TRUSKY EAST STREAM FLOOD STUDY

STRATEGIC HOUSING DEVELOPMENT
AT TRUSKY EAST, BEARNA

for BURKEWAY HOMES

B861-OCSC-XX-XX-RP-C-0003-A1-C04

October 2020

OCSC
O'CONNOR | SUTTON | CRONIN
Multidisciplinary
Consulting Engineers

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PROJECT NO. B861

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1. INTRODUCTION

1.1 Background

1.1.1 O'Connor Sutton Cronin (OCSC) was appointed by Burkeway Homes to assess the flood risk associated with a proposed development site at Bearna, Co. Galway, arising from the Trusky East Stream. The site is located at Trusky East, Bearna, approximately 400m north of the R336 Regional Road – see ***Figure 1***.

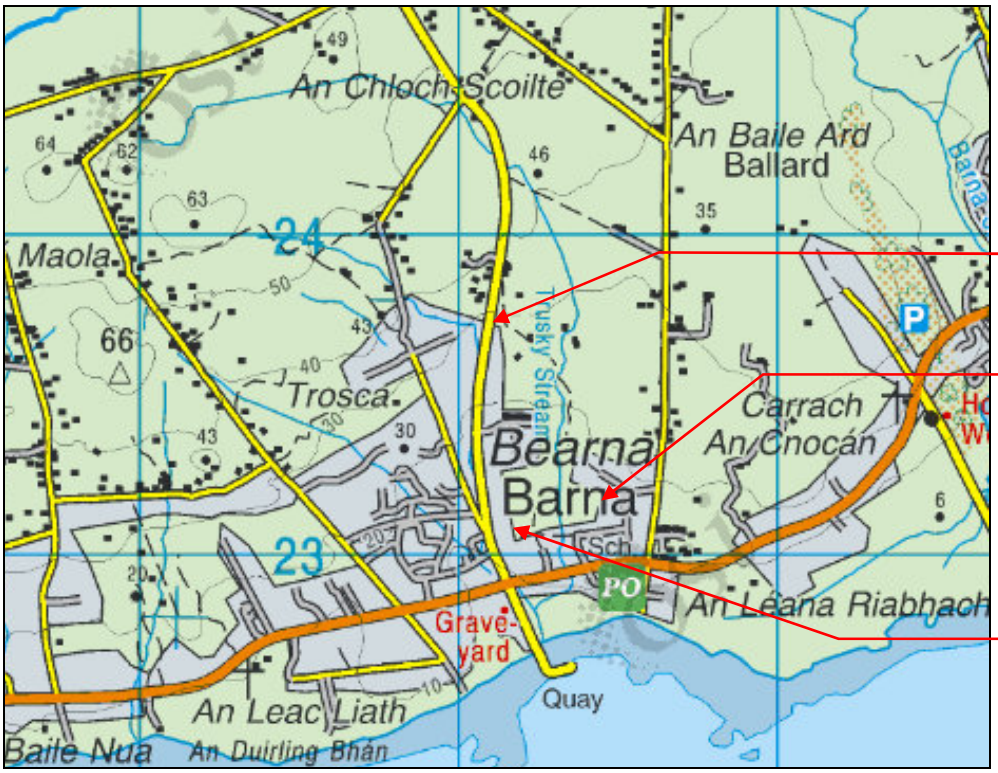


Figure 1: Location of proposed development at Bearna

1.1.2 The Trusky East Stream begins approximately 1.4km northwest of the site, reaches the subject lands at the northeast corner and flows southwards along the eastern boundary of the site. The stream continues south, passes beneath the R336 road, joins with the Trusky West Stream and discharges to Galway Bay at Bearna Harbour.

1.1.3 The Trusky East Stream is identified in Ordnance Survey mapping as the Trusky Stream. In the Western Catchment Flood Risk

Assessment and Management study, the stream is identified as the Cloghscoltia watercourse. For the purposes of this study, the stream is referred to as the Trusky East Stream.

1.1.4 This study was conducted with consideration to the recommendations of:

- *The Planning System and Flood Risk Management Guidelines for Planning Authorities* (Department of Environment, Heritage and Local Government and the Office of Public Works, November 2009);
- Circular PL 2/2014 dated 13th August 2014 from the Department of the Environment, Community and Local Government;
- *C624 Development and Flood Risk* (Construction Industry Research and Information Association, CIRIA, October 2004); and
- *Galway County Development Plan 2015-2021, as varied*.

1.1.5 This study of the Trusky East Stream was based on the following information:

- *The Flood Studies Report and Flood Studies Supplementary Reports (Institute of Hydrology) and;*
- *The OPW's Flood Studies Update (FSU) Web Portal;*
- *Topographical and bathymetrical (channel) survey;*
- *JBA Flood Risk Review for Western CFRAM.*

1.1.6 OCSC carried out an inspection of the site, consisting of a walkover and visual inspection of the stream channel from its source to where it discharges to Galway Bay. A selection of site photographs is provided in ***Appendix A***.

1.2 OPW Preliminary Flood Risk Assessment

1.2.1 The OPW is the national agency responsible for overseeing flood management. Under this remit and in accordance with the requirements of European Union 'Floods' Directive (2007/60/EC),

the OPW published the draft Preliminary Flood Risk Assessment (PFRA) in 2011. The PRFA includes an assessment of fluvial and tidal flood plains and produces indicative national flood extent maps – see PFRA drawing 2019/MAP/209/A in ***Appendix B***; an extract is shown in ***Figure 2***. The PFRA maps provide no information on expected flood water levels.

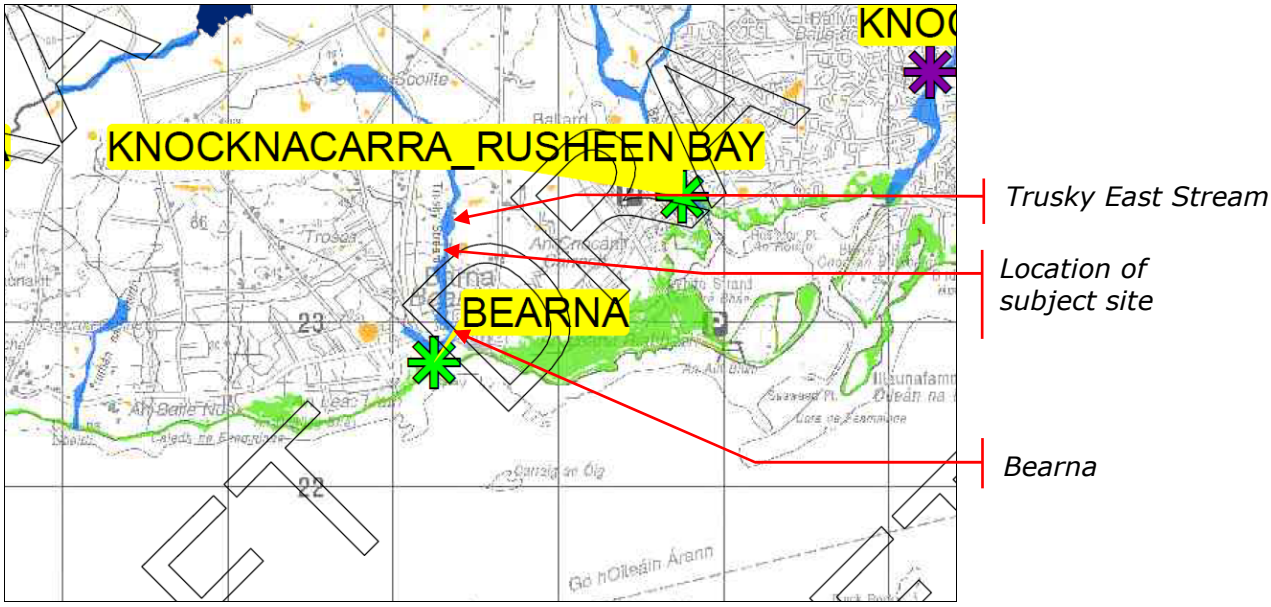


Figure 2: Extract from OPW Preliminary Flood Risk Assessment

1.2.2 The PFRA was intended to provide only a preliminary assessment of flooding in order to screen for areas of flood risk and identify "Areas of Further Assessment", which were later subjected to detailed Catchment Flood Risk Assessment and Management studies. As such, it was appropriate for the purposes of the PFRA to simplify the assessment methodology in order that the study could efficiently cover the entire country.

1.2.3 The OPW's report National Preliminary Flood Risk Assessment Overview Report, describes the method used to develop these maps – see extract included in ***Appendix B***. The method omits from the assessment the impact of man-made hydraulic structures such as bridges. Furthermore, the method is based on an assumption of river channel capacity and models only the floodplain for excess

flow (this obviated the need for detailed bathymetrical survey of all the river channels in Ireland).

1.2.4 The method is further described in the OPW's report Fluvial Flood Hazard Mapping – Normal Depth Method (prepared by Compass Informatics) – see extract included in ***Appendix B***.

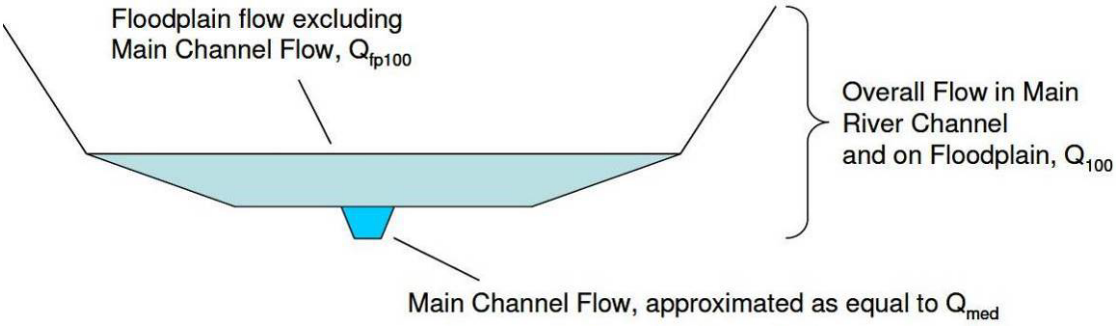


Figure 3: Diagram illustrating separation of main channel from floodplain for PFRA modelling (from Compass Informatics report)

1.2.5 The PFRA therefore modelled only the excess flow in the floodplain and omitted the river channels entirely. The National Preliminary Flood Risk Assessment Overview Report defines the term "Indicative" in a glossary, which states that the PFRA maps "are developed using simple methods, and generally national datasets, and are hence approximate, and not highly detailed, with some local anomalies." The report goes on to state in Section 4.2 that the maps "should not be used for local decision-making or any other purpose without verification and seeking the advice of a suitable professional".

1.3 Development Plan – Indicative Flood Zones

1.3.1 Variation No.2(a) Galway County Development Plan 2015-2021 ("the Bearna Plan") includes a Flood Risk Management map, which shows "Indicative Flood Zones" – see extract in ***Figure 4*** over.

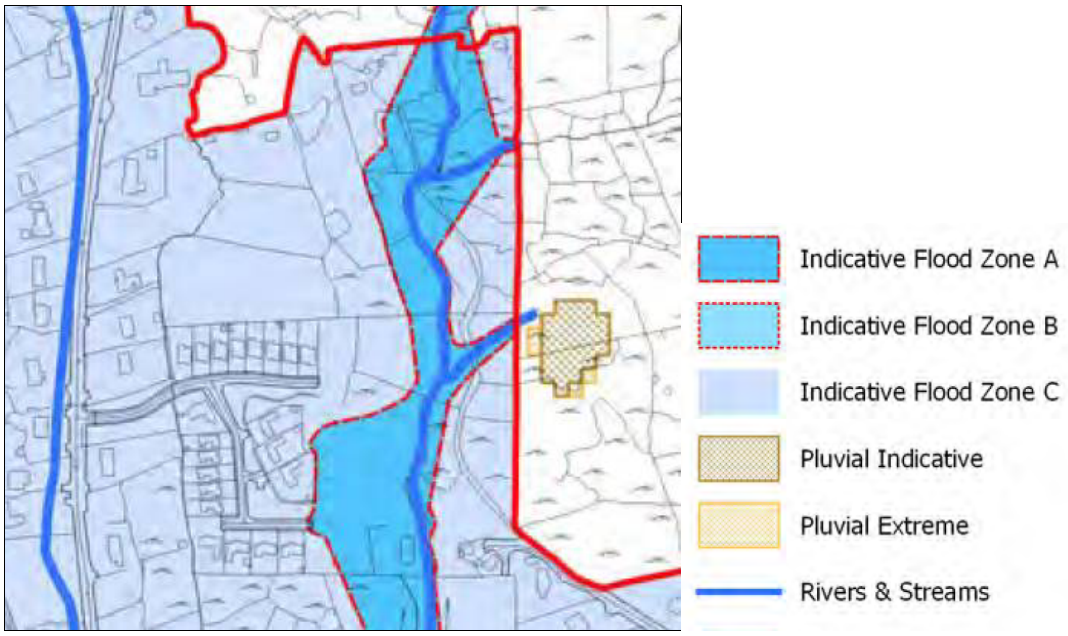


Figure 4: Extract from Flood Risk Management map in Variation No.2(a) Galway County Development Plan 2015-2021 Bearna Plan

1.3.2 The Strategic Flood Risk Assessment (SFRA) for Variation No. 2 (a) to the Galway County Development Plan 2015-2021 identifies the source information used in determination of the Indicative Flood Zones. In the lower reaches of the Trusky East Stream, downstream of the subject site, the Indicative Flood Zones were informed by JBA Extreme Flood Outline modelling. At the subject site, relevant sources identified in the SFRA comprise PFRA flood mapping, historical indicators, site walkovers and submissions by members of the public including photographs of flooding. No detailed flood modelling informed the determination of Indicative Flood Zones at the subject site.

1.3.3 Section 1.2 of the SFRA states that the SFRA "provides an appropriately strategic assessment of flood risk within the town of Bearna and has been undertaken in full compliance with the 2009 Flood Guidelines." Section 1.5 of the SFRA acknowledges that compliance "is currently based on emerging and incomplete data as well as estimates of the locations and likelihood of flooding."

1.3.4 Section 1.4.4.3 of the SFRA sets out the following three stages of flood risk appraisal and assessment:

- Stage 1 Flood Risk Identification
- Stage 2 Initial Flood Risk Assessment
- Stage 3 Detailed Flood Risk Assessment

The SFRA progressed Stage 1 and Stage 2 but did not proceed to Stage 3, which is described as "to provide a quantitative appraisal of potential flood risk".

1.4 Quantitative Appraisal of Flood Risk

1.4.1 Whilst remaining cognisant of the Indicative Flood Zones identified in the Development Plan and bearing in mind the source data for the identified Indicative Flood Zones, it was considered necessary to quantify the fluvial flood risk by detailed and robust hydrological assessment and hydraulic modelling in order to inform scheme design and flood risk management measures.

1.4.2 The assessment detailed in the current report provides quantitative analysis and predicted flood water levels, for use in scheme design. The analysis identifies the predicted flood extents for the 100-year and 1000-year return period flood events, based on a computational modelling. As will be demonstrated, the analysis shows that some areas of the subject site shown to be within Indicative Flood Zone C in the Flood Risk Management map (Variation No.2(a) Galway County Development Plan 2015-2021 Bearna Plan) are, in fact, subject to flooding in the 100-year and 1000-year return period events and appropriate mitigation measures will be required.

2. HYDROLOGICAL ASSESSMENT

2.1 Catchment

2.1.1 The subject lands are located at Bearna, approximately 7 km west of Galway City. The entire site drains to the Trusky East Stream. At the downstream end of the subject site, the Trusky East Stream has a catchment of 1.79km². The catchment area was determined with reference to OS Discovery Series mapping, reference data and site inspections – see ***Figure 5***.

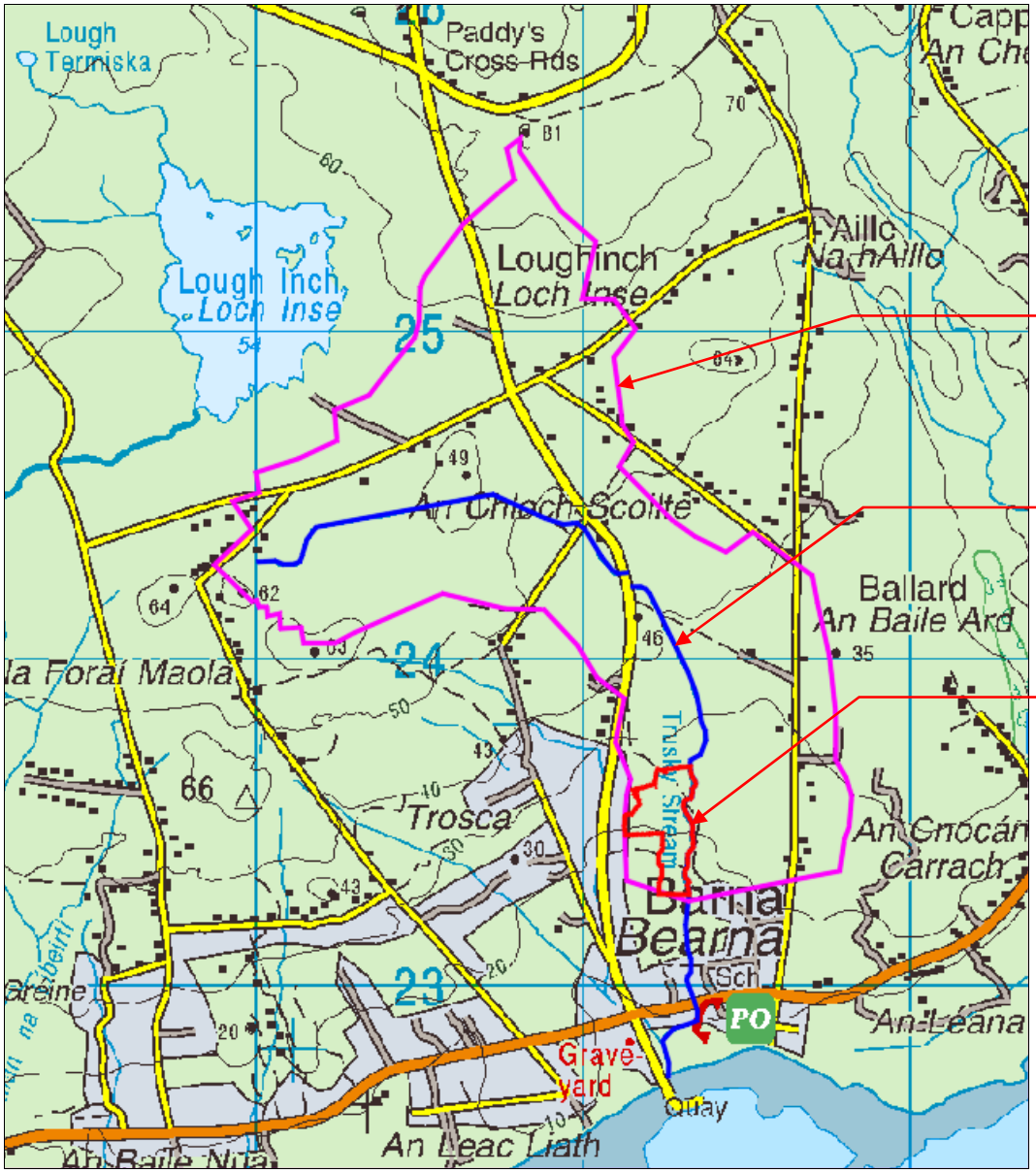


Figure 5: Trusky East Stream Catchment

2.1.2 Upstream of the subject site, the catchment is rural in character, with mixed agriculture being the predominant land use. Downstream of the site, the stream flows through developed areas at Bearna before discharging to Galway Bay. The stream is un-gauged for its entire length.

2.2 Analysis Methods

2.2.1 As the catchment in question is ungauged, alternative methods to determine the design flow were assessed, as described in the Flood Studies Report (1975) and the Flood Studies Update (2014). The following methods were assessed:

- Flood Studies Update (FSU) method;
- Flood Studies Report 3-Variable equation;
- Institute of Hydrology Report No. 124 (IH124) method and;
- Flood Studies Report 6-Variable equation (with FSSR 5).

2.2.2 The FSU programme is a research and development programme undertaken by the OPW, and is designed as a replacement for the Flood Studies Report (FSR). It has been in development since 2005 with a series of research programmes being undertaken by the OPW, or on behalf of the OPW, in order to inform the contents of the FSU. The final report and the web-portal were released in the second quarter of 2014.

2.2.3 The aim of the FSU is to provide improved methods of extreme rainfall and flood estimation at both gauged and ungauged locations in the Republic of Ireland. It is a substantial update on the FSR, and adopts some of the methodologies found in the Flood Estimation Handbook (FEH) (Institute of Hydrology, 1999) which has superseded the FSR as the main method of extreme rainfall and flow estimation in the UK.

2.2.4 The FSU method is considered a good practice method for catchments greater than 25km^2 in size; however, the catchment of the Trusky East Stream at the subject site is considerably less than this at 1.79km^2. Following best practice for small catchments, the IH124 method was used to determine the appropriate design flood flows.

2.3 Institute of Hydrology Report No. 124 Method

2.3.1 The 3-Variable equation presented in the Institute of Hydrology (IoH) Report No. 124 (Marshall and Bayliss 1994) represents the outcome of a 5 year research programme by the IoH with the aim of developing and implementing new procedures for rainfall and flood frequency estimation.

$$\mathbf{Q_{BAR} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}}$$

2.3.2 It is recommended that the IoH Report No. 124 Method only be used for calculating peak flows on catchments between 0.5km^2 and 25km^2 in area.

2.3.3 In accordance with best practice, the Factorial Standard Error is applied and a Climate Change Factor of 20% is added for the Future Climate Design Flow. Calculations are included in ***Appendix C***.

2.4 Recommended Design Flows

2.2.1 The 1-in-100-year return period flood flow was, for many years, the benchmark design flow for flood assessment in Ireland. However, in November 2009, the Department of the Environment, Heritage and Local Government and the OPW published guidelines on *The Planning System and Flood Risk Management Guidelines for Planning Authorities*. These guidelines establish best practice methods for flood risk management in Ireland. The guidelines

recommend that highly vulnerable types of development (such as residential, schools, hospitals) be protected from the 1-in-1000-year return period flood and that less vulnerable types of development (such as retail, warehousing, industrial) be protected from the 100-year return period flood. It is therefore recommended that flood risk be assessed for both the 1-in-100-year and 1-in-1000-year return period flood flows.

Table 1: Trusky East Stream Design Peak Flows

Climate	**Event (AEP)**	**Peak Flow (m^3/s)**
Current (pre-climate change)	1.0%	1.81
	0.1%	2.40
Future (post-climate change)	1.0%	2.17
	0.1%	2.88

3. HYDRAULIC ANALYSIS

3.1 Computational Model

3.1.1 In order to accurately assess the flood extents for the Trusky East Stream, a computational model of the river was constructed. The HEC-RAS modelling software package (version 5.0) was used to create the model. Developed by the US Army Corps of Engineers, HEC-RAS is used worldwide to provide an integrated hydraulic model of river channels, floodplains and hydraulic structures such as bridges, culverts, weirs and embankments.

3.2 Model Extents – Longitudinal Boundaries

3.2.1 The Trusky East Stream reaches the subject site at the northeast boundary. It then flows south along the eastern boundary of the site and leaves the site at the southeast boundary. The stream continues south, passes beneath the R336 road, joins with the Trusky West Stream and discharges to Galway Bay at Bearna Harbour. Immediately upstream of the site the stream is relatively uniform; being reasonably trapezoidal in shape, with a 1.0m deep and a 1m wide bed, and a channel gradient in the region of 0.01 (1-in-33).

3.2.2 The stream exits the site at the southern boundary and travels a straight course to the culvert on the R336 Regional Road. The channel downstream of the site is relatively uniform; being reasonably trapezoidal in shape, with a 1.0m deep and a 1m wide bed, and a channel gradient in the region of 0.012 (1-in-81). As the channel downstream of the site is steep and the ground level at the R336 culvert is 4m below site ground levels, the culvert is considered not to impact hydraulic performance at the site. Therefore, the downstream channel was selected as the downstream boundary condition for the computational model.

3.2.3 The total modelled reach is 431m in length. The bed level changes from 22.13mAOD at the upstream end to 11.74mAOD at the downstream end. This 10.39m drop in level results in a channel gradient of 0.024 (1-in-41.5), which is steep.

3.3 Model Extents – Cross-sections

3.3.1 A survey of the modelled river reach and its potential floodplain was carried out in preparation for the planning application. The survey includes a bathymetric survey of the river channel and detailed topographical data of the surrounding lands. The survey also provided details of the existing structures within the study area.

3.3.2 After analysing the topographical and bathymetric data, 15nr. cross-sections were selected to represent the subject reach within the surveyed study area. With a modelled reach length of 431m, this provides a model with 35 cross-sections per kilometre. The model used for the current study therefore provides a high resolution that is appropriate for the intended purpose.

3.3.3 Throughout the subject lands, the river generally comprises a 1m wide bed and 1m deep channel, with the channel widening in several locations where pools and riffles occur. Access for livestock watering and crossing is provided at some riffles with low bank heights. The potential floodplain extends across currently agricultural land on both banks of the river. Therefore, the cross-sections used in the model extend beyond the channel itself. Both sides of the river model, therefore, are defined by the ground profile. The layout of the model representing the existing river geometry is shown in ***Figure 6*** and a sample cross section is shown in ***Figure 7.***

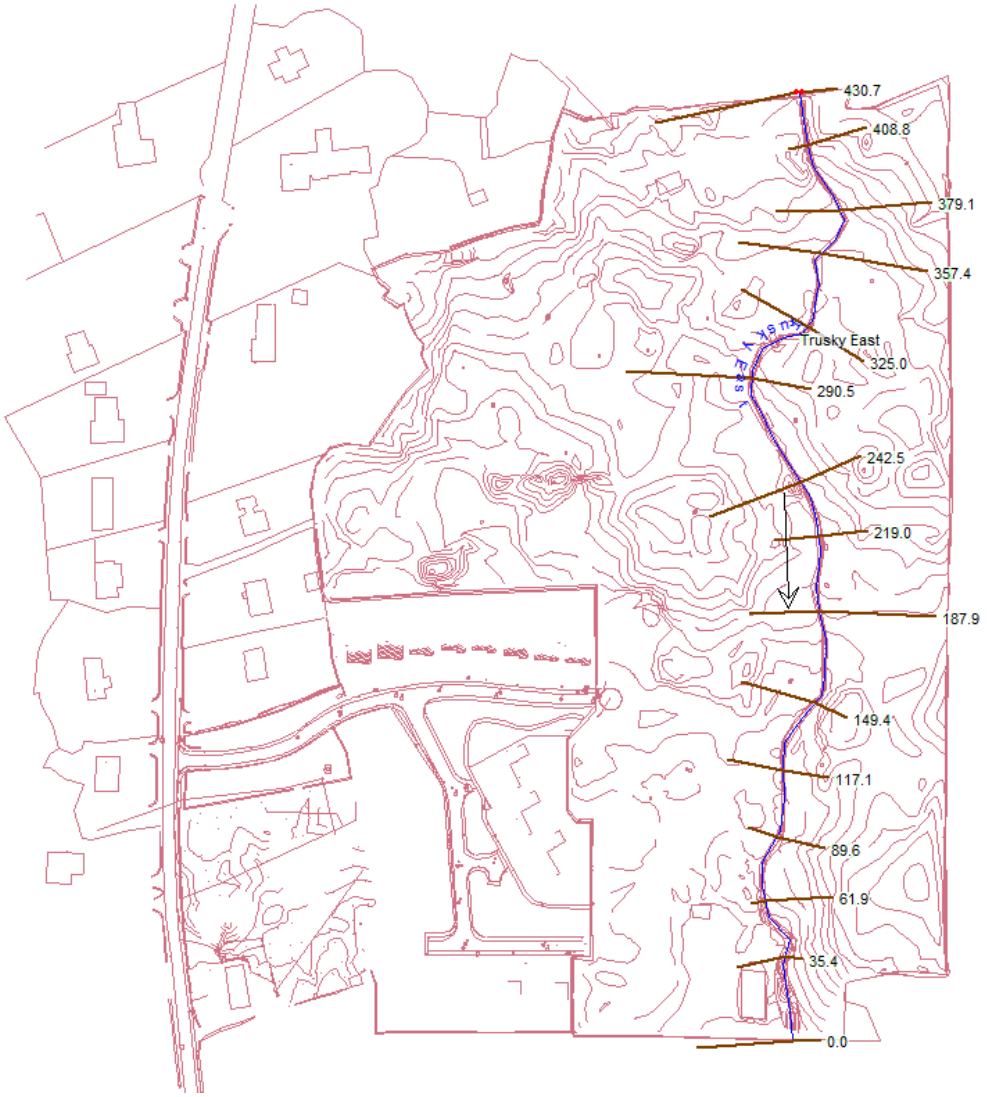


Figure 6: Plan Layout of River Model Geometry

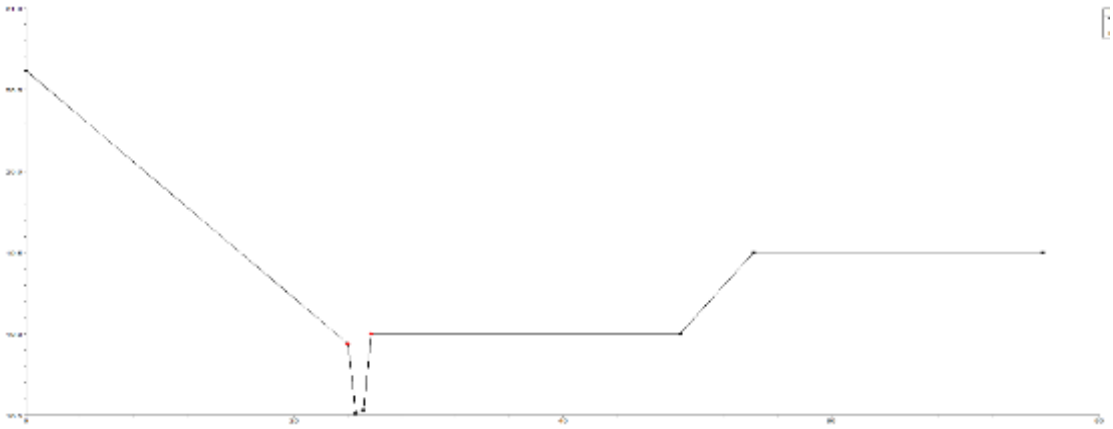


Figure 7: Sample Cross-Section

3.4 Manning's n Values

3.4.1 HEC-RAS uses the Manning's Equation in the analysis of open channel flows. The roughness of channels is defined by the Manning's n variable. Values for this variable were determined by site inspection with reference to Open Channel Hydraulics (V.T. Chow, 1959). Photographs of typical channel and floodplain conditions are included in ***Appendix A***. The selected values Manning's n are presented in ***Table 2***.

Table 2: Selected values for Manning's n

Location	Manning's n
Channels – Natural streams, clean, winding, some pools and shoals, some weeds and stones	0.045
Flood Plains – scattered brush, heavy weeds	0.050

3.5 Computational Model Results

3.5.1 The model was run for each of the four design flood flow events, as set out in ***Table 1*** earlier. A full set of results is included in ***Appendix D***. Predicted flood water levels for 1.0% AEP and 0.1% AEP flood events in both the current and future climate scenarios are set out in ***Table 3*** over.

Table 3: Predicted Water Levels (mAOD)

Section Reference	Current Climate Scenario		Future Climate Scenario	
	1.0% AEP	0.1% AEP	1.0% AEP	0.1% AEP
430.7	22.74	22.79	22.77	22.82
408.8	21.9	22.02	21.97	22.11
379.1	20.99	21.03	21.02	21.06
357.4	20.59	20.64	20.63	20.67
325.0	19.91	19.97	19.95	20.01
290.5	19.12	19.17	19.15	19.2
242.5	18.53	18.6	18.58	18.65
219.0	17.91	18.03	17.98	18.1
187.9	16.86	16.94	16.91	17.07
149.4	15.87	15.93	15.91	15.97
117.1	15.42	15.49	15.47	15.54
89.6	15.06	15.17	15.12	15.25
61.9	14.19	14.29	14.25	14.35
35.4	13.39	13.47	13.44	13.53
0.0	12.3	12.39	12.35	12.45

3.5.2 The extent of the modelled current 1.0% AEP and 0.1% AEP flood events are plotted on ***Drawing B861-OCSC-XX-XX-DR-C-2801*** – a reduced A4 copy of which is included in ***Appendix E***. It is noted that the Indicative Flood Zones are presented in the Flood Risk Management map included in Variation No.2(a) Galway County Development Plan 2015-2021 Bearna Plan. However, the Indicative Flood Zones alone are insufficient for a detailed assessment of flood risk: predicted flood water levels are required to determine proposed Finished Floor Levels (FFLs) with sufficient freeboard over the flood water level to comply with GDSDS recommendations. Furthermore, the flood extents predicted in computational modelling for the 100-year and 1000-year return period events, whilst remaining largely within the Indicative Flood Zones A and B, encroach into Indicative Flood Zone C at four locations – see ***Figure 8*** over. The computational modelling has therefore identified a flood risk that is not apparent from the Flood Risk Management map.

Figure 8: Indicative Flood Zones and Predicted Flood Extents

3.5.1 The proposed Finished Floor Levels (FFLs) have been compared to the predicted water levels presented in ***Table 3*** earlier and they have been found to provide no less than 500mm freeboard to the predicted 1.0%AEP flood levels, in accordance with GDSDS recommendations.

4. PROPOSED DEVELOPMENT

4.1 Proposed Layout

4.1.1 In the Variation No.2(a) of Galway County Development Plan 2015-2021 ("the Bearna Plan"), the subject site is partly zoned 'R' for residential development Phase 1 and partly zoned 'OS' for open space/recreation and amenity uses. Some of the lands zoned 'R' are subject to Objective CCF6, which requires that the development proposal will need to be accompanied by a detailed hydrological assessment and robust SUDS design which demonstrates the capacity to withstand potential flood events to maintain water quality and avoid potential effects to ecological features. . All the lands zoned 'OS' within the proposed development site are subject to Objective LU8 – Constrained Land Use Zone ('CL'); DM Guideline FL1 – Flood Zones and Appropriate Land Uses apply to lands zoned CL – see ***Figure 9*** overleaf.

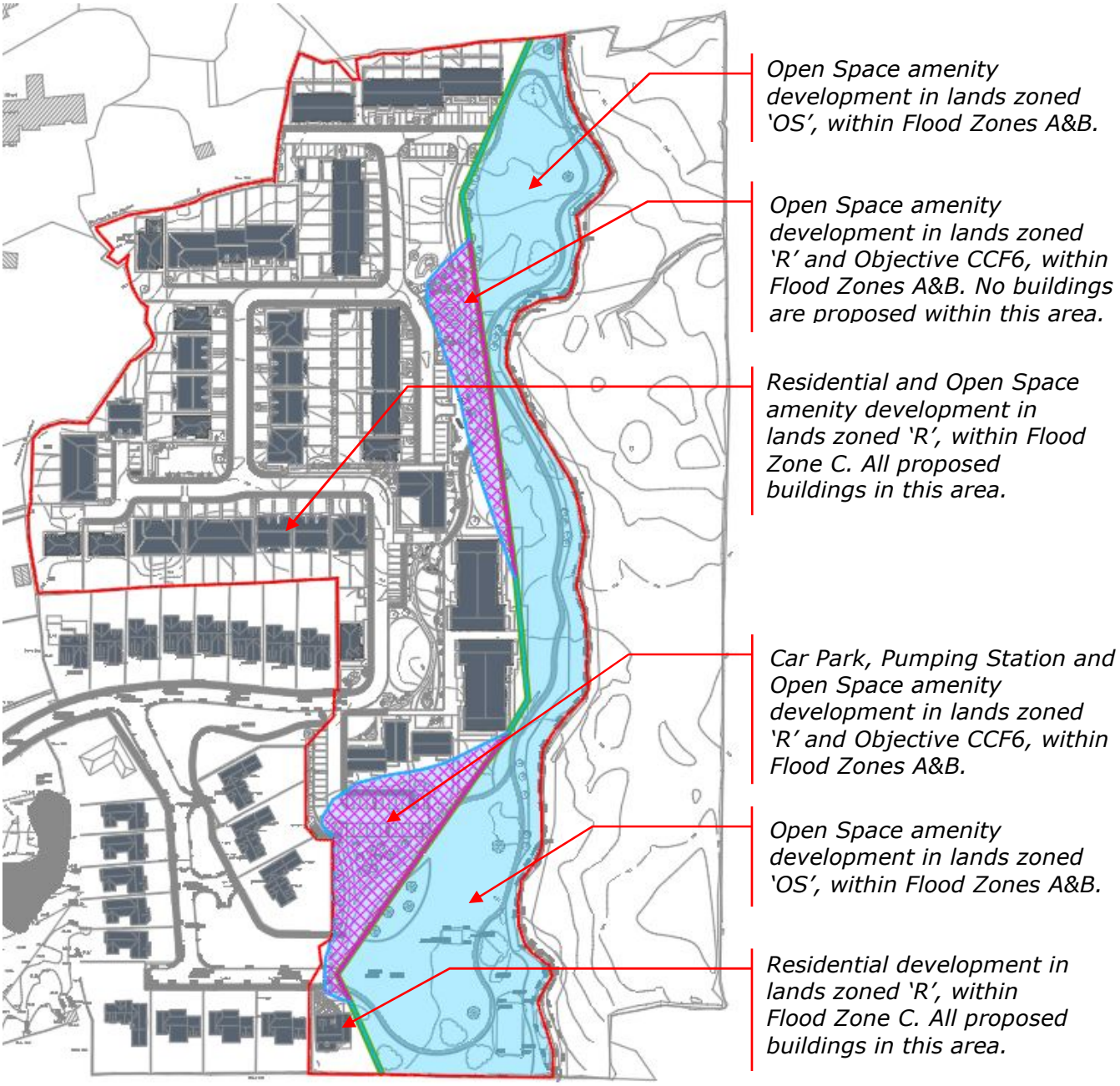


Figure 9: Proposed Development Layout with Development Plan Zoning

4.1.2 There are no proposals for bridges or culverts on the existing watercourse and there are no proposals for modification of the stream channel.

4.2 Lands Zoned 'OS'

4.2.1 The area of the subject site zoned 'OS' will be developed as new open space amenity. This area is entirely within Indicative Flood

Zones A&B identified in the Bearna Plan. There are no proposals to raise ground levels in this area. The following is proposed on OS zoned lands: ground cultivation; sowing of wildflower meadow; sowing of grass for grass pathways; planting of trees, hedgerows, waterside planting, native and naturalised planting; erection of post and chainlink fence; surface water drainage and the decommissioning of an existing wastewater treatment works. The proposed fence line runs generally parallel with the direction of flow and so does not comprise a barrier to flood conveyance along the route of the stream. Where proposed trees, hedgerows and fence are located within the predicted flood extent, they will displace flood storage volume provided by the existing floodplain. It is therefore proposed to provide compensatory storage on a direct "level-for-level" basis, in accordance with CIRIA C624 and the Flood Risk Management Guidelines; details of the proposed compensatory storage is shown on ***Drawing B861-OCSC-XX-XX-DR-C-2802***.

4.3 Lands Zoned 'R' with Objective CCF6

4.3.1 There are two areas within the subject site that are zoned 'R' where the Objective CCF6 applies. Both of these areas of lands are entirely within Indicative Flood Zones A&B identified in the Bearna Plan. The first, more northerly, of these two areas will be developed for open space amenity only; it is not proposed to provide buildings in this area. There are no proposals to raise ground levels in this area. The proposals for this area include items such as trees, park benches and playground equipment. Where these proposed items are located within the predicted flood extent, they will displace flood storage volume provided by the existing floodplain. It is therefore proposed to provide compensatory storage on a direct "level-for-level" basis, in accordance with CIRIA C624 and the Flood Risk Management Guidelines; details of the proposed compensatory storage is shown on ***Drawing B861-OCSC-XX-XX-DR-C-2802***.

4.3.2 The second, more southerly, of the two areas zoned 'R' where the Object CCF6 applies will be developed for open space/amenity, car parking and wastewater pumping station ancillary to the residential development. The provision of the car park will entail some re-profiling of existing ground levels; the road alignment drawing for this car park (***Drawing B861-OCSC-XX-XX-DR-C-0107***) indicates fill not exceeding 47mm and cut exceeding 400mm. The proposals also include tree planting within this area. The wastewater pumping station will be largely below ground, with only associated kiossk above ground. However, none of this area is located within the predicted flood extent and so the proposed works in this area will result in no displacement of flood storage. The ground level at the location of the wastewater pumping station is more than 500mm above the adjacent 1.0%AEP flood level; no further measure is required to manage fluvial flood risk at the pumping station.

4.4 Lands Zoned 'R' (without Objective CCF6)

4.4.1 The remainder of the site is zoned 'R' (where Objective CCF6 does not apply). This portion of the site is entirely within Indicative Flood Zone C identified in the Bearna Plan. However, as discussed earlier in Section 3.5.2, there are four locations where the predicted flood extents extend into this area. At three of these locations, the proposals provide open space amenity development with no proposals to raise ground levels or provide items such as trees, park benches, etc. At the fourth location, which corresponds to Chainage 44-58m on road alignment BL07, the proposals entail ground level raising, which will displace flood storage volume provided by the existing floodplain. It is therefore proposed to provide compensatory storage on a direct "level-for-level" basis, in accordance with CIRIA C624 and the Flood Risk Management Guidelines; details of the proposed compensatory storage is shown on ***Drawing B861-OCSC-XX-XX-DR-C-2802***.

4.5 Compensatory Storage

4.5.1 Compensatory storage is permitted as a mitigation measure in *The Planning System and Flood Risk Management, Guidelines for Planning Authorities* (DOEHLG and OPW, Nov 2009) where it is described in Appendix Section 3.3 – see extract in ***Figure 10***. The proposed "level-for-level" direct compensatory storage is to be provided in accordance with the recommendations of CIRIA C624. Details of the proposed compensatory storage are shown on ***Drawing B861-OCSC-XX-XX-DR-C-2802*** – a reduced A4 copy of which is included in ***Appendix E***.

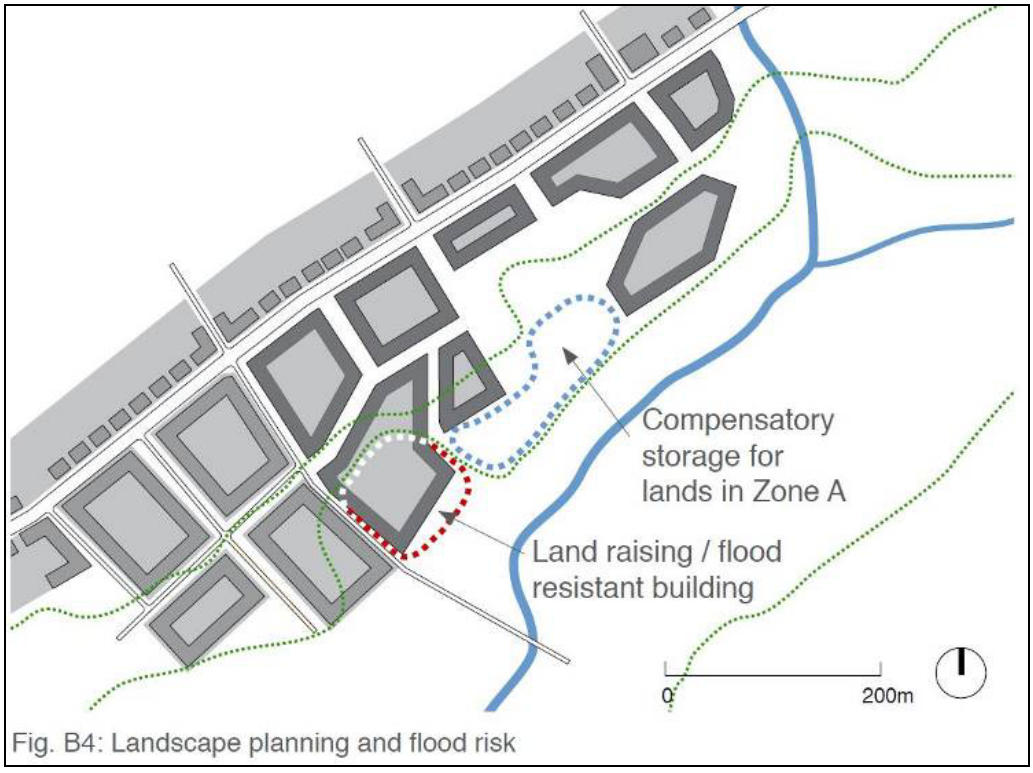


Figure 10: Extract from 2009 Planning Guidelines

5. CONCLUSION

5.1 The catchment of the Trusky East Stream has been assessed using the IH124 method in order to estimate river flood flows. Resulting calculated flows for both current climate and future climate scenarios were used for hydraulic analysis.

5.2 Design flood events have been selected to comply with best practice, taking cognisance of guidelines on The Planning System and Flood Risk Management Guidelines for Planning Authorities and Circular PL 2/2014.

5.3 The geometry of the river channel has been modelled using bathymetric and topographical survey data and site observations.

5.4 The current flood extents for the 1.0% AEP and 0.1% AEP flood events have been mapped.

5.5 The extent of future floods, i.e. including the effect of climate change, have also been modelled to inform the design of the proposed development.

5.6 The proposed scheme will involve no bridges or culverts and no modifications to the channel. Encroachments into the predicted flood extents have been identified and it is proposed to provide "level-for-level" direct compensatory storage to offset loss of floodplain storage.

APPENDIX A

Site Photographs

APPENDIX B

Extracts from OPW's Preliminary Flood Risk Assessment

No Fluvial Data Available For Area

NA FORBACHA

KNOCKNACARRA_RUSHEEN BAY

KNOCKNACARRA

BEARNA

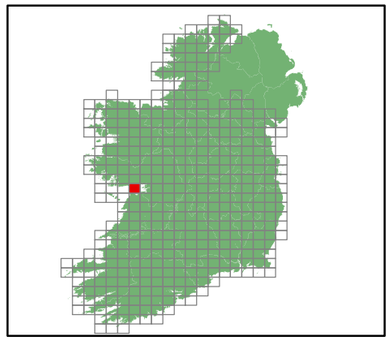
No Fluvial Data Available For Area

Galway Bay
Cuan na Gaillimhe

Black Head
Ceann Boirne

0.5 0.25 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Kilometers

Location Plan :



Legend:

Flood Extents

- Fluvial - Indicative 1% AEP (100-yr) Event
- Fluvial - Extreme Event
- Coastal - Indicative 0.5% AEP (200-yr) Event
- Coastal - Extreme Event
- Pluvial - Indicative 1% AEP (100-yr) Event
- Pluvial - Extreme Event
- Groundwater Flood Extents
- Lakes / Turloughs

PFRA Outcomes

- Probable Area for Further Assesment
- Possible Area for Further Assesment

Important User Note:

The flood extents shown on these maps are based on broad-scale simple analysis and may not be accurate for a specific location. Information on the purpose, development and limitations of these maps is available in the relevant reports (see www.cfram.ie). Users should seek professional advice if they intend to rely on the maps in any way.

If you believe that the maps are inaccurate in some way please forward full details by contacting the OPW (refer to PFRA Information leaflets or 'Have Your Say' on www.cfram.ie).

Office of Public Works
Jonathon Swift Street
Trim
Co Meath
Ireland

Project :
PRELIMINARY FLOOD RISK ASSESMENT (PFRA)

Map :
PFRA Indicative extents and outcomes
- Draft for Consultation

Figure By :	PJW	Date :	July2011
Checked By :	MA	Date :	July 2011

Figure No. : 2019 / MAP / 209 / A

Revision 0

Drawing Scale : 1:50,000

Plot Scale : 1:1 @ A3

THE NATIONAL PRELIMINARY FLOOD RISK ASSESSMENT (PFRA)

OVERVIEW REPORT

MARCH 2012

2019/RP/001/D

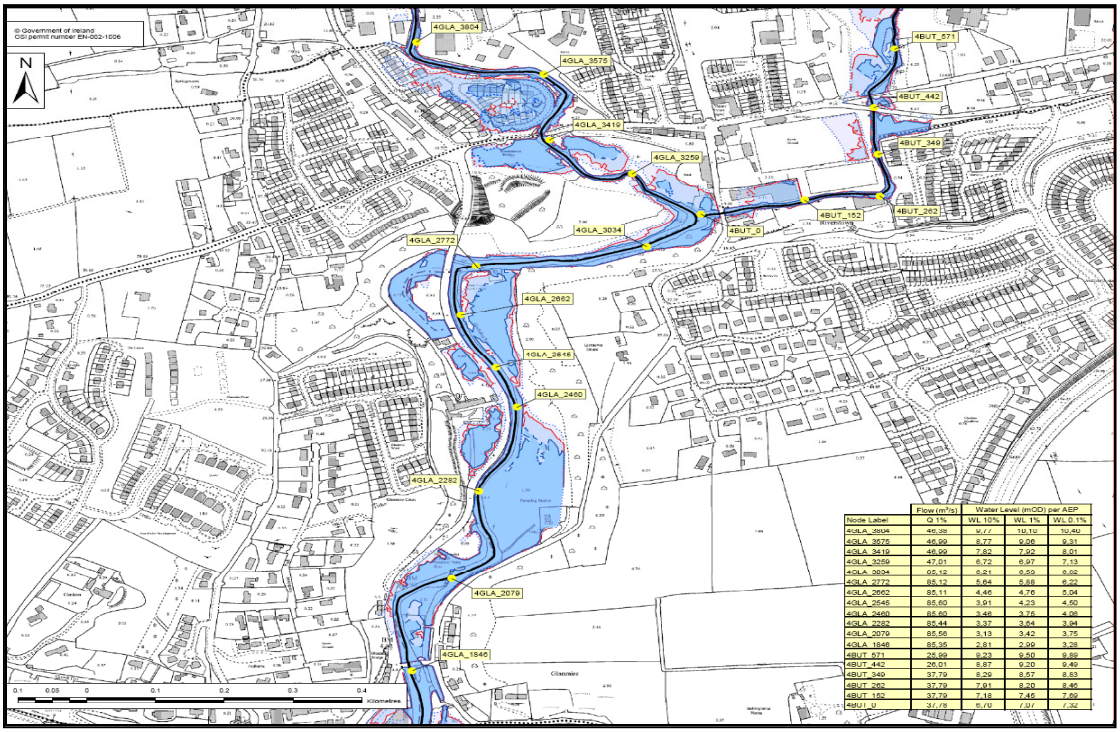
FLOOD RELIEF & RISK MANAGEMENT DIVISION
ENGINEERING SERVICES
OFFICE OF PUBLIC WORKS

GLOSSARY

TERMS USED

Area for Further Assessment (AFA)	Areas where, based on the Preliminary Flood Risk Assessment, the risks associated with flooding are potentially significant, and where further, more detailed assessment is required to determine the degree of flood risk, and develop measures to manage and reduce the flood risk.
Communities	Cities, towns, villages or townlands where there are a collection of homes, businesses and other properties
Consequences	The impacts of flooding, which may be physical (e.g., damage to a property or monument) or a disruption (e.g., loss of electricity supply or blockage of a road).
Flood Extent	The extent of land that has been, or might be, flooded. Flood extent is often represented on a flood map.
Hazard	Something that can cause harm or detrimental consequences. In this report, the hazard referred to is flooding.
Indicative	This term is typically used to refer to the flood maps developed under the Preliminary Flood Risk Assessment. The maps are developed using simple methods, and generally national datasets, and are hence approximate, and not highly detailed, with some local anomalies.
Point Receptor	Something that might suffer hamr or damage as a result of flood, that is at a particular location that does not cover a large area, such as a house, office, monument, hospital, etc.
Receptor	Something that might suffer harm or damage as a result of a flood, such as a house, office, monument, hospital, agricultural land or environmentally designated sites.
Risk	The combination of the probability of flooding, and the consequences of a flood.

Figure 4.1: Example of Flood Map



Flood maps can be developed in a range of ways, using different levels of analysis. Detailed flood maps, such as that shown in figure 4.1, are developed using hydraulic modelling, which is a complex and expensive process, and is the level of analysis that is being, or will be, undertaken for the AFAs during the CFRAM Studies. However, for the PFRA, which is a screening exercise based on available or readily-derivable information, a simpler and less expensive process was required to prepare the flood mapping information.

At the outset of the PFRA, flood maps with a national coverage were not available for any source of flooding. This section outlines the processes undertaken to prepare indicative flood maps for a range of flood sources, as set out in Section 2.3.

It should be stressed that the PFRA flood maps are *indicative*. They have been developed using simple and cost-effective methods that are suitable for the PFRA. They should not be used for local decision-making or any other purpose without verification and seeking the advice of a suitable professional.

4.2.1. Indicative Fluvial Flood Mapping

A project was commissioned, and undertaken by Compass Informatics, to prepare indicative fluvial flood maps suitable for the PFRA. A Technical Report[6] describes the process for the development of these maps in detail. Set out below is a summary description of the process and the mapping produced.

[6] Preliminary Flood Risk Assessment, Fluvial Flood Hazard Mapping – Normal Depth Mapping, Compass Information, 2011

To determine fluvial flood levels and then flood extents, using any level of hydraulic analysis, estimates of the flood flows are required. The OPW generated flood flow estimates for a range of flood event probabilities at major nodes every 500m, and upstream and downstream of confluences, on the entire river network in the country (based on the EPA 'blue-line' GIS data). These were generated using equations derived through the OPW Flood Studies Update research programme. A typical Irish river will carry what is called the 'mean annual flood' in-bank, with flows greater than this spilling out as flood water. The out-of-bank, or flood, flow was hence determined at the nodes by deducting the mean annual flood flow from the derived flood flow for the relevant flood event probability.

At each major node, and at intermediate nodes at 100m spacing, a floodplain cross-section was derived from the OPW's national Digital Terrain Model (DTM), which is a computer model of the topography of surface of the land. A hydraulic calculation, using Manning's equation, was then used to calculate a flood level for the given out-of-bank flood flow, based on the cross-section, slope and resistance to flow. This level was extrapolated across the cross-section derived as above to identify the outer extents of the flood on that cross-section. The outer extents of the flood were then joined up (linearly) to create a map of the projected flood extents. This process was undertaken, for the national river network for all nodes with a catchment area greater than 1 km^2, for three flood event probabilities (the 10%, 1% and 0.1% AEP events) to create the indicative national fluvial flood maps.

It should be noted that the maps have certain limitations and potential sources of local error, notably:

- Local errors in the DTM: For example, where bank-side vegetation was not filtered out of the DTM, the flood levels are likely to be over-estimated
- Local channel works: The method assumes a certain channel capacity, so the flood levels are likely to be over-estimated where works have been carried out to enhance channel capacity (e.g., where arterial drainage schemes have been completed)
- Flood defences: The method does not take account of flood defences
- Channel structures: The method does not take account of structures in or over the channel, and so where such structures exist and constrict flow capacity, the flood levels may be under-estimated

Further, Some buildings and other infrastructure may be shown as being within the flooded area, but may in reality be above the flood level.

The indicative national fluvial flood maps were included in the Draft PFRA Maps, provided in a separate volume, for the purposes of consultation on the PFRA.

4.2.2. Indicative Seawater Flood Mapping

Consultants RPS, in conjunction with the OPW, undertook a project to develop maps indicating coastal and estuarine areas prone to flooding from the sea. The predicted flood extents which were produced under the Irish Coastal Protection Strategy Study (ICPSS)[7] are based on analysis and modelling. The project included:

- Analysis of historic recorded sea levels
- Numerical modelling and statistical analysis of combined tide levels and storm surges to estimate extreme water levels along the national coastline for defined probabilities
- Calculation of the extent of the predictive flooding, by comparing calculated extreme tide and surge waters levels along the coast with ground level based on a Digital Terrain Model (DTM).

The maps have been produced at a strategic level to provide an overview of coastal flood hazard and risk in Ireland. It should be noted that the maps have certain limitations and potential sources of local error, notably:

- The flood extents are determined by horizontal projection in-land of the extreme sea levels. This may over-estimate the extent of flooding in large, flat areas as the method does not account for the inland propagation and then recession of the flooding following the rise and fall of the water levels according to the tidal cycle
- Flood defences, structures in or around river channels and other minor or local features have not been included in the preparation of the maps
- The methods (and maps) do not take account of (or represent flooding from) wave action or overtopping

These indicative national coastal flood maps were included in the Draft PFRA Maps, provided in a separate volume, for the purposes of consultation on the PFRA.

4.2.3. Indicative Groundwater Flood Mapping

A project was commissioned, and undertaken by Mott MacDonald Ltd, to prepare indicative groundwater flood maps suitable for the PFRA. A Technical Report[8] describes the process for the development of these maps in detail. Set out below is a summary description of the process and the mapping produced.

The methodology used to map areas potentially prone to groundwater flooding was evidence-based and incorporates the experience of groundwater experts at the Geological Survey of Ireland, Trinity College Dublin, and the Environmental Protection Agency. The evidence indicates that the vast majority of extensive, recurring groundwater floods originate at turloughs, and so this was the focus of the groundwater mapping project.

---

[7] Irish Coastal Protection Strategy Study, Phase 2, 3a and 3b – South East, North East and South Coasts – Technical Reports, RPS Consultants, 2010 & 2011

[8] Preliminary Flood Risk Assessment, Groundwater Flooding, Mott Macdonald, 2010

Project Title: **Preliminary Flood Risk Assessment**

Fluvial Flood Hazard Mapping-

Normal Depth Method

Client: **Office of Public Works**

Authors **Paul Mills (Compass Informatics Ltd)**
Anthony Badcock (Mott McDonald Ltd)

Status: **Final Draft – July 2011**

Revision History

Version	Description	Author	Date
1.0	Original draft	P. Mills	3/08/2010
2.0	Final Draft	P. Mills / A. Badcock	07/07/2011

Sign Off

Organisation	Name	Position	Date
Compass Informatics	G O Riain	Director	07/07/2011

2.4 Calculation of Floodplain Flows at Ungauged Nodes for Design Events

2.4.1 Summary of Process for Flow Calculation

Estimates of floodplain flow values for the 10%, 1% and 0.1 AEP events at the ungauged nodes were provided by OPW. These have been derived through the FSU project component studies, including the analysis of GIS derived parameters (FSU 5-3 Physical Catchment Descriptors project), the Base Flow Index project (FSU 5-2) and other FSU work-packages.

The process followed by OPW to estimate floodplain flow was:

- Calculation of the median flow (Q_{med}) at each ungauged node, which is assumed to approximate the bankfull in-channel flow. The Q_{med} values were adjusted to account for the proportion of urban land cover upstream of the target node and had correction factors applied as determined from the FSU project.

- Calculation of the specific design event flows at each node, scaled from the Q_{med} flow using the statistical growth curve for Republic of Ireland and thereby generating the following total flow values for each node: Q_{10}, Q_{100}, Q_{1000}.

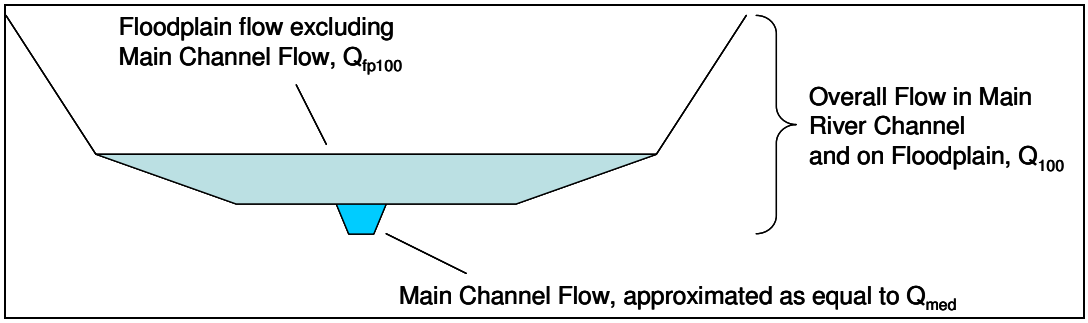
- Calculation of the floodplain flow (Q_{fp}) for each event from the subtraction of the adjusted Q_{med} value from the design flow at each ungauged node.

- This process results in three sets of floodplain flows, Q_{fp10}, Q_{fp100}, Q_{fp1000} corresponding to the different design flood events.

- Calculation of a notional maximum flow at each ungauged node for the calculations, $Q_{fpMax.}$ This was determined by multiplying the Q_{fp1000} flows at each node by a factor of 1.3. This process provided some degree of future proofing for the water level and flow data at each node, considering any potential need in the future for the generation of flood polygons for climate change scenarios, for example.

The schematic in Figure 4 shows how these divisions between the floodplain and channel flow conditions have been applied for the example of 1% AEP flood event.

Figure 4 Schematic showing Components of the Cross-sections



APPENDIX C

IH124 Outputs

B861 - Bearna

Institute of Hydrology Report No.124
0.5km^2 < Catchment Area < 25km^2

Date: 15/05/2020
Calcs by: Niall Mc Menamin
Checked by: Andrew McDermott

$Q_{BAR} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$

Global Variables		***Trusky East***
AREA	km^2	1.79
SAAR	mm	1250
SOIL		0.3
URBAN	Fraction	0
CWI	Graph	125

$$\frac{\overline{Q_u}}{\overline{Q_r}} = (1 + URBAN)^{2\,NC} \left(1 + URBAN\left(\frac{21}{CIND} - 0.3\right)\right)$$

$$CIND = 102.4SOIL + 0.28(CWI - 125)$$

$$NC = 0.74 - 0.000082\ SAAR$$

[For 1100 < SAAR < 3000mm]

$Q_{BAR\ RURAL}$	m^3/s	0.559
Factorial Standard Error		1.651
$Q_{BAR\ RURAL}$	m^3/s	0.922
CIND		30.720
NC		0.638
$Q_{bar\ URBAN}$	m^3/s	0.922

Not Applicable

Return Period (years)	GDSDS Growth Curve			FSR Irish Growth Curve		
	Growth Factor	Design Flow (m^3/s)		Growth Factor	Design Flow (m^3/s)	
		Current Climate	Future Climate (+20%)		Current Climate	Future Climate (+20%)
1	0.85	0.78	0.94	0.85	0.78	0.94
2	0.92	0.85	1.01	0.95	0.88	1.05
2.33	1.00	0.92	1.11	1.00	0.92	1.11
5	1.37	1.26	1.52	1.20	1.11	1.33
10	1.67	1.54	1.85	1.37	1.26	1.52
20	1.96	1.81	2.17	1.54	1.42	1.70
100	2.61	2.41	2.89	1.96	1.81	2.17
200	2.89	2.66	3.20	2.14	1.97	2.37
1000	3.53	3.26	3.91	2.60	2.40	2.88

APPENDIX D

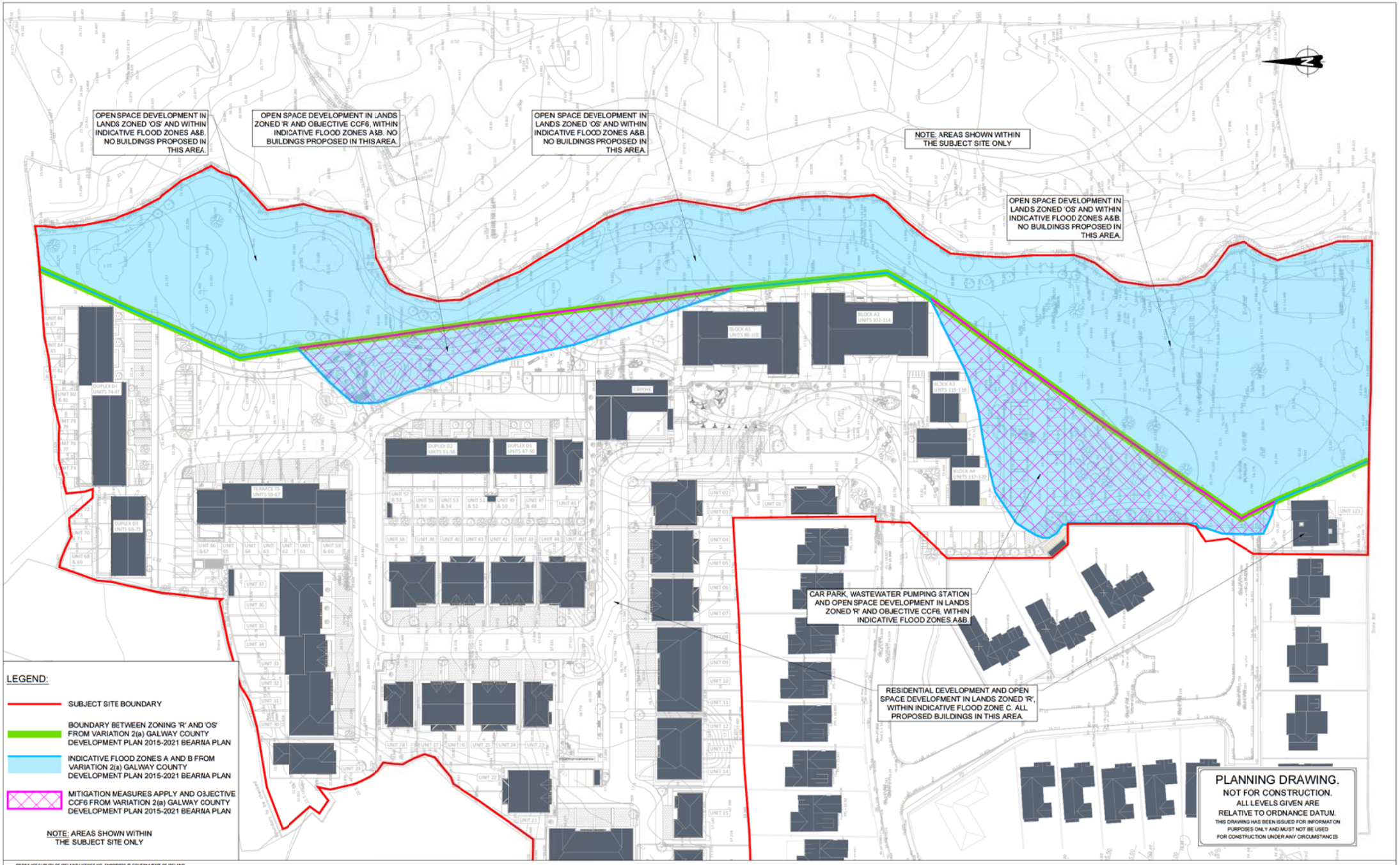
HEC-RAS Model Outputs

HEC-RAS Plan: Plan 01 River: Trusky East Reach: Trusky East

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Trusky East	430.7	Current_1.0	1.81	22.13	22.74	22.74	22.83	0.017000	1.51	1.62	9.54	0.74
Trusky East	430.7	Current_0.1	2.40	22.13	22.79	22.79	22.89	0.016849	1.59	2.17	11.71	0.74
Trusky East	430.7	Future_1.0	2.17	22.13	22.77	22.77	22.87	0.016786	1.55	1.96	10.96	0.74
Trusky East	430.7	Future_0.1	2.88	22.13	22.82	22.82	22.92	0.016661	1.63	2.60	13.18	0.74
Trusky East	408.8	Current_1.0	1.81	21.19	21.90	21.90	22.12	0.036123	2.09	0.87	2.04	0.99
Trusky East	408.8	Current_0.1	2.40	21.19	22.02	22.02	22.25	0.030059	2.15	1.16	2.91	0.93
Trusky East	408.8	Future_1.0	2.17	21.19	21.97	21.97	22.20	0.032108	2.13	1.04	2.59	0.95
Trusky East	408.8	Future_0.1	2.88	21.19	22.11	22.11	22.33	0.023280	2.11	1.52	4.40	0.84
Trusky East	379.1	Current_1.0	1.81	20.41	20.99	20.99	21.07	0.015192	1.50	1.86	11.06	0.71
Trusky East	379.1	Current_0.1	2.40	20.41	21.03	21.03	21.12	0.015813	1.62	2.36	12.80	0.74
Trusky East	379.1	Future_1.0	2.17	20.41	21.02	21.02	21.10	0.015610	1.58	2.17	12.16	0.73
Trusky East	379.1	Future_0.1	2.88	20.41	21.06	21.06	21.15	0.016546	1.72	2.72	13.92	0.76
Trusky East	357.4	Current_1.0	1.81	19.91	20.59	20.59	20.68	0.013008	1.41	1.87	13.96	0.65
Trusky East	357.4	Current_0.1	2.40	19.91	20.64	20.64	20.72	0.011884	1.45	2.71	18.41	0.64
Trusky East	357.4	Future_1.0	2.17	19.91	20.63	20.63	20.71	0.011443	1.40	2.48	17.30	0.62
Trusky East	357.4	Future_0.1	2.88	19.91	20.67	20.67	20.75	0.012877	1.55	3.15	20.35	0.67
Trusky East	325.0	Current_1.0	1.81	19.39	19.91	19.91	20.02	0.020746	1.59	1.41	7.37	0.83
Trusky East	325.0	Current_0.1	2.40	19.39	19.97	19.97	20.08	0.018179	1.65	1.94	9.97	0.80
Trusky East	325.0	Future_1.0	2.17	19.39	19.95	19.95	20.06	0.019002	1.63	1.73	9.03	0.81
Trusky East	325.0	Future_0.1	2.88	19.39	20.01	20.01	20.12	0.017453	1.71	2.35	11.56	0.79
Trusky East	290.5	Current_1.0	1.81	18.51	19.12	19.08	19.14	0.006223	0.92	3.77	28.63	0.44
Trusky East	290.5	Current_0.1	2.40	18.51	19.17		19.18	0.004443	0.83	5.22	29.88	0.38
Trusky East	290.5	Future_1.0	2.17	18.51	19.15		19.16	0.005025	0.86	4.65	29.39	0.40
Trusky East	290.5	Future_0.1	2.88	18.51	19.20	19.12	19.22	0.003723	0.80	6.30	30.77	0.35
Trusky East	242.5	Current_1.0	1.81	17.64	18.53		18.67	0.016756	1.61	1.18	2.92	0.66
Trusky East	242.5	Current_0.1	2.40	17.64	18.60	18.52	18.77	0.020207	1.88	1.40	4.26	0.74
Trusky East	242.5	Future_1.0	2.17	17.64	18.58	18.46	18.73	0.018464	1.77	1.33	3.77	0.70
Trusky East	242.5	Future_0.1	2.88	17.64	18.65	18.65	18.85	0.020989	2.02	1.66	5.67	0.76
Trusky East	219.0	Current_1.0	1.81	17.33	17.91	17.91	18.11	0.034251	1.98	0.91	2.35	1.01
Trusky East	219.0	Current_0.1	2.40	17.33	18.03	18.03	18.23	0.026732	1.99	1.26	3.79	0.92
Trusky East	219.0	Future_1.0	2.17	17.33	17.98	17.98	18.19	0.029910	2.01	1.10	3.17	0.96
Trusky East	219.0	Future_0.1	2.88	17.33	18.10	18.10	18.30	0.023121	2.00	1.58	4.93	0.87
Trusky East	187.9	Current_1.0	1.81	16.36	16.86	16.86	17.04	0.033978	1.88	0.96	2.68	1.00
Trusky East	187.9	Current_0.1	2.40	16.36	16.94	16.94	17.15	0.033048	2.01	1.19	2.92	1.01
Trusky East	187.9	Future_1.0	2.17	16.36	16.91	16.91	17.11	0.033559	1.97	1.10	2.83	1.01
Trusky East	187.9	Future_0.1	2.88	16.36	17.07	17.07	17.12	0.009004	1.18	4.74	49.13	0.54
Trusky East	149.4	Current_1.0	1.81	15.30	15.87	15.87	15.99	0.021053	1.65	1.32	5.89	0.83
Trusky East	149.4	Current_0.1	2.40	15.30	15.93	15.93	16.06	0.020628	1.76	1.71	7.09	0.84
Trusky East	149.4	Future_1.0	2.17	15.30	15.91	15.91	16.04	0.020943	1.72	1.56	6.59	0.84
Trusky East	149.4	Future_0.1	2.88	15.30	15.97	15.97	16.11	0.019853	1.84	2.03	8.07	0.83
Trusky East	117.1	Current_1.0	1.81	14.53	15.42		15.43	0.002569	0.74	4.28	20.04	0.29
Trusky East	117.1	Current_0.1	2.40	14.53	15.49		15.50	0.002135	0.73	5.90	23.95	0.27
Trusky East	117.1	Future_1.0	2.17	14.53	15.47		15.48	0.002229	0.73	5.32	22.63	0.27
Trusky East	117.1	Future_0.1	2.88	14.53	15.54		15.55	0.002011	0.73	7.03	26.35	0.26
Trusky East	89.6	Current_1.0	1.81	14.48	15.06	15.06	15.24	0.033337	1.91	0.95	2.60	1.01
Trusky East	89.6	Current_0.1	2.40	14.48	15.17	15.17	15.35	0.023191	1.88	1.37	5.17	0.88
Trusky East	89.6	Future_1.0	2.17	14.48	15.12	15.12	15.31	0.028867	1.94	1.14	3.72	0.96
Trusky East	89.6	Future_0.1	2.88	14.48	15.25	15.25	15.41	0.018039	1.84	1.85	7.36	0.80
Trusky East	61.9	Current_1.0	1.81	13.54	14.19	14.15	14.38	0.028990	1.92	0.94	1.97	0.89
Trusky East	61.9	Current_0.1	2.40	13.54	14.29	14.25	14.52	0.031363	2.13	1.13	2.11	0.93
Trusky East	61.9	Future_1.0	2.17	13.54	14.25	14.21	14.47	0.030434	2.05	1.06	2.06	0.91
Trusky East	61.9	Future_0.1	2.88	13.54	14.35	14.33	14.61	0.033211	2.28	1.26	2.21	0.96
Trusky East	35.4	Current_1.0	1.81	12.93	13.39	13.39	13.57	0.032748	1.87	0.97	2.74	1.01
Trusky East	35.4	Current_0.1	2.40	12.93	13.47	13.47	13.67	0.031684	2.01	1.20	2.95	1.01
Trusky East	35.4	Future_1.0	2.17	12.93	13.44	13.44	13.63	0.032051	1.96	1.11	2.87	1.01
Trusky East	35.4	Future_0.1	2.88	12.93	13.53	13.53	13.75	0.031033	2.10	1.37	3.10	1.01
Trusky East	0.0	Current_1.0	1.81	11.74	12.30	12.16	12.38	0.012005	1.28	1.41	3.33	0.63
Trusky East	0.0	Current_0.1	2.40	11.74	12.39	12.24	12.49	0.012001	1.39	1.73	3.59	0.64
Trusky East	0.0	Future_1.0	2.17	11.74	12.35	12.21	12.45	0.012002	1.35	1.61	3.49	0.63
Trusky East	0.0	Future_0.1	2.88	11.74	12.45	12.29	12.56	0.012014	1.46	1.98	3.77	0.64

APPENDIX E

Report Drawings



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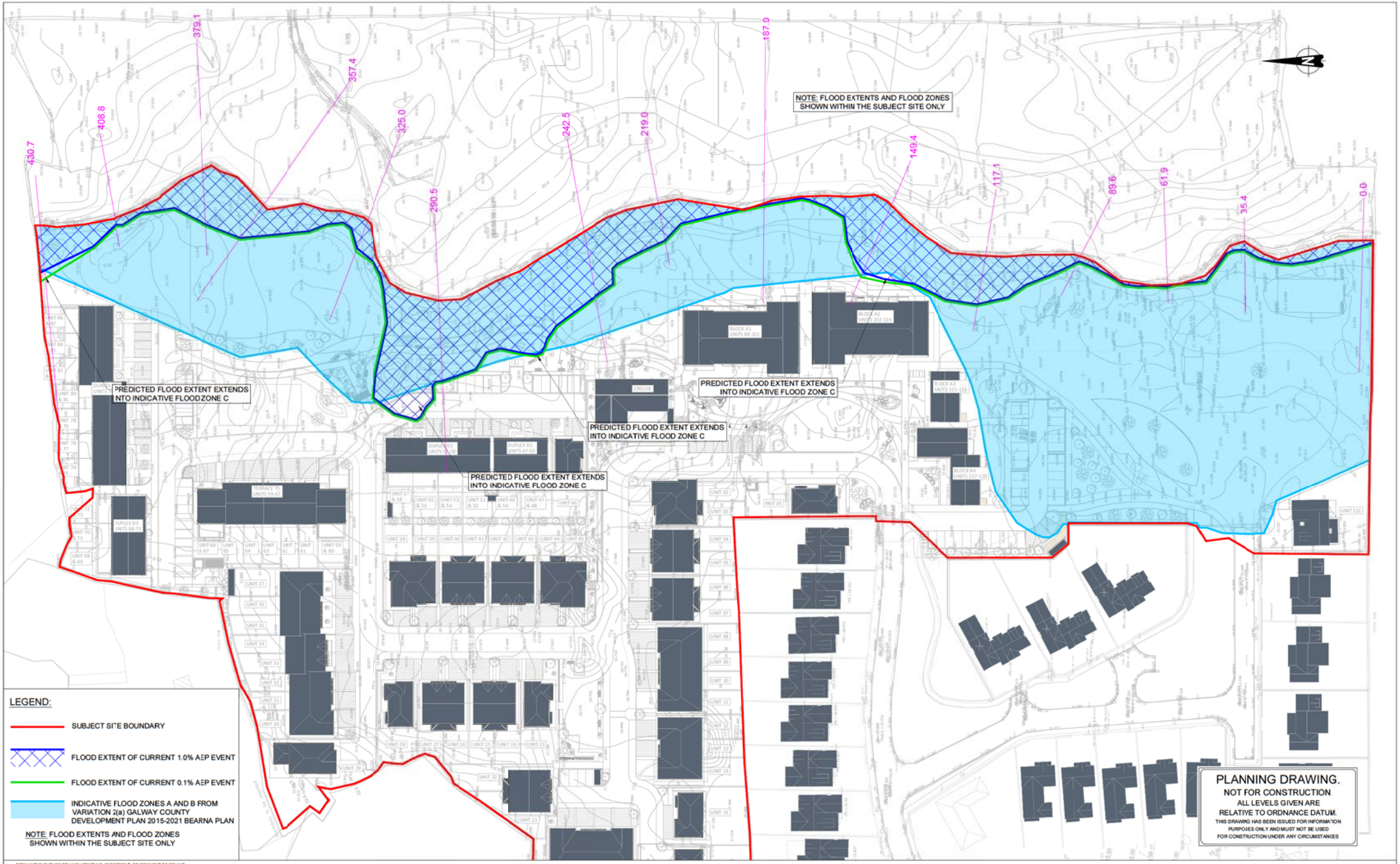
Client: BURKEWAY HOMES LTD
Project: RESIDENTIAL DEVELOPMENT AT TRUSKY EAST, BEARNA
Title: TRUSKY EAST STREAM FLOOD RISK DEVELOPMENT PLAN ZONING AND OBJECTIVES

Code	Originator	Zone	Level	Type	Role	Number	Status	Revision
B861	OCSC	XX	XX	DR	C	2800	A1	C01

Date: 15.05.20 Scale:1:500 @ A1 Drn by:QA Chkd by:NMM Aprvd by:AMD



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Rev No.	Date	Revision Note	Drn by	Chkd by
C01	16.07.20	ISSUED FOR PLANNING	QA	NMM

Rev No.	Date	Revision Note	Drn by	Chkd by

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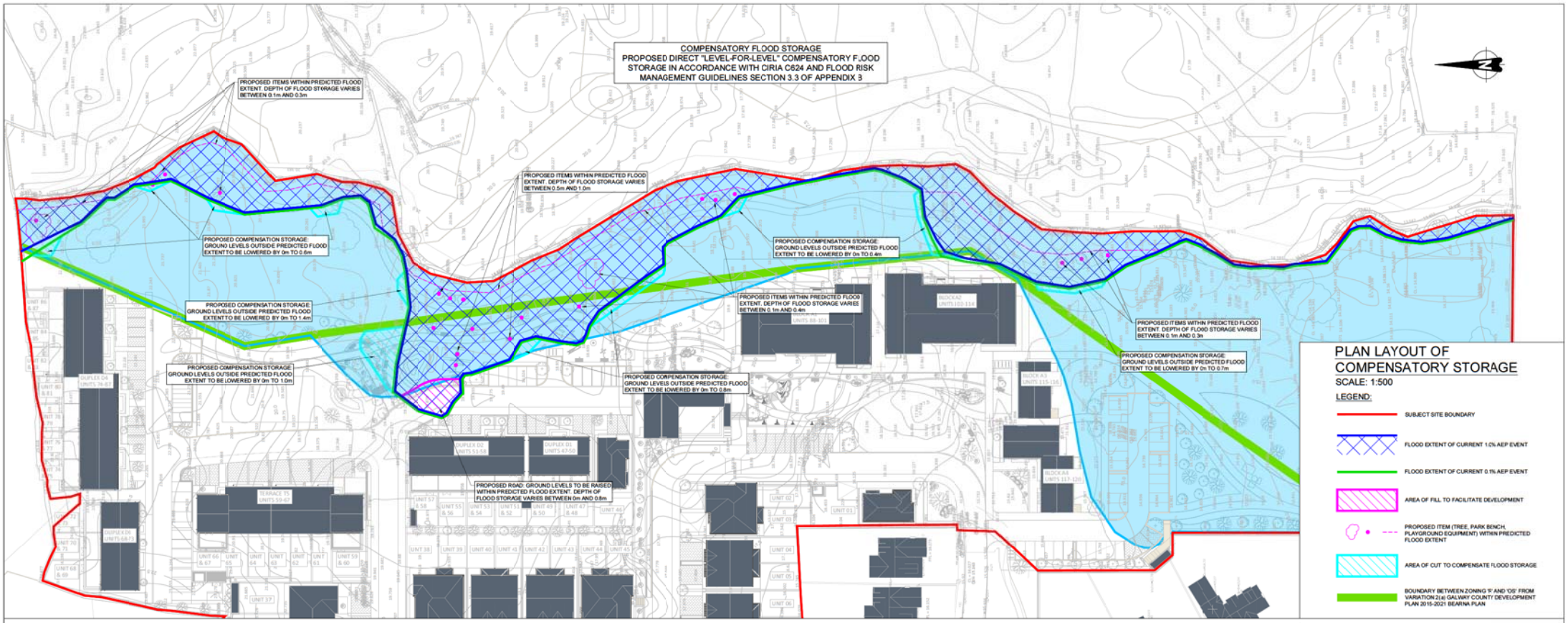
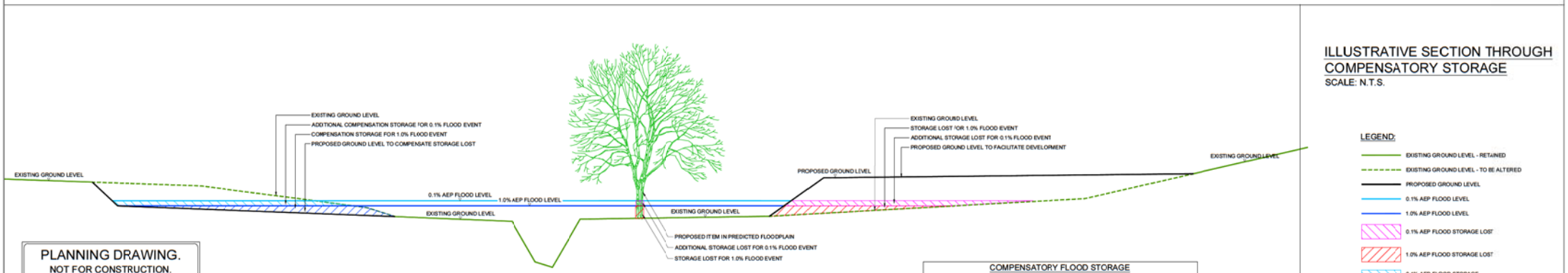
Client: BURKEWAY HOMES LTD
Project: RESIDENTIAL DEVELOPMENT AT TRUSKY EAST, BEARNA
Title: TRUSKY EAST STREAM FLOOD RISK EXISTING FLOOD EXTENTS CURRENT CLIMATE SCENARIO

Code	Originator	Zone	Level	Type	Role	Number	Status	Revision
B861	OCSC	XX	XX	DR	C	2801	A1	C01

Date: 15.05.20 Scale: 1:500 @ A1 Drn by:QA Chkd by:NMM Aprvd by:AMD





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ILLUSTRATIVE SECTION THROUGH COMPENSATORY STORAGE
SCALE: N.T.S.

COMPENSATORY FLOOD STORAGE
PROPOSED DIRECT "LEVEL-FOR-LEVEL" COMPENSATORY FLOOD STORAGE IN ACCORDANCE WITH CIRIA C624 AND FLOOD RISK MANAGEMENT GUIDELINES SECTION 3.3 OF APPENDIX B

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Client: BURKEWAY HOMES LTD
Project: RESIDENTIAL DEVELOPMENT AT TRUSKY EAST, BEARNA
Title: TRUSKY EAST STREAM FLOOD RISK COMPENSATORY STORAGE

Code	Originator	Zone	Level	Type	Role	Number	Status	Revision
B861	OCSC	XX	XX	DR	C	2802	A1	C01

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