer	37.0	22.2	9.3	68.5	8.3402	1.3402	35.1	2626.5	O K
180 Summer	37.9	22.8	13.0	73.7	8.4062	1.4062	96.4	2808.9	O K
240 Summer	38.3	23.2	13.8	75.2	8.4402	1.4402	141.4	2905.3	O K
360 Summer	38.6	23.4	14.3	76.4	8.4682	1.4682	203.8	2985.1	O K
480 Summer	38.8	23.6	14.6	77.0	8.4812	1.4812	245.6	3022.4	O K
600 Summer	38.8	23.6	14.7	77.2	8.4857	1.4857	274.9	3035.6	O K
720 Summer	38.8	23.6	14.7	77.1	8.4847	1.4847	295.3	3032.9	O K
960 Summer	38.7	23.5	14.4	76.6	8.4727	1.4727	306.9	2997.4	O K
1440 Summer	38.2	23.1	13.6	74.8	8.4312	1.4312	265.6	2878.6	O K
2160 Summer	37.3	22.4	11.7	71.5	8.3627	1.3627	177.3	2687.1	O K
2880 Summer	36.6	21.8	5.5	63.9	8.3002	1.3002	72.8	2517.4	O K
4320 Summer	34.9	20.4	0.0	55.3	8.1613	1.1613	0.0	2154.9	O K
5760 Summer	33.3	18.7	0.0	52.0	8.0198	1.0198	0.0	1810.4	O K
7200 Summer	32.2	17.2	0.0	49.4	7.8873	0.8873	0.0	1514.3	O K
8640 Summer	31.7	15.8	0.0	47.3	7.7603	0.7603	0.0	1253.0	O K
10080 Summer	31.7	14.8	0.0	46.3	7.6433	0.6433	0.0	1027.1	O K
15 Winter	32.0	16.9	0.0	49.0	7.8673	0.8673	0.0	1471.9	O K
30 Winter	34.1	19.6	0.0	53.8	8.0953	1.0953	0.0	1991.1	O K
60 Winter	36.4	21.7	4.9	63.1	8.2917	1.2917	9.4	2495.0	O K
120 Winter	38.5	23.4	14.2	76.0	8.4592	1.4592	109.6	2958.7	O K
180 Winter	39.5	24.1	15.7	79.3	8.5382	1.5382	181.2	3187.9	O K
240 Winter	40.0	24.5	16.5	81.1	8.5812	1.5812	235.1	3316.3	O K
360 Winter	40.4	24.9	17.1	82.4	8.6162	1.6162	311.7	3421.5	FLOOD RISK
480 Winter	40.5	25.0	17.3	82.8	8.6252	1.6252	364.2	3448.7	FLOOD RISK

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
15 Summer	81.66	24
30 Summer	55.68	38
60 Summer	35.66	66
120 Summer	22.22	126
180 Summer	16.71	184
240 Summer	13.63	242
360 Summer	10.19	310
480 Summer	8.28	374
600 Summer	7.05	438
720 Summer	6.18	506
960 Summer	5.01	646
1440 Summer	3.73	924
2160 Summer	2.78	1324
2880 Summer	2.25	1736
4320 Summer	1.67	2552
5760 Summer	1.35	3304
7200 Summer	1.15	4040
8640 Summer	1.00	4760
10080 Summer	0.89	5456
15 Winter	81.66	24
30 Winter	55.68	37
60 Winter	35.66	66
120 Winter	22.22	122
180 Winter	16.71	180
240 Winter	13.63	236
360 Winter	10.19	342
480 Winter	8.28	388

Summary of Results for 100 year Return Period (+10%)

Storm Duration (mins)	Maximum Control (l/s)	Maximum Filtration (l/s)	Maximum Overflow (l/s)	Maximum Outflow (l/s)	Maximum Water Level (m OD)	Maximum Depth (m)	Overflow Volume (m³)	Maximum Volume (m³)	Status
600 Winter	40.6	25.0	17.3	82.9	8.6287	1.6287	401.7	3459.5	FLOOD RISK
720 Winter	40.5	25.0	17.3	82.7	8.6242	1.6242	428.9	3445.7	FLOOD RISK
960 Winter	40.3	24.7	16.9	81.8	8.6007	1.6007	461.9	3375.4	FLOOD RISK
1440 Winter	39.4	24.0	15.6	79.0	8.5312	1.5312	454.8	3168.2	O K
2160 Winter	38.0	23.0	13.3	74.3	8.4197	1.4197	331.6	2847.4	O K
2880 Winter	36.9	22.1	8.0	67.0	8.3282	1.3282	151.6	2593.6	O K
4320 Winter	34.5	20.0	0.0	54.6	8.1303	1.1303	0.0	2076.7	O K
5760 Winter	32.5	17.6	0.0	50.0	7.9203	0.9203	0.0	1586.3	O K
7200 Winter	31.7	15.4	0.0	46.9	7.7128	0.7128	0.0	1159.7	O K
8640 Winter	31.7	13.7	0.0	45.4	7.5257	0.5257	0.0	814.6	O K
10080 Winter	31.0	12.6	0.0	43.7	7.3967	0.3967	0.0	597.5	O K

Storm Duration (mins)	Rain (mm/hr)	Time-Peak (mins)
600 Winter	7.05	464
720 Winter	6.18	542
960 Winter	5.01	696
1440 Winter	3.73	994
2160 Winter	2.78	1416
2880 Winter	2.25	1848
4320 Winter	1.67	2720
5760 Winter	1.35	3464
7200 Winter	1.15	4248
8640 Winter	1.00	4848
10080 Winter	0.89	5448

Rainfall Details

Region	SCOT+NI	Cv (Summer)	0.750	Summer Storms	Yes
Return Period (years)	100	Cv (Winter)	0.840	Winter Storms	Yes
M5-60 (mm)	16.500	Shortest Storm (mins)	15	Climate Change %	+10
Ratio-R	0.300	Longest Storm (mins)	10080		

Time / Area Diagram

Total Area (ha) = 8.873

Time from:	(mins) to:	Area (ha)	Time from:	(mins) to:	Area (ha)	Time from:	(mins) to:	Area (ha)
0	4	2.694	4	8	5.359	8	12	0.820

Infiltration Basin Details

Infil Coef - Base (m/hr)	0.054355	Porosity	1.00
Infil Coef - Sides (m/hr)	0.054355	Invert Level (m)	7.000
Safety Factor	2.0	Ground Level (m)	8.700

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.00	1394.0	2.40	0.6	4.80	0.6	7.20	0.6	9.60	0.6
0.40	1621.0	2.80	0.6	5.20	0.6	7.60	0.6	10.00	0.6
0.80	2025.0	3.20	0.6	5.60	0.6	8.00	0.6		
1.20	2581.0	3.60	0.6	6.00	0.6	8.40	0.6		
1.60	3015.0	4.00	0.6	6.40	0.6	8.80	0.6		
2.00	3465.0	4.40	0.6	6.80	0.6	9.20	0.6		

Hydro-Brake Outflow Control

Design Head (m)	1.600	Hydro-Brake Type	MD5	Invert Level (m)	7.000
Design Flow (l/s)	40.3	Diameter (mm)	230		

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.10	8.2	0.60	31.5	1.60	40.2	2.60	51.2	5.00	71.0	7.50	87.0
0.20	20.0	0.80	31.5	1.80	42.6	3.00	55.0	5.50	74.5	8.00	89.8
0.30	28.0	1.00	33.1	2.00	44.9	3.50	59.4	6.00	77.8	8.50	92.6
0.40	31.1	1.20	35.3	2.20	47.1	4.00	63.5	6.50	80.9	9.00	95.3
0.50	31.7	1.40	37.8	2.40	49.2	4.50	67.4	7.00	84.0	9.50	97.9

Pipe Overflow Control

Pipe Diameter (m)	0.150	Roughness (mm)	1.500	Invert Level (m)	8.200
Slope (1:x)	150.0	Entry Loss Coef	0.500		
Length (m)	35.000	Coef of Contraction	0.600		

Appendix E

KINGSBRIDGE CONSULTANCY LTD

PROPOSED DEVELOPMENT SITE AT

HAGGARDSTOWN, BLACKROCK, CO. LOUTH

HYDRAULIC ASSESSMENT & ANALYSIS OF CONVEYANCE CHANNELS

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Integrated Engineering Consulting

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

KINGSBRIDGE CONSULTANCY LTD

PROPOSED DEVELOPMENT SITE AT

HAGGARDSTOWN, BLACKROCK, CO. LOUTH

HYDRAULIC ASSESSMENT & ANALYSIS OF CONVEYANCE CHANNELS

IE Consulting - Carlow Office

Innovation Centre

Green Road
Carlow

Tel: 059 91 33084
Fax: 059 91 40499
Email: info@iece.ie
Web: www.iece.ie

IE Consulting - Newry Office

1 RDC House
WIN Business Park
Newry
Co Down
BT35 6PH

Tel: 028 3025 7974
Email: info@iece.ie
Web: www.iece.ie

Client :-
Finn Design Partnership
Blakestown
Ardee
Co. Louth

Document No:	IE1723-2931
Issue No:	02-ISSUE
Project No:	IE1723
Date:	21st November 2018
Revision:	6.0
Prepared By:	Logan McMillan BEng(Hons)
Checked By:	P McShane BEng(Hons) MIEI

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Table of Contents

1 Executive Summary

IE Consulting was requested by Finn Design Partnership, on behalf of Kingsbridge Consultancy Ltd, to undertake hydraulic modelling, assessment and analysis of the existing surface water conveyance channels in the vicinity of the proposed development site. Permission is sought to construct a new residential development at Haggardstown, Blackrock, Dundalk, Co. Louth and all associated site works.

The purpose of the hydraulic assessment is to predict the effects of an attenuated surface water of $0.106m^3/s$ discharging to an existing nearby drainage channel and a seperate attenuated surface water of $0.0021m^3/s$ discharging to the existing nearby wetlands system and associated conveyance channels.

Using the methodology detailed in the Flood Studies Report (FSR) and Flood Studies Supplementary Reports (FSSR) and the Institute of Hydrology Report (IH) No. 124 'Flood Estimation for Small Catchments' the mean annual flood volume in the northern conveyance channel and the eastern conveyance channel associated with the wetlands system was estimated. The 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood volumes in the eastern and northern conveyance channels were then estimated using the index flood methodology.

A detailed hydraulic model was constructed for the eastern and northern conveyance channels over reach lengths of approximately 273.19m and 124.02m respectively. The model was run for the existing scenario to form a baseline and again incorporating the additional attenuated discharge from the proposed development site.

The results of the simulation indicate that the maximum attenuated surface water discharges from the proposed development site would not result in an increase in flood water levels in the conveyance channels due to the occurrence of a 10% AEP (1 in 10 year) or 2% AEP (1 in 50 year) flood event in the catchment area upstream of the conveyance channels.

In the context of the occurrence of a 1% AEP (1 in 100 year) or a 0.1% AEP (1 in 1000 year) fluvial flood event these small predictive increases in flood levels in the northern drainage conveyance channel are imperceptible and immeasurable and would not result in an adverse impact to the existing hydrological regime or result in an increased flood risk to adjacent lands or properties or result in an adverse impact to the existing hydrological regime of the area.

The input of attenuated surface water discharge from the proposed new access road to the eastern drainage channels at a maximum discharge rate of $0.0021m^3/s$ is not predicted to result in any measurable increase in current scenario fluvial flood levels within these drainage channel or the existing wetland areas.

Development of the new access road as proposed is not predicted to result in any adverse impact to the existing hydrological regime of the area or to result in an increased flood risk elsewhere and is considered to be appropriate from a hydrological and flood risk perspective.

2 Introduction

IE Consulting was requested by Finn Design Partnership, on behalf of Kingsbridge Consultancy Ltd, to undertake hydraulic modelling, assessment and analysis of the existing surface water conveyance channels in the vicinity of the proposed development site. Permission is sought to construct a new residential development at Haggardstown, Blackrock, Dundalk, Co. Louth and all associated site works.

A Stage 1/ Stage 2 Flood Risk Assessment undertaken by Finn Design Partnership Ltd for the proposed development site identified potential flood risks associated with the discharge of attenuated surface water from the site to the nearby existing northern drainage channel and from the proposed new access road to the existing wetlands. The purpose of this hydraulic assessment is to assess the impact that the maximum volume of attenuated surface water discharge from the site and from the access road may or may not have on receiving watercourses.

It is proposed to discharge attenuated surface water runoff from the proposed development site at a maximum discharge rate of 0.106m^3/s to an existing drainage channel downstream of the site and to discharge attenuated surface water runoff from the proposed access road at a maximum discharge rate of 0.0021m^3/s to the wetland area located adjacent to and on the western side of the Blackrock Road. Outflow from this wetland area is conveyed through existing open drainage channels and a secondary wetland area adjacent to the Blackrock Road in a south to north direction after which the channel is culverted under Blackrock Road where discharge is then to Dundalk Bay estuary.

The purpose of this hydraulic assessment and analysis is to assess the hydraulic capacity or not of the existing conveyance channel watercourses and existing culvert crossing of the Blackrock Road and other culverts to convey the additional volume of attenuated surface waters and to determine if this additional conveyance volume may or may not result in an adverse impact to the existing hydrological regime of the area or to increase flood risk elsewhere.

In accordance with *'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' DOEHLG 2009'* the hydraulic assessment and analysis has been undertaken on a joint probability scenario of attenuated discharge at the rate of 0.106m^3/s to the existing drainage channel downstream and north of the proposed development site and at a rate of 0.00021m^3/s to the existing wetland area during the occurrence of a 1% AEP (1 in 100 year) and a 0.1% AEP (1 in 1000 year) fluvial flood event in the conveyance channel watercourses. In addition, the occurrence of a mean annual fluvial flood event in the conveyance channel watercourses has been assessed.

An assessment is also undertaken in relation to the proposed new access roadway to serve the proposed development site, including an analysis of the impact that this roadway may or may not have on the existing hydrological regime of the area. Quoted ground levels or estimated flood levels relate to ordnance datum (Malin) unless stated otherwise.

3 Proposed Site Description

3.1 General

The proposed development site is located on lands between Blackrock Road and Birches Lane at Haggardstown, Blackrock, Co. Louth. The site is bounded to the north and east by existing residential properties, to the west by a golf course, and to the south by agricultural lands. The total area of the proposed development site is approximately 17.5 hectares.

The regional location of the proposed development site is illustrated on *Figure 1* below and shown on *Drawing Number IE1723-001-A in Appendix A*.

Figure 1 - Site Location

3.2 Existing Topography Levels at Site

The proposed development site slopes moderately in a south-west to north-east direction at an approximate slope of 3.18% (1 in 31).

Ground elevations at the proposed development site range from 23.78mOD (Malin) at the south-west corner of the site to 2.71mOD (Malin) at the north-east boundary of the site.

3.3 Local Hydrology, Landuse & Existing Drainage

The most immediate hydrological features in the vicinity of the proposed development are two drainage conveyance channels located beyond the eastern boundary of the site and adjacent to the Blackrock road (eastern drainage channels), the northern drainage channel located adjacent to and north of Blackrock road (northern drainage channel), the Upper Marshes Stream located approximately 225m beyond the north site boundary and the Irish Sea located approximately 220m beyond the eastern site boundary.

The scope of this particular hydraulic assessment and analysis is specific to the existing eastern and northern drainage conveyence channels listed above and as illustrated in *Figure 1*.

3.4 Conveyance Channel Catchment Areas

The catchment areas of the conveyance channels were delineated utilising 1:50,000 Discovery Series Mapping and a Light Detection and Ranging (LiDAR) derived Digital Terrain Model (DTM) acquired from Ordnance Survey Ireland, and have been estimated to be 0.092km^2 and 0.373km^2 to points downstream of the proposed development site as illustrated in *Figure 2* below.

An assessment of the upstream catchment area of the northern conveyance channel indicates a mainly rural catchment area, with an urban fraction accounting for approximately 10.14% of the total catchment area. The upstream catchment area of the eastern conveyance channels indicates a mainly rural catchment area, with an urban fraction accounting for approximately 13.31% of the total catchment area.

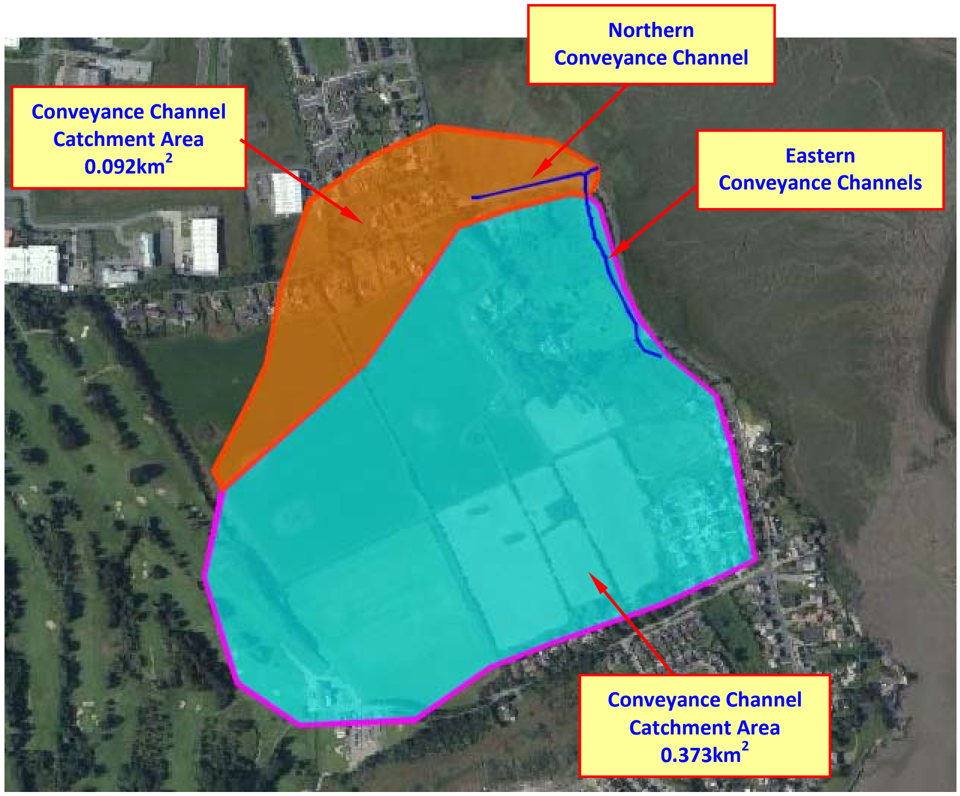


Figure 2 – Conveyance Channel Catchment Areas

3.5 Peak Flow Estimation –Mean Annual Flood Method for Small Catchments

Given the small size of the catchment area of the conveyance channels, the FSU portal software is not considered appropriate to estimate the median or mean flood volume. The mean annual flood , Q_{BAR} (m^3/s), is therefore estimated by utilising any of the three multiple parameter regression equations detailed in the Flood Studies Report (FSR) and Flood Studies Supplementary Reports (FSSR) or the Institute of Hydrology Report (IH) No. 124 'Flood Estimation for Small Catchments' regression equation.

These equations are listed below:-

$Qbar\ Rural = 0.00066 \times Area^{0.92} \times SAAR^{1.22} \times SOIL^{2.0}$ EQN 1.5 (FSSR)

$Qbar\ Rural = 0.0288 \times Area^{0.90} \times RSMD^{1.23} \times SOIL^{1.77} \times STMFRQ^{0.23}$ EQN 1.6 (FSR)

$Qbar\ Rural = 0.00108 \times Area^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$ EQN 7.1 (IH124) *where,*

AREA = the topographic catchment area

Area** $_{eastern\ channel}$ **= 0.373 Km^2

Area** $_{northern\ channel}$ **= 0.092 Km^2

SAAR = Standard Annual Average Rainfall

***SAAR = 843 mm (**from Met Éireann data)*

STMFRQ = the stream frequency of the catchment, which is equal to the number of channel junctions within the catchment divided by the catchment area. STMFRQ = (J/ A) = 1/0.373 (eastern channels) & = 1/0.092 (northern channel)

STMFRQ** $_{eastern\ channels}$ **= 2.691

STMFRQ** $_{northern\ channel}$ **= 10.869

RSMD = the 5 year, 1 day rainfall excess (mm) for the catchment and is estimated using the following equation or can be directly derived from Figure 3 below:

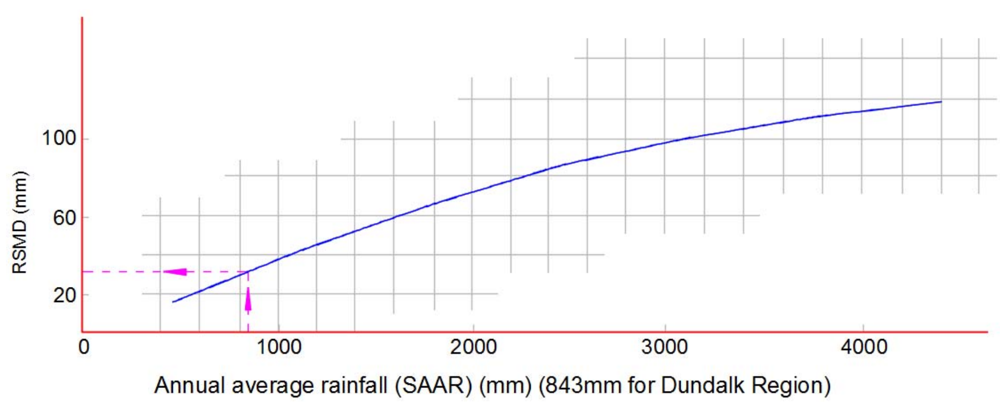


Figure 3 – Plot of 5 year, 1 day rainfall excess, RSMD, against mean annual rainfall, SAAR

***RSMD = 32mm,** for SAAR value of 843mm taken from Met Éireann data*

SOIL = A number depending on the soil type and relating to the winter rain acceptance potential of the soils in the catchment. Values for SOIL are obtained from *Figure 4* and *Figure 5* below, which are replicated from map I. 4.18 (I) in the FSR.

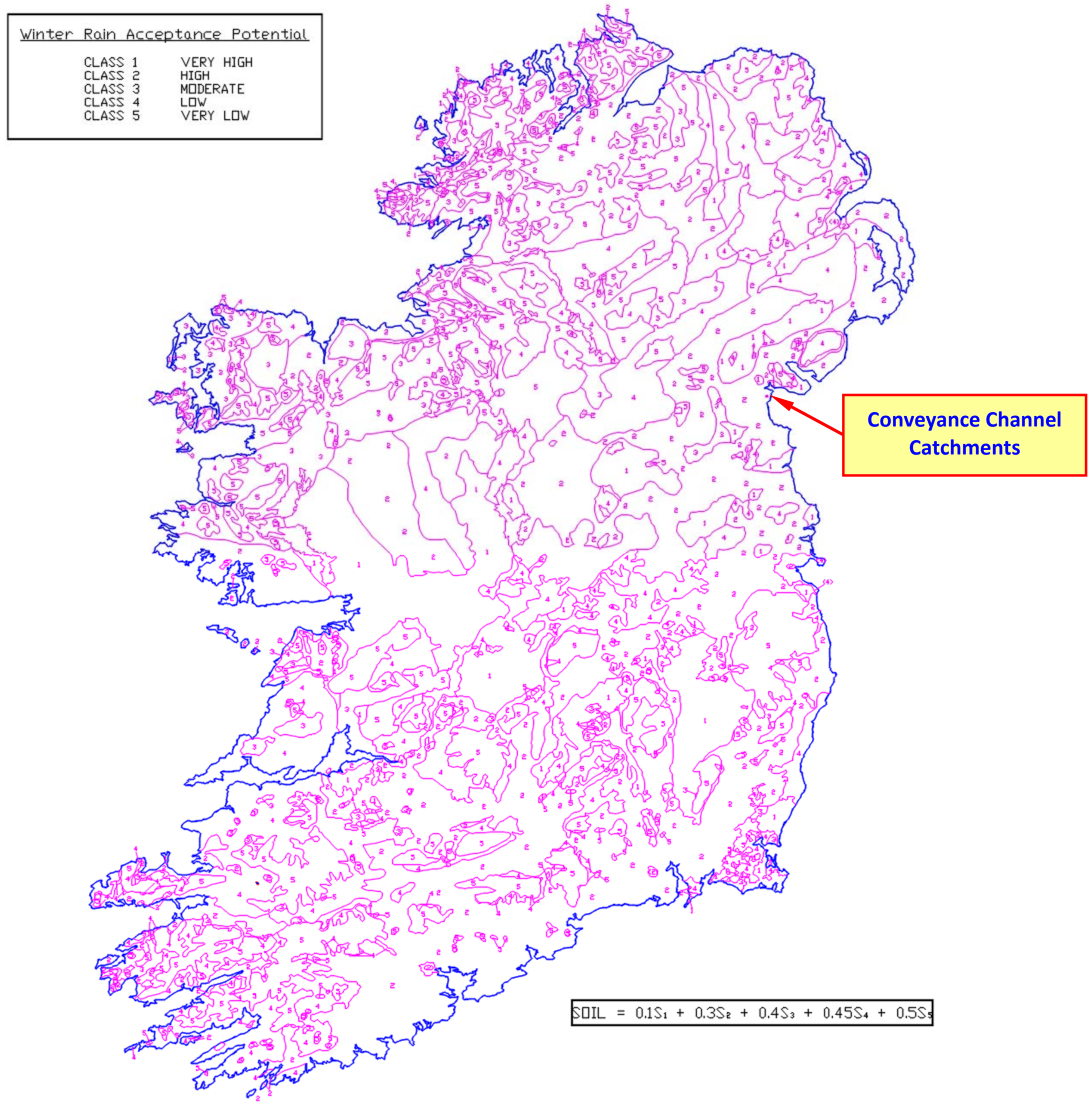


Figure 4 - Winter Rainfall Acceptance Potential

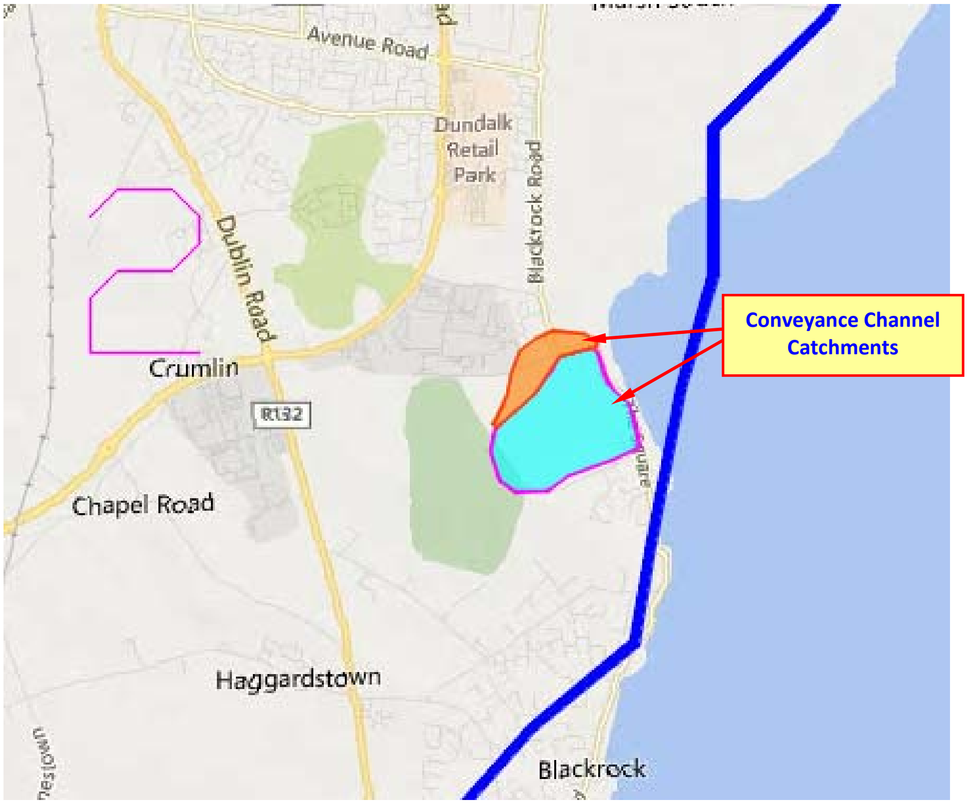


Figure 5 - Winter Rainfall Acceptance Potential

From *Figure 4* and *Figure 5* above (not to scale) the conveyance channel catchment areas comprise 100% SOIL Type 2.

Therefore:

SOIL = 0.15(S1) + 0.3(S2) + 0.40(S3) + 0.45(S4) + 0.5(S5)

SOIL = 0.15(0) + 0.3(1) + 0.40(0) + 0.45(0) + 0.5(0)

SOIL = 0.3

For catchment areas less than 50 hectares (0.5 km^2) in area it is recommended that the mean annual runoff rate be calculated for a 50 hectare catchment and the runoff for the actual catchment is then determined through linear interpolation.

Therefore:

Qbar Rural = 0.00066 x $Area^{0.92}$ x $SAAR^{1.22}$ x $SOIL^{2.0}$ **EQN 1.5(FSSR)**

$\Rightarrow Q_{BAR} = 0.00066 \times 0.5^{0.92} \times 843^{1.22} \times 0.3^{2.0}$

$\Rightarrow$ **Q_{BAR} = <u>0.1165 m^3/s</u>** *(for 50 hectare catchment area)*

Qbar Rural = 0.0288 x $Area^{0.90}$ x $RSMD^{1.23}$ x $SOIL^{1.77}$ x $STMFRQ^{0.23}$ **EQN 1.6 (FSR)**

$\Rightarrow Q_{BAR\ eastern\ channel} = 0.0288 \times 0.5^{0.90} \times 35.41^{1.23} \times 0.3^{1.77} \times 2.691^{0.23}$

$\Rightarrow$ **$Q_{BAR\ eastern\ channels}$ = <u>0.185 m^3/s</u>** *(for 50 hectare catchment area)*

$\Rightarrow Q_{BAR\ northern\ channel} = 0.0288 \times 0.5^{0.90} \times 35.41^{1.23} \times 0.3^{1.77} \times 10.869^{0.23}$

$\Rightarrow$ **$Q_{BAR\ northern\ channel}$ = <u>0.2551 m^3/s</u>** *(for 50 hectare catchment area)*

Qbar Rural = 0.00108 x $Area^{0.89}$ x $SAAR^{1.17}$ x $SOIL^{2.17}$ **EQN 7.1 (IH124)**

$\Rightarrow 0.00108 \times 0.5^{0.89} \times 843^{1.17} \times 0.3^{2.17}$

$\Rightarrow$ **Q_{BAR} = <u>0.1133 m^3/s</u>** *(for 50 hectare catchment area)*

For the purposes of this Site Specific Flood Risk Assessment, the more conservative Q_{BAR} estimates of ***0.185 m^3/s*** and ***0.2551 m^3/s*** are utilised for the eastern and northern drainage channels respectively. The FSR equation has a standard factorial error of 1.58, therefore the design ***Q_{BAR} Rural*** estimates are:

$\Rightarrow Q_{BAR\ eastern\ channels}$ = 0.185 m^3/s x 1.58 = ***<u>0.2923 m^3/s.</u>***

$\Rightarrow Q_{BAR\ northern\ channel}$ = 0.2551 m^3/s x 1.58 = ***<u>0.4031 m^3/s.</u>***

The flow for the catchment areas under consideration is then estimated via linear interpolation as listed below:-

$$\text{Catchment Qbar Rural} = \frac{\text{Qbar Design}}{0.5} \times \text{Catchment Area}$$

Therefore:-

$$\text{Site Qbar Rural}_{eastern\ channels} = \frac{0.2923.}{0.5} \times 0.373$$

$\Rightarrow$ ***$Q_{BAReast\ channel}$ = <u>0.2181 m^3/s</u>***

$$\text{Site Qbar Rural}_{northern\ channel} = \frac{0.4031.}{0.5} \times 0.092$$

$\Rightarrow$ ***$Q_{BARnorthern\ channel}$ = <u>0.0742 m^3/s</u>***

The urban fraction for the eastern conveyance channels catchment is 13.31%. The urban fraction for the northern conveyance channel catchment is 10.14%. The ratio of stormwater runoff generated by urban areas to those generated by rural areas can be estimated by utilising the multiple parameter equation, *EQN 7.4*, detailed in the Institute of Hydrology Report No. 124 'Flood Estimation for Small Catchments'. This equation is as listed below:-

$$\Rightarrow Qbar_{Urban}/Qbar_{Rural} = (1+Urban\%)^{2NC} \times (1+Urban\%((21/CIND)-0.3)$$

where,

Urban% = the overall decimal percentage of the catchment area that is considered to be urbanised

$Urban\%_{eastern\ channels} = 0.1331$

$Urban\%_{northern\ channel} = 0.1014$

$NC = 0.92 - 0.00024\ SAAR$ (for $500 \leq SAAR \leq 1100mm$)

$NC = 0.92 - 0.00024(843) = 0.718$

CIND = Catchment Index ***CIND = 102.4 SOIL +0.28 (CWI – 125)***

CWI = Catchment Wetness Index which is a function of SAAR and can be estimated from Figure 6 below:

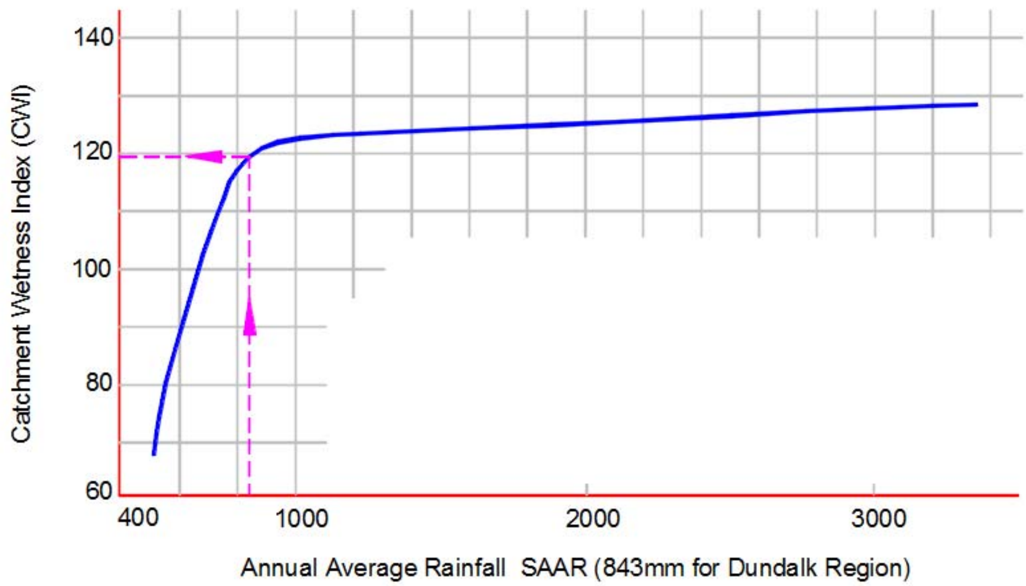


Figure 6 – Plot of Catchment Wetness Index, CWI against mean annual rainfall, SAAR

CWI = 122.23, *for SAAR of 843*

Therefore:

CIND = 102.4(SOIL) +0.28(CWI – 125) *EQN 1.5*

CIND = 29.94

$Qbar_{Urban}/Qbar_{Rural\ Eastern\ Channels} = (1+Urban\%)^{2NC} \times (1+Urban\%((21/CIND)-0.3))$

$Qbar_{Urban}/Qbar_{Rural\ Eastern\ Channels} = (1+0.1331)^{(2 \times 0.718)} \times (1+0.1331((21/29.94)-0.3))$

$\mathbf{Qbar_{Urban}/Qbar_{Rural\ Eastern\ Channels} = 1.26}$

$Qbar_{Urban}/Qbar_{Rural\ Northern\ Channel} = (1+0.1014)^{(2 \times 0.718)} \times (1+0.1014((21/29.94)-0.3))$

$\mathbf{Qbar_{Urban}/Qbar_{Rural\ Northern\ Channel} = 1.196}$

Therefore:

$Qbar_{Urban\ Eastern\ Channels} = Qbar_{Rural} \times Qbar_{Urban}/Qbar_{Rural}$

$\mathbf{Qbar_{Urban\ Eastern\ Channels} = 0.2181 \times 1.26 = 0.2748\ m^3/s}$

$\mathbf{Qbar_{Urban\ Northern\ Channel} = 0.0742 \times 1.196 = 0.0885\ m^3/s}$

3.6 Estimated Flows for Different Return Periods

The return period flows 'Q_T' are estimated using the index flood method and multiplying the annual maximum flow by the appropriate growth factor 'X_T' using the FSR (1975) national growth curve for Ireland, as shown in *Figure 7* below: -

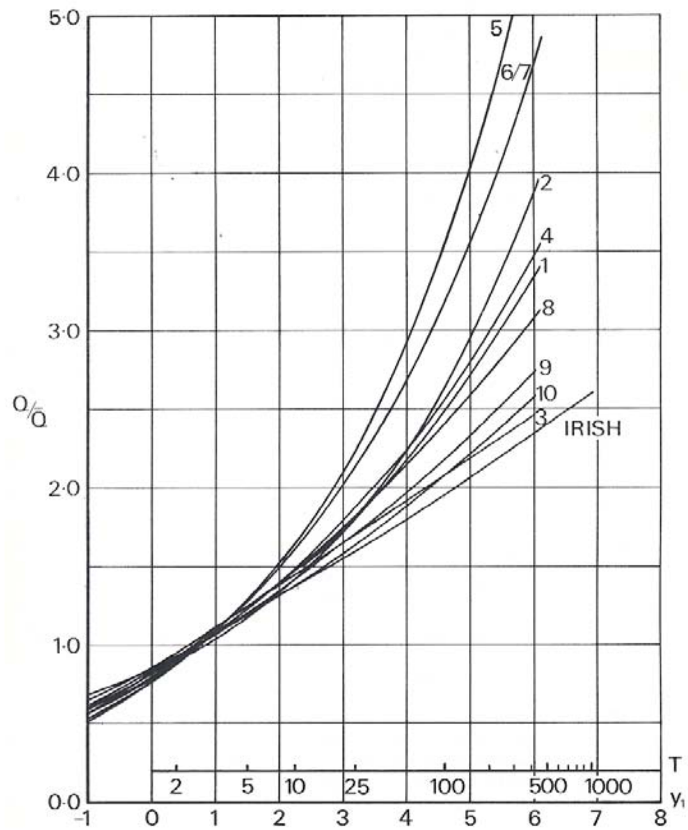


Figure 7 – Regional Growth Factors

For flood return periods 2, 5, 10, 20, 50, 100 and 1000 years the growth factors determined from *Figure 5* are listed in *Table 1* below: -

Flood Return Period (Yrs)	2	5	10	20	50	100	1000*
Growth Curve Factor (Q_T/Q_{BAR})	0.95	1.20	1.37	1.54	1.77	1.96	2.59

Table 1 - Growth Factors Applied to Irish Catchments for Q_{BAR} Discharge Prediction

Table 2 below lists the estimated peak flood flow in the watercourse at the point of interest for different return periods: -

Flood Return Period (Yrs)	*2*	*5*	*10*	*20*	*50*	*100*	*1000**
Eastern Channels Estimated Peak Flow (m^3/s)	*0.2611*	*0.3298*	*0.3765*	*0.4232*	*0.4864*	*0.5386*	*0.7117*
Northern Channel Estimated Peak Flow (m^3/s)	*0.0840*	*0.1062*	*0.1212*	*0.1362*	*0.1566*	*0.1734*	*0.2292*

Table 2 – Estimated Peak Flows in the Drainage channel for Different Return Periods

The estimated 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) flood flows for the conveyance channel watercourses is therefore:-

$Q_{100\ Eastern\ Channels} = 0.5386\ m^3/s$

$Q_{1000\ Eastern\ Channesl} = 0.7117\ m^3/s$

$Q_{100\ Northern\ Channel} = 0.1734\ m^3/s$

$Q_{1000\ Northern\ Channel} = 0.2292\ m^3/s$

*(*Note – The Q_{100} value is a design flow. The Q_{1000} value is estimated and is presented only to assess the 1000 year Average Recurrence Interval (ARI) in the context of the 'Planning System and Flood Risk Management Guidelines')*

3.7 Hydraulic Analysis of Drainage Channels

A hydraulic model was developed for the eastern and northern conveyance channels along a reach length of approximately 273.19m and 124.02m respectively, including existing hydraulic structures (culverts).

The hydraulic model developed is usually based on an appropriate computer software package that utilises topographical information from the watercourse channel and flood plain geometry, the hydraulic resistance characteristics *(Manning's 'n')* of the watercourse and flood plain and appropriate boundary conditions at the upstream and downstream extent of the study area. The extent of modelled reach length is illustrated in *Figure 8* below:-

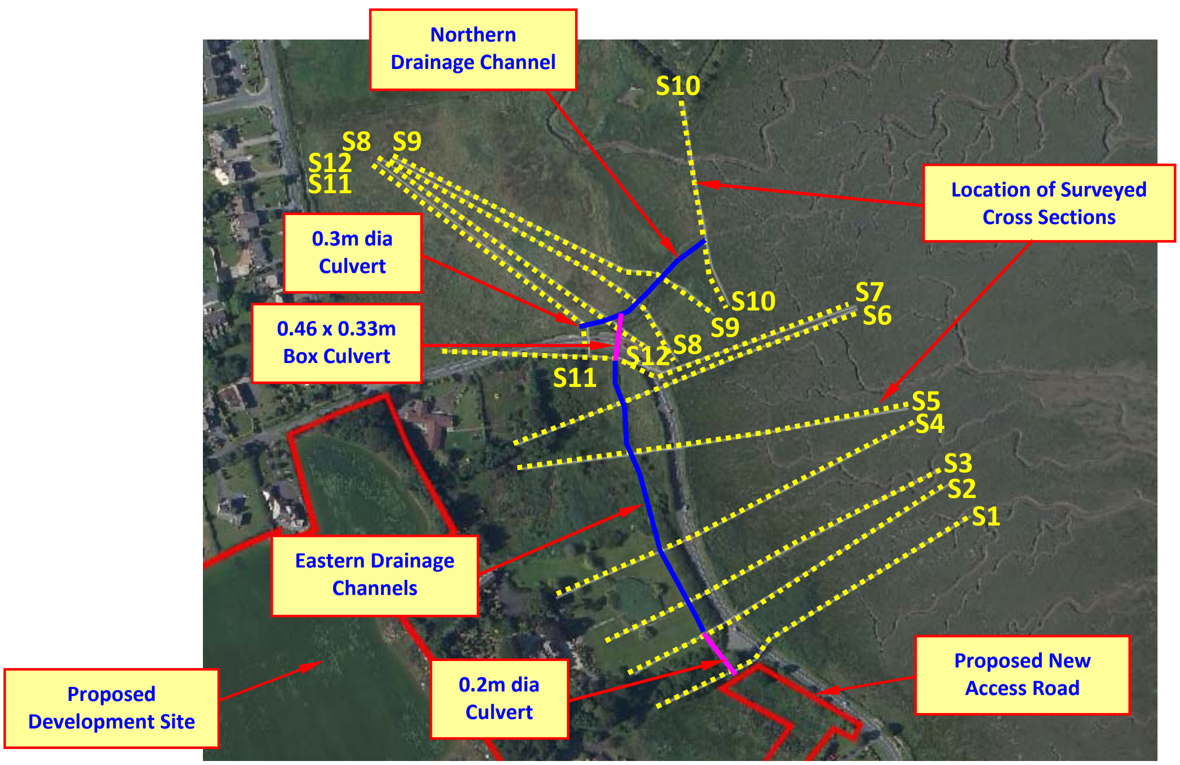


Figure 8 - Hydraulic Model Extents

Detailed topographical cross-sectional survey data at each of the cross-sectional locations illustrated above was acquired from a topographical survey undertaken by Land Survey Services Ltd. In addition the hydraulic structures (culverts) along the modelled conveyance channels were surveyed.

A copy of the full cross-sectional survey is contained in *Appendix B*.

3.7.1 Hydraulic Model Selection and Assumptions

A number of computer based hydraulic models are available which will predict flood levels for a given design flow. For this particular assessment the HEC-RAS V4.1 computer model was employed. HEC-RAS was developed by the Hydrologic Engineering Centre of the US Army Corps of Engineers and is a one-dimensional hydraulic model that computes both steady and unsteady flow profiles for specified upstream and downstream flow conditions. HEC-RAS is a robust and well-regarded application and is in wide spread use by engineering consultants, hydrologists and relevant authorities throughout the world. The program also supports hydraulic structures such as bridges, culverts, and weirs and can also analyse floodplain storage. It is well regarded for use in the application of watercourses and flood plain modelling.

The following are the main assumptions used in the development of the HEC-RAS hydraulic model:

- Cross-section information between successive surveyed cross-sections was obtained by interpolation, where required.
- The openings of the culverts and the reach modelled were assumed to be free from blockages or debris in all events.
- The hydraulic model assumes that flood volume input to the existing wetland areas equals flood volume output and does not account for any possible attenuating effect offered by the wetland areas.

3.7.2 Initial Boundary Conditions

In consideration the eastern and northern conveyance channel ultimately discharge to Dundalk Bay, the hydraulic model was developed utilising a known downstream tidal water level.

The Register of Hydrometric Stations Ireland indicates that station 06061 is an active recorder station located within Dundalk Harbour. Tidal water level data from this hydrometric station is applicable for use in the developed hydraulic model. Annual maxima tidal Water level data for this gauging station was therefore acquired from the OPW and the mean tidal level data was incorporated as a downstream boundary condition in the hydraulic model.

3.7.3 Watercourse Channel Roughness Coefficients

The Manning's 'n' coefficient represents the hydraulic resistance to flow of the stream channel or flood plain. The Manning's 'n' coefficients chosen are estimated from a visual inspection of the conveyance channels and associated flood plain lands.

Guidance is available on selecting appropriate Manning's 'n' values *(from Chow 1959, French 1986),* however the Manning's 'n' coefficients are usually subsequently refined upon the development of the model by calibrating with any historical flooding data in the area, but only if available.

Table 3 below lists recommended watercourse channel overbank land roughness co-efficient for various vegetation types.

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200

Table 3 – Manning's 'n' Values for Channels and Flood Plains

With reference to *Table 3* above, varying roughness co-efficients were applied to the hydraulic model to reflect the type and form of vegetation observed during the survey of the watercourse undertaken by a hydrological engineer from IE Consulting. In respect of the main channel of the eastern and northern conveyance channels, an applied roughness co-efficent of 0.050 was chosen, reflecting the relatively sluggish and somewhat densely vegetated nature of the channels. An applied flood plain roughness co-efficent of 0.040 was utilised reflecting the relatively dense vegetative nature of these lands.

3.7.4 Initial Hydraulic Model Development

A total channel length of approximately 273.19m and 124.02m along the eastern and northern conveyance channels was modelled as illustrated in *Figure 7* above. The cross-sections surveyed were incorporated into the model together with various culverts as shown in *Figures 7* above.

3.8 Digital Terrain Model Construction

In order to assist in the hydraulic assessment and analysis and to enable an accurate representation of flood zone delineation mapping to be developed, a detailed Digital Terrain Model (DTM) was developed for the modelled area of the eastern and northern conveyance channels. The DTM was developed utilising the LiDAR height data for the area acquired from Ordnance Survey Ireland and topographical survey data for the area provided to IE Consulting. Development of a DTM allows the flood level predictions from the modelling software to be analysed in more detail at the specific location of the modelled conveyance channels. The contour mapping and DTM developed for the area is illustrated in *Figure 9*, *Figure 10* and *Figure 11* below.

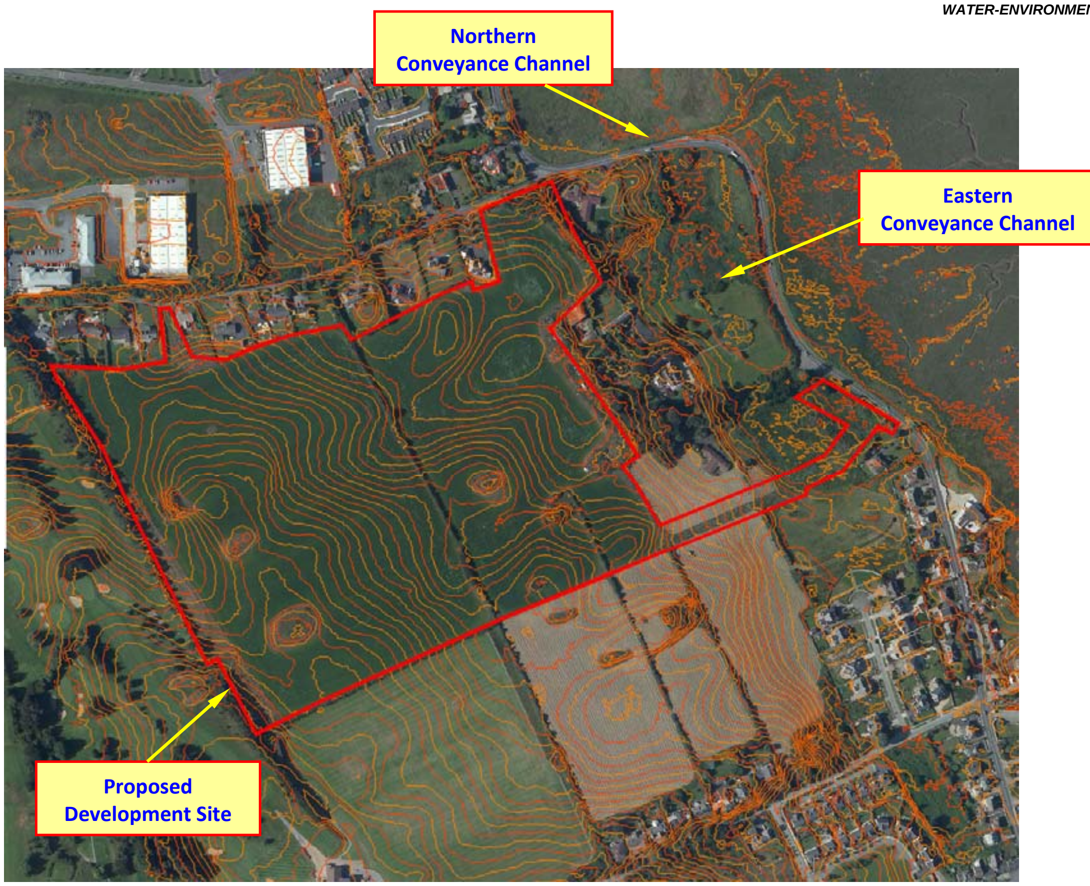
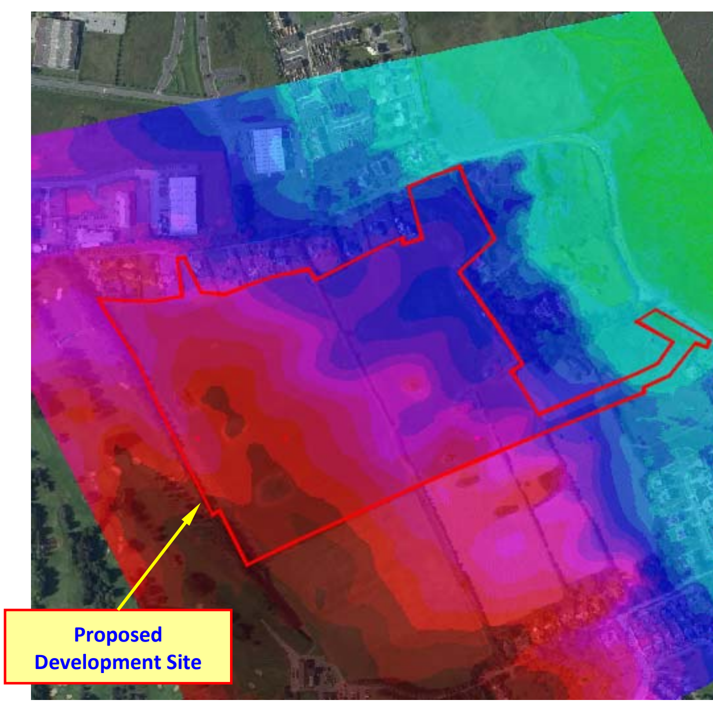


Figure 9 –LiDAR Derived Contour Mapping



Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	0.86	1.91	
2	1.91	2.55	
3	2.55	3.10	
4	3.10	4.03	
5	4.03	4.64	
6	4.64	5.55	
7	5.55	7.05	
8	7.05	9.13	
9	9.13	10.64	
10	10.64	12.38	
11	12.38	13.37	
12	13.37	14.57	
13	14.57	15.61	
14	15.61	16.88	
15	16.88	18.78	
16	18.78	20.39	
17	20.39	21.58	
18	21.58	23.23	
19	23.23	24.90	
20	24.90	28.29	

Figure 10 – LiDAR Derived DTM

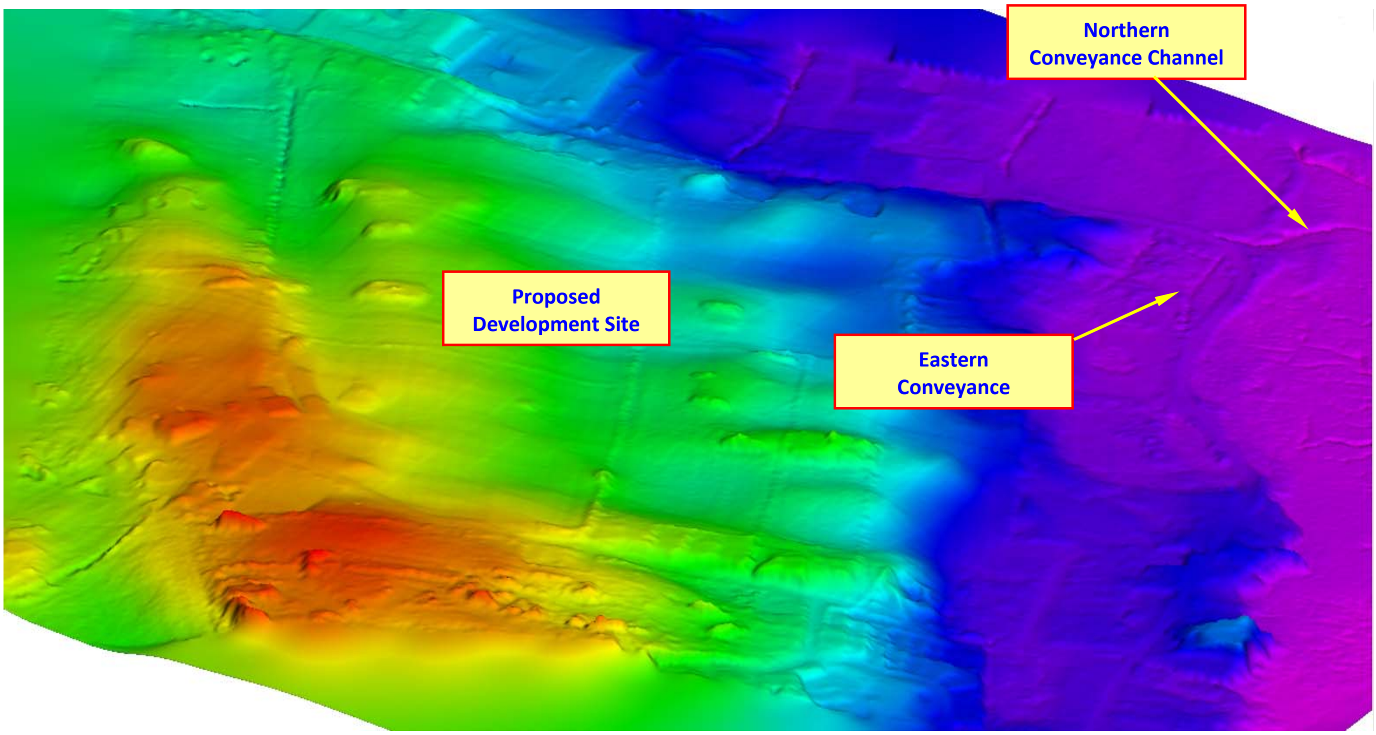


Figure 11 – LiDAR Derived DTM (Exaggerated Vertical Scale)

3.9 Hydraulic Model Simulation Results

The predicted 1% AEP (1 in 100 year) return period volumes of 0.539m³/s and 0.1734m³/s were utilised as the critical flow parameter in the HEC-RAS hydraulic model for the eastern and northern conveyance channels respectively. For the purposes of flood zone delineation peak flows of 0.712m³/s and 0.230m³/s were utilised for the 0.1% AEP (1 in 1000 year) return period volumes for the eastern and northern conveyance channels respectively.

The model simulation is represented by a longitudinal profile through the modeled reach. *Figure 12* below illustrates the longitudinal profiles of the predicted 1% AEP and 0.1% AEP flood levels along the modeled reach of the eastern and northern conveyance channels.

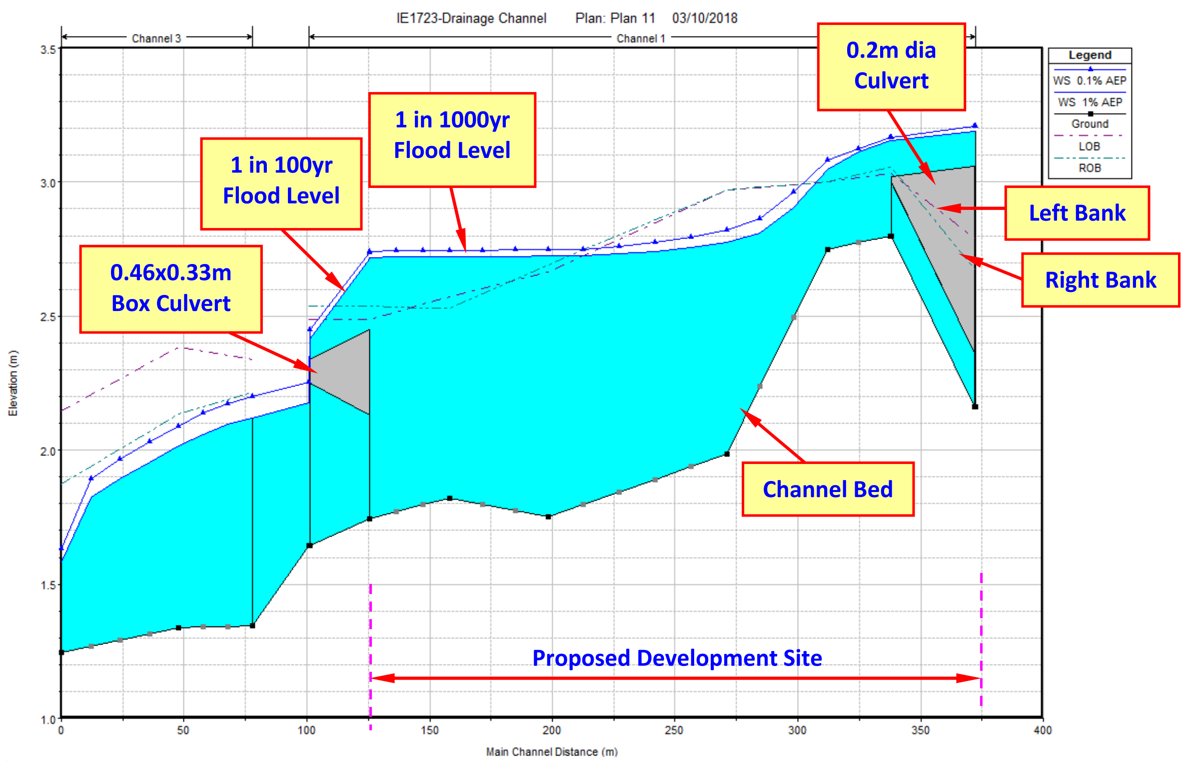


Figure 12 – Modelled Conveyance Channel Profile

Table 4 below summarises the predicted 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) flood levels at cross-sectional locations along the modelled reach of the conveyance channels.

Cross Section Location (Upstream to Downstream)	Predicted Flood Levels (m Malin)	
	1 in 100 Year (1% AEP)	1 in 1000 Year (0.1% AEP)
1	3.19	3.21
2	3.15	3.17
3	3.05	3.08
4	2.78	2.82
5	2.72	2.75
9	2.72	2.75
7	2.72	2.74
8	2.12	2.2
9	2.01	2.09
10	1.58	1.63
11	2.26	2.31
12	2.15	2.18

Table 4 –Predicted Current Scenario 1% AEP & 0.1% AEP Flood Levels

The hydraulic model indicates that some out of bank flooding may occur at certain locations along the channel length during the 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood events in consideration of the current scenario.

Drawing Number IE1723-002-A, Appendix A, illustrates the delineated flood zones along the modeled reach of the conveyance channels in consideration of the current scenario.

3.10 Proposed Scenario Hydraulic Model Simulation Results

It is proposed to discharge attenuated surface water runoff from the proposed development site at a maximum discharge rate of 0.106m^3/s to the northern drainage conveyance channel and discharge attenuated surface water runoff from the proposed access road at a maximum discharge rate of 0.0021m^3/s to existing wetland area located adjacent to and on the western side of the Blackrock Road. Outflow from this wetland area is conveyed through the existing eastern conveyance channel and a secondary wetland area adjacent to the Blackrock Road in a south to north direction after which the channel is culverted under Blackrock Road where discharge is then to Dundalk Bay estuary via the northern conveyance channel.

The hydraulic simulation model was therefore re-run in consideration of the $0.106m^3/s$ and $0.0021m^3/s$ attenuated surface water runoff from the proposed development site and access road as an additional maximum input to the 1% AEP and 0.1% AEP flow volumes in the northern and eastern conveyance channels – i.e. the Proposed Scenario.

Table 5 below summarises the predicted 1% AEP and 0.1% AEP flood levels at cross-sectional locations along the modelled reach of the drainage channels for the existing and proposed scenarios.

Cross Section Location (Upstream to Downstream)	Predicted Water Levels (m Malin)				Change in Level (m)	Change in Level (m)
	Existing Scenario		Proposed Scenario			
	1 in 100 Year (1% AEP)	1 in 1000 Year (0.1% AEP)	1 in 100 Year (1% AEP)	1 in 1000 Year (0.1% AEP)	1 in 100 Year (1% AEP)	1 in 1000 Year (0.1% AEP)
1 (Eastern Channels)	3.19	3.21	3.19	3.21	0.00	0.00
2 (Eastern Channels)	3.15	3.17	3.15	3.17	0.00	0.00
3 (Eastern Channels)	3.05	3.08	3.05	3.08	0.00	0.00
4 (Eastern Channels)	2.78	2.82	2.78	2.82	0.00	0.00
5 (Eastern Channels)	2.72	2.75	2.72	2.75	0.00	0.00
6 (Eastern Channels)	2.72	2.75	2.72	2.75	0.00	0.00
7 (Eastern Channels)	2.72	2.74	2.72	2.74	0.00	0.00
8 (Northern Channel)	2.12	2.2	2.16	2.23	0.04	0.03
9 (Northern Channel)	2.01	2.09	2.05	2.12	0.04	0.03
10 (Northern Channel)	1.58	1.63	1.61	1.66	0.03	0.03
11 (Eastern Channel)	2.26	2.31	2.26	2.31	0.00	0.00
12 (Northern Channel)	2.15	2.18	2.15	2.20	0.00	0.02

Table 5 –Predicted Existing & Proposed Scenario 1% AEP & 0.1% AEP Flood Levels

As listed in *Table 5* above, the hydraulic simulation model in consideration of the proposed scenario indicates that the input of attenuated surface water discharges from the proposed development site to the northern drainage channel at a maximum discharge rate of $0.106m^3/s$ has the potential to increase 1% AEP and 0.1% AEP flood levels to between 0.03m (30mm) and 0.04m (40mm) between cross-sectional locations 8-8 to 10-10 and 0.02m (20mm) at cross-sectional locations 12-12.

The input of attenuated surface water discharge from the proposed new access road to the eastern drainage channels at a maximum discharge rate of 0.0021m^3/s is not predicted to result in any measurable increase in current scenario fluvial flood levels within these drainage channel or the existing wetland areas.

In the context of the occurrence of a 1% AEP (1 in 100 year) or a 0.1% AEP (1 in 1000 year) fluvial flood event these small predictive increases in flood levels in the northern drainage conveyance channel are imperceptible and immeasurable and would not result in an adverse impact to the existing hydrological regime or result in an increased flood risk to adjacent lands or properties or result in an adverse impact to the existing hydrological regime of the area.

It is also noted that this analysis assumes an absolute worst-case scenario where the maximum discharge rate (0.106m^3/s) of attenuated stormwater from the proposed development site would discharge to the northern conveyance channel in conjunction with the occurrence of a 1% AEP or a 0.1% AEP fluvial flood event. The probability of both of these events occurring in conjunction with each other is extremely low.

It is also noted that the maximum discharge rate of 0.106m^3/s of attenuated stormwaters from the proposed development site includes a climate change factor allowance, and therefore in reality the actual maximum discharge rate will be less than 0.106m^3/s.

Drawing Number IE1723-003-B, Appendix A, illustrates the delineated flood zones along the modeled reach of the conveyance channels in consideration of the proposed scenario.

Drawing Number IE1723-004-B, Appendix A, illustrates a comparison of the existing scenario and proposed scenario 1% AEP (1 in 100 year) flood extents along the modeled reach of the conveyance channels.

Drawing Number IE1723-005-B, Appendix A, illustrates a comparison of the existing scenario and proposed scenario 0.1% AEP (1 in 1000 year) flood extents along the modeled reach of the conveyance channels.

As illustrated on *Drawings Number IE1723-004-B and IE1723-005-B*, in the context of the occurrence of a 1% AEP (1 in 100 year) or a 0.1% AEP (1 in 1000 year) the proposal to discharge attenuated surface water discharge from the proposed development site at a maximum discharge rate of 0.106m^3/s and from the proposed access road at a maximum discharge rate of 0.0021m^3/s is not predicted to result in an adverse impact to the existing hydrological regime of the area or result in an increased flood risk to adjacent properties.

4 Hydrological Impact of Proposed Access Road

As illustrated on the drawings and details produced by Finn Design Partnership the proposed development site shall be served by a new 6m wide access road, incorporating a 1.5m wide grass verge, 2m wide cycle track and a 2m wide footpath. The access road shall tie into the existing R172 Public Road at the location illustrated on Finn Design Partnership Drawing Number 100.

An assessment and analysis has therefore been undertake in order determine the impact that the proposed access road may or may not have on the existing hydrological and flooding regime of the area.

4.1 Initial Screening Assessment

The purpose of the screening assessment is to establish the level of flooding risk that may or may not exist for a particular site and to collate and assess existing current or historical information and data which may indicate the level or extent of any flood risk. An initial screening assessment has therefore been undertaken in order to determine the potential fluvial, pluvial, tidal /coastal and groundwater flooding mechanism pertaining to the location of the proposed access road.

The following information and data was collated as part of the flood risk screening assessment for the site of the proposed access road:-

OPW PFRA Flood Mapping

Preliminary Flood Risk Assessment (PFRA) Mapping for Ireland was produced by the OPW in 2011. OPW PFRA flood map number 2019/MAP/134/A illustrates indicative flood zones within this area of Co. Louth.

Figure 13 below illustrates an extract from the above indicative flood map in the vicinity of the proposed development site.

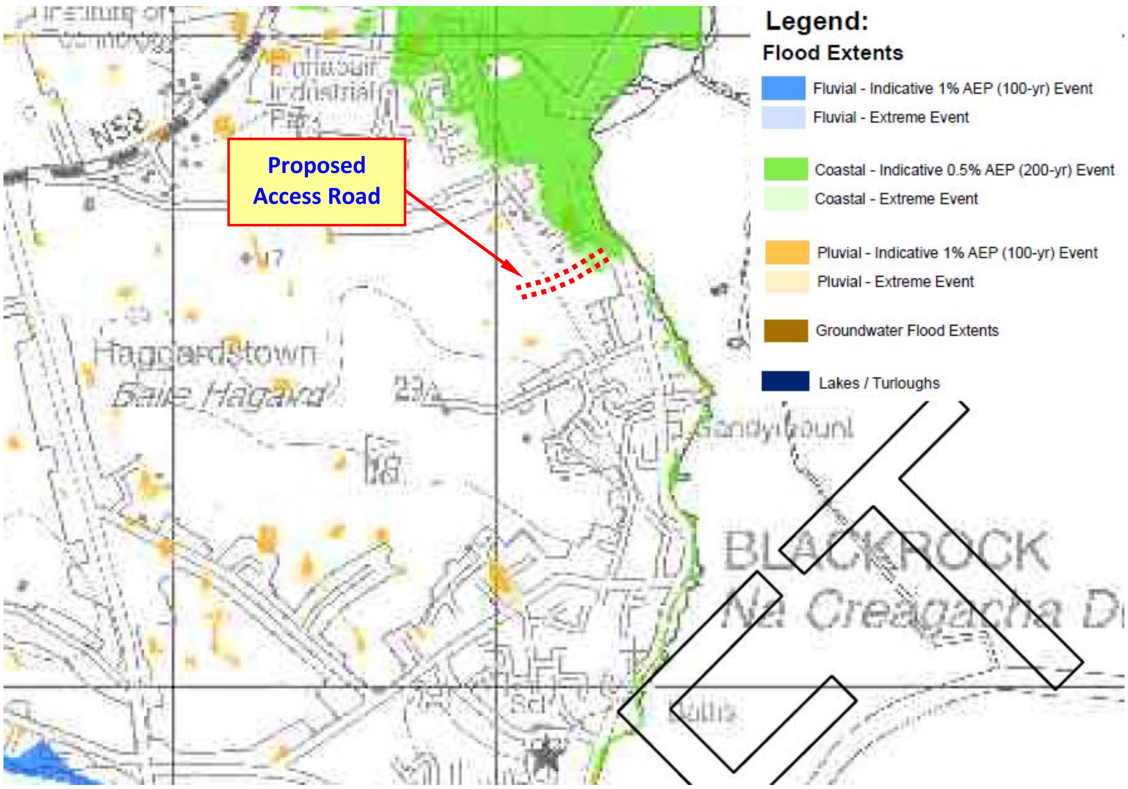


Figure 13 – OPW PFRA Indicative Flood Mapping

Figure 13 above indicates that part of the proposed access road falls within an indicative coastal flood zone. No fluvial, pluvial or groundwater flood zones are mapped within or immediately adjacent to the boundary of the proposed access road.

Figure 14 below illustrates the PFRA indicative flood zones from *Figure 13* overlaid onto higher resolution background mapping.

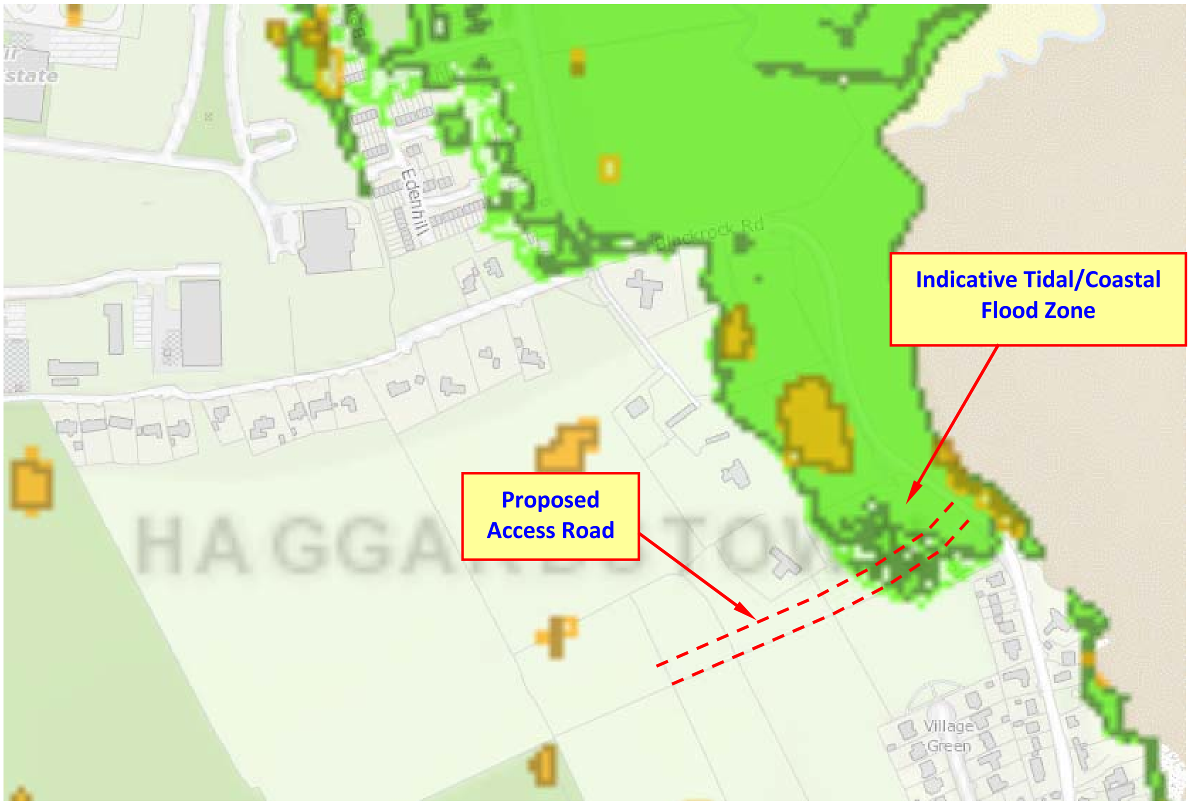
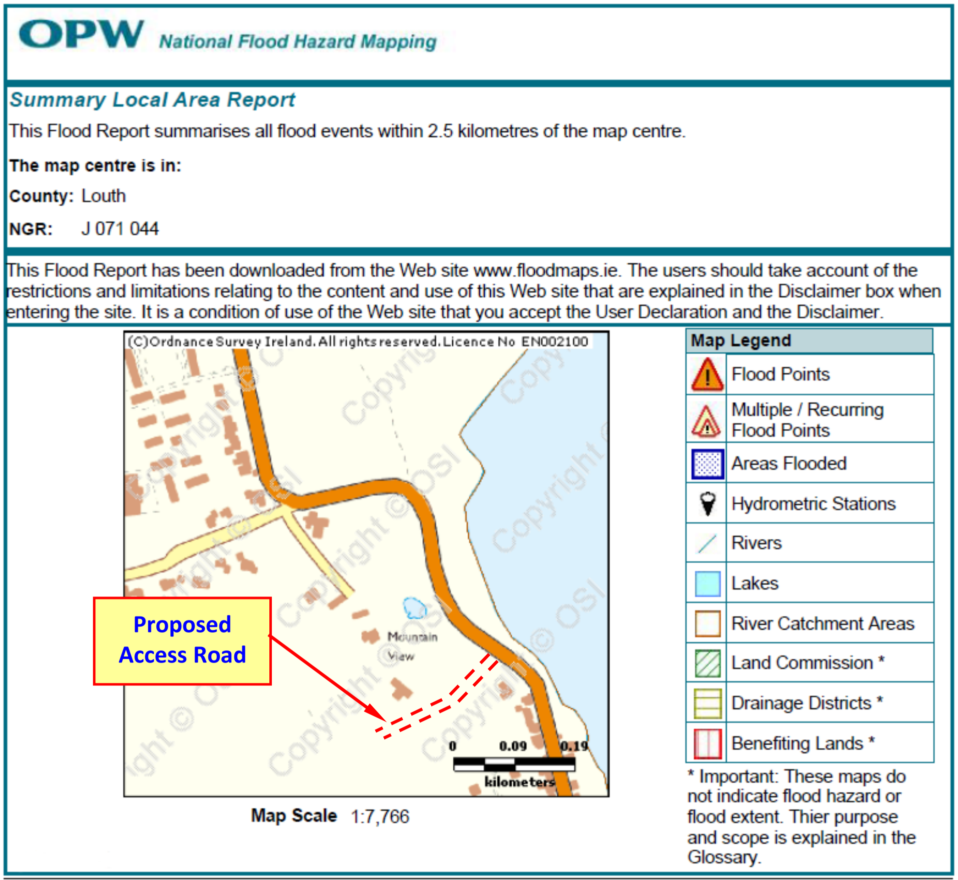


Figure 14 – OPW PFRA Indicative Flood Mapping

It should be noted that the indicated extent of flooding illustrated on these maps was developed using a low resolution digital terrain model (DTM) and illustrated flood extents are intended to be indicative only. The flood extents mapped on the PFRA maps are not intended to be used on a site specific basis.

OPW Flood Maps Website

The OPW Flood Maps Website (www.floodmaps.ie) was consulted in relation to available historical or anecdotal information on any flooding incidences or occurrences in the vicinity of the proposed access road. *Figure 15* below illustrates mapping from the Flood Maps website in the vicinity of the access road site.



OPW National Flood Hazard Mapping

Summary Local Area Report

This Flood Report summarises all flood events within 2.5 kilometres of the map centre.

The map centre is in:

County: Louth

NGR: J 071 044

This Flood Report has been downloaded from the Web site www.floodmaps.ie. The users should take account of the restrictions and limitations relating to the content and use of this Web site that are explained in the Disclaimer box when entering the site. It is a condition of use of the Web site that you accept the User Declaration and the Disclaimer.

Map Scale 1:7,766

Map Legend
Flood Points
Multiple / Recurring Flood Points
Areas Flooded
Hydrometric Stations
Rivers
Lakes
River Catchment Areas
Land Commission *
Drainage Districts *
Benefiting Lands *

* Important: These maps do not indicate flood hazard or flood extent. Thier purpose and scope is explained in the Glossary.

Figure 15 – OPW Flood Maps

Figure 15 above does not indicate and historical or anecdotal instances of flooding at the location of the proposed access road.

North-Western Neagh Bann CFRAM Study

The North-Western Neagh Bann Catchment Flood Risk & Management Study (CFRAMS) has been undertaken by the OPW and the Final version of the flood maps were issued in August 2016. Fluvial and tidal/coastal flood risk extent and depth maps for further assessment areas within the general Blackrock have also been produced. OPW CFRAMS predictive flood map numbers *N06BRK_EXFCD_F0_02* and *N06BRK_EXCCD_F0_02* illustrate predictive extreme fluvial and tidal/coastal flood extent zones in the general vicinity of the proposed access road site.

Figure 16 below (extracted from CFRAMS flood map *N06BRK_EXFCD_F0_02*), illustrates the predicted extreme 10% AEP (1 in 10 year), 1% AEP (1 in 100 year) or 0.1% AEP (1 in 1000 year) fluvial flood extents in the vicinity of the proposed access road site

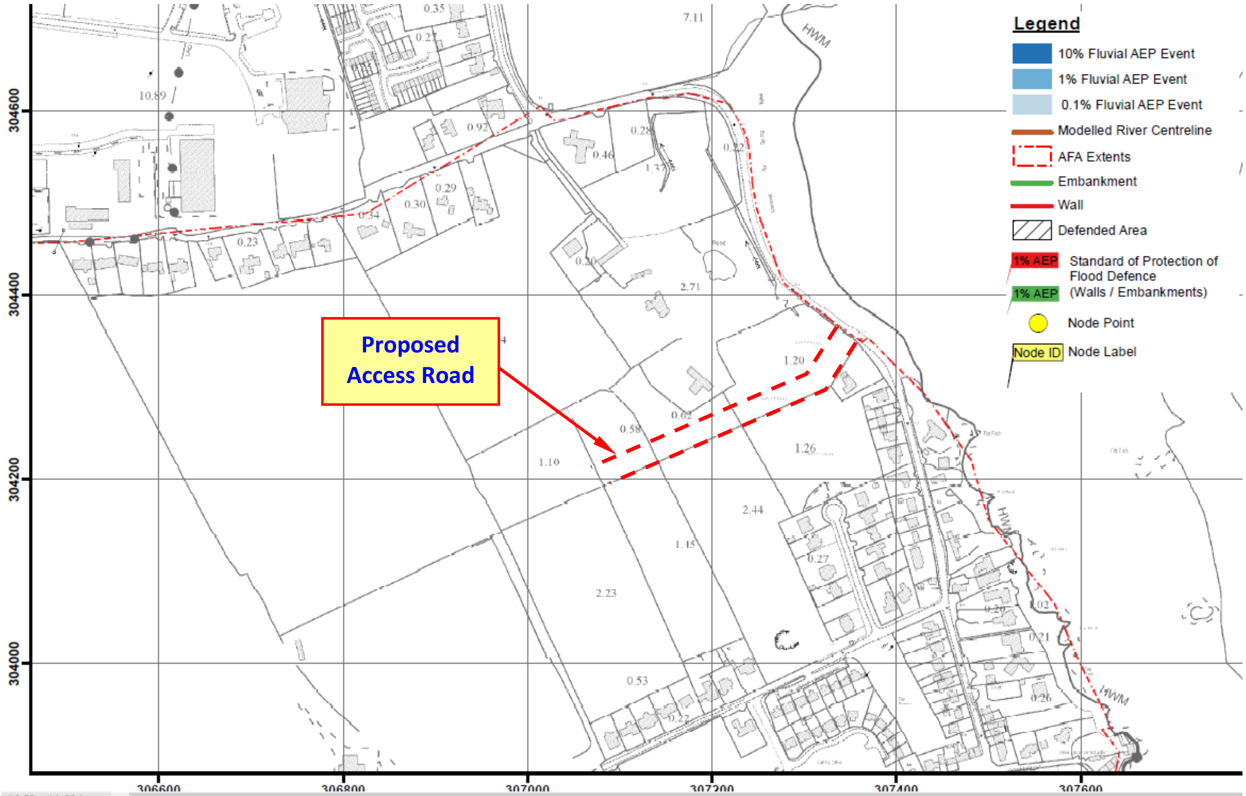
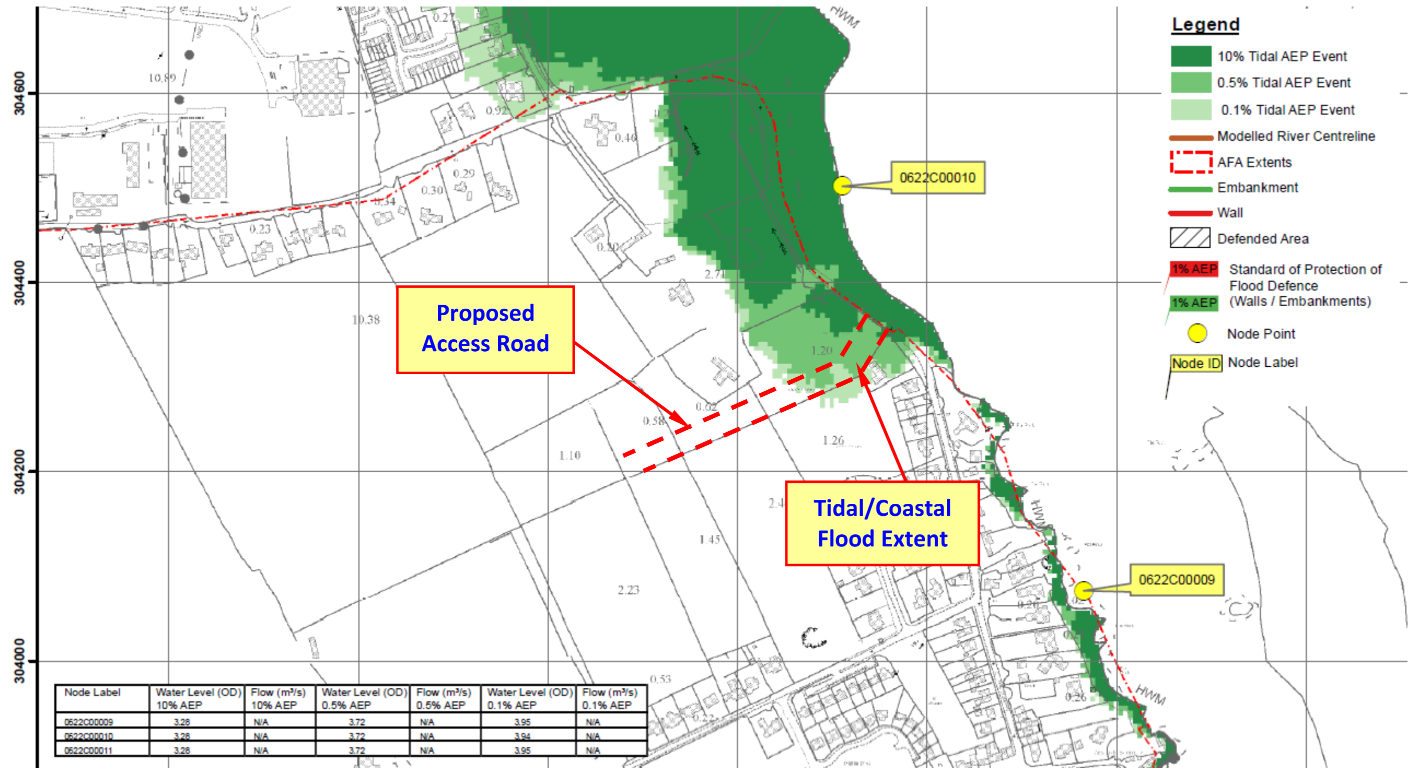


Figure 16 – OPW CFRAMS Fluvial Flood Extent Maps

Figure 16 above indicates that the proposed access road does not fall with any 10% AEP (1 in 10 year), 1% AEP (1 in 100 year) or 0.1% AEP (1 in 1000 year) predictive fluvial flood zone.

A full copy of the above OPW predictive CFRAMS flood map is contained in *Appendix C.*

Figure 17 below (extracted from CFRAMS flood map *N06BRK_EXCCD_F0_02*), illustrates the predicted extreme 10% AEP (1 in 10 year), 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) tidal/coastal flood extents in the vicinity of the proposed access road.



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
0622C00009	3.28	N/A	3.72	N/A	3.95	N/A
0622C00010	3.28	N/A	3.72	N/A	3.94	N/A
0622C00011	3.28	N/A	3.72	N/A	3.95	N/A

Figure 17 – OPW CFRAMS Fluvial Flood Extent Maps

Figure 17 above indicates that the part of the proposed access road falls with a 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) or 0.1% AEP (1 in 1000 year) predictive tidal/coastal flood zone.

A full copy of the above OPW predictive CFRAMS flood map is contained in *Appendix C.*

The OPW CFRAMS tidal/coastal flood map also provides information and data in relation to predicted flood water levels for 10% AEP, 0.5% AEP and 0.1% AEP tidal/coastal flood events at node points with Dundalk Bay estuary. As illustrated in *Figure 17* above, the node point closest to the site of the proposed access road is referenced as node point *0622C0010*, which is located approximately 165m north of the access road site. Details of the predicted current scenario tidal/coastal flood levels for this node point are illustrated in *Table 6* below, which has been extracted from OPW CFRAMS flood map reference *N06BRK_EXCCD_F0_02*.

Node Label	Flood Level (m OD)	Flood Level (m OD)	Flood Level (m OD)
	10% AEP	0.5% AEP	0.1% AEP
N06BRK_EXCCD_F0_02	3.28	3.72	3.94

Table 6 – CFRAMS Predicted Tidal/Coastal Flood Levels

4.2 Site Specific Current & Mid-Range Future Scenario Flood Zone Delineation

Utilising a LiDAR derived digital terrain model, the flood level information listed in *Table 6* above, and a specialist software package employed by IE Consulting, a site specific delineation of the 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) current and mid-range future scenario flood zones were delineated. The software enables a user defined flood level to the thematically mapped and delineated over a generated digital terrain model.

In addition to the current scenario tidal/coastal flood levels listed in *Table 6* above, the 'Planning system & Risk Management Guidelines' recommends that potential flood impact be assessed in consideration of a mid-range future climate change scenario. The OPW Irish Coastal Protection Strategy Study (ICPSS) recommends that an allowance of 0.5m be added to predictive current scenario tidal/coastal flood levels in order to account for a mid-range future climate change scenario. Therefore the mid-range future climate change scenario 0.5% AEP and 0.1% AEP tidal/coastal flood levels applicable to the location of the proposed access road site are 3.72m+0.5m = **4.22m OD** and 3.94m+0.5m = **4.44m OD** respectively.

Drawing Number IE1723-006-A, Appendix A, illustrates the site specific delineation of the current scenario 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) tidal/coastal flood extents at the location of the proposed access road.

Drawing Number IE1723-007-A, Appendix A, illustrates the site specific delineation of the mid-range future climate change scenario 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) tidal/coastal flood extents at the location of the proposed access road.

As illustrated on the above drawings a small area of the proposed access road may be impacted due to a current scenario and mid-range future climate change scenario 0.5% AEP and 0.1% AEP tidal/coastal flood event.

4.3 Flood Depth & Volume Analysis

An analysis was undertaken to assess the depths and volumes of tidal/coastal flood waters that may potentially inundate the small area of the proposed access road during the occurrence of a 0.1% AEP (1 in 1000 year) mid-range future climate change scenario tidal/coastal flood event.

Using the hydrology module of an appropriate software package further analysis was therefore undertaken to determine the range of 0.1% AEP flood water depths and volumes that may possibility inundate this small area of the proposed access road and to determine the potential volume of tidal/coastal flood water that may be offset due to construction of the road.

Drawing Number IE1723-008-A, Appendix A, illustrates the calculated depth of mid-range future climate change scenario0.1% AEP flood waters that may occur within the boundary of the proposed access road site in consideration of the existing undeveloped scenario and in consideration of the proposed developed and constructed scenario.

The possible depth of tidal/coastal flood waters is illustrated on the drawing via a graphical representation of flood depths within the boundary of the proposed access road site and via a table of predicted flood water depths. The tidal/coastal flood water depth table presents flood water depths over 20 separate elevation ranges within the boundary of the proposed access road site for the existing undeveloped scenario and the proposed developed scenario.

The potential maximum and mean 0.1% AEP flood depths and flood volumes predicted to occur with the boundary of the proposed access road site are summarised in *Table 9* below.

	Existing Undeveloped Scenario 0.1% AEP + CC Flood	Proposed Developed Scenario 0.1% AEP + CC Flood
Maximum Flood Depth (m)	**2.03**	**1.56**
Mean Flood Depth (m)	**1.04**	**0.65**
Total Flood Water Volume (m^3)	**3785**	**1967**

Table 9 – Pre and Post Development Site Flood Depth and Inundation Volumes

As listed in *Table 9* above, in consideration of the occurrence of a mid-range future climate change scenario 0.1% AEP (1 in 1000 year) tidal/coastal flood event, development of the proposed access road has the potential to result in the displacement of approximately 1818m^3 (3785-1967) of tidal/coastal flood waters.

4.4 Impact of the Proposed Access Road

As presented above, the site of the proposed access road does not fall within an indicative or predictive fluvial, pluvial or groundwater flood zone, therefore development of the road as proposed will not result in any adverse impact to the existing fluvial, pluvial or groundwater flooding regime of the area.

A small area of the proposed access road falls with a delineated current scenario and mid-range future climate change scenario 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) tidal/coastal flood zone. The assessment and analysis presented above indicates that the proposed access road has the potential to displace approximately 1818m^3 of 0.1% AEP mid-range future climate change scenario tidal / coastal flood waters.

This volume of potentially displaced tidal / coastal food waters is imperceptible in consideration of the occurrence of a 0.1% AEP mid-range future climate change scenario tidal / coastal flood event in Dundalk Bay estuary and the wholly massive volume of flood waters associated with this tidal/coastal flood event.

It is generally acknowledged by the OPW that infilling and other development works within any coastal flood plain area shall have a negligible effect on the extent of the coastal flood plain now, or in the future, taking account of anticipated climate change. Accordingly, such development within any coastal flood plain will not result in additional flood risk elsewhere within the coastal flood plain.

In summary, development of the access road as proposed is not predicted to result in any adverse impact to the existing hydrological regime of the area or to result in an increased flood risk elsewhere and is considered to be appropriate from a hydrological and flood risk perspective.

5 Summary Conclusions

In consideration of the findings of this hydraulic assessment and analysis the following conclusions are made:-

- *A hydrological analysis has been undertaken in order to predict estimated 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood volumes in the eastern and northern conveyance channels.*
- *A detailed hydraulic model has been developed for the eastern and northern drainage channels over reach lengths of approximately 273.19m and 124.02m respectively.*
- *In consideration of the proposed developed scenario, the hydraulic simulation model indicates that the input of attenuated surface water discharges from the proposed development site to the northern drainage channel at a maximum discharge rate of 0.106m^3/s has the potential to increase 1% AEP and 0.1% AEP flood levels to between 0.03m (30mm) and 0.04m (40mm) between cross-sectional locations 8-8 to 10-10 and 0.02m (20mm) at cross-sectional locations 12-12.*
- *In the context of the occurrence of a 1% AEP (1 in 100 year) or a 0.1% AEP (1 in 1000 year) fluvial flood event these small predictive increases in flood levels in the northern drainage conveyance channel are imperceptible and immeasurable and would not result in an adverse impact to the existing hydrological regime or result in an increased flood risk to adjacent lands or properties or result in an adverse impact to the existing hydrological regime of the area.*
- *The hydraulic simulation model indicates that the input of attenuated surface water discharge from the proposed new access road to the eastern drainage channels and at a maximum discharge rate of 0.0021m^3/s is not predicted to result in any measurable increase in current scenario fluvial flood levels within these drainage channel or the existing wetland areas.*
- *Development of the access road as proposed is not predicted to result in any adverse impact to the existing hydrological regime of the area or to result in an increased flood risk elsewhere and is considered to be appropriate from a hydrological and flood risk perspective.*

APPENDIX A

Drawing Number IE1723-001-A

Drawing Number IE1723-002-B

Drawing Number IE1723-003-B

Drawing Number IE1723-004-B

Drawing Number IE1723-005-B

Drawing Number IE1723-006-A

Drawing Number IE1723-007-A

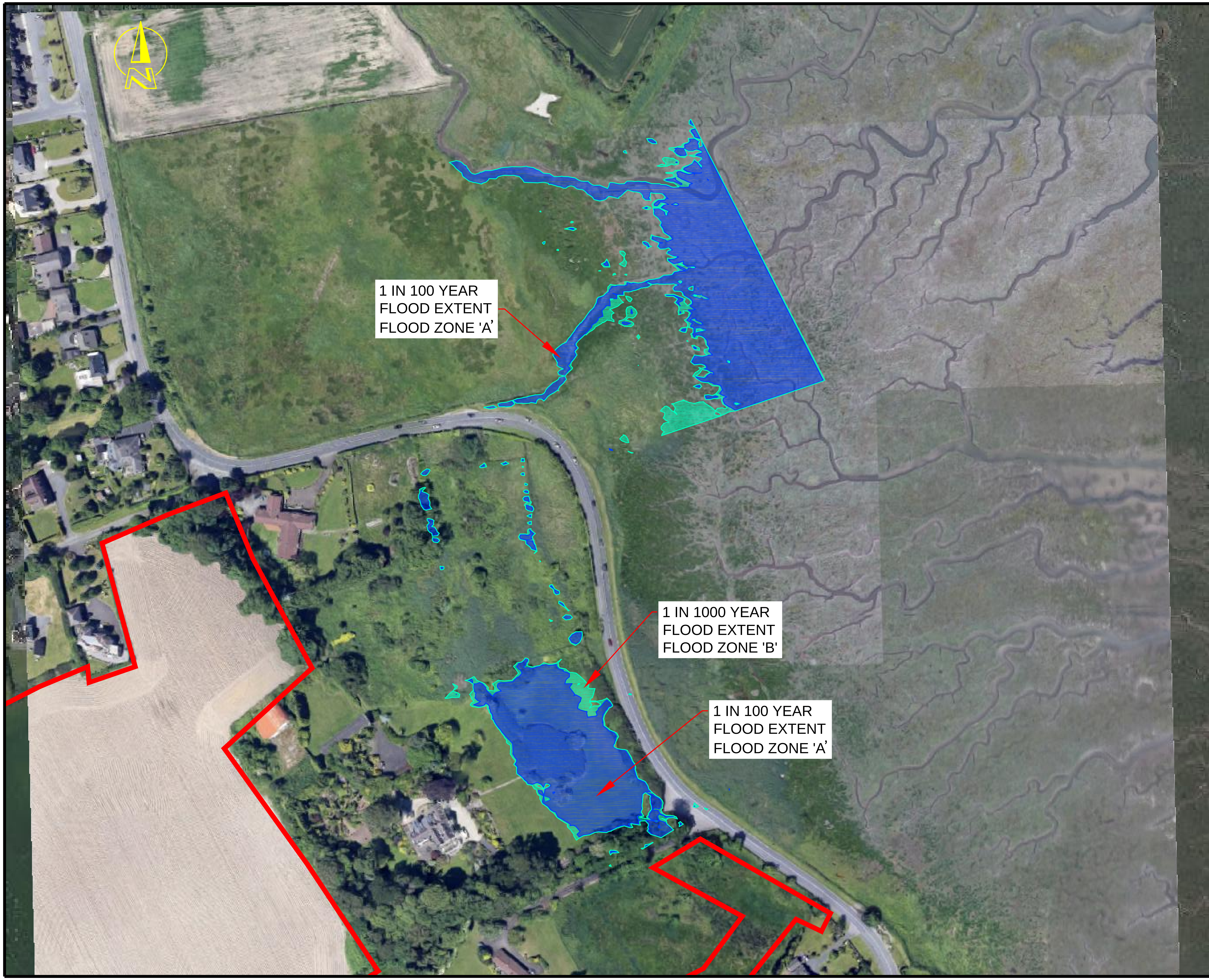
Drawing Number IE1723-008-A

Project Title:	Proposed Development Hydraulic Assessment
Project Address:	Haggardstown, Blackrock, Co. Louth
Client:	Kingsbridge Consultancy Ltd
Drg. Title:	Site Location Map

Dwg.Scale:	Date:	Dwg.No:	Job No:	Revision:	Dwg.By:
1:50,000	03/10/18	IE1723-001	IE1723	A	LM

IE Consulting
Innovation Centre,
Green Rd.,
Carlow.
Ph: 059-9133084
Fax: 059-9140499
E-mail: info@iece.ie

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL



LEGEND

- SITE BOUNDARY
- 100 YEAR FLOOD EXTENT (1% AEP) FLOOD ZONE 'A'
- 1000 YEAR FLOOD EXTENT (0.1% AEP) FLOOD ZONE 'B'
- FLOOD ZONE 'C'

rev.	date	amendment	drn	ckd
A	03.10.18	PLANNING	LMc	PMS

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PROPOSED DEVELOPMENT AT
HAGGARDSTOWN, BLACKROCK, CO.LOUTH

HYDRAULIC MODELING
ASSESSMENT & ANALYSIS

EXISTING SCENARIO 1 IN 100 YEAR (1% AEP)
& 1 IN 1000 YEAR (0.1% AEP)
FLUVIAL FLOOD EXTENTS

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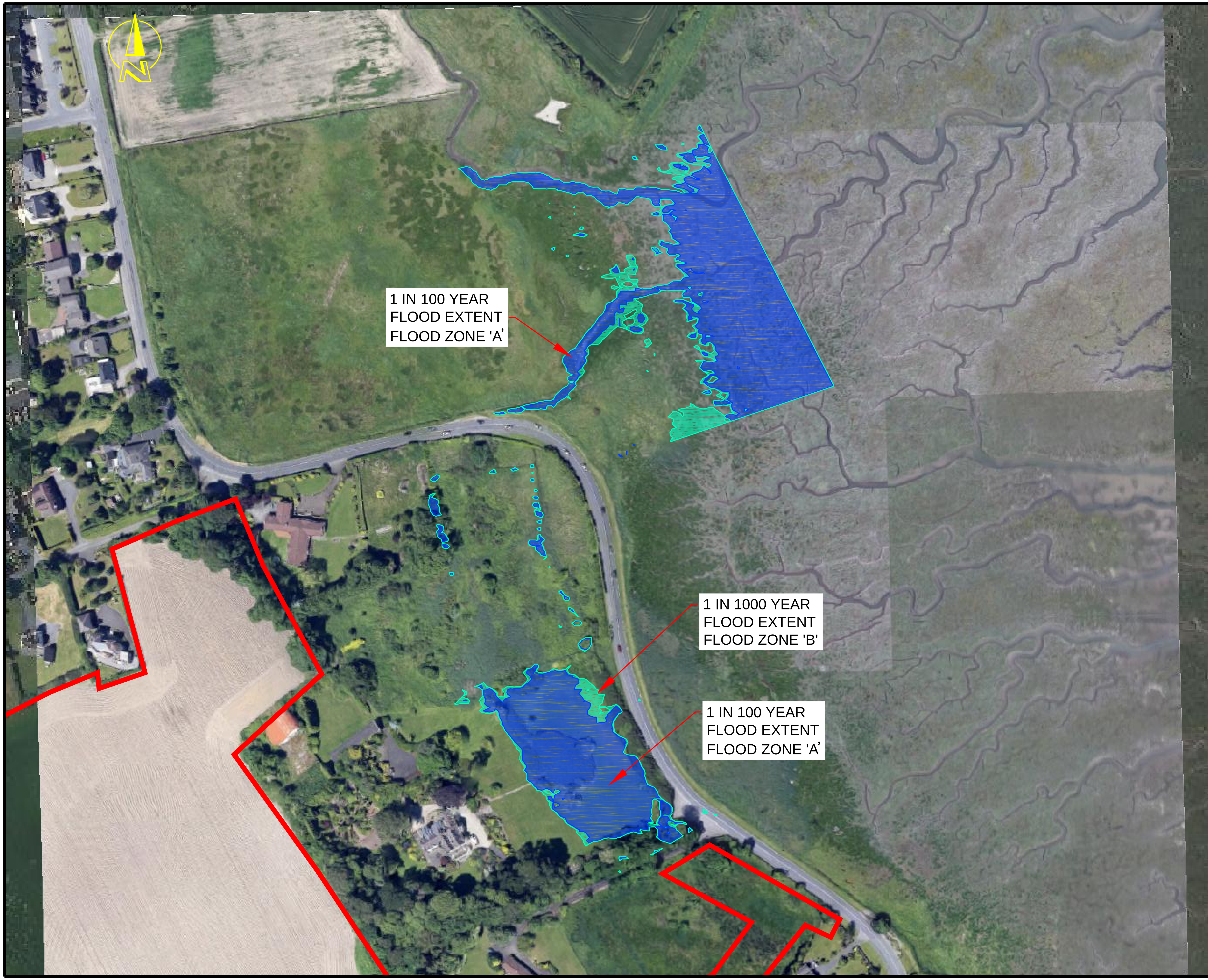

LEGEND

- SITE BOUNDARY
- 100 YEAR FLOOD EXTENT (1% AEP) FLOOD ZONE 'A'
- 1000 YEAR FLOOD EXTENT (0.1% AEP) FLOOD ZONE 'B'
- FLOOD ZONE 'C'

rev.	date	amendment	drn	ckd
B	09.08.19	PLANNING	LMc	PMS
A	03.10.18	PLANNING	LMc	PMS

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(1% AEP) & 1 IN 1000 YEAR (0.1% AEP)
FLUVIAL FLOOD EXTENTS

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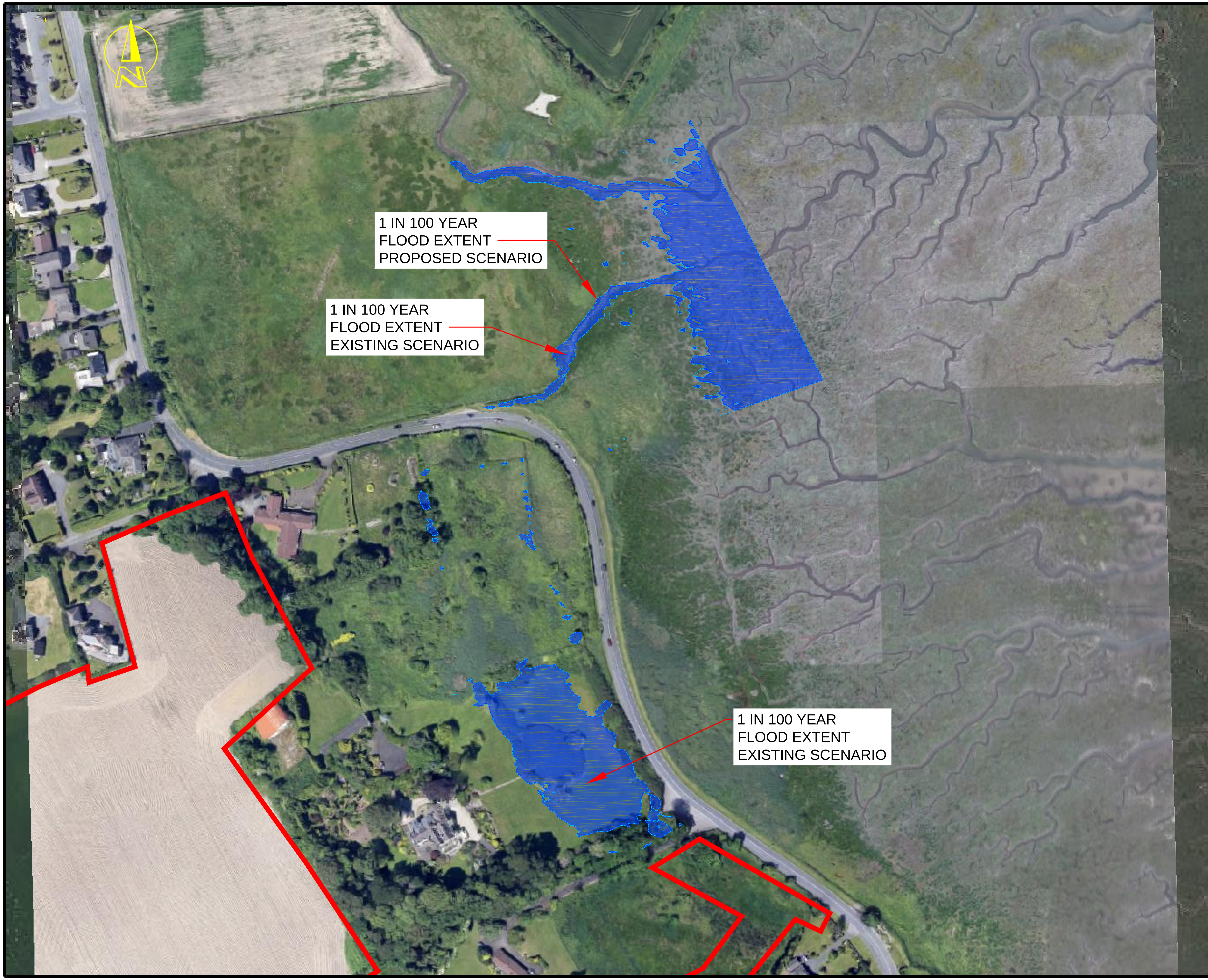

LEGEND

- SITE BOUNDARY
- 100 YEAR FLOOD EXTENT (1% AEP) EXISTING SCENARIO
- 100 YEAR FLOOD EXTENT (1% AEP) PROPOSED SCENARIO

rev.	date	amendment	drn	ckd
B	09.05.19	PLANNING	LMc	PMS
A	03.10.18	PLANNING	LMc	PMS

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HYDRAULIC MODELING
ASSESSMENT & ANALYSIS

EXISTING & PROPOSED SCENARIO
1 IN 100 YEAR (1% AEP)
FLUVIAL FLOOD EXTENT COMPARISON

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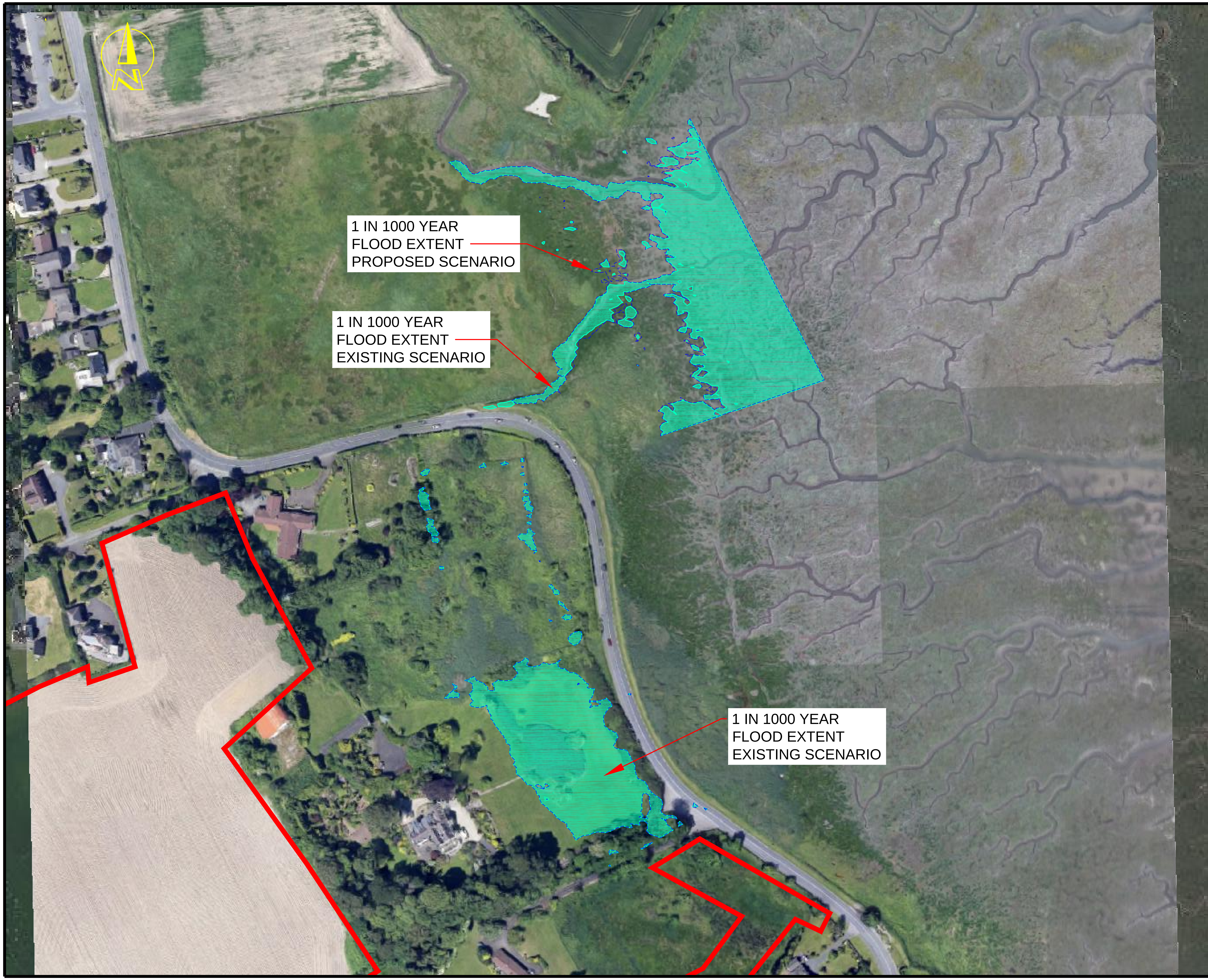

LEGEND

SITE BOUNDARY

1000 YEAR FLOOD EXTENT (0.1% AEP) EXISTING SCENARIO

1000 YEAR FLOOD EXTENT (0.1% AEP) PROPOSED SCENARIO

rev.	date	amendment	drn	ckd
B	09.05.19	PLANNING	LMc	PMS
A	03.10.18	PLANNING	LMc	PMS

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ASSESSMENT & ANALYSIS

EXISTING & PROPOSED SCENARIO
1 IN 1000 YEAR (0.1% AEP)
FLUVIAL FLOOD EXTENTS

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drawing no. IE1723-005	rev B	checked: NOM	
		approved: PMS	
		date: 02.10.2018	

LEGEND

- SITE BOUNDARY
- CURRENT SCENARIO 200 YEAR COASTAL FLOOD EXTENT (0.5% AEP)
- CURRENT SCENARIO 1000 YEAR COASTAL FLOOD EXTENT (0.1% AEP)

rev.	date	amendment	drn	ckd
A	30.04.19	PLANNING	LMc	PMS

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PROPOSED DEVELOPMENT AT
HAGGARDSTOWN, BLACKROCK, CO.LOUTH

HYDROLOGICAL IMPACT ASSESSMENT
OF PROPOSED ACCESS ROAD

CURRENT SCENARIO
1 IN 200 YEAR (0.5% AEP) & 1 IN 1000 YEAR
(0.1% AEP) COASTAL FLOOD EXTENTS

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drawing no. IE1723-006	rev A	checked:	NOM
		approved:	PMS
		date:	30.04.2019

LEGEND

- SITE BOUNDARY
- MID RANGE SCENARIO 200 YEAR COASTAL FLOOD EXTENT (0.5% AEP)
- MID RANGE SCENARIO 1000 YEAR COASTAL FLOOD EXTENT (0.1% AEP)

rev.	date	amendment	drn	ckd
A	30.04.19	PLANNING	LMc	PMS

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HYDROLOGICAL IMPACT ASSESSMENT
OF PROPOSED ACCESS ROAD

MID RANGE FUTURE SCENARIO
1 IN 200 YEAR (0.5% AEP) & 1 IN 1000 YEAR
(0.1% AEP) COASTAL FLOOD EXTENTS

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drawing no. IE1723-007	rev A	checked: NOM	
		approved: PMS	
		date: 30.04.2019	

1 in 1000 Year Flood Depths - Existing

Number	Minimum Elevation	Maximum Elevation	Color
1	0.0	0.1	
2	0.1	0.2	
3	0.2	0.3	
4	0.3	0.4	
5	0.4	0.5	
6	0.5	0.6	
7	0.6	0.7	
8	0.7	0.8	
9	0.8	0.9	
10	0.9	1.0	
11	1.0	1.1	
12	1.1	1.2	
13	1.2	1.3	
14	1.3	1.4	
15	1.4	1.5	
16	1.5	1.6	
17	1.6	1.7	
18	1.7	1.8	
19	1.8	1.9	
20	1.9	2.1	

PROJECT NO. IE1723
Blackrock, Co. Louth

Number of points	1534
Minimum Flood Depth	0.00 m
Maximum Flood Depth	2.03 m
Mean Flood Depth	1.038m

TIN

Number of triangles	2439
Maximum triangle area	4.000 sq.m
Minimum triangle area	0.001 sq.m
Minimum triangle length	0.001 m
Maximum triangle length	4.472 m

1 in 1000 YEAR FLOOD VOLUME

Base Surface:	Existing Site
Comparison Surface:	1000 Year Water Level

Flood volume = 3784.87 m^3

1 in 1000 Year Flood Depths - Proposed

Number	Minimum Elevation	Maximum Elevation	Color
1	0.0	0.1	
2	0.1	0.2	
3	0.2	0.3	
4	0.3	0.4	
5	0.4	0.5	
6	0.5	0.6	
7	0.6	0.7	
8	0.7	0.8	
9	0.8	0.9	
10	0.9	1.0	
11	1.0	1.1	
12	1.1	1.2	
13	1.2	1.3	
14	1.3	1.4	
15	1.4	1.5	
16	1.5	1.6	
17	1.6	1.7	
18	1.7	1.8	
19	1.8	1.9	
20	1.9	2.1	

PROJECT NO. IE1723
Blackrock, Co. Louth

Number of points	715
Minimum Flood Depth	0.00 m
Maximum Flood Depth	1.566 m
Mean Flood Depth	0.649m

TIN

Number of triangles	911
Maximum triangle area	145.59 sq.m
Minimum triangle area	0.001 sq.m
Minimum triangle length	0.001 m
Maximum triangle length	30.847 m

1 in 1000 YEAR FLOOD VOLUME

Base Surface:	Proposed Site
Comparison Surface:	1000 Year Water Level

Flood volume = 1966.93 m^3

LEGEND

SITE BOUNDARY

rev.	date	amendment	drn	ckd
A	30.04.19	PLANNING	LMc	PMS

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HYDROLOGICAL IMPACT ASSESSMENT
OF PROPOSED ACCESS ROAD

EXISTING & PROPOSED SCENARIO COMPARISON
OF 1 IN 1000 YEAR (0.1% AEP +CC) COASTAL
FLOOD VOLUME & DEPTH ANALYSIS

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		drawn:	LMC
drawing no.	IE1723-008	checked:	NOM
rev	A	approved:	PMS
		date:	30.04.2019

APPENDIX B

Topographical Cross-Sectional Survey

● Notes
-Section levels surveyed 06-09-2018.
-Original survey shown grey (CSS survey).
-LSS survey shown pink.
-Section lines shown magenta.
-Sections drawn from left to right looking downstream.

Land Survey Services
Riverview House, 76 Hill Street, Milford, Co. Armagh, BT60 3PB
Tel ● 028 37 525045 Fax ● 028 37 524346 Mobile ● 07860429910
email:info@landsurveyservicesni.com ● web:www.landsurveyservicesni.com

● Location:
Blackrock, Dundalk.

● Client:
Finn Design.

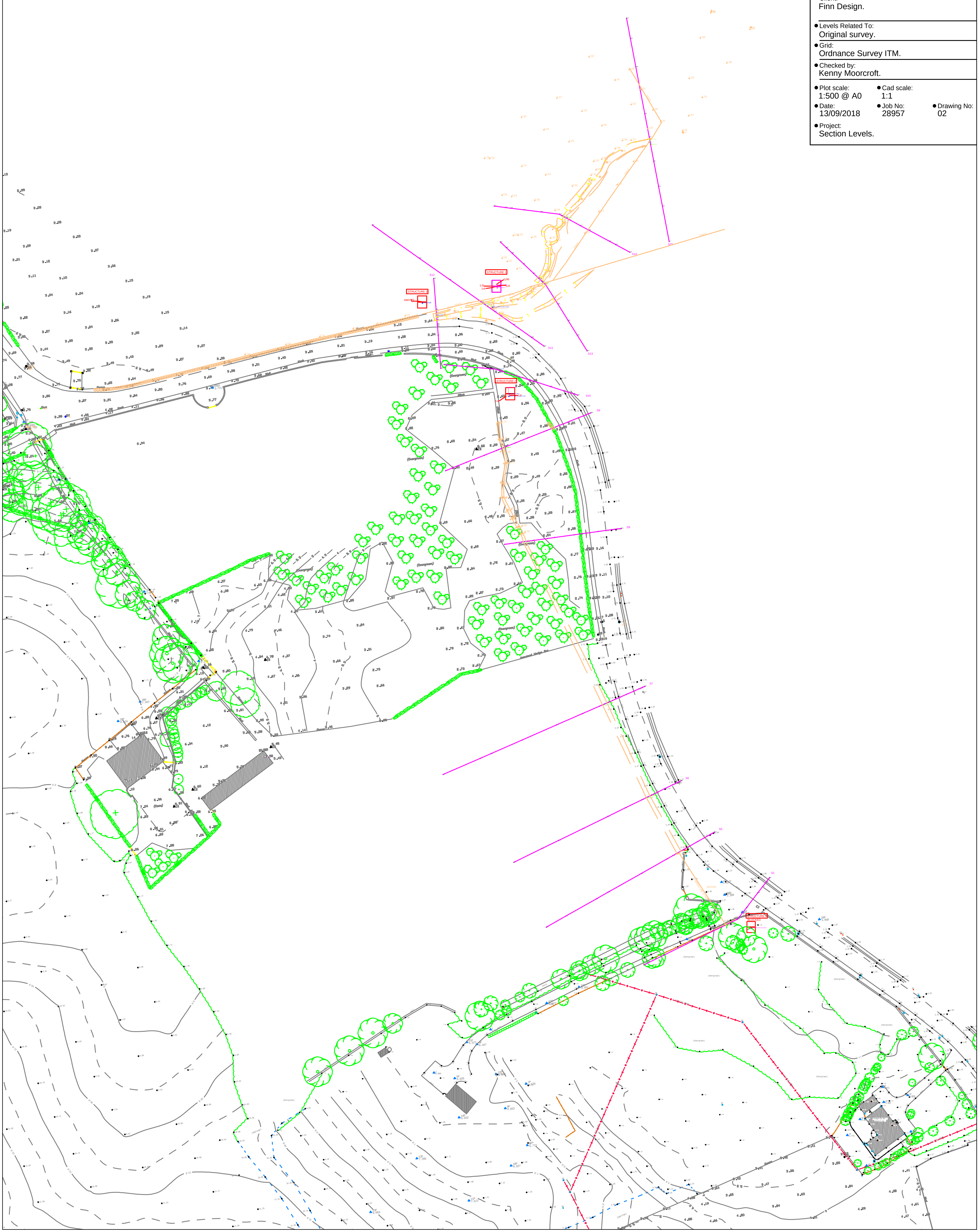
● Levels Related To:
Original survey.

● Grid:
Ordnance Survey ITM.

● Checked by:
Kenny Moorcroft.

● Plot scale: 1:500 @ A0
● Cad scale: 1:1
● Date: 13/09/2018
● Job No: 28957
● Drawing No: 02

● Project:
Section Levels.



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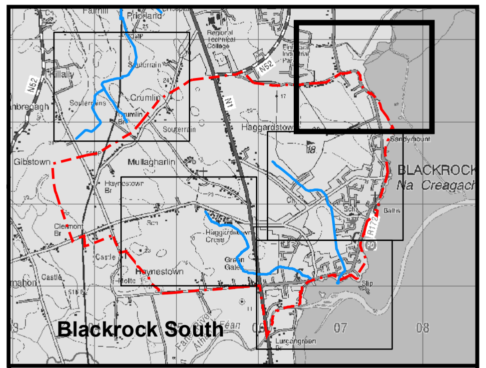
APPENDIX C

OPW CFRAMS Fluvial & Tidal/Coastal Flood Extent Maps

0 50 100 200 300 400 500 Metres



IMPORTANT USER NOTE:
THE VIEWER OF THIS MAP SHOULD REFER TO THE DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE THAT ACCOMPANY THIS MAP.

Legend

- 10% Fluvial AEP Event
- 1% Fluvial AEP Event
- 0.1% Fluvial AEP Event
- Modelled River Centreline
- AFA Extents
- Embankment
- Wall
- Defended Area
- 1% AEP / 1% AEP — Standard of Protection of Flood Defence (Walls / Embankments)
- Node Point
- Node ID — Node Label

FINAL

REV:	NOTE:	DATE:

NORTH WESTERN NEAGH BANN CFRAM STUDY

The Office of Public Works
Jonathan Swift Street
Trim
Co Meath

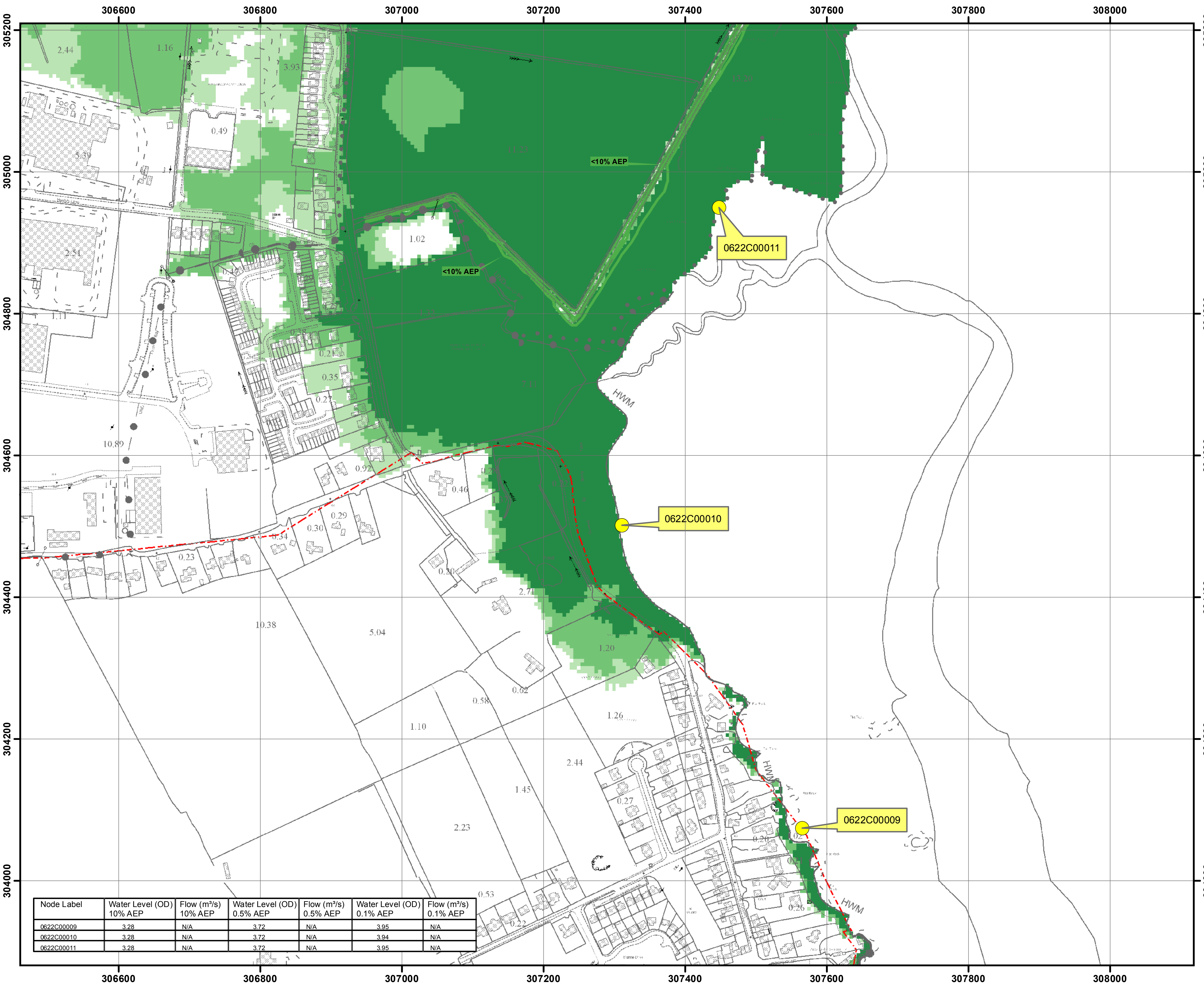
Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44(0) 28 90 667914
F +44(0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

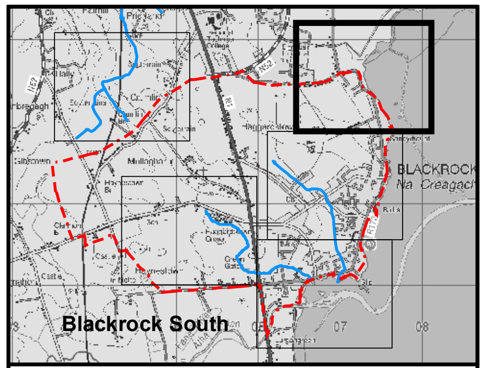
Map:

Blackrock South Fluvial Flood Extents

Map Type:	EXTENT
Source:	Fluvial
Map Area:	HPW
Scenario:	CURRENT
Drawn By : C.C.	Date : 9 August 2016
Checked By : E.H.	Date : 9 August 2016
Approved By : S.P.	Date : 9 August 2016
Drawing No. :	N06BRK_EXFCD_F0_02
Map Series :	Page 2 of 5
Drawing Scale :	1:5,000 @A3



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
0622C00009	3.28	N/A	3.72	N/A	3.95	N/A
0622C00010	3.28	N/A	3.72	N/A	3.94	N/A
0622C00011	3.28	N/A	3.72	N/A	3.95	N/A



IMPORTANT USER NOTE:
THE VIEWER OF THIS MAP SHOULD REFER TO THE DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE THAT ACCOMPANY THIS MAP.

Legend

- 10% Tidal AEP Event
- 0.5% Tidal AEP Event
- 0.1% Tidal AEP Event
- Modelled River Centreline
- AFA Extents
- Embankment
- Wall
- Defended Area
- 1% AEP / 1% AEP — Standard of Protection of Flood Defence (Walls / Embankments)
- Node Point
- Node ID — Node Label

FINAL

REV:	NOTE:	DATE:

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Map:
Blackrock South Tidal Flood Extents

Map Type:	EXTENT
Source:	TIDAL
Map Area:	COASTAL
Scenario:	CURRENT
Drawn By : C.C.	Date : 4 August 2016
Checked By : E.H.	Date : 4 August 2016
Approved By : S.P.	Date : 4 August 2016
Drawing No. :	N06BRK_EXCCD_F0_02
Map Series :	Page 2 of 5
Drawing Scale :	1:5,000 @A3