Appendix 14-1 Site Specific Flood Risk Assessment

SITE SPECIFIC FLOOD RISK ASSESSMENT

GLENAMUCK DISTRICT ROADS SCHEME

FEBRUARY 2019

DBFL Consulting Engineers

Job Title: **Glenamuck District Roads Scheme**

Job Number: **170172**

Report Title: **SITE SPECIFIC FLOOD RISK ASSESSMENT - GLENAMUCK DISTRICT ROADS SCHEME**

Report Reference: **EIAR Appendix 14.1**

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Revision	Issue Date	Description	Prepared	Reviewed	Approved
-	2019-02-28	Issue for Planning	JPC	KJS	DJR

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1.0 INTRODUCTION

1.1 Background

DBFL Consulting Engineers been appointed as designers of the Glenamuck District Roads Scheme (GDRS) by Dun Laoghaire Rathdown County Council (DLRCC). The roads scheme is set out in the Kiltiernan Glenamuck Local Area Plan (LAP) and is also included in the Dun Laoghaire-Rathdown County Council County Development Plan 2016–2022 as a Six–Year Road Objective. The scope of work for DBFL is to develop the roads objective set out in the LAP through Preliminary Design, Detailed Design, Planning, Compulsory Purchases, Tender, Construction and Handover. An Environmental Impact Assessment (EIA) is required as part of the statutory planning process. This Site Specific Flood Risk Assessment (SSFRA) was prepared to support the identification and assessment of flood risk to support the EIA process and forms part of proposed planning application for the subject site.

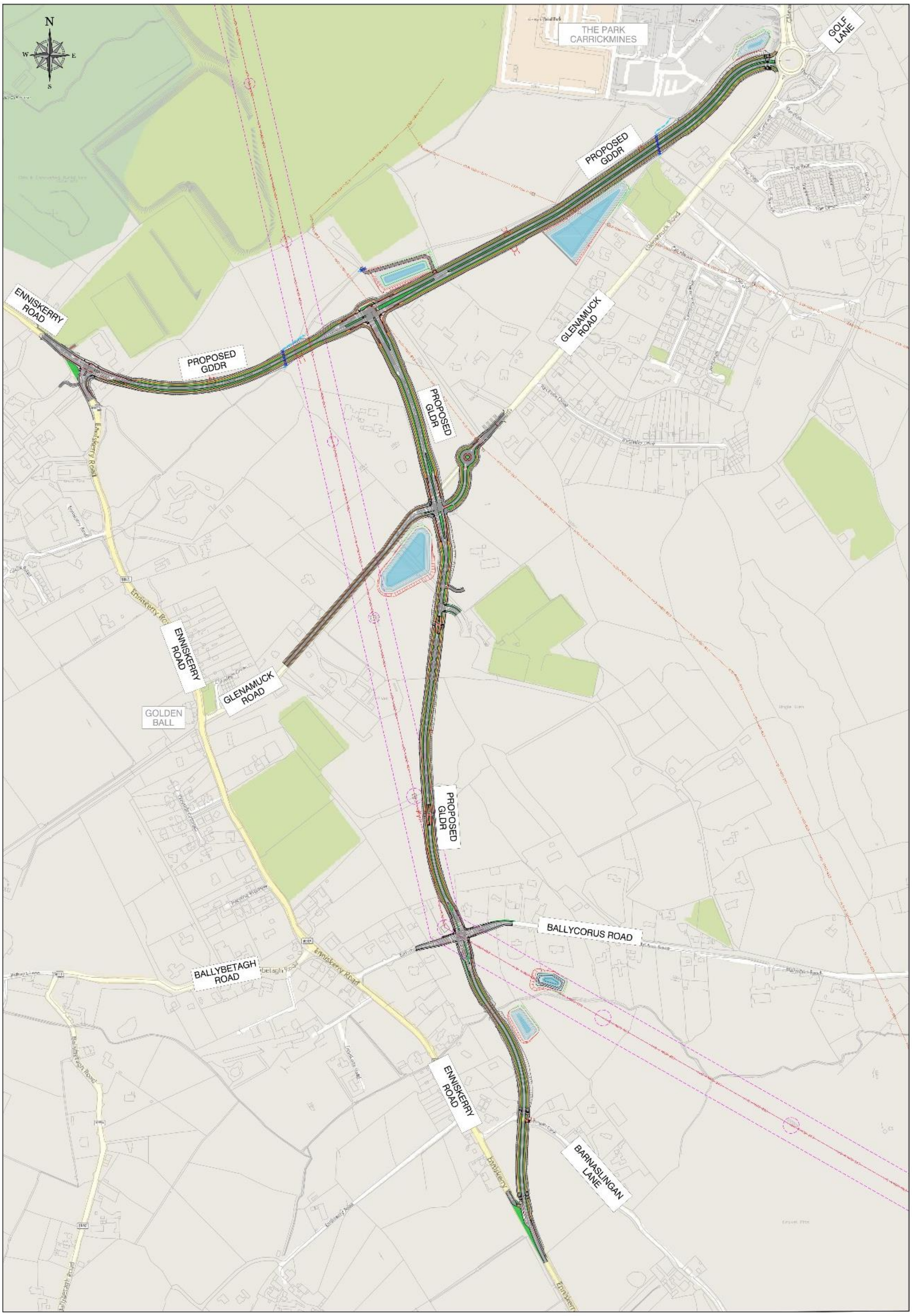


Figure 1-1 - Context Plan

1.2 Objectives

The objectives of this report are to inform the planning authority regarding flood risk for the potential development of the lands. The report will assess the site and development proposals in general accordance the requirements of *“The Planning System and Flood Risk Management Guidelines for Planning Authorities”*.

The report will provide the following;

- The site’s flood zone category.
- Information to allow an informed decision of the planning application in the context of flood risk.
- Appropriate flood risk mitigation and management measures for any residual flood risk

1.3 Flood Risk Assessment Scope

This SSFRA relates only to the proposed scheme and its immediate surroundings. This report uses information obtained from various sources, together with an assessment of flood risk for the existing land and proposed development. The report follows the requirements of ‘The Planning System & Flood Risk Management – Guidelines for Planning Authorities’, (referred to as the Guidelines for the remainder of this report).

1.4 Approach

Chapter 2 of this report considers ‘*The Planning System & Flood Risk Management – Guidelines for Planning Authorities*’ as they relate to the proposed application.

Flood risk identification is presented in Chapter 3 and initial flood risk assessment in Chapter 4.

Conclusions and recommendations are presented in Chapter 5.

1.5 Existing Site

The proposed development site is located in south County Dublin, west of the M50 generally within the townlands of Carrickmines, Glenamuck and Kiltiernan. The entire scheme is within in the administrative area of Dun Laoghaire Rathdown County Council.

With the exception of interfaces with existing roads/parking areas the entire scheme extents is currently agricultural land.

The scheme lies entirely within the catchment of the Loughlinstown River (also known as the Shanganagh River and Bridesglen River). The study area affects two primary hydrological subcatchments. Southern Portions of the scheme are within the “Shanganagh” Sub-catchment (EPA Ref: IE/EA/10S010600) and northern portions are in the “Carrickmines Stream” sub-catchment (EPA Ref: IE/EA/10C040350). The Carrickmines Stream merges with the Loughlinstown River upstream of its discharge to the Irish Sea at Shanganagh

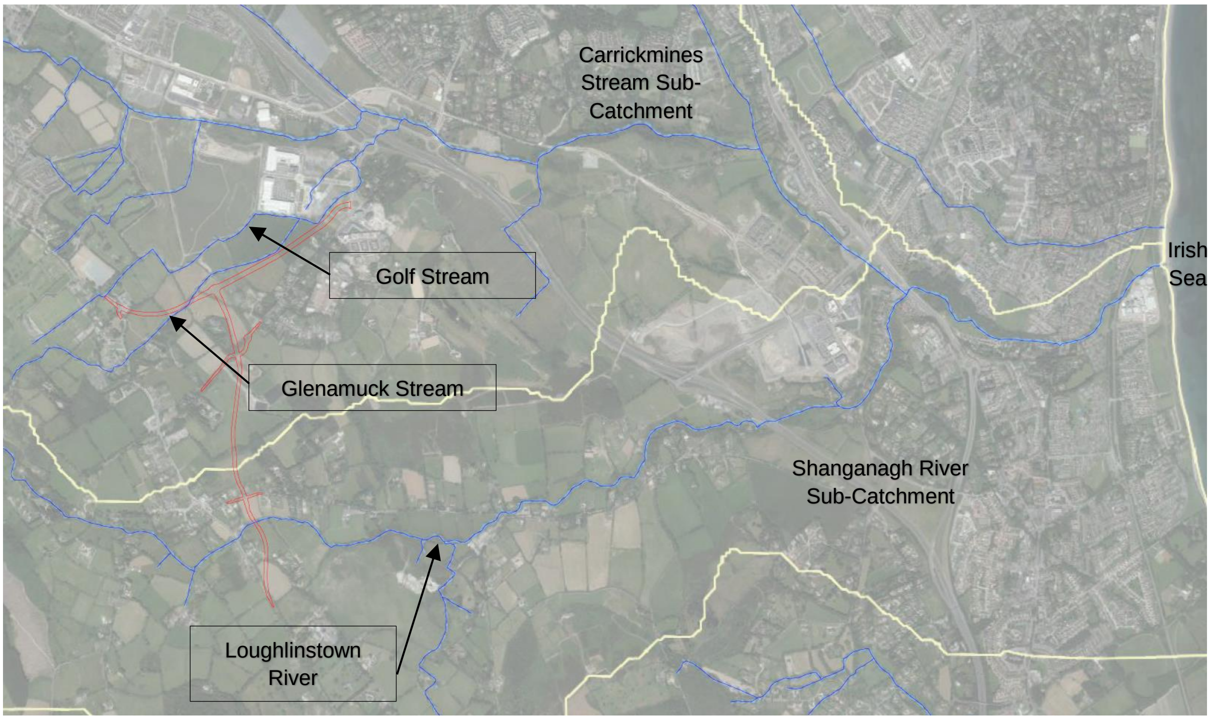


Figure 1-2: Catchments

In the direct vicinity of the roads scheme there are a number of minor tributaries of the Loughlinstown River. These include the headwater channel of the Loughlinstown River, Glenamuck Stream, Golf Stream & some minor field and roadside drainage channels. The local hydrological features are presented in Figure 1-2 & Figure 1-4.

1.5.1 Existing Watercourse Crossings

There are a number of existing culverts on the reach of the Glenamuck Stream adjacent to the scheme as depicted in Figure 1-3. The only existing crossing on the Loughlinstown River in the vicinity of the scheme is the existing bridge over Enniskerry Road located over 100m upstream of the scheme.

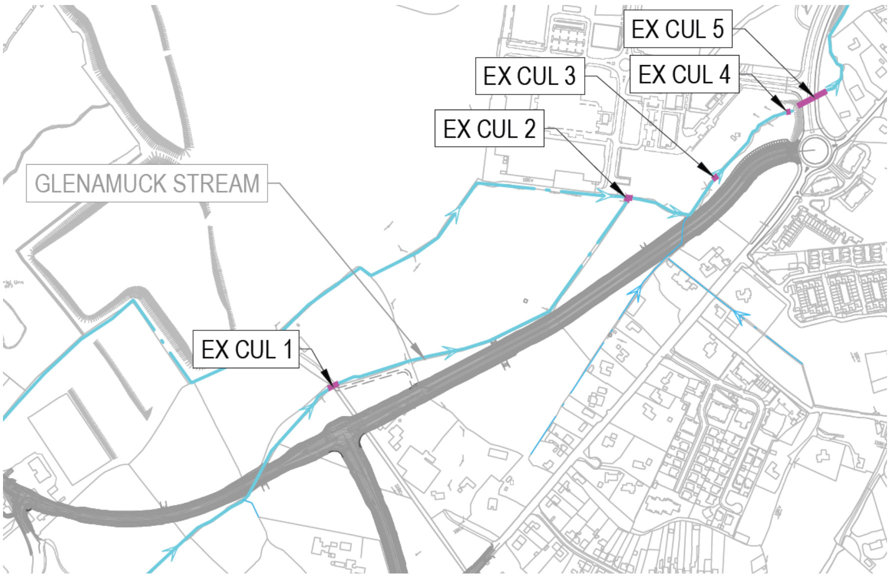


Figure 1-3: Glenamuck Stream - Existing Culverts

1.6 Proposed Development

The scheme consists of two proposed roads. The Glenamuck District Distributor Road (GDDR) connects from the Enniskerry Road adjacent to De La Salle Palmerstown Rugby Club to a tie in at the Glenamuck Road East/Golf Lane Roundabout. The Glenamuck Link Distributor Road (GLDR) connects from the approximate midpoint of the GDDR to the Enniskerry Road south of Kiltiernan and will connect the new distributor road with the existing Glenamuck Road, Ballycorus Road and Barnaslingan Lane. The scheme will involve;

- Clearance of the existing site
- Creation of cut slopes and fill embankments to proposed grade,
- Installation of watercourse crossings (see 1.6.1)
- Creation of surface water attenuation ponds
- Installation of various utilities, signage, traffic signals
- Placement of road gravels and concrete/bituminous surfaces
- Landscaping of verges, slopes and ponds. Placement of trees, scrubs, surfacing, soils seeding etc. Construction of permanent boundary treatments
- Various ancillary works

A detailed description of the scheme is presented in Chapter 5 of the EIAR.

1.6.1 Proposed Watercourse Crossings

The proposed scheme will require a new crossing of a branch of the Loughlinstown River, two crossings of the Glenamuck Stream and a crossing of an unnamed watercourse. Locations of proposed crossings are shown in Figure 1-4 and preliminary details of proposed watercourse crossings are shown in EIAR Volume 3 Figures 14-1 to 14-5.

Table 1-1: Watercourse Crossing (WX) Schedule

Crossing Ref	Crossing Type	Watercourse	Status
WX-01	Box Culvert	Glenamuck Stream	New
WX-02	Box Culvert	Glenamuck Stream	Replacement *[Ex Cul 1]*
WX-03	Box Culvert	Unnamed Drain	New
WX-04	Bridge	Loughlinstown River	New

All existing watercourse crossings (with the exception of Ex Cul 1) are assumed to remain in place and be unaffected by the proposed works.

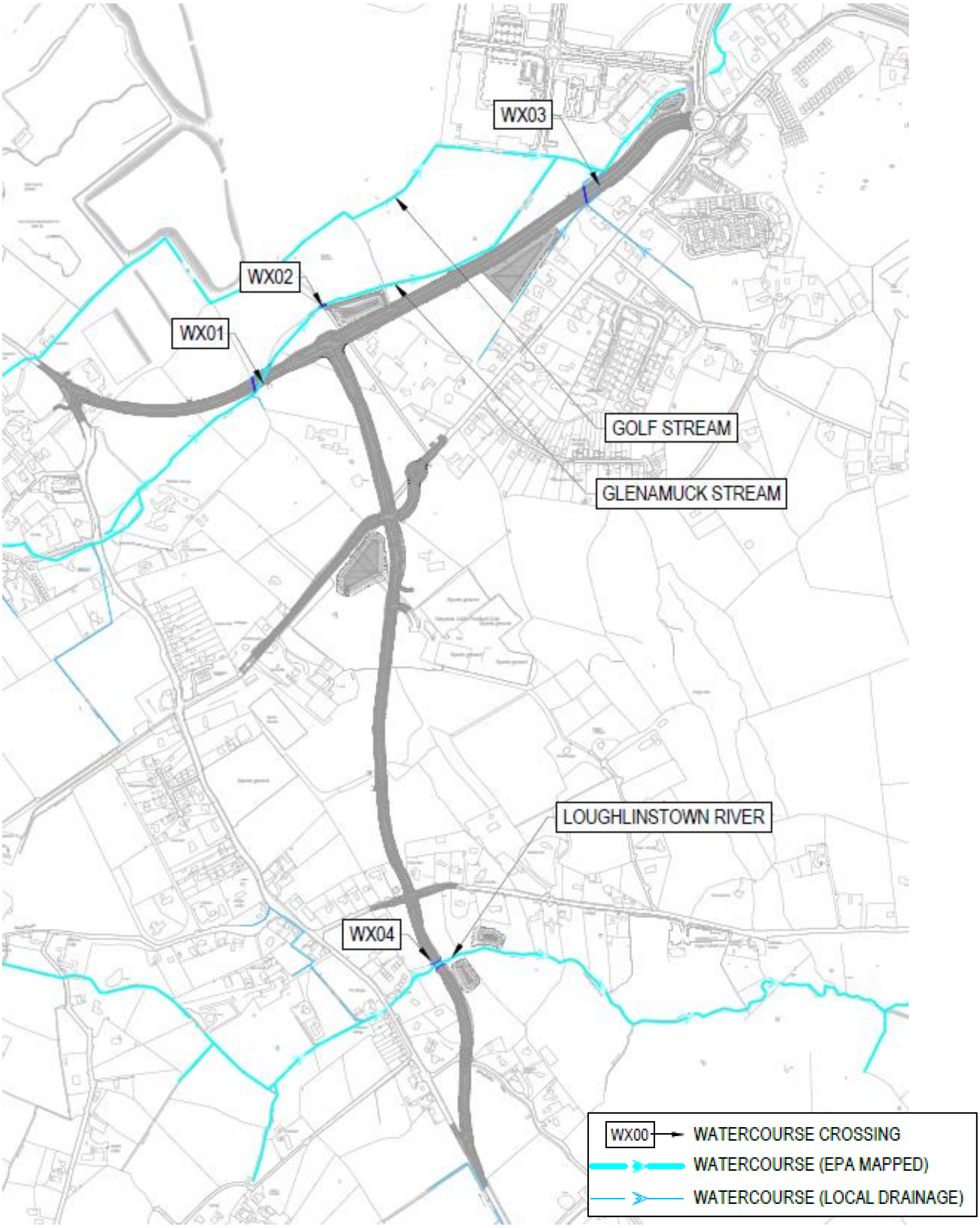


Figure 1-4: Hydrological Setting and Proposed Watercourse Crossings

2.0 PLANNING GUIDELINES & FLOOD RISK ASSESSMENT

2.1 The Planning System and Flood Risk Management, Guidelines for Planning Authorities

The FRM Guidelines provide "mechanisms for the incorporation of flood risk identification, assessment and management into the planning process….". They ensure a consistent approach throughout the country requiring identification of flood risk and flood risk assessment to be key considerations when preparing development plans, local area plans and planned development.

"The core objectives of The FRM Guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and
- Ensure the requirements of EU and national law in relation to the natural environment and nature conservation are complied with for flood risk management."

The key principles of The FRM Guidelines are to apply the Sequential Approach to the planning process i.e.;

- "Avoid the risk, where possible,
- Substitute less vulnerable uses, where avoidance is not possible, and
- Mitigate and manage the risk, where avoidance and substitution are not possible."

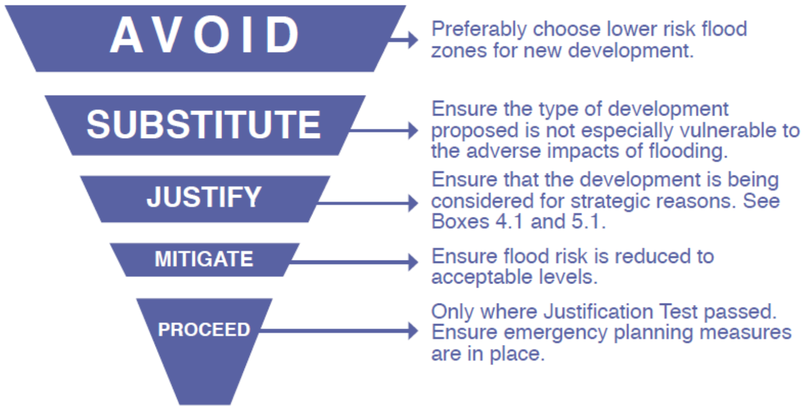


Figure 2-1: Sequential Approach Principles in Flood Risk Management

Where the *Sequential Test's* **avoid** and **substitute** principals are not appropriate then the FRM Guidelines propose that a *Justification Test* be applied to assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk.

2.2 Flood Risk Assessment Methodology

The assessment of flood risk requires an understanding of where water comes from (the source), how and where it flows (the pathways) and the people and assets affected by it (the receptors).

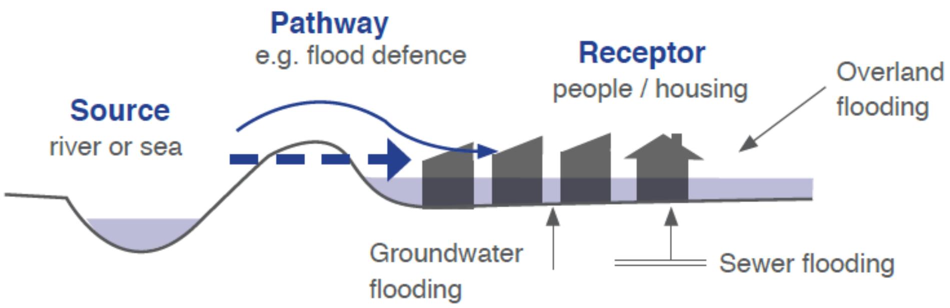


Figure 2-2 - Source-Pathway-Receptor Model

The principal sources are rainfall or higher than normal sea levels. The principal pathways are rivers, drains, sewers, overland flow and river and coastal floodplains and their defence assets. The receptors can include people, their property and the environment. All three elements are examined as part of the flood risk assessment including the vulnerability and exposure of receptors to determine potential consequences. Mitigation measures typically used in development management can reduce the impact of flooding on people and communities e.g. by blocking or impeding pathways. The planning process is primarily concerned with the location of receptors and potential sources and pathways that might put those receptors at risk.

Risks to people, property and the environment should be assessed over the full range of probabilities, including extreme events. Flood risk assessment should cover all sources of flooding, including effects of run-off from a development locally and beyond the development site.

2.3 Flood Zones

The FRM Guidelines use flood zones to determine the likelihood of flooding and for flood risk management within the planning process. The three flood zones levels are:

- Flood Zone A – where the probability of flooding from rivers and the sea is highest (greater than 1% AEP (Annual Exceedance Probability) or 1 in 100 for river flooding;
- Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% AEP or 1 in 1000 and 1% AEP or 1 in 100 for river flooding); and

- Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% AEP or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas outside zones A and B.

The FRM Guidelines categorises all types of development as either;

- Highly Vulnerable e.g. dwellings, hospitals, fire stations, essential infrastructure,
- Vulnerable e.g. retail, commercial or industrial buildings, local transport infrastructure,
- Water Compatible e.g. flood infrastructure, docks, amenity open space.

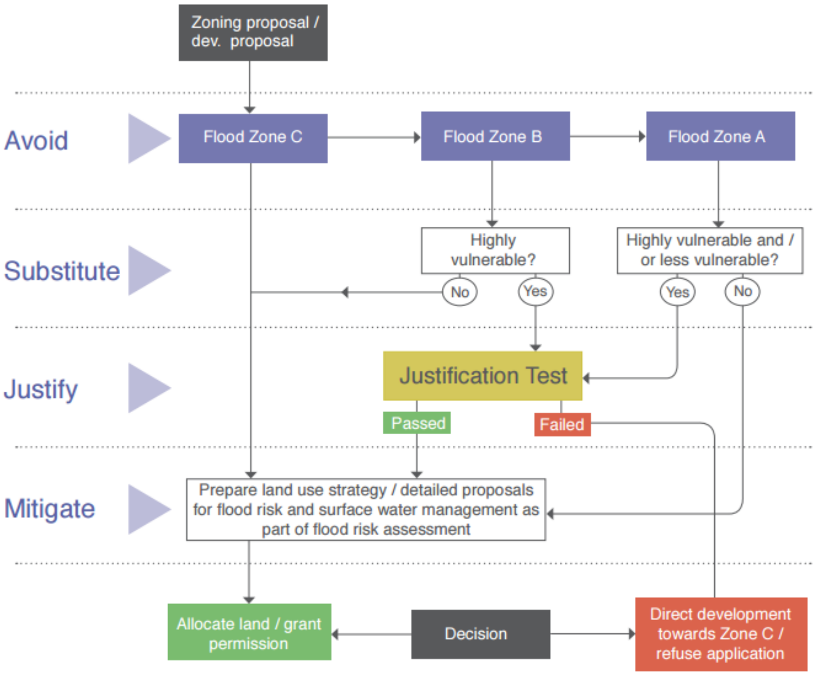


Figure 2-3: Sequential Approach mechanism in the Planning Process

2.4 Vulnerability v Flood Zone

The Sequential Approach restricts development types to occur within the flood zone appropriate to their vulnerability class, see Table 3.1.

	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 2.1 *– Matrix of Vulnerability versus Flood Zone to illustrate appropriate development and that required to meet the Justification Test*

2.5 Proposed Development's Vulnerability

The proposed type of development for this site is to be local transport infrastructure which is categorised by the Guidelines as **less vulnerable** development and appropriate to be located within Flood Zones C or B. This type of development may also be compatible with flood zone category A depending on its performance in a site justification test.

2.6 Site Specific Flood Risk Assessment for Development

The FRM Guidelines require a SSFRA to "gather relevant information sufficient to identify and assess all sources of flood risk and the impact of drainage from the proposal". It should "quantify the risks and the effects of any necessary mitigation, together with the measures needed or proposed to manage residual risks". It considers the nature of flood hazard, taking account of the presence of any flood risk management measures such as flood protection schemes and how development will reduce the flood risk to acceptable levels. A detailed assessment for a development application should conclude that core flood risk elements of the Justification Test are passed and that residual risks can be successfully managed with no unacceptable impacts on adjacent lands.

2.6.1 SSFRA Key Outputs

Key outputs of an SSFRA are:

- Plans showing the site and development proposals including its relationship with watercourses and structures which may influence local hydraulics;
- Surveys of site levels and comparison of development levels relative to sources of flooding and likely flood water levels;
- Assessments of;
- Potential sources of flood risk;
- Existing flood alleviation measures;
- Potential impact of flooding on the site.
- How the layout and form of the development can reduce those impacts, including arrangements for safe access and egress.
- Proposals for surface water management and sustainable drainage.
- The effectiveness and impact of any mitigation measures.
- The residual risks to the site after the construction of any necessary measures and the means of managing those risks; and
- How flood risks are managed for occupants / employees of the site and its infrastructure.

3.0 STAGE 1 FLOOD RISK IDENTIFICATION

The initial flood risk identification stage uses existing information to identify and confirm whether there may be flooding or surface water management issues for the lands in question that may warrant further investigation.

3.1 Available Flood Risk Information

To initially identify potential flood risks for the existing Site and surrounding area a number of available data sources were consulted, these are listed in Table 3.1 below.

Table 3-1 Review of Available Flood Risk Information

	Information Source	Coverage	Quality	Confidence	Identified Flood Risks	Flood Risk
Primary Data Source & Modelled Data	OPW ECFRAM	Regional	High	High	The mapping does not include the watercourse reaches affected by the proposed scheme and only maps downstream flooding	X
	ICPSS	Nationwide	High	High	None	X
	Dun Laoghaire Rathdown SFRA within County Development Plan 2016-2022	Local	High	High	The mapping does not include the watercourse reaches affected by the proposed scheme and only maps downstream flooding	X
	Carrickmines & Shanganagh River Catchment Study Update 2007	Local	High	Moderate	Some flooding shown in vicinity of Golf stream/Glenamuck Stream confluence outside scheme extents.	X
Secondary Data Source	Walkover Survey	Local	Varies	Varies	The site is currently greenfield. No evidence of flooding. Generally consistent topographic fall across site	X
	OPW Historic Flood Records & Benefitting Lands	Nationwide	Varies	Varies	There is a recorded 2002 flood event is associated with the Carrickmines River however this is well outside the road corridor on the eastern side on the M50. Further records exist of a recurring flood event on the Glenamuck Road outside the scheme extents. This flooding appears to be associated with local road drainage deficiencies rather than fluvial or coastal flood risk.	X
	Historic OSI Maps	Nationwide	Moderate	Low	None	X
	EPA Ex. Rivers	Nationwide	Moderate	Moderate	Scheme in close proximity to Glenamuck Stream and crosses at two points. Scheme crosses Loughlinstown Rover	X
	Drainage Records	County	Moderate	Moderate	No Irish Water assets running through site	X

	Geological Survey Ireland Maps	Nationwide	Moderate	Low	No indication of flood risk from GSI mapping	X
	Topographic Survey	Local	High	High	Generally consistent topographic fall across site and towards watercourse channels	X

3.2 Identified Flood Risks/Flood Sources

3.2.1 OPW Flood Hazard Information

The OPW CFRAM flood extents does not depict flooding within the scheme extents however this assessment does not model the reaches relevant to the scheme

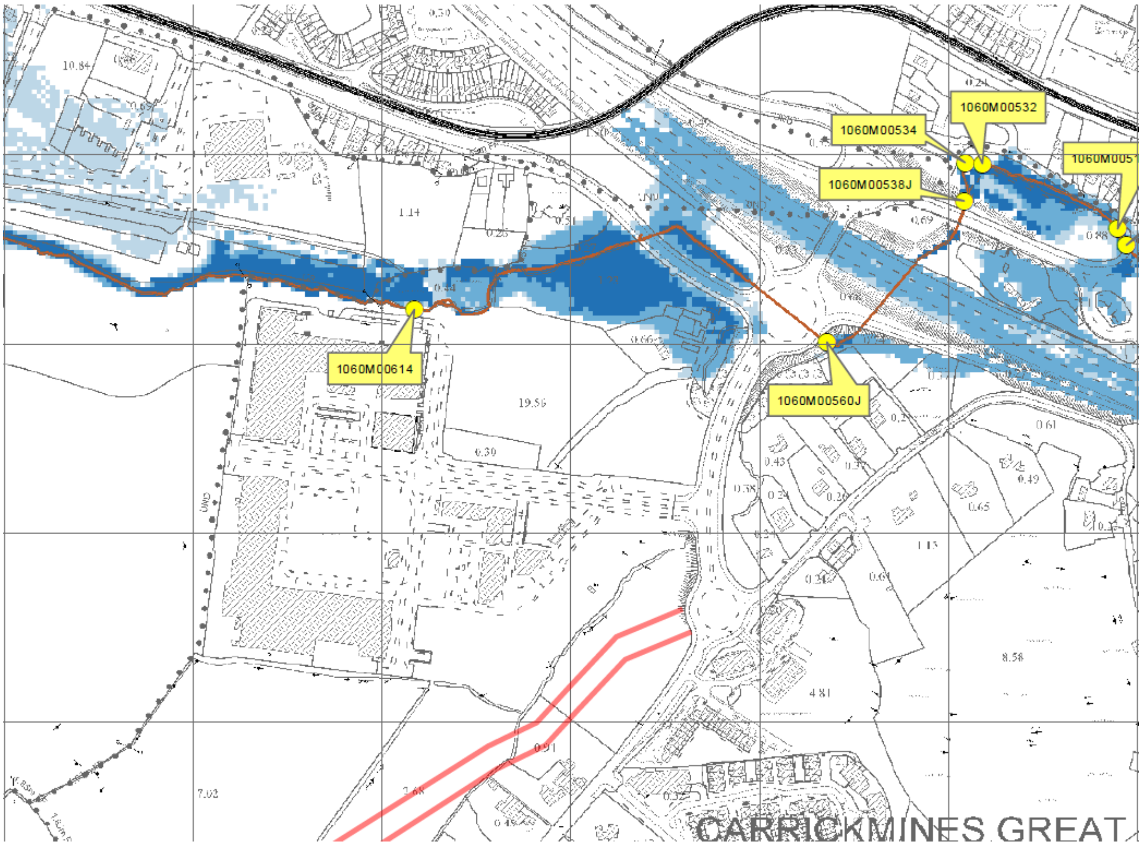


Figure 3.1 – Extract from OPW's Draft ECFRAM Map E10LOU_EXFCD_F1_02

3.2.2 Tidal Flood Maps

After reviewing the ICPSS coastal flood extents maps the site is located far above and outside the extent of predicted tidal flooding.

3.2.3 Carrickmines & Shanganagh River Catchment Study Update 2007

The above referenced study by RPS for DLRCC modelled the river reaches in the vicinity of the scheme. The Q100 flood mapping produced indicated that flood extents were largely retained within watercourse channels in the vicinity of the site.

An area of flooding associated with an existing undersized agricultural culvert was identified at the Golf stream/Glenamuck Stream confluence outside the scheme extents.

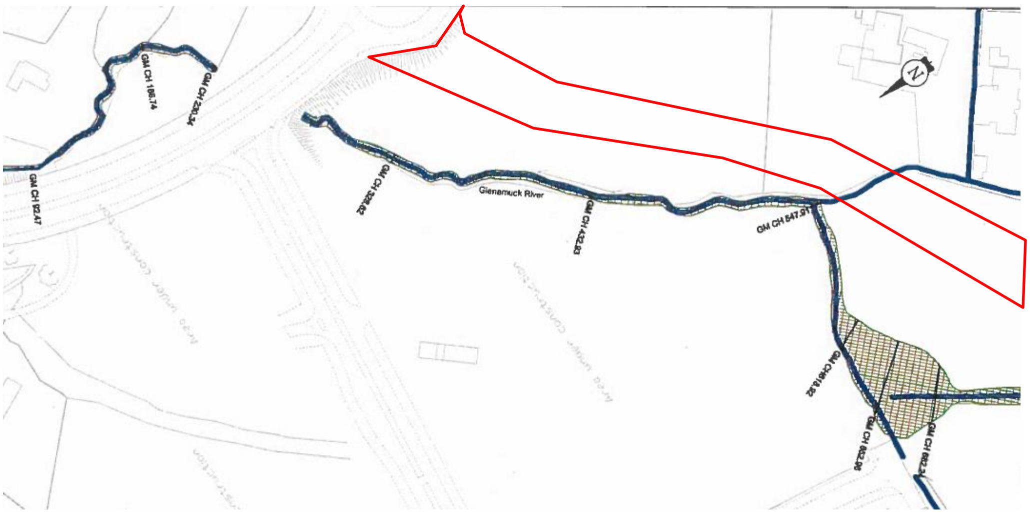


Figure 3-1: Extract from 2007 Study - DG2052

3.2.4 Topographical Survey

The proposed road route traverses an area of undulating lands generally falling from west to east from the Dublin mountains towards the coast. Survey data indicates the highest elevations on the scheme are at the southern tie in to the Enniskerry Road (approx. 138m) and lowest elevations at the tie in to the Glenamuck Road South Roundabout at Carrickmines (approx. 85m).

3.2.5 Walkover Survey

The site levels appear to be consistent with the topographical survey and no other evidence of flooding or flow paths are evident on site.

3.2.6 Other Sources

Other information sources were consulted to determine if there was any additional flood risk to the subject site, these included;

- Existing Local Authority Drainage Records – There is existing road drainage, foul and watermain infrastructure alongside the Glenamuck Road and Enniskerry Road. There is also trunk foul and watermain infrastructure approximatly following the route of the Glenamuck Stream

- Historic Maps – no evidence of flooding or marsh areas within the site.

3.3 Summary of Flood Risk Identification

A Source-Pathway-Receptor model was produced to summarise the possible sources of flooding, the people, infrastructure and assets (receptors) that could be affected by potential flooding (with specific reference to the proposals) and the pathways by which flood water for a 0.1%AEP (Annual Exceedance Probability) and 1% AEP storms could reach the receptors.

Table 3-2: Summary of Potential Flood Mechanisms

Source	Summary	Likelihood	Impact	Risk
Tidal	Coast is over 4.5km away, minimum site levels are over 80m above sea level.	Remote	-	-
Fluvial	Portion of proposed scheme is alongside Glenamuck Stream and Loughlinstown River which may have flood extents within the scheme footprint which may be affected by the construction of the scheme. Scheme requires new crossings of Glenamuck Stream & Loughlinstown River and various earthworks elements associated with the scheme. All of which have the potential to affect flood risk in the area	Possible	Medium	Medium
Surface Water Drainage (Pluvial)	Flooding from the surcharging or blockage of the development's drainage systems. Unmitigated increases in runoff rates caused by new surfacing may affect flood risk	Possible	Medium	Medium
Groundwater flooding	No Evidence of groundwater flooding identified.. Underlying geology and topography would not indicate a risk of groundwater flooding	Remote	-	-
Infrastructural - Human or Mechanical Error	Scale of existing infrastructure insufficient to cause significant flooding given topography in the area	Remote	-	-

Table 3.1 - Source-Pathway-Receptor Analysis

In order to adequately assess the risk of/on fluvial flooding, additional data is required to define existing flood extents and assess the impact of proposed culverts on flood risk. In order to adequately assess the risk of/on pluvial flooding, additional mitigation measures will be required.

4.0 FLOOD RISK ASSESSMENT

4.1 Introduction

In order to adequately assess the risk of/on fluvial flooding, a hydraulic model of the river reaches in question has been created to define existing flood extents and assess the impact of the proposed scheme and the proposed culverts on flood risk. The model has been created using HEC-RAS software as developed by the US Army Corps of Engineers. HEC-RAS is an industry standard for 1D hydraulic models.

4.2 Topographical Data

A detailed topographical survey for the scheme extents was procured to support the planning and design of the scheme. Additional topographic data was available from previous studies for the scheme at LAP stage. Lidar data for the wider area was made available by the client which was used to supplement the surveyed data and to verify catchment areas beyond the scheme extents.

A 3d surface model of the river channels and surrounding areas was created in Autocad Civil 3d based on the best available channel data from the available topographical surveys which facilitated the export of river cross sections to HEC RAS.

4.3 Model Extents

Two models were created, one for the Glenamuck Stream and its tributaries and one for the Loughlinstown River. Models for both the existing scenarios and proposed scenarios were created to assess the impact of proposed works on flood risk in the area

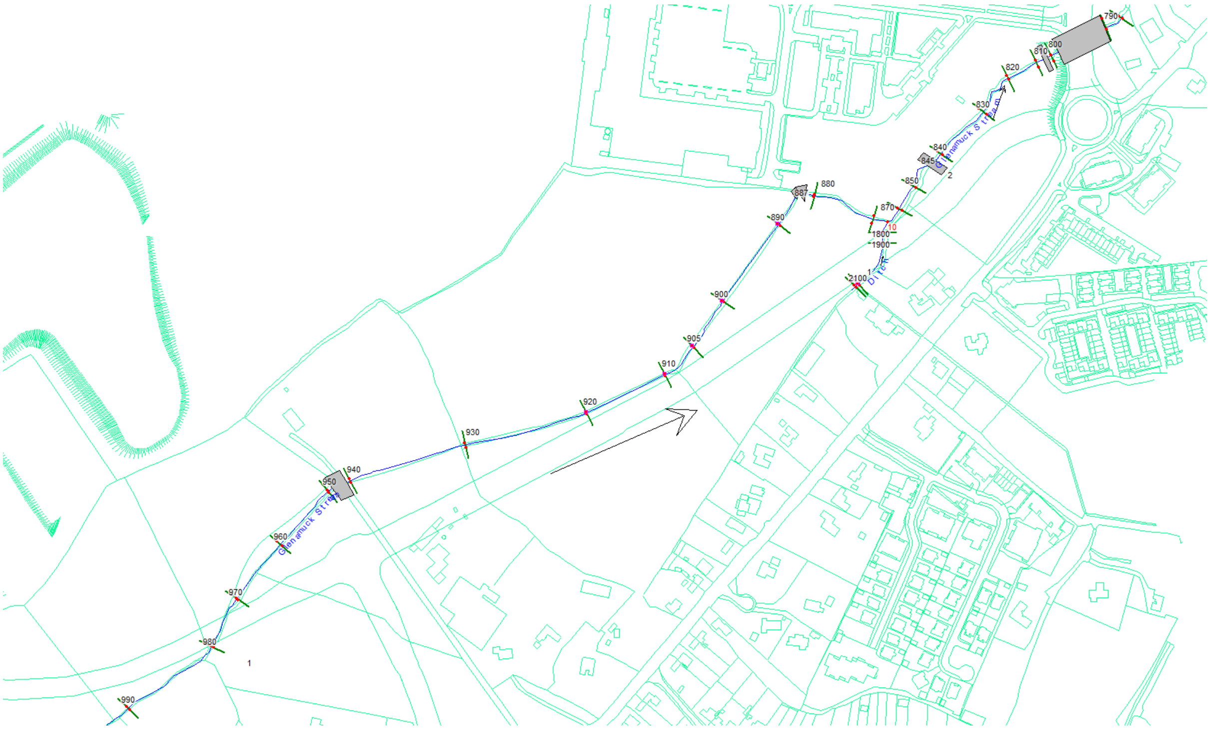


Figure 4-1 – Model Schematic – Glenamuck Stream (existing)

Figure 4-2 – Model Schematic – Loughlinstown River (existing)

4.4 Hydrology

An estimate of stream flows was required to input to the hydraulic model. Stream catchments and catchment descriptors were generally determined from the OPW Flood Studies update (FSU) web portal where available or generated manually from topographical data and site review.

Table 4.1: River Flows

Location	Ref	Q100 Flow (m³/s)	Q1000 Flow (m³/s)
Glenamuck Stream Reach 1 (upstream of drain confluence)	HEP 01	1.46	1.93
Glenamuck Stream Reach 1 (downstream of drain confluence)	HEP 02	3.17	4.21
Un-named Drain	HEP 03	1.13	1.50
Loughlinstown River Crossing	HEP 04	5.73	7.60

Hydrological calculations were carried out using a variety of calculation methods including Institute of Hydrology (IoH) 124, FSR Regional Statistical Method (FSR 6 Variable) & Flood Studies Update (FSU) 7 Variable. In general IoH124 results were the highest and were therefore adopted to ensure a conservative assessment. Hydrological calculations are included in Appendix B.

It is noted that the design standard for new culverts is the Q100 + 20% Climate Change event. All proposed culverts have been designed to convey the Q1000 event which for all calculated locations is greater than Q100+20% to ensure a conservative assessment.

4.5 Summary of Existing Model Results

An analysis of the existing flood conditions was carried out by applying the calculated watercourse flows to the geometry file for the existing conditions.

The results indicated that along the majority of the reaches in question, the Q100 and Q1000 flows were retained in channel. Out of bank flooding was noted in a few areas and was typically associated with deficiencies in the capacity in existing culverts. Ex Cul 1 (Bective Rangers access) and Ex Cul 4 were predicted to be overtopped during a Q1000 event and significantly surcharged during a Q100 event. Ex Cul 2 & Ex Cul 3 were predicted to be overtopped during a Q100 & Q1000 event. Overland flooding across agricultural land was predicted due to incapacities in Ex Cul 2

The Loughlinstown river is located in a deeply incised channel and peak flood flows were predicted to be retained in channel.

Flood mapping is presented in Appendix A and model results are presented in Appendix C.

4.6 Summary of Proposed Model Results

The primary impact on the existing river reaches and floodplains in question were

- Construction of new/replacement culverts as described in Section 1.6.1
- Minor ingress in to floodplains by earthworks associated with roads & ponds

The proposed culvert works and all significant earthworks within identified floodplains were reflected in a proposed model geometry to establish the impact on flooding in the area. In general the findings indicated

- Proposed Culvert WX01 reduces modelled Q100 flood levels in the vicinity of the works (by approx. 0.16m).
- The proposed replacement of undersized culvert Ex Cul 1 with WX02 reduces modelled Q100 flood levels (by approx. 0.28m) in the vicinity of the works.
- Modelled Q100 water levels at section 960 (between WX01 and WX02) show very minor increases (0.06m) attributable to smoothing of the model hydraulic profile.
- Proposed Culvert WX03 reduces modelled Q100 flood levels in the vicinity of the works (by approx. 0.3m).
- Modelled water levels at proposed bridge WX04 show some minor fluctuations between existing and proposed models (+0.03m to –0.15m). Since this structure is entirely outside the flow conveyance area and has no impact on bed or banks of the river this is attributable to model anomalies introduced by additional calculation points in the proposed model (due to the inclusion of the bridge).
- All new watercourse crossings are predicted to convey the Q100 and Q1000 flows and maintain min 300mm freeboard.
- The minor infill of Q1000 floodplain adjacent to the Golf Lane roundabout has no effect on Q100 flood levels and a negligible (<100mm increase) on Q1000 levels. It is noted that adjacent roads/development are far higher (>3m) than predicted flood levels at this location. Due to the steep slopes in this area there no perceptible change in flood extents.

Flood mapping is presented in Appendix A and model results are presented in Appendix C.

4.7 Initial Pluvial Flood Risk Assessment

Pluvial (direct rainfall) related flood risk associated with the proposed development has been addressed in detail within Chapter 5 and Chapter 14 of the EIAR and incorporates the following;

- New drainage collection system incorporating SUDS features and large attenuation ponds. Outflow rates to be restricted to 2 l/s per hectare of contributing catchment
- Surface water to be designed in accordance with GDSDS recommendations and incorporate allowance for climate change.
- Existing runoff rates will be reduced by the provision of a surface water network with attenuated outlet and flood volume storage. This mitigates against any potential increase in downstream flood risk

It is noted that proposed attenuation measures to be implemented are the site will restrict peak runoff from the scheme (and some adjacent lands) to below existing greenfield rates and will tend to reduce peak watercourse flows. The positive effect of these measures has not been reflected in the hydraulic modelling to ensure a conservative assessment.

4.8 Flood Exceedance

For storms greater than the 1%AEP + climate change (1/100 year return) pluvial event, the development's drainage attenuation design may be exceeded.

To mitigate this initially, there will be additional volume within the surface water network which will be able to surcharge before flooding. When this tolerance has been exceeded the drainage network may surcharge above ground level, with overland flows expected to be retained by kerbs/pond banks and flow towards existing watercourses.

4.9 Site Flood Risk Summary

"The Planning System and Flood Risk Management Guidelines for Planning Authorities", November 2009 classifies road developments as "less vulnerable development" (Table 3.1 of the Guidelines). Table 3.2 of the Guidelines indicates that this type of development ("Highly Vulnerable") is appropriate in Flood Zone C (and potentially Flood Zone B subject to Justification Test).

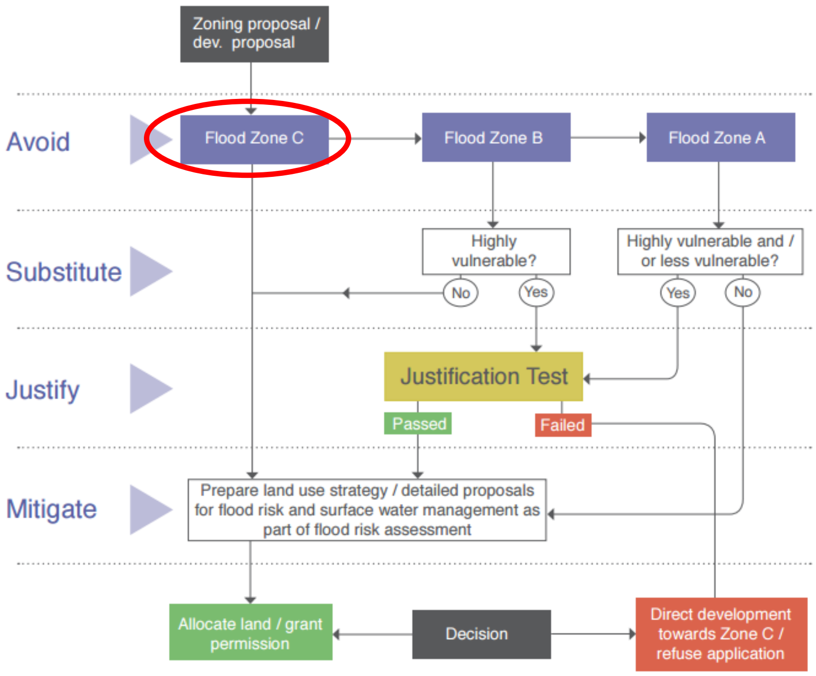


Figure 4.1: Sequential Approach mechanism in the Planning Process

The assessment carried out has identified that the proposed roads are within Flood Zone C and are at low risk of fluvial flooding.

In accordance with the sequential approach above, the development will need to develop "detailed proposals for flood risk and surface water management", these are outlined in the EIAR and have been summarised previously in this report.

4.10 Residual Risks

Remaining residual flood risks, following the initial assessment include the following;

1. Pluvial flooding from the drainage system related to blockage.
2. Pluvial flooding from the development's drainage system for storms in excess of the 100 year design capacity.

4.11 Residual Risks - Mitigation Measures

Proposed mitigation measures to address residual flood risks are summarized below;

M1. The proposed drainage system and culverts to be maintained on a regular basis to reduce the risk of a blockage.

M2. In the event of storms exceeding the 100 year design capacity of the drainage system, then possible flood routing for overland flows towards existing streams should not be blocked.

4.11.1 Effectiveness of Mitigation Measures

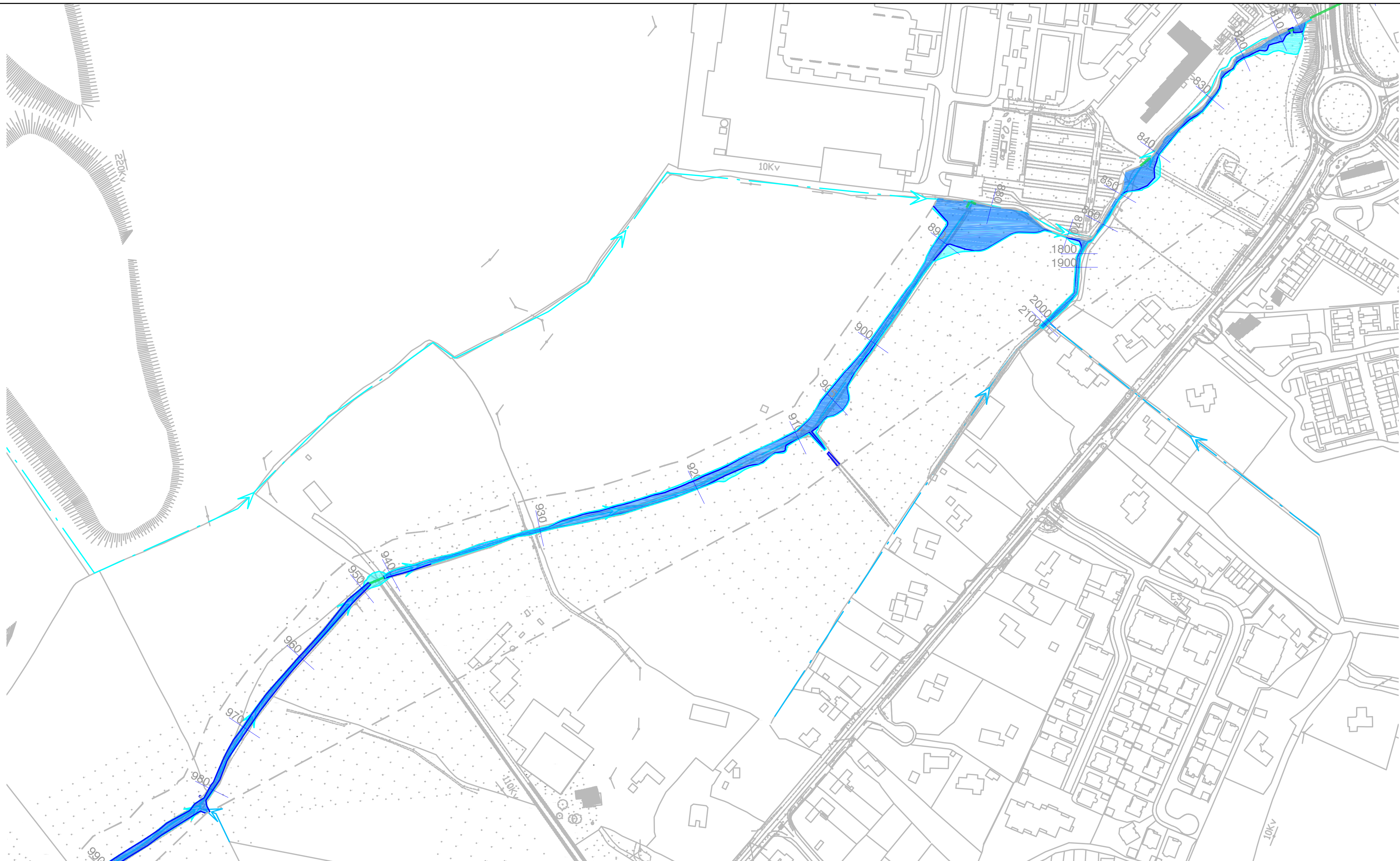
It is considered that the flood risk mitigation measures once fully implemented are sufficient to provide a suitable level of protection to the proposed development. The proposed development lands are located in Flood Zone C (low risk of flooding)

5.0 CONCLUSION

- This Site Specific Flood Risk Assessment for the proposed roads scheme, was undertaken in accordance with the requirements of the Planning System and Flood Risk Management Guidelines for Planning Authorities", November 2009.
- The SSFRA identified that the proposed roads are within Flood Zone C and are at low risk of fluvial flooding.
- Measures to restrict the development outflows are required to restrict post development flow to at least greenfield levels. Substantial SuDS and surface water attenuation measures are proposed as part of the scheme to satisfy this requirement
- The impact of proposed scheme does not increase the flood risk to adjacent lands
- Surcharging or blockage of the development's drainage systems may introduce a residual flood risk. This risk is mitigated by suitable design of the drainage network, regular maintenance and inspection of the network and establishment of exceedance overland flow routes
- In conclusion, the proposed development is considered to have the required level of flood protection up to and including the 1% AEP storm event.

Appendix A

Flood Extents Mapping



GLENAMUCK STREAM & TRIBS - PLAN

1:5000

LOUGHLINSTOWN RIVER - PLAN

1:5000

Legend

- WATERCOURSE (EPA MAPPED)
- WATERCOURSE (LOCAL DRAINAGE)
- EXTENT OF FLOOD MAPPING
- Q100 FLOOD EXTENTS
- Q1000 FLOOD EXTENTS
- XX CROSS SECTION LOCATION
- EXISTING CULVERT
- PROPOSED CULVERT

Notes

1. DRAWINGS ARE PRELIMINARY DESIGNS FOR PLANNING ONLY AND ARE SUBJECT TO DETAILED DESIGN
2. ALL WATERCOURSE CROSSING WORKS SUBJECT TO OPW SECTION 50 APPROVAL AND APPROVAL BY INLAND FISHERIES IRELAND

Client

dlr
Comhairle Contae County Council

Project
Glenamuck District Roads Scheme

Key Plan

Drawing Title
EXISTING FLOOD EXTENTS

Scale at A3
AS SHOWN

Discipline
HYDROLOGY

Drawing Status
PLANNING

Drawing No	Issue
APPENDIX 14-1 FIGURE 1	-

Prepared By

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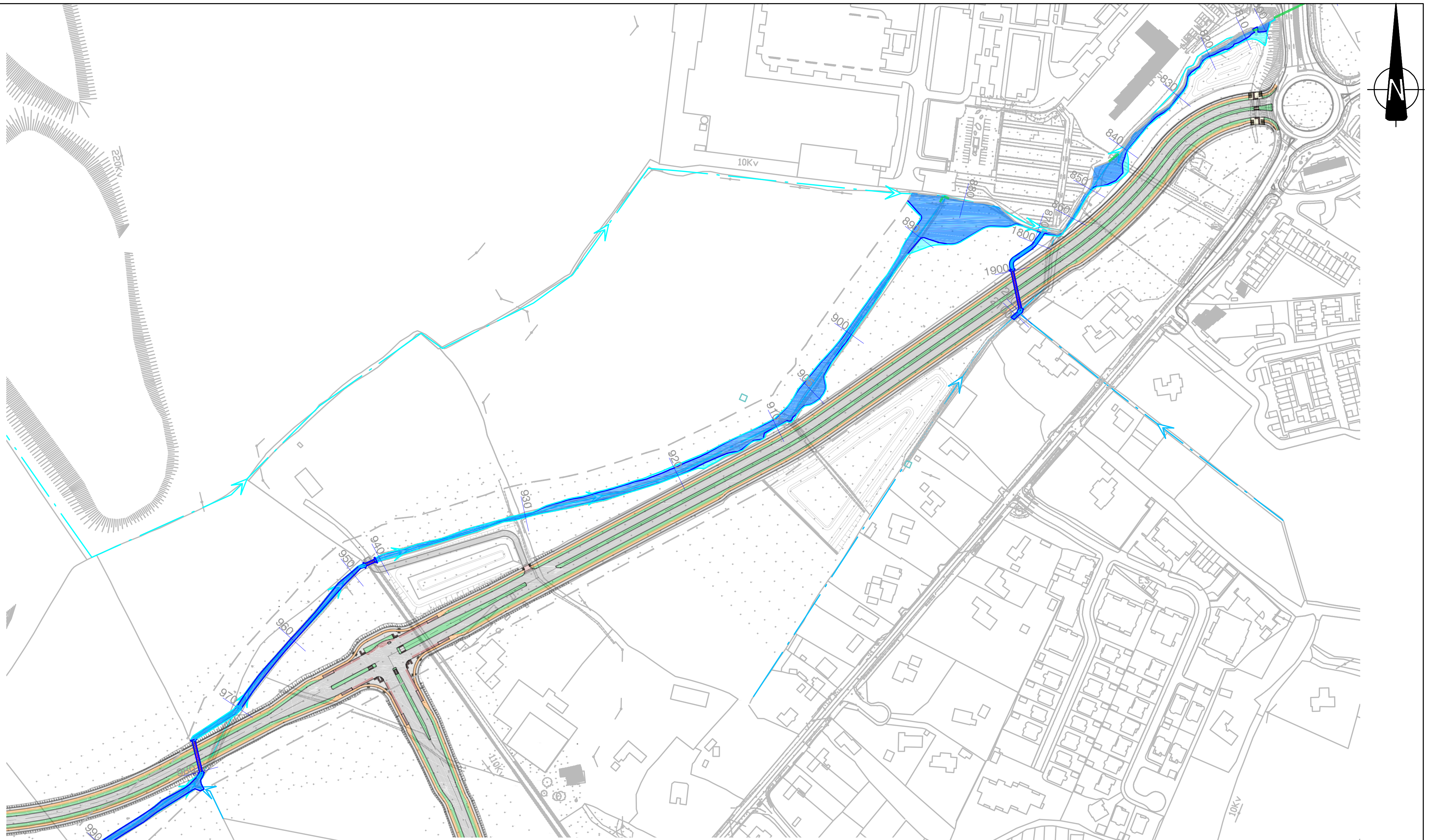
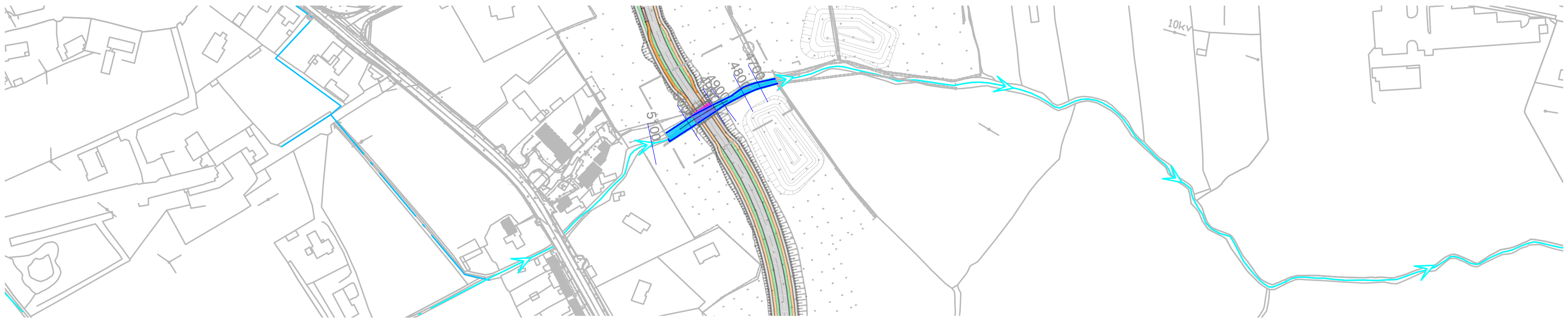
WATERFORD OFFICE Unit 2, The Chandlery, 1-2 O' Connell Street, Waterford, Ireland. PHONE +353 51 309 500
DBFL Consulting Engineers EMAIL info@dbfl.ie SITE www.dbfl.ie



GLENAMUCK STREAM & TRIBS - PLAN

1:5000



LOUGHLINSTOWN RIVER - PLAN

1:5000

Legend

- WATERCOURSE (EPA MAPPED)
- WATERCOURSE (LOCAL DRAINAGE)
- EXTENT OF FLOOD MAPPING
- Q100 FLOOD EXTENTS
- Q1000 FLOOD EXTENTS
- XX CROSS SECTION LOCATION
- EXISTING CULVERT
- PROPOSED CULVERT

Notes

1. DRAWINGS ARE PRELIMINARY DESIGNS FOR PLANNING ONLY AND ARE SUBJECT TO DETAILED DESIGN
2. ALL WATERCOURSE CROSSING WORKS SUBJECT TO OPW SECTION 50 APPROVAL AND APPROVAL BY INLAND FISHERIES IRELAND

Client

dlr
Comhairle Contae County Council

Project

Glenamuck District Roads Scheme

Key Plan

Drawing Title

PROPOSED FLOOD EXTENTS

Scale at A3

AS SHOWN

Discipline

HYDROLOGY

Drawing Status

PLANNING

Drawing No	Issue
APPENDIX 14-1 FIGURE 2	-

Prepared By

DBFL

DBFL Consulting Engineers

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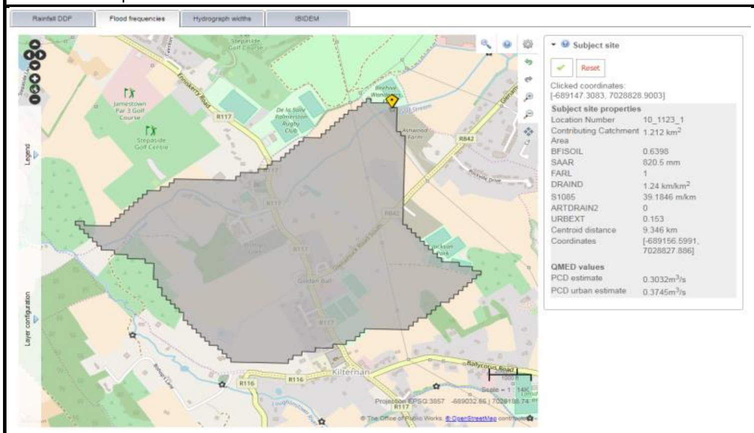
Appendix B

Hydrological Calculations

TITLE	Job Reference
Glenamuck Distributor Road Scheme	170172
SUBJECT	**Calc. Sheet No.**
Hydrological Flow Estimation - HEP 01	-

DRAWING NUMBER	Calculations by	Checked by	Date
-	JPC	KJS	01/11/2018

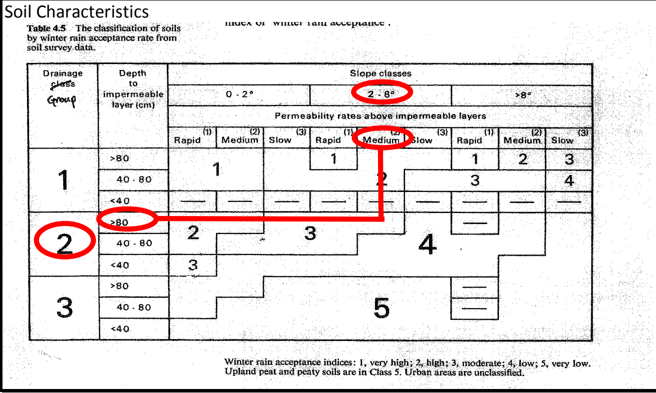
Catchment Map



Catchment Characteristics

Area	1.212	km²
BFISOIL	0.6398	
SAAR	820.5	mm
FARL	1	
DRAIND	1.24	km/km²
S1085	39.1846	m/km
ARTDRAIN2	0	
URBEXT	0.153	
LAKE	0	

Soil Characteristics



Property		Classes
A Drainage group	1	Rarely waterlogged within 60 cm at any time (well and moderately well drained)
	2	Commonly waterlogged within 60 cm during winter (imperfect and poor)
	3	Commonly waterlogged within 60 cm during winter and summer (very poorly drained)
B Depth to 'impermeable' layers	1	>80 cm
	2	80–40 cm
	3	<40 cm
C Permeability group (above 'impermeable' layers or to 80 cm)	1	Rapid
	2	Medium
	3	Slow
D Slope	1	0–2°
	2	2–8°
	3	>8°

Soil Type	3
SOIL Index	0.40

Institute of Hydrology (IoH) 124

$$QBAR_{Rural} = 0.00108\ AREA^{0.89}\ SAAR^{1.17}\ SOIL^{2.17}$$

QBARrural	0.450	m³/s
Factorial Standard Error	1.65	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

Q100	1.46
Q1000	1.93

FSR Regional Statistical Method (FSR 6 Variable)

$$QBAR = 0.0172\ AREA^{0.94} * STRMFRQ^{0.27} * S1085^{0.16} * SOIL^{1.23} * RSMD^{1.03} * (1+LAKE)^{-0.85}$$

QBAR	0.364	m³/s
Factorial Standard Error	1.47	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

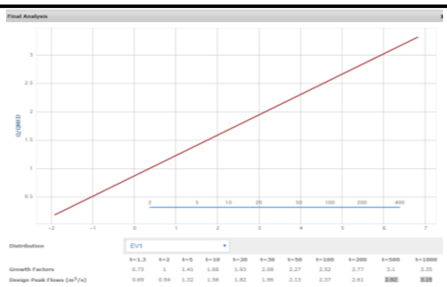
Q100	1.05
Q1000	1.39

Flood Studies Update (FSU) 7 Variable

$$Qmed_{Rural} = 1.237\ x\ 10^{-5} AREA^{0.937} BFIsoils^{-0.922} SAAR^{1.306} FARL^{2.217}$$
$$DRAIND^{0.341}\ S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$

$$QMED_{urban} = QMED\,(1 + URBEXT)^{1.482}$$

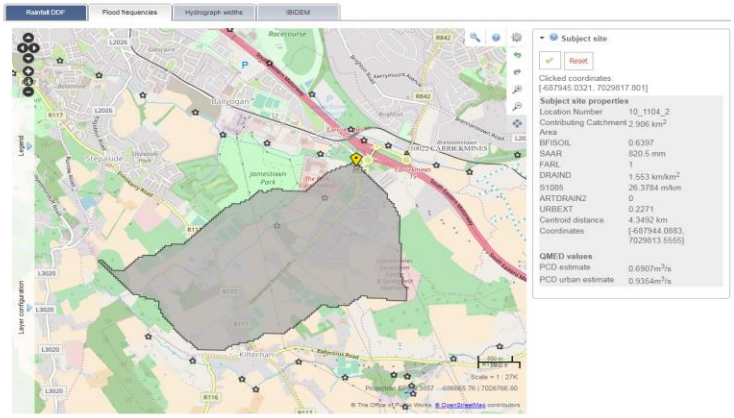
QMED Rural	0.303	m³/s
QMED Urban	0.374	m³/s
Factorial Standard Error	1.37	
Growth Factor to Q100	2.52	<- From Pooling Group Analysis
Growth Factor to Q1000	3.35	<- From Pooling Group Analysis



Q100	1.05
Q1000	1.72

TITLE		Job Reference	
Glenamuck Distributor Road Scheme		170172	
SUBJECT		Calc. Sheet No.	
Hydrological Flow Estimation - HEP 02		-	
DRAWING NUMBER	Calculations by	Checked by	Date
-	JPC	KJS	01/11/2018

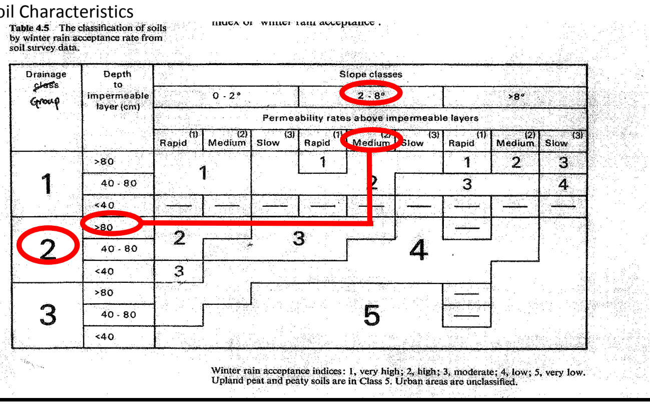
Catchment Map

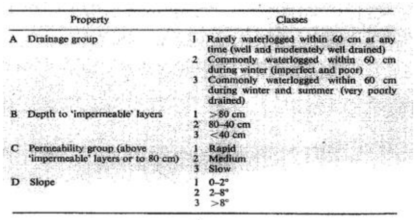


Catchment Characteristics

Area	2.906	km²
BFISOIL	0.6397	
SAAR	820.5	mm
FARL	1	
DRAIND	1.553	km/km²
S1085	26.378	m/km
ARTDRAIN2	0	
URBEXT	0.2271	
LAKE	0	

Soil Characteristics





SOIL Type	3
SOIL Index	0.40

Institute of Hydrology (IoH) 124

$$QBAR_{Rural} = 0.00108\, \mathbf{AREA}^{0.89}\, \mathbf{SAAR}^{1.17}\, \mathbf{SOIL}^{2.17}$$

QBARrural	0.981	m³/s
Factorial Standard Error	1.65	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

Q100	3.17
Q1000	4.21

FSR Regional Statistical Method (FSR 6 Variable)

$$QBAR = 0.0172\, AREA^{0.94} * STMFRQ^{0.27} * S1085^{0.16} * SOIL^{1.23} * RSMD^{1.03} * (1+LAKE)^{-0.85}$$

QBAR	0.827	m³/s
Factorial Standard Error	1.47	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

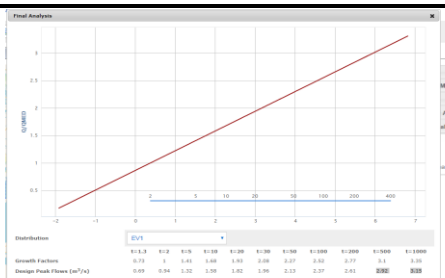
Q100	2.38
Q1000	3.16

Flood Studies Update (FSU) 7 Variable

$$Qmed_{Rural} = 1.237\ x\ 10^{-5} AREA^{0.937} BFIsoils^{-0.922} SAAR^{1.306} FARL^{2.217}$$
$$DRAIND^{0.341}\ S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$

$$QMED_{urban} = QMED\,(1 + URBEXT)^{1.482}$$

QMED Rural	0.691	m³/s
QMED Urban	0.935	m³/s
Factorial Standard Error	1.37	
Growth Factor to Q100	2.52	<- From Pooling Group Analysis
Growth Factor to Q1000	3.35	<- From Pooling Group Analysis

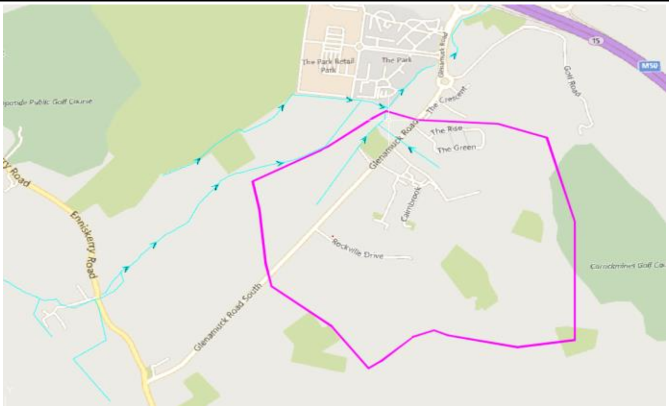


Q100	2.38
Q1000	4.29

TITLE	Job Reference	
Glenamuck Distributor Road Scheme	170172	
SUBJECT	Calc. Sheet No.	
Hydrological Flow Estimation - HEP 03	-	

DRAWING NUMBER	Calculations by	Checked by	Date
-	JPC	KJS	01/11/2018

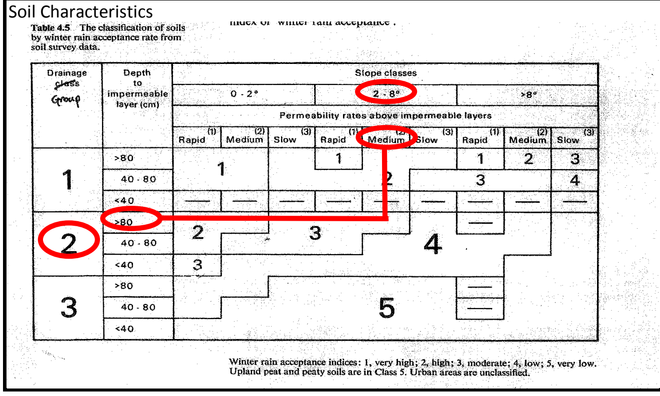
Catchment Map

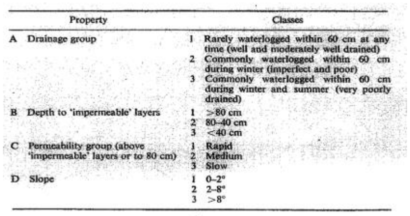


Catchment Characteristics

Area	0.91	km²
BFISOIL	0.64	
SAAR	820.5	mm
FARL	1	
DRAIND	1.553	km/km²
S1085	26.378	m/km
ARTDRAIN2	0	
URBEXT	0.3	
LAKE	0	

Soil Characteristics





Property	Classes
A Drainage group	1 Rarely waterlogged within 60 cm at any time (well and moderately well drained) 2 Commonly waterlogged within 60 cm during winter (imperfect and poor) 3 Commonly waterlogged within 60 cm during winter and summer (very poorly drained)
B Depth to 'impermeable' layers	1 >80 cm 2 80-40 cm 3 <40 cm
C Permeability group (above 'impermeable' layers or to 80 cm)	1 Rapid 2 Medium 3 Slow
D Slope	1 0-2° 2 2-8° 3 >8°

SOIL Type	3
SOIL Index	0.40

Institute of Hydrology (IoH) 124

$$QBAR_{Rural} = 0.00108\, \boldsymbol{AREA}^{0.89}\, \boldsymbol{SAAR}^{1.17}\, \boldsymbol{SOIL}^{2.17}$$

QBARrural	0.349	m³/s
Factorial Standard Error	1.65	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

Q100	1.13
Q1000	1.50

FSR Regional Statistical Method (FSR 6 Variable)

$$QBAR = 0.0172\ AREA^{0.94} * STRMFRQ^{0.27} * S1085^{0.16} * SOIL^{1.23} * RSMD^{1.03} * (1+LAKE)^{-0.85}$$

QBAR	0.380	m³/s
Factorial Standard Error	1.47	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

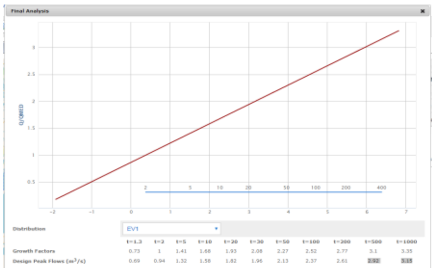
Q100	1.09
Q1000	1.45

Flood Studies Update (FSU) 7 Variable

$$Qmed_{Rural} = 1.237 \times 10^{-5} AREA^{0.937} BFIsoils^{-0.922} SAAR^{1.306} FARL^{2.217}$$

$$DRAIND^{0.341}\ S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$

$$QMED_{urban} = QMED\,(1 + URBEXT)^{1.482}$$



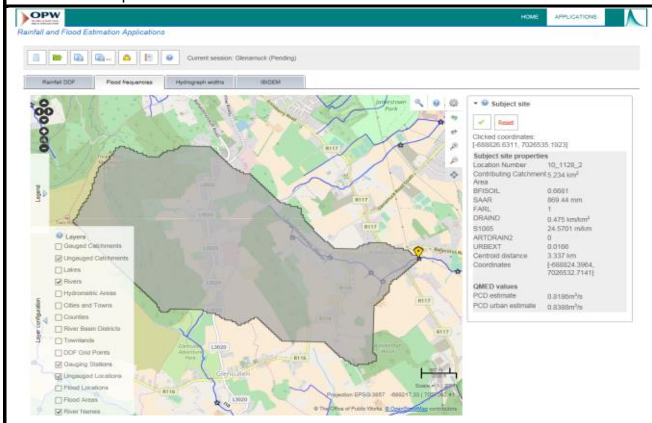
QMED Rural	0.233	m³/s
QMED Urban	0.343	m³/s
Factorial Standard Error	1.37	
Growth Factor to Q100	2.52	<- From Pooling Group Analysis
Growth Factor to Q1000	3.35	<- From Pooling Group Analysis

Q100	0.80
Q1000	1.57

TITLE	Job Reference
Glenamuck Distributor Road Scheme	170172
SUBJECT	Calc. Sheet No.
Hydrological Flow Estimation - HEP 04	-

DRAWING NUMBER	Calculations by	Checked by	Date
-	JPC		18/12/2017

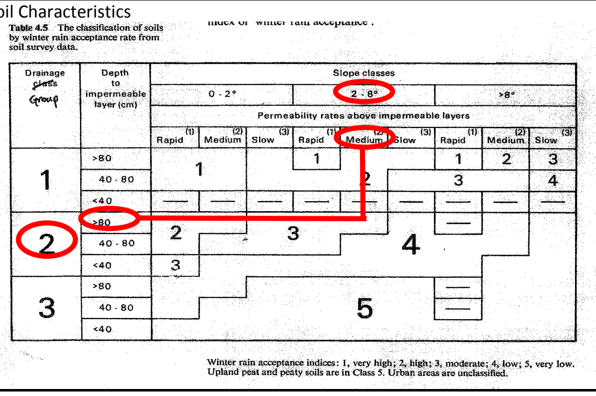
Catchment Map

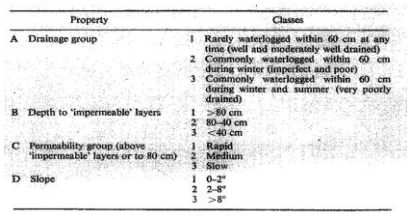


Catchment Characteristics

Area	5.234	km²
BFISOIL	0.6681	
SAAR	869.44	mm
FARL	1	
DRAIND	0.475	km/km²
S1085	24.5701	m/km
ARTDRAIN2	0	
URBEXT	0.0166	
LAKE	0	

Soil Characteristics





Property	Classes
A Drainage group	1 Rarely waterlogged within 60 cm at any time (well and moderately well drained) 2 Commonly waterlogged within 60 cm during winter (imperfect and poor) 3 Commonly waterlogged within 60 cm during winter and summer (very poorly drained)
B Depth to 'impermeable' layers	1 >80 cm 2 80–40 cm 3 <40 cm
C Permeability group (above 'impermeable' layers or to 80 cm)	1 Rapid 2 Medium 3 Slow
D Slope	1 0–2° 2 2–8° 3 >8°

SOIL Type	3
SOIL Index	0.40

Institute of Hydrology (IoH) 124

$$QBAR_{Rural} = 0.00108\ \mathbf{AREA}^{0.89}\ \mathbf{SAAR}^{1.17}\ \mathbf{SOIL}^{2.17}$$

QBARrural	1.772	m³/s
Factorial Standard Error	1.65	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

Q100	5.73
Q1000	7.60

FSR Regional Statistical Method (FSR 6 Variable)

$$QBAR = 0.0172\ AREA^{0.94} * STRMFRQ^{0.27} * S1085^{0.16} * SOIL^{1.23} * RSMD^{1.03} * (1+LAKE)^{-0.85}$$

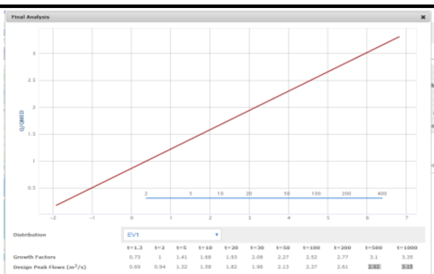
QBAR	1.294	m³/s
Factorial Standard Error	1.47	
Growth Factor to Q100	1.96	<- From FSR
Growth Factor to Q1000	2.6	<- From FSR

Q100	3.73
Q1000	4.95

Flood Studies Update (FSU) 7 Variable

$$Qmed_{Rural} = 1.237\ x\ 10^{-5} AREA^{0.937} BFIsoils^{-0.922} SAAR^{1.306} FARL^{2.217}$$
$$DRAIND^{0.341}\ S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$
$$QMED_{urban} = QMED\,(1 + URBEXT)^{1.482}$$

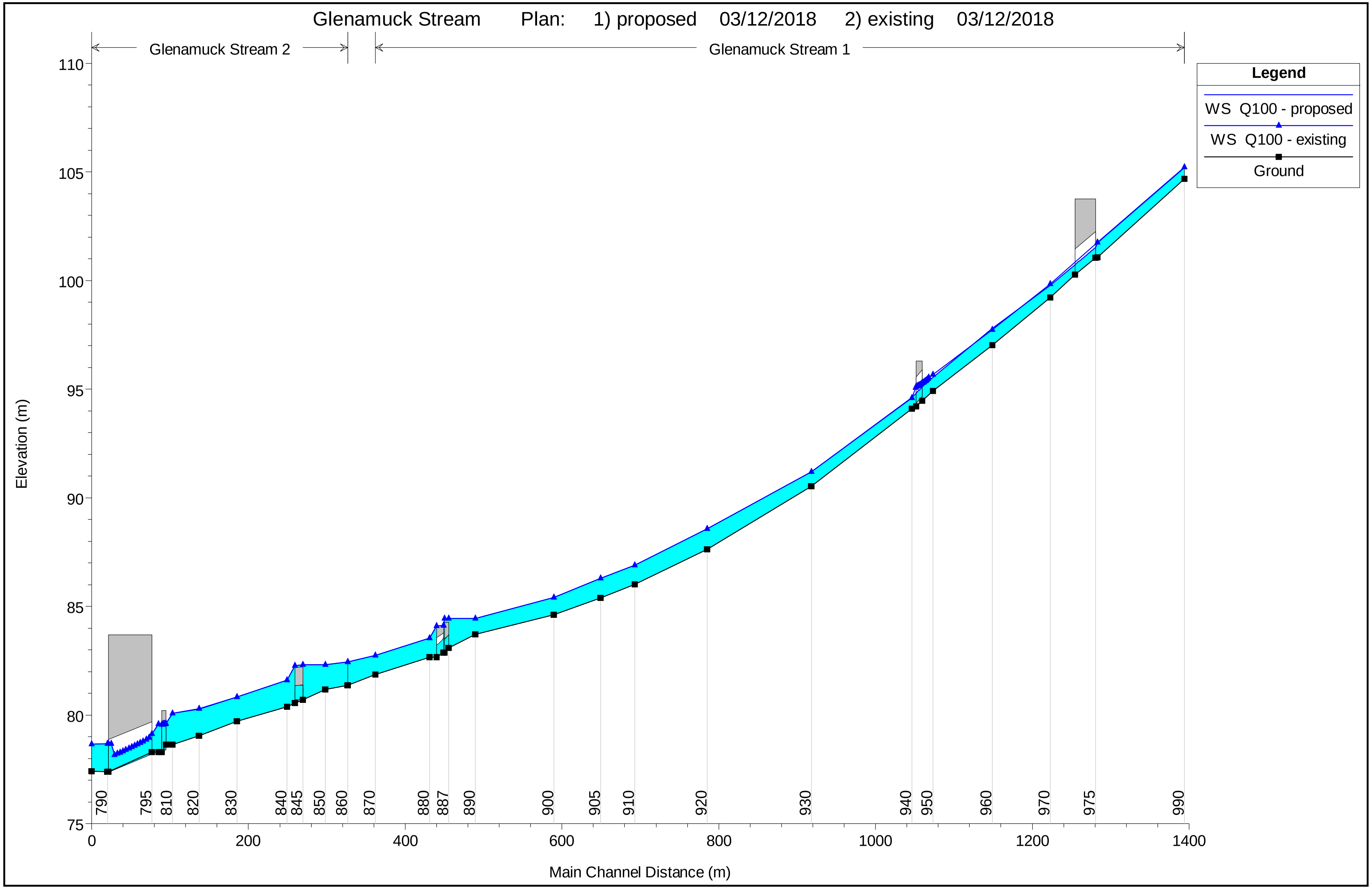
QMED Rural	0.819	m³/s
QMED Urban	0.839	m³/s
Factorial Standard Error	1.37	
Growth Factor to Q100	2.52	<- From Pooling Group Analysis
Growth Factor to Q1000	3.35	<- From Pooling Group Analysis



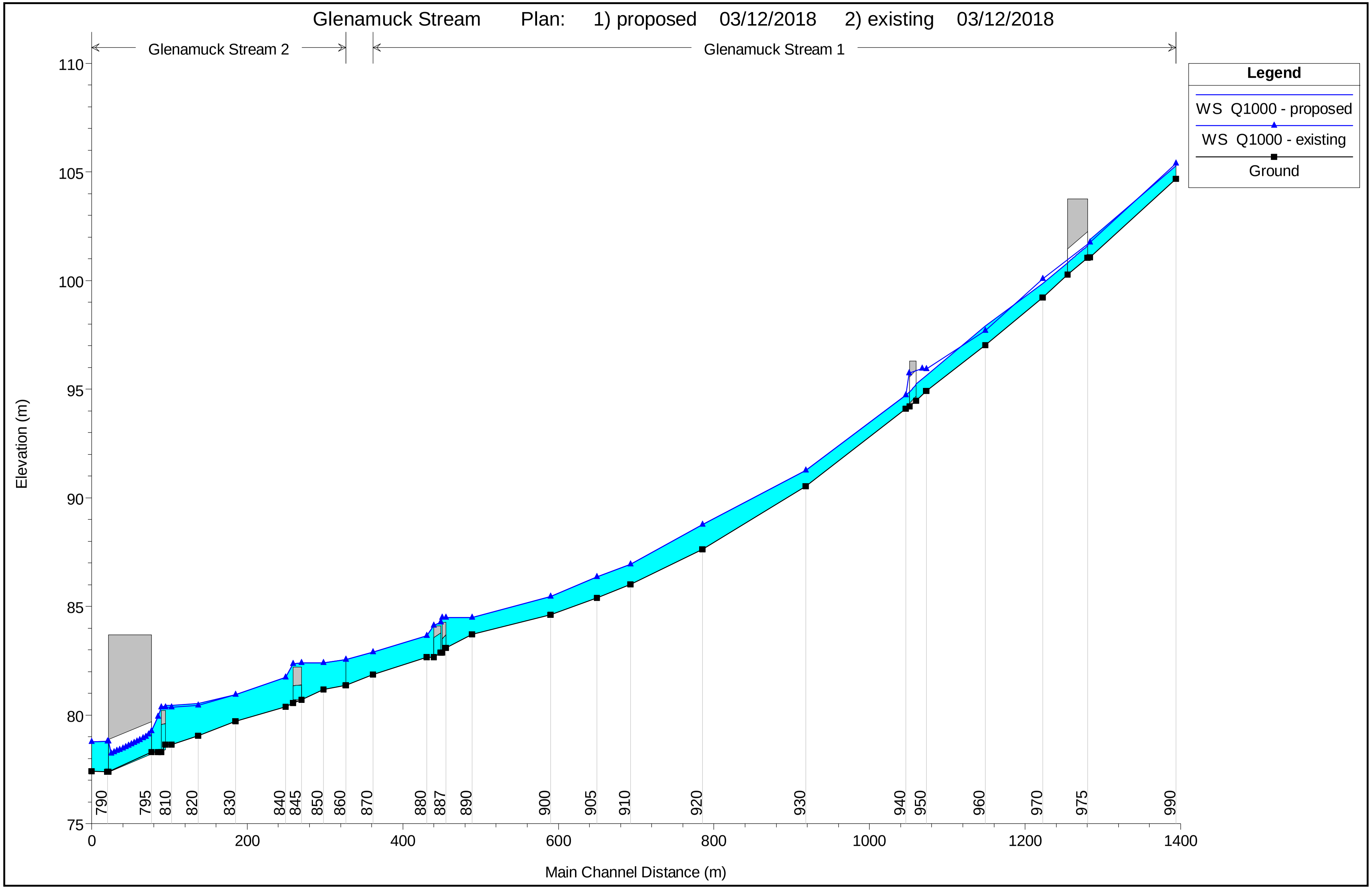
Q100	2.83
Q1000	3.85

Appendix C

Model Results

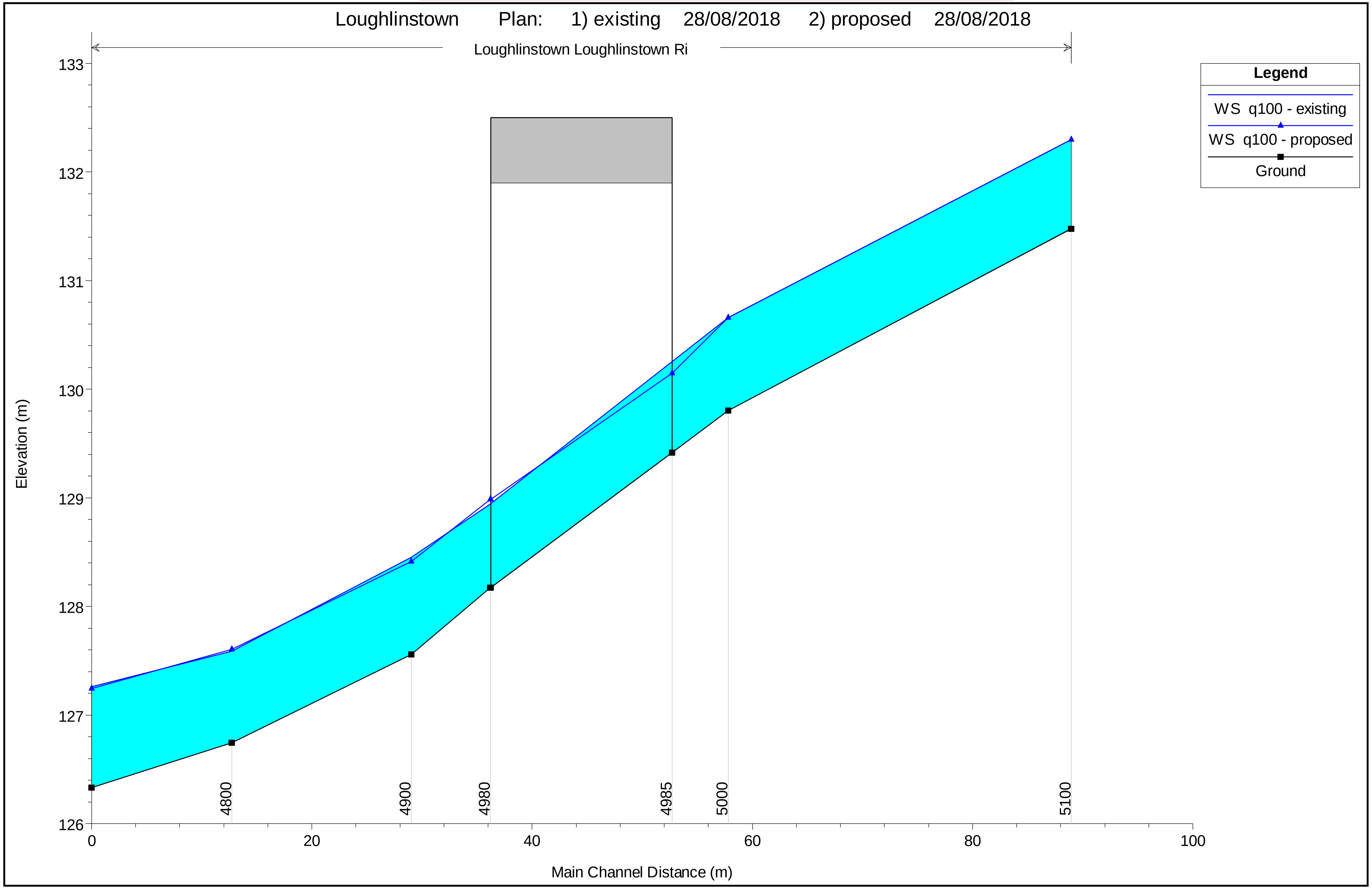


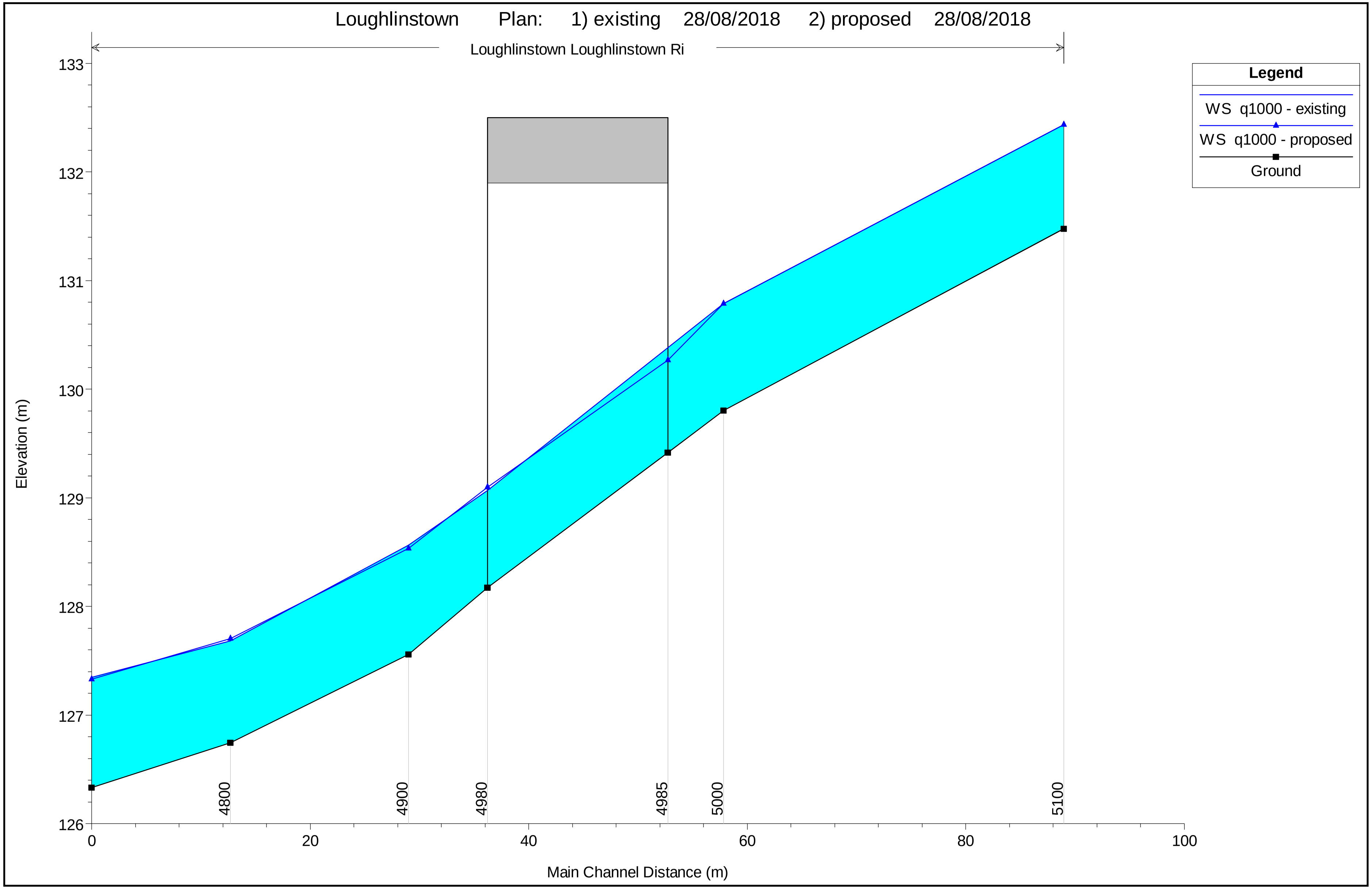
Glenamuck Stream Plan: 1) proposed 03/12/2018 2) existing 03/12/2018
Glenamuck Stream 2
Glenamuck Stream 1
Legend
WS Q100 - proposed
WS Q100 - existing
Ground
Elevation (m)
110
105
100
95
90
85
80
75
Main Channel Distance (m)
0
200
400
600
800
1000
1200
1400
790
795
810
820
830
840
845
850
860
870
880
887
890
900
905
910
920
930
940
950
960
970
975
990


Glenamuck Stream Plan: 1) proposed 03/12/2018 2) existing 03/12/2018
Glenamuck Stream 2
Glenamuck Stream 1
Legend
WS Q1000 - proposed
WS Q1000 - existing
Ground
Elevation (m)
110
105
100
95
90
85
80
75
790
795
810
820
830
840
845
850
860
870
880
887
890
900
905
910
920
930
940
950
960
970
975
990
0
200
400
600
800
1000
1200
1400
Main Channel Distance (m)

HEC-RAS Profile: Q1000

River	Reach	River Sta	Profile	Plan	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)	
Glenamuck Stream	1	990	Q1000	proposed	1.93	104.69	105.28	105.28	105.47	0.082111	1.91	1.01	2.79	1.01
Glenamuck Stream	1	990	Q1000	existing	1.93	104.69	105.39	105.28	105.50	0.037589	1.44	1.34	3.07	0.70
Glenamuck Stream	1	980	Q1000	proposed	1.93	101.08	101.89	101.55	101.93	0.009810	0.90	2.15	3.65	0.37
Glenamuck Stream	1	980	Q1000	existing	1.93	101.14	101.77	101.63	101.85	0.028990	1.30	1.49	3.41	0.63
Glenamuck Stream	1	975			Culvert									
Glenamuck Stream	1	970	Q1000	proposed	1.93	99.23	99.87	99.87	100.10	0.088510	2.12	0.91	2.02	1.01
Glenamuck Stream	1	970	Q1000	existing	1.93	99.21	100.09	99.87	100.18	0.026486	1.36	1.44	3.23	0.57
Glenamuck Stream	1	960	Q1000	proposed	1.93	97.02	97.92	97.58	97.97	0.012590	1.00	1.93	3.23	0.41
Glenamuck Stream	1	960	Q1000	existing	1.93	97.02	97.69	97.58	97.81	0.039579	1.52	1.27	2.70	0.71
Glenamuck Stream	1	950	Q1000	proposed	1.93	94.92	95.63	95.63	95.88	0.096203	2.21	0.87	1.78	1.01
Glenamuck Stream	1	950	Q1000	existing	1.93	94.92	95.93	95.64	95.99	0.015832	1.12	1.81	5.33	0.42
Glenamuck Stream	1	945			Culvert									
Glenamuck Stream	1	940	Q1000	proposed	1.93	94.11	94.73	94.57	94.83	0.030634	1.39	1.39	2.65	0.61
Glenamuck Stream	1	940	Q1000	existing	1.93	94.04	94.73	94.56	94.82	0.030506	1.37	1.41	2.65	0.60
Glenamuck Stream	1	930	Q1000	proposed	1.93	90.54	91.26	91.05	91.33	0.024284	1.13	1.71	4.09	0.56
Glenamuck Stream	1	930	Q1000	existing	1.93	90.54	91.26	91.05	91.33	0.024284	1.13	1.71	4.09	0.56
Glenamuck Stream	1	920	Q1000	proposed	1.93	87.62	88.77	88.38	88.83	0.014911	1.11	1.74	2.38	0.41
Glenamuck Stream	1	920	Q1000	existing	1.93	87.62	88.77	88.38	88.83	0.014911	1.11	1.74	2.38	0.41
Glenamuck Stream	1	910	Q1000	proposed	1.93	86.02	86.94	86.68	87.03	0.026198	1.36	1.42	2.24	0.54
Glenamuck Stream	1	910	Q1000	existing	1.93	86.02	86.94	86.68	87.03	0.026198	1.36	1.42	2.24	0.54
Glenamuck Stream	1	905	Q1000	proposed	1.93	85.39	86.35	86.11	86.38	0.009463	0.81	2.79	17.09	0.34
Glenamuck Stream	1	905	Q1000	existing	1.93	85.39	86.35	86.11	86.38	0.009463	0.81	2.79	17.09	0.34
Glenamuck Stream	1	900	Q1000	proposed	1.93	84.61	85.45	85.24	85.53	0.023359	1.28	1.58	6.55	0.53
Glenamuck Stream	1	900	Q1000	existing	1.93	84.61	85.45	85.24	85.53	0.023359	1.28	1.58	6.55	0.53
Glenamuck Stream	1	890	Q1000	proposed	1.93	83.71	84.49	84.25	84.51	0.005464	0.62	3.39	16.56	0.27
Glenamuck Stream	1	890	Q1000	existing	1.93	83.71	84.49	84.25	84.51	0.005464	0.62	3.39	16.56	0.27
Glenamuck Stream	1	887			Culvert									
Glenamuck Stream	1	885	Q1000	proposed	1.93	82.88	84.28	83.44	84.31	0.004970	0.73	2.65	2.86	0.22
Glenamuck Stream	1	885	Q1000	existing	1.93	82.88	84.28	83.44	84.31	0.004970	0.73	2.65	2.86	0.22
Glenamuck Stream	1	883			Culvert									
Glenamuck Stream	1	880	Q1000	proposed	1.93	82.65	83.64	83.36	83.72	0.020536	1.23	1.57	2.56	0.50
Glenamuck Stream	1	880	Q1000	existing	1.93	82.65	83.64	83.36	83.72	0.020536	1.23	1.57	2.56	0.50
Glenamuck Stream	1	870	Q1000	proposed	1.93	81.87	82.89	82.48	82.92	0.007163	0.75	2.57	4.52	0.32
Glenamuck Stream	1	870	Q1000	existing	1.93	81.87	82.89	82.48	82.92	0.007163	0.75	2.57	4.52	0.32
Glenamuck Stream	2	860	Q1000	proposed	4.21	81.37	82.56	82.06	82.62	0.009357	1.10	3.89	5.72	0.38
Glenamuck Stream	2	860	Q1000	existing	4.21	81.37	82.56	82.06	82.62	0.009356	1.10	3.89	5.72	0.38
Glenamuck Stream	2	850	Q1000	proposed	4.21	81.18	82.40	81.81	82.43	0.004476	0.80	5.29	6.22	0.28
Glenamuck Stream	2	850	Q1000	existing	4.21	81.18	82.40	81.81	82.43	0.004475	0.80	5.29	6.22	0.28
Glenamuck Stream	2	845			Culvert									
Glenamuck Stream	2	840	Q1000	proposed	4.21	80.37	81.74	81.21	81.79	0.007432	0.95	4.49	7.32	0.35
Glenamuck Stream	2	840	Q1000	existing	4.21	80.37	81.74	81.21	81.78	0.007534	0.96	4.46	7.28	0.35
Glenamuck Stream	2	830	Q1000	proposed	4.21	79.71	80.93	80.63	81.01	0.022649	1.30	3.24	5.86	0.56
Glenamuck Stream	2	830	Q1000	existing	4.21	79.71	80.94	80.63	81.03	0.020962	1.26	3.34	5.98	0.54
Glenamuck Stream	2	820	Q1000	proposed	4.21	79.05	80.53	79.93	80.57	0.004735	0.84	4.90	6.33	0.28
Glenamuck Stream	2	820	Q1000	existing	4.21	79.05	80.44	79.93	80.49	0.006704	0.96	4.44	6.93	0.33
Glenamuck Stream	2	810	Q1000	proposed	4.21	78.63	80.45	79.63	80.46	0.001967	0.59	7.22	9.34	0.19
Glenamuck Stream	2	810	Q1000	existing	4.21	78.63	80.36	79.63	80.37	0.001796	0.51	8.62	18.43	0.18
Glenamuck Stream	2	805			Culvert									
Glenamuck Stream	2	800	Q1000	proposed	4.21	78.29	79.92	79.00	79.94	0.001445	0.53	8.23	11.50	0.16
Glenamuck Stream	2	800	Q1000	existing	4.21	78.29	79.92	79.00	79.94	0.001445	0.53	8.23	11.50	0.16
Glenamuck Stream	2	795			Culvert									
Glenamuck Stream	2	790	Q1000	proposed	4.21	77.40	78.78	78.05	78.79	0.001536	0.49	8.69	13.57	0.17
Glenamuck Stream	2	790	Q1000	existing	4.21	77.40	78.78	78.05	78.79	0.001536	0.49	8.69	13.57	0.17
Glenamuck Stream	2	780	Q1000	proposed	4.21	77.42	78.76	78.09	78.77	0.001002	0.44	9.97	21.28	0.14
Glenamuck Stream	2	780	Q1000	existing	4.21	77.42	78.76	78.09	78.77	0.001002	0.44	9.97	21.28	0.14
Ditch	1	2100	Q1000	proposed	1.50	83.10	83.87	83.69	83.96	0.032603	1.34	1.12	2.20	0.60
Ditch	1	2100	Q1000	existing	1.50	83.10	83.95	83.69	83.99	0.016289	1.00	1.74	12.02	0.43
Ditch	1	2000	Q1000	proposed	1.50	82.88	83.54	83.54	83.75	0.088682	1.99	0.75	1.86	1.00
Ditch	1	2000	Q1000	existing	1.50	82.88	83.88	83.54	83.93	0.014576	1.02	1.47	2.46	0.42
Ditch	1	1950			Culvert									
Ditch	1	1900	Q1000	proposed	1.50	82.66	83.32	83.07	83.37	0.010742	0.93	1.54	3.15	0.40
Ditch	1	1900	Q1000	existing	1.50	82.12	83.06	82.73	83.11	0.016334	1.04	1.44	2.39	0.43
Ditch	1	1800	Q1000	proposed	1.50	81.96	82.92	82.52	82.96	0.010769	0.89	1.68	2.66	0.36
Ditch	1	1800	Q1000	existing	1.50	81.96	82.92	82.52	82.96	0.010765	0.89	1.68	2.66	0.36


Loughlinstown Plan: 1) existing 28/08/2018 2) proposed 28/08/2018
Loughlinstown Loughlinstown Ri
Legend
WS q100 - existing
WS q100 - proposed
Ground
Elevation (m)
133
132
131
130
129
128
127
126
4800
4900
4980
4985
5000
5100
0
20
40
60
80
100
Main Channel Distance (m)



Loughlinstown Plan: 1) existing 28/08/2018 2) proposed 28/08/2018
Loughlinstown Loughlinstown Ri
Legend
WS q1000 - existing
WS q1000 - proposed
Ground
Elevation (m)
133
132
131
130
129
128
127
126
4800
4900
4980
4985
5000
5100
0
20
40
60
80
100
Main Channel Distance (m)

HEC-RAS River: Loughlinstown Reach: Loughlinstown Ri Profile: q1000

Reach	River Sta	Profile	Plan	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)	
Loughlinstown Ri	5100	q1000	existing	7.60	131.48	132.44	132.44	132.80	0.049864	2.65	2.86	4.05	1.01
Loughlinstown Ri	5100	q1000	proposed	7.60	131.48	132.44	132.44	132.80	0.049954	2.65	2.86	4.05	1.01
Loughlinstown Ri	5000	q1000	existing	7.60	129.80	130.79	130.81	131.16	0.055121	2.72	2.79	4.09	1.05
Loughlinstown Ri	5000	q1000	proposed	7.60	129.80	130.79	130.80	131.16	0.055148	2.72	2.79	4.09	1.05
Loughlinstown Ri	4980	q1000	existing	7.60	128.17	129.07	129.22	129.63	0.092212	3.32	2.29	3.67	1.34
Loughlinstown Ri	4980	q1000	proposed	7.60	128.17	129.10	129.21	129.61	0.080373	3.16	2.40	3.74	1.26
Loughlinstown Ri	4900	q1000	existing	7.60	127.56	128.56	128.64	129.02	0.071009	2.98	2.55	3.83	1.16
Loughlinstown Ri	4900	q1000	proposed	7.60	127.56	128.53	128.63	129.03	0.080891	3.12	2.44	3.80	1.24
Loughlinstown Ri	4800	q1000	existing	7.60	126.75	127.68	127.75	128.01	0.050299	2.56	3.05	6.39	1.03
Loughlinstown Ri	4800	q1000	proposed	7.60	126.75	127.70	127.75	128.01	0.045352	2.47	3.17	6.59	0.98
Loughlinstown Ri	4700	q1000	existing	7.60	126.33	127.35	127.35	127.53	0.025060	2.03	4.18	11.52	0.72
Loughlinstown Ri	4700	q1000	proposed	7.60	126.33	127.33	127.36	127.53	0.028281	2.13	3.97	11.00	0.76