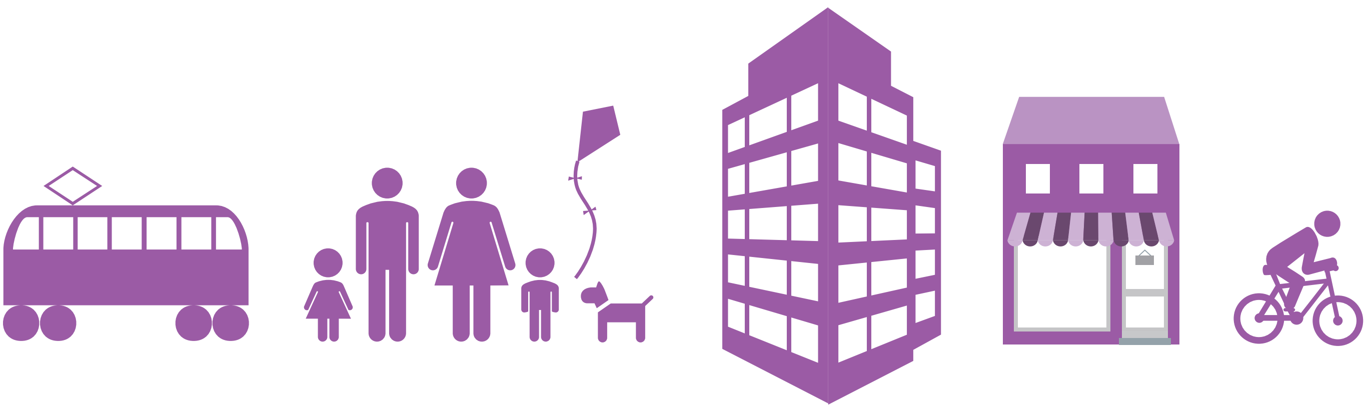
Appendix C

Estuary West Masterplan

Surface Water Management Plan (SWMP)



May 2019

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25 BLIANA YEARS

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Fingal County Council

Estuary West Masterplan

Surface Water Management Plan
[FINAL – May 2019]

ROD
ROUGHAN & O'DONOVAN

Comhairle Contae
Fhine Gall
Fingal County
Council

INTRODUCTION

The following Surface Water Management Plan has been prepared by ROD to supplement the Estuary West Masterplan for Fingal County Council. The Surface Water Management Plan comprises of two parts which should be read in conjunction with one another:

- Part 1 – Strategic Flood Risk Assessment
- Part 2 – Sustainable Drainage Systems (SuDS) Strategy

As part of the iterative assessment process ROD were a part of a team of consultants that fed into the process of preparing the final version of the Masterplan. The draft Masterplan was published for a period of public consultation from the 12th March to 3rd April 2019. Submissions received after this period of public consultation were taken into account during the subsequent stages in the preparation of the Final Surface Water Management Plan issued May 2019. The final report issued May 2019 is cognisant of the various stages in the preparation of the Masterplan.

Part 1 of the Surface Water Management Plan consists of a Stage I, II and III Flood Risk Assessment for the lands.

Part 2 of the Surface Water Management Plan outlines a Sustainable Drainage Systems (SuDS) Strategy for the lands which should be adapted for particular types of future development.

The full scope this Surface Water Management is as follows:

- Provide an assessment/identification of flood risk for the Masterplan lands in accordance with "The Planning System and Flood Risk Management – Guidelines for Planning Authorities" (The Guidelines), 2009, published by the Department for the Environment, Heritage and Local Government and the Office of Public Works (OPW).
- Undertake a Flood Risk Assessment Report assessing the hydrology and hydraulics and determining, modelling and mapping the cause, extents, depths and mechanisms of flooding in the Masterplan lands, taking into account anticipated future increases in rainfall, river flows and sea level rise as a result of climate change.
- Provide recommendations for future flood risk assessments for proposed developments and planning applications, in accordance with The Guidelines.
- Generate flood depth and extent maps for the 1% & 0.1% AEP fluvial flood events, the 0.5% & 0.1% AEP coastal flood events, (as applicable to the Masterplan lands), and the 1% & 0.1% pluvial flood events. The flood maps consider the Current Climate Scenario as well as the OPWs Mid-Range Future Scenario and the High-End Future climate change scenarios (Climate Change Sectoral Adaptation Plan Flood Risk Management 2015 - 2019).
- Review the existing drainage network servicing the lands and provide an assessment of the Masterplan lands in terms of sustainable drainage possibilities, in accordance with the requirements of the GDSDS, CIRIA SuDS Manual C753 and the current Fingal County Development Plan (2017 – 2023).
- Prepare a SuDS Strategy with recommendations regarding appropriate SuDS systems and devices for the implementation of the SuDS strategy for all proposed development within the Estuary West masterplan boundary.

- Incorporate the effects of Climate Change, soil type and groundwater into the SuDS Strategy.
- Determine the effects on and of flooding, groundwater and surface water drainage system in the masterplan area due to the incorporation of the SuDS Strategy.
- Make recommendations on the discharge rate to be applied across the Masterplan lands and as to the future development and sustainable drainage of the Plan lands.
- Liaison with Consultants completing the Strategic Environmental Assessment (SEA), Appropriate Assessment and Fingal County Council as well as public consultation.

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Fingal County Council

Estuary West Masterplan

Surface Water Management Plan Part 1: Strategic Flood Risk Assessment

May 2019 (FINAL)

ROD
ROUGHAN & O'DONOVAN

Comhairle Contae Fhine Gall
Fingal County Council

Estuary West Masterplan
Surface Water Management Plan
Part 1: Strategic Flood Risk Assessment

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1. INTRODUCTION

1.1 Commission

Roughan & O'Donovan Consulting Engineers (ROD) was commissioned by Fingal County Council (FCC) to prepare a Surface Water Management Plan to supplement the Estuary West Masterplan in Swords, County Dublin. As part of this commission, the Stage I, II and III Flood Risk Assessment for the Masterplan lands was undertaken. The Masterplan will set out the local land use and planning policy for the Estuary West site and provide a strategy for the future planning and sustainable development of the Area.

1.2 Scope

The scope of this report is as follows:

- Provide an assessment/identification of flood risk for the Masterplan lands in accordance with "*The Planning System and Flood Risk Management – Guidelines for Planning Authorities"* (The Guidelines), 2009, published by the Department for the Environment, Heritage and Local Government and the Office of Public Works (OPW).
- Undertake a Flood Risk Assessment Report assessing the hydrology and hydraulics and determining, modelling and mapping the cause, extents, depths and mechanisms of flooding in the Masterplan lands, taking into account anticipated future increases in rainfall, river flows and sea level rise as a result of climate change.
- Provide recommendations for future flood risk assessments for proposed developments and planning applications, in accordance with The Guidelines.
- Generate flood depth and extent maps for the 1% & 0.1% AEP fluvial flood events, the 0.5% & 0.1% AEP coastal flood events, (as applicable to the Masterplan lands), and the 1% & 0.1% pluvial flood events. The flood maps consider the Current Climate Scenario as well as the OPWs Mid-Range Future Scenario and the High-End Future climate change scenarios (Climate Change Sectoral Adaptation Plan Flood Risk Management 2015 - 2019).
- Liaison with Consultants completing the Strategic Environmental Assessment (SEA), Appropriate Assessment and Fingal County Council as well as public consultation.

1.3 Study Area

1.3.1 Overview

The subject area is located at Estuary West, Swords, North County Dublin. The Masterplan lands are located approximately 1.5km west of the M1 motorway, 6.6km north of the M50 motorway and 4.5km north of Dublin Airport. The Masterplan lands are located within an urban environment, consisting predominantly of residential and commercial development. The lands are bounded by residential development to the west and south, commercial developments to the east and the River Broadmeadow to the north. The Glen Ellen Road runs adjacent to the southern boundary of the lands, with the Balheary Road running parallel to the eastern boundary of the lands.

The Estuary West site comprises approximately 19.4ha and is zoned ME – Metro Economic Corridor with the objective to "Facilitate opportunities for high density mixed use employment generating activity and commercial development, and support the provision of an appropriate quantum of residential development within the Metro Economic Corridor". Refer to Figure 1.1 below.

Figure 1.1: Estuary West Masterplan lands

The topography of the Estuary West site generally falls from approximately 16mOD to 5mOD in a south-western to north-eastern direction towards the River Broadmeadow.

1.3.2 Catchment Description

The Masterplan study area lies within the catchment of the Broadmeadow River and the River Ward, which is a tributary to the Broadmeadow River. The confluence of these two watercourses is located approximately 1.4km west of Malahide Estuary, as outlined in Figure 1.2. This Broadmeadow drains to the Malahide Estuary prior to discharging to the Irish Sea.

The River Broadmeadow rises approximately 21km north west of the subject lands in Dunshaughlin. The River Ward rises approximately 16km south west of the Masterplan lands. Both rivers generally flow in an easterly direction towards the Malahide Estuary.

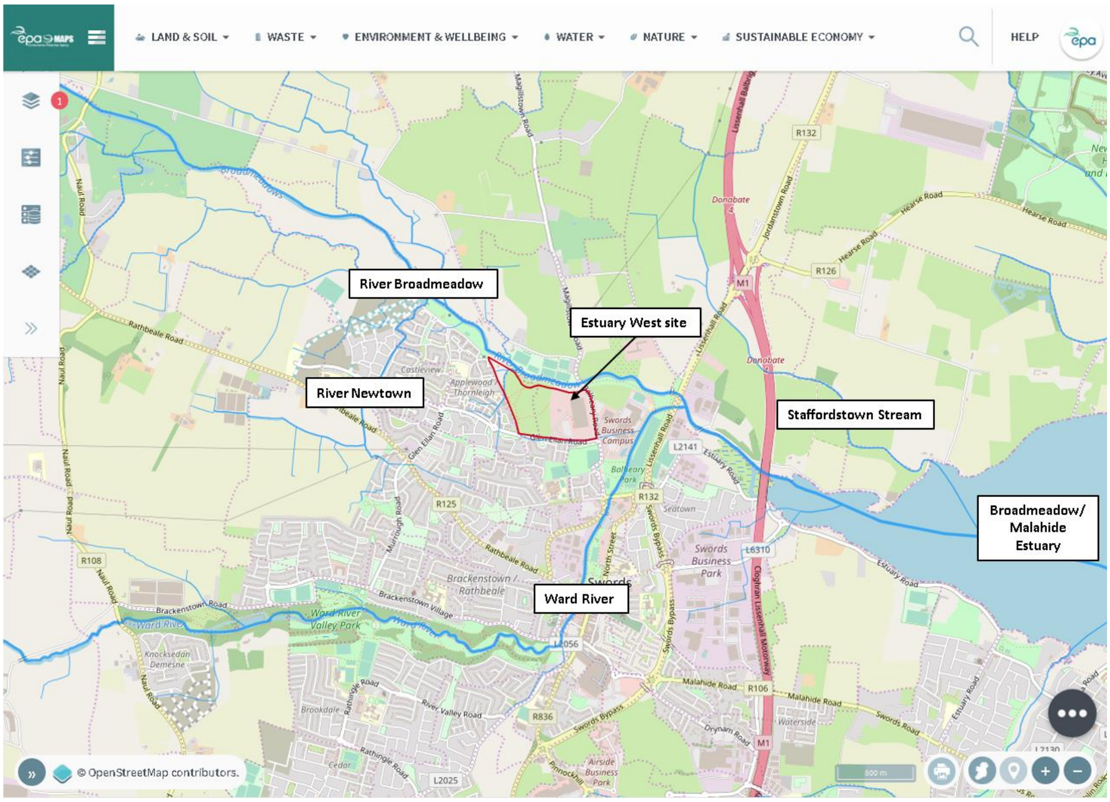


Figure 1.2: Watercourses around the Estuary West site (EPA Catchments.ie)

Irish Water records indicate that there is existing surface water drainage infrastructure within the vicinity of the Masterplan lands. There is also a drainage ditch located at the north western corner of the lands which drains to the River Broadmeadow. Upon inspection on the 21/11/2018, this ditch was found to be dry.

1.3.3 Environment

There are no Natura 2000 sites located within the study area; however, the Natura 2000 sites Malahide Estuary (SPA and SAC) is located 2km east of the Masterplan lands, Rogerstown Estuary (SPA and SAC) is located 4.5km north east of the Masterplan lands and Baldoyle Bay (SPA and SAC) is located 8.00km south east of the Masterplan lands.

Under Article 6(3) of the EU Habitats Directive, an “appropriate assessment” (AA) is required where any plan or project, either alone or ‘in combination’ with other plans or projects, could have an adverse effect on the integrity of a Natura 2000 site.

Natural Heritage Areas (NHAs) are sites of national importance for nature conservation and are afforded protection under planning policy and the Wildlife Acts, 1976-2012. Proposed NHAs (pNHAs) are published sites identified as of similar conservation interest but have not been statutorily proposed or designated. The nearest NHA/pNHAs to the study area are:

- Malahide Estuary (proposed NHA) ~ 2km east of Estuary West Masterplan lands
- Rogertown Estuary (proposed NHA) ~ 4.50km north-east of the Estuary West Masterplan lands
- Baldoyle Bay (proposed NHA), ~8.00km south-east of the Estuary West Masterplan lands

- Sluice River Marsh (proposed NHA), ~ 7.00km south-east of the Estuary West Masterplan lands
- Feltrim Hill (proposed NHA), ~4km south-east of the Estuary West Masterplan lands
- Portrane Shore (proposed NHA) ~ 8km north-east of the Estuary West Masterplan lands

Therefore, the management of flood risk within the Masterplan study area must have regard to potential negative impacts to this environment.

1.4 Proposed Development

The Estuary West area comprises one zoning objective in the Fingal Development Plan 2017 – 2023 which is shown in Table 1.1 below.

Table 1.1 Estuary West Zoning Objectives

Objective	Description	Area
ME - Metro Economic Corridor	Facilitate opportunities for high density mixed use employment generating activity and commercial development, and support the provision of an appropriate quantum of residential development within the Metro Economic Corridor.	Estuary West

The Fingal Development Plan for the Estuary West zoning objective is reproduced in Figure 1.3 below.

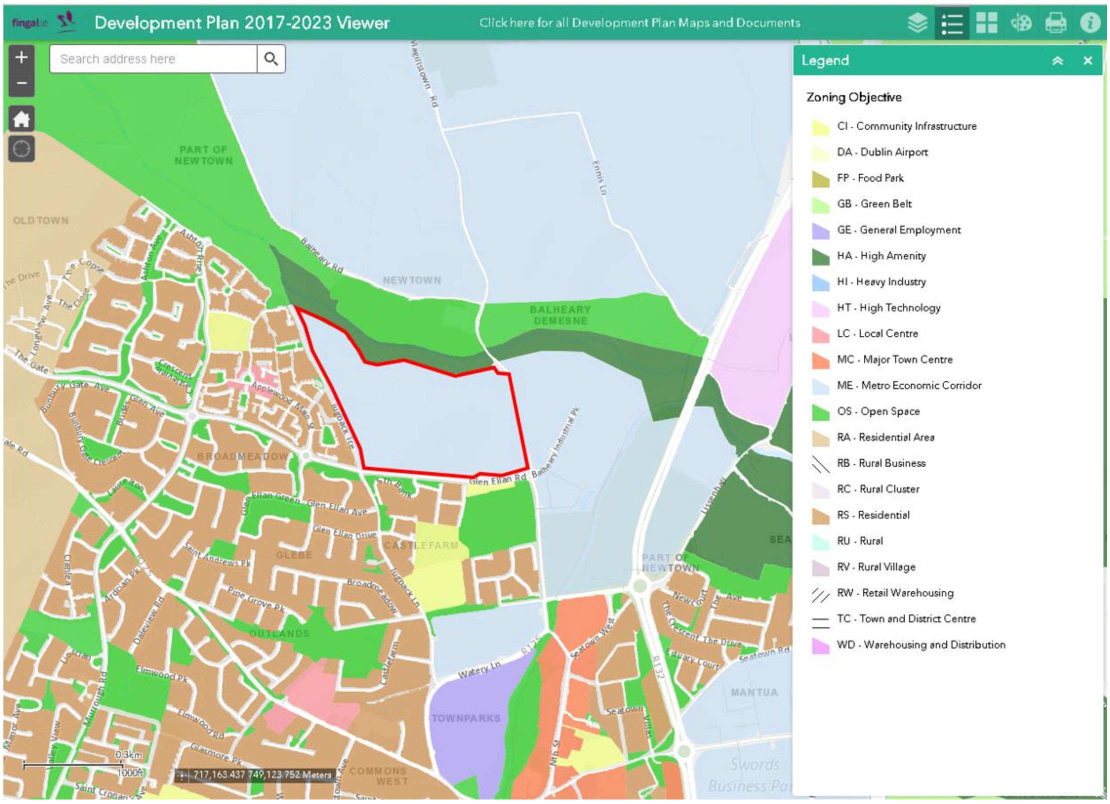


Figure 1.3: Estuary West Zoning Objective (Fingal Co Co Development Plan 2017 – 2023)

2. METHODOLOGY

2.1 Introduction

This report has been prepared in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' herein referred to as 'The Guidelines' as published by the Office of Public Works (OPW) and Department of Environment, Heritage and Local Government (DoHLG) in 2009.

2.2 Definition of Flood Risk

Flood risk is a combination of the likelihood of a flood event occurring and the potential consequences arising from that flood event and is then normally expressed in terms of the following relationship:

Flood risk = Likelihood of flooding x Consequences of flooding.

To fully assess flood risk an understanding of where the water comes from (i.e. the source), how and where it flows (i.e. the pathways) and the people and assets affected by it (i.e. the receptors) is required. Figure 2.1 below shows a source-pathway-receptor model reproduced from 'The Guidelines'.

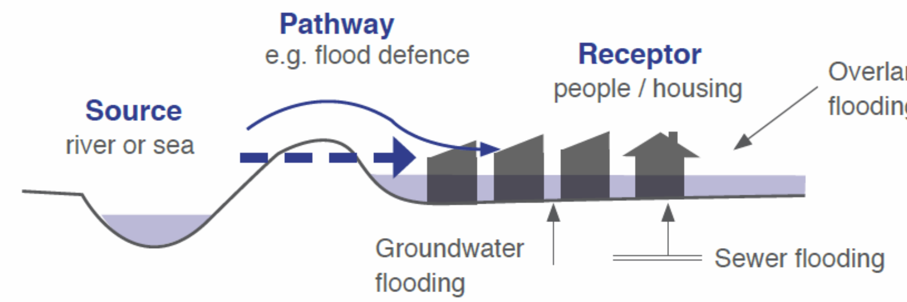


Figure 2.1 Source-Pathway-Receptor Model

The principal sources of flooding are rainfall or higher than normal sea levels. The principal pathways are rivers, drains, sewers, overland flow and river and coastal floodplains. The receptors can include people, their property and the environment. All three elements as well as the vulnerability and exposure of receptors must be examined to determine the potential consequences.

2.3 Likelihood of Flooding

The Guidelines define the likelihood of flooding as the percentage probability of a flood of a given magnitude or severity occurring or being exceeded in any given year. It is generally expressed as a return period or annual exceedance probability (AEP). A 1% AEP flood indicates a flood event that will be equalled or exceeded on average once every hundred years and has a return period of 1 in 100 years. Annual Exceedance Probability is the inverse of return period as shown in Table 2.1 below.

Table 2.1 Correlation between return period and AEP

Return Period (years)	Annual Exceedance Probability (%)
1	100
10	10
50	2
100	1

Return Period (years)	Annual Exceedance Probability (%)
200	0.5
1000	0.1

2.4 Definition of Flood Zones

Flood zones are geographical areas within which the likelihood of flooding is in a particular range and are split into three categories in The Guidelines:

Flood Zone A

Flood Zone A where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);

Flood Zone B

Flood Zone B where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 and 0.5% or 1 in 200 for coastal flooding);

Flood Zone C

Flood Zone C where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding. Flood Zone C covers all plan areas which are not in zones A or B.

It is important to note that when determining flood zones the presence of flood protection structures should be ignored. This is because areas protected by flood defences still carry a residual risk from overtopping or breach of defences and the fact that there is no guarantee that the defences will be maintained in perpetuity.

2.5 Objectives and Principles of the Planning Guidelines

The principle actions when considering flood risk are set out in the planning guidelines and are summarised below:

- *"Flood hazard and potential risk should be determined at the earliest stage of the planning process..."*
- *"Development should preferentially be located in areas with little or no flood hazard thereby avoiding or minimising the risk...."*
- *"Development should only be permitted in areas at risk of flooding when there are no alternatives, reasonable sites available..."*
- *"Where development is necessary in areas at risk of flooding an appropriate land use should be selected"*
- *A precautionary approach should be applied, where necessary, to reflect uncertainties in flooding datasets and risk assessment techniques..."*
- *"Land required for current and future flood management... should be pro-actively identified..."*
- *"Flood risk to, and arising from, new development should be managed through location, layout and design incorporating Sustainable Drainage Systems (SuDS) and compensation for any loss of floodplain..."*
- *Strategic environmental assessment (SEA) of regional planning guidelines, development plans and Masterplans should include flood risk as one of the key environmental criteria..."*

2.6 The Sequential Approach and Justification Test

The Guidelines outline the sequential approach that is to be applied to all levels of the planning process. This approach should also be used in the design and layout of a development and the broad philosophy is shown in Figure 2.2 below. In general, development in areas with a high risk of flooding should be avoided as per the sequential approach. However, this is not always possible as many town and city centres are within flood zones and are targeted for development.

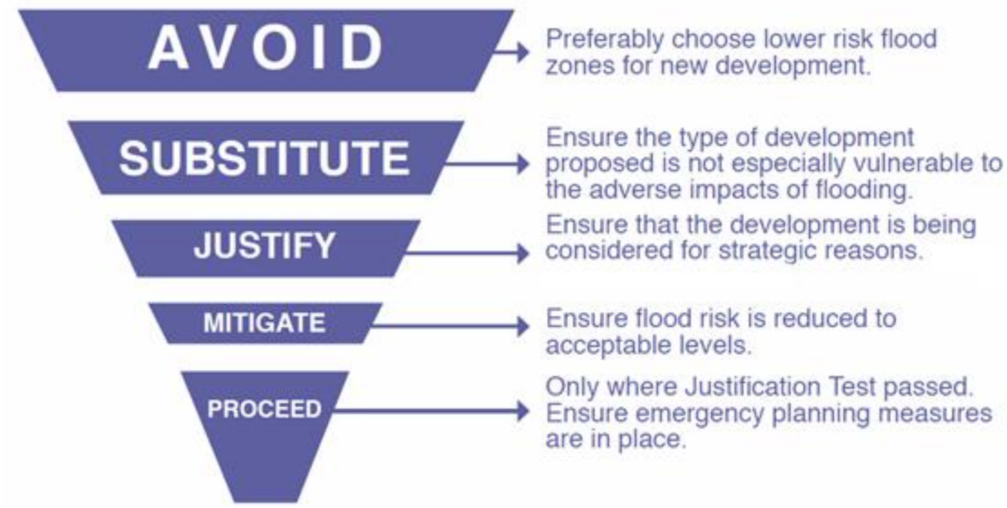


Figure 2.2 Sequential Approach (The Guidelines)

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of developments that are being considered in areas of moderate or high flood risk. The test comprises the following two processes.

- The first is the Plan-making Justification Test and is used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding.
- The second is the Development Management Justification Test and is used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land.

Table 2.2 below illustrates the types of development that would be required to meet the Justification Test.

Table 2.2 Matrix of Vulnerability Versus Flood Zone to Illustrate Appropriate Development and that Required to Meet the Justification Test (The Guidelines)

Vulnerability Class (The Guidelines section 3.5)	**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

3. STAGE 1 - FLOOD RISK IDENTIFICATION

3.1 General

This Flood Risk Identification phase includes a review of the existing information and the identification of any flooding or surface water management issues in the vicinity of the Estuary West Masterplan lands that may warrant further investigation.

3.2 Information Sources Consulted

The following information sources were consulted as part of the Flood Risk Identification:

Table 3.1 Information Sources Consulted

Source	Comments
OPW Preliminary Flood Risk Assessment (PFRA) maps	Fluvial, Pluvial, Coastal and Groundwater flooding examined;
OPW Benefitting Land Maps	Available at OPW Drainage District Viewer
OPW National Flood Hazard Mapping	www.floodmaps.ie
Geological Survey of Ireland (GSI) Maps	Utilised multiple data layers available at the GSI Groundwater Data viewer
OSI Historical Maps	OSI 6" and 25" mapping examined
Catchment Flood Risk Assessment and Management Study (CFRAM)	CFRAM mapping available at fem.cfram.com
Irish Coastal Protection Strategy Study (ICPSS)	No ICPSS maps are not available for Masterplan lands
Fingal Development Plan 2017-2023	Relevant sections of the Development Plan
Flood Risk Assessment and Management Studies	Fingal East Meath Flood Risk Assessment and Management Study (FEMFRAMS)
Irish Water / Fingal Co. Co. Drainage Records	Existing drainage records used in determining the drainage catchment

3.2.1 Predictive Flood Maps and Flood Hazard Records

(i) OPW Preliminary Flood Risk Assessment

The PFRA is a national screening exercise to identify the areas where there may be a significant risk associated with flooding (referred to as Areas for Further Assessment or AFA's). As part of the PFRA study, maps of the country were produced showing the indicative fluvial, coastal, pluvial and groundwater flood extents.

Fluvial flooding is indicated along the length of the Broadmeadow River but this is limited to riparian corridor immediately adjacent to the Broadmeadow River there is no fluvial flooding indicated within the Estuary West site.

Pluvial flooding is indicated to occur at the south western corner of the site.

It is important to note that these maps have limitations as any local errors in the digital terrain model (DTM) were not filtered out, local channel works were not included, flood defences were excluded and channel structures were not considered.

The *PFRA Maps for the area are reproduced in Appendix A.*

(ii) OPW Drainage Districts

Under the Arterial Drainage Act, 1945 the OPW undertook a number of arterial drainage schemes to improve land for agricultural production. The OPW has a statutory duty to maintain these schemes, which is delivered through their arterial drainage maintenance programme. The OPW does not have powers to undertake river or channel maintenance other than where these rivers form part of an arterial drainage scheme or flood relief schemes.

The OPW Drainage district maps show that lands at the northern and eastern boundary of Estuary West are “benefiting lands”, i.e. lands that have benefited from flood alleviation works previously completed under the Arterial Drainage Act, 1945.

The OPW Drainage Districts are reproduced in Appendix B.

(iii) OPW National Flood Hazard Mapping

The OPW National Flood Hazard Mapping Web Site, www.floodmaps.ie, was examined to identify any recorded flood events within and in the vicinity of the Masterplan lands.
Recurring flood events have been recorded at Balheary Road just north of the site.

The OPW Flood Hazard Mapping is reproduced in Appendix C.

(iv) Fingal East Meath Flood Risk Assessment and Management Study (FEM-FRAM Study)

The FEM-FRAM Study was undertaken by FCC in conjunction with project partners Meath County Council and the OPW and is a catchment based flood risk management study of nineteen rivers and streams and their catchments.

The fluvial flood extent mapping for the current scenario indicates that the north-eastern part of the Estuary West site is subject to flooding in the 0.1% AEP fluvial flood event. Furthermore, the FEM-FRAM mapping indicates fluvial flooding along the Ward River, however the flood extents do not encroach on the subject site.

The tidal flood extent mapping for the current scenario indicates that there is no tidal flooding within the subject site. There is a small portion of out of bank tidal flooding along the southern bank of the Broadmeadow River, however the 0.1% AEP flood extents do not encroach onto the subject site. The mapping indicates that the majority of tidal flooding at this location is confined to the northern side of the Broadmeadow River. There are also indications of tidal flooding to the east of the site along the Ward River, however, these flood extents do not encroach the subject site.

The FEM-FRAM Mapping is reproduced in Appendix D.

(v) Secondary Sources of Baseline data

Table 3.2 below lists secondary sources examined to identify areas that may be liable to flooding:

Table 3.2 Secondary Sources of Baseline Data

Source	Data Gathered
GSI Maps	GSI Teagasc subsoils map shows that the Estuary West Masterplan lands are underlain by BminDW - Deep well drained mineral (Mainly basic), BminPD - Mineral poorly drained (Mainly basic), AlluvMIN – Alluvium (mineral), BminSW – Shallow well drained mineral (Mainly basic) and Made Ground. Soil permeability is generally low across the majority of the site. There is high soil permeability at the north western extents of the lands adjacent the Broadmeadow River. The groundwater recharge rates for the Masterplan lands are indicated to be between 1-50 up to 101-150 mm/yr. No evidence of Karst features has been identified within the Estuary West Masterplan lands. Refer to Appendix E for GSI maps.
Historical Maps	No areas of the site are labelled as “liable to flooding” or have other indicators of historic flooding. Refer to Appendix F for Historical Maps.

4. FLOOD RISK IDENTIFICATION SUMMARY

In accordance with The Guidelines the sources of flooding within the Estuary West Masterplan boundary have been identified. These are summarised in Table 5.1 below.

Table 5.1 Possible Sources of Flooding Associated within the Estuary West Masterplan lands

Source	Pathway	Receptor	Likelihood	Consequence	Risk
Tidal	River Broadmeadow / Ward River – out of bank flooding	Estuary West Masterplan Lands	Possible	High – The subject site is distant from the Ward River. However, the FemFram Study indicates tidal flooding immediately north of the subject site along the southern bank of the River Broadmeadow.	High - Sources indicate potential Tidal flooding from River Broadmeadow immediately north of the site
Fluvial	River Broadmeadow / Ward River – out of bank flooding		Possible	High – The FemFram Study indicates fluvial flooding within the subject site	High - Multiple sources indicate potential fluvial flooding from the River Broadmeadow and the Ward River
Surface Water / Pluvial	Overland flow		Possible	Medium – possible pluvial flooding within subject site	Low - If appropriate drainage system incorporating SuDS are adopted in potential development areas and maintained appropriately
Ground Water	Rising levels		Low possibility	Medium (No indications of previous groundwater flooding)	Low - Due to soil drainage characteristics and site topography
The following potential flood sources were also scoped but no perceptible flood risk was identified: dam breach, flood defence failure, canal bank breach, snow melt, watermain burst.					

The findings of the stage 1 assessment indicate that the lands identified for development within the Estuary West Masterplan are at risk of flooding. Therefore, in accordance with The Guidelines (OPW 2009), a Stage 2 flood risk assessment should be carried out. This is outlined in Section 5 of this report.

5. STAGE 2 – INITIAL FLOOD RISK ASSESSMENT

5.1 General

A Stage 2 SFRA (initial flood risk assessment) was undertaken to:

- Confirm the sources of flooding that may affect the Estuary West Masterplan lands;
- Appraise the adequacy of existing information as identified by the Stage 1 FRA.

5.2 Sources of Flooding

Flooding from Fluvial & Sea Level Rises / Coastal Flooding

The main source of fluvial flooding is the River Broadmeadow, as identified in the Stage I FRA and is discussed in more detail below.

The River Broadmeadow generally flows in a west – east direction, immediately north of the development site. This section of the river is fluvially dominated, as such; the most prevalent flood risk to the site is from extreme fluvial inundation events or fluvial events in combination with extreme tidal events. A small portion of the lands at the north eastern corner are indicated to be within flood zone A and B in the OPW FEM-FRAM Study and the OPW PFRA. It should be noted that the FEM FRAM flood extent maps are given a confidence rating. The confidence rating at the Estuary West lands is “low”. The Estuary West Masterplan lands are therefore considered to require a stage 3 detailed flood risk assessment with respect to flooding derived from Fluvial and Tidal sources.

Surface Water Flooding

Surface water flooding occurs when a local drainage system cannot convey stormwater flows from extreme rainfall events. In such circumstances, rainwater does not drain away through the normal drainage pathways or infiltrate into the ground but instead ponds on or flows over the ground. Surface water flooding is unpredictable as it depends on several factors including ground levels, rainfall and the local drainage network. All future developments within the Estuary West Masterplan lands shall incorporate SuDS features as described in the Estuary West Masterplan Surface Water Management Plan Part 2: Sustainable Drainage Systems (SuDS) Strategy for the purposes of managing flood risk, assisting in the attainment of obligations made under the Water Framework Directive (WFD). The Masterplan lands do not require a stage 3 detailed flood risk assessment with respect to surface water flooding.

Groundwater Flooding

Ground water flooding is a result of upwelling in occurrences where the water table or confined aquifers rises above the ground surface. This tends to occur after long periods of sustained rainfall and/or very high tides. High volumes of rainfall and subsequent infiltration to ground will result in a rising of the water table. Groundwater flooding tends to occur in low-lying areas, where with additional groundwater flowing towards these zones, the water table can rise to the surface causing groundwater flooding. The sources consulted such as the PFRA mapping show no indication that the lands within the Estuary West Masterplan area are subject to groundwater derived flooding. Factors such as soil permeability and drainage characteristics indicate that the risk of groundwater flooding is low. Thus, the Masterplan lands do not require a stage 3 detailed flood risk assessment with respect to groundwater flooding.

Pluvial Flood Risk

Pluvial flooding results from heavy rainfall that exceeds ground infiltration capacity or more commonly in Ireland where the ground is already saturated from previous rainfall events. This causes ponding and flooding at localized depressions. Pluvial flooding is usually caused by changes to the natural flow regime such as the adverse effects of urbanisation. The sources consulted such as the PFRA mapping indicate that the Estuary West Masterplan lands are subject to pluvial derived flooding at topographic low points (south western corner of the site). Pluvial flooding will be managed through the appropriate design and implementation of Sustainable Drainage Systems (SuDS) as part of all future planned development within the Estuary West Masterplan lands. Refer to the Estuary West SuDS Strategy Report. Therefore, the Masterplan lands will require a stage 3 flood risk assessment with respect to flooding derived from pluvial sources.

The findings of the stage 2 assessment indicate that the Estuary West Masterplan lands are at risk of flooding from fluvial/tidal and pluvial sources. Therefore, in accordance with The Guidelines (OPW 2009), a Stage 3 detailed flood risk assessment should be carried out. This is outlined in Section 6 of this report.

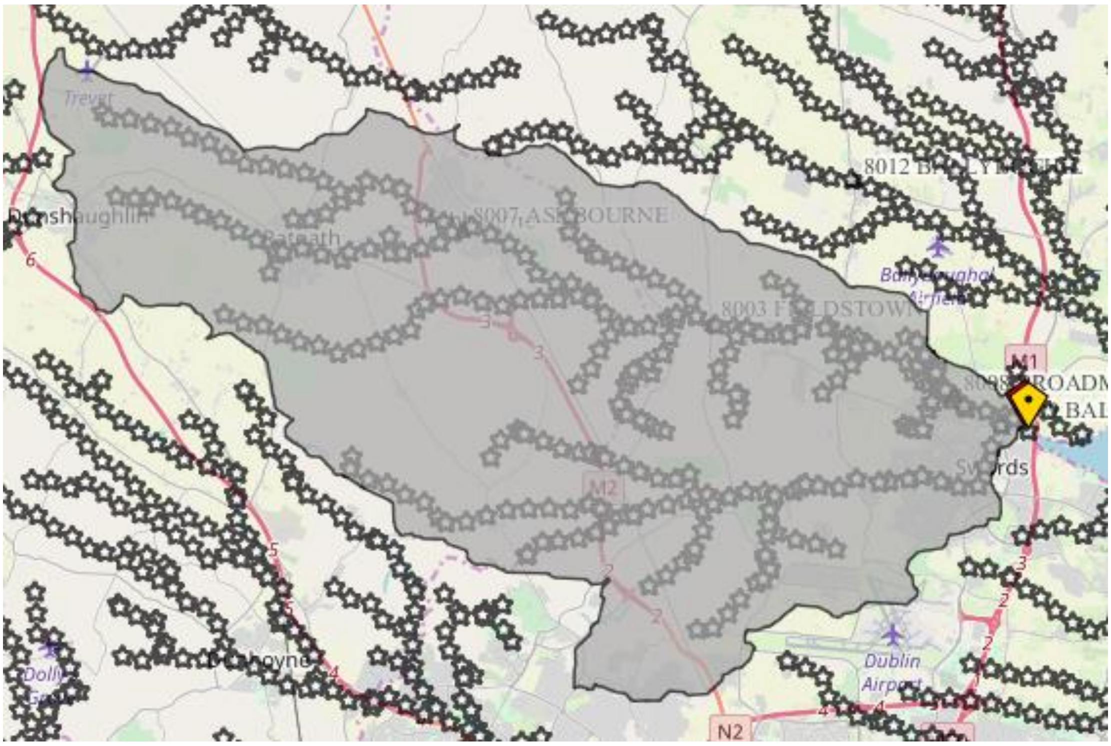
6. STAGE 3 DETAILED FLOOD RISK ASSESSMENT

6.1 Introduction

Stages 1 and 2 of the flood risk assessment for the Estuary West Masterplan indicate that the Masterplan lands are subject to flooding in medium and high probability exceedance events from fluvial, tidal and pluvial sources. Thus, this assessment has been progressed to stage 3 as per The Guidelines (OPW, 2009). This section outlines the hydrological analysis carried out for the Broadmeadow and Ward Rivers including an outline of hydraulic modelling methodology.

6.2 Hydrological Analysis

The River Gaybrook catchment upstream of Masterplan lands is shown in Figure 6.1 below.



The peak flows for a series of pluvial and combination tidal/fluvial events were estimated for the Broadmeadow and Ward catchments. The combination fluvial/tidal events used as part of the analysis are detailed in Table 6.1 below.

Table 6.1 Combination fluvial/tidal flood events

Simulation	Tidal Return Period (1 in XX year)	Fluvial Return Period (1 in XX year)
Fluvial 1 in 100 Year	5	100
Fluvial 1 in 1000 Year	50	1000
Tidal 1 in 200 Year	200	10
Tidal 1 in 1000 Year	1000	50

6.2.1 Fluvial Flow Estimation

The peak fluvial flows for a series of return periods events were estimated for the Broadmeadow and Ward catchments using the OPW Flood Studies Update (FSU)

Hydronet Portal. The FSU portal calculations include an urbanisation factor which is applied to the urban area within the catchment, this accounts for the surface water drainage network discharging to the watercourses.

In additional to the current climate scenario, flows were estimated for two climate change scenarios as stated in the OPWs Climate Change Sectoral Adaptation Plan - Flood Risk Management (2015 - 2019): the Mid-Range Future Scenario (MRFS) and High End Future Scenario (HEFS). Climate change. OPW climate change allowances are stated in table 2 below.

Table 6.2 Allowances in Flood Parameters for Mid-Range and High-End Future Scenarios

Parameter	MRFS	HEFS
Extreme Rainfall Depths	+ 20%	+ 30%
Peak Flood Flows	+ 20%	+ 30%
Mean Sea Level Rise	+ 500 mm	+ 1000 mm
Land Movement	- 0.5 mm / year[1]	- 0.5 mm / year[1]
Urbanisation	*No General Allowance – Review on Case-by-Case Basis*	*No General Allowance – Review on Case-by-Case Basis*
Forestation	- 1/6 Tp[2]	- 1/3 Tp[2] + 10% SPR[3]

Note 1: Applicable to the southern part of the country only (Dublin – Galway and south of this)

Note 2: Reduction in the time to peak (Tp) to allow for potential accelerated runoff that may arise as a result of drainage of afforested land

Note 3: Add 10% to the Standard Percentage Runoff (SPR) rate: This allows for temporary increased runoff rates that may arise following felling of forestry.

The FSU calculated flows plus climate change allowances are shown in Table 6.3 below.

Table 6.3 Summary of ROD Hydrological Assessment

Watercourse	Return Period (1:x year)	Peak flow Current Scenario (m^3/s)	Peak flow MRFS Scenario (m^3/s)	Peak flow HEFS Scenario (m^3/s)
Broadmeadow	10	66.21	79.45	86.07
	50	93.76	112.51	121.88
	100	107.9	129.48	140.27
	1000	169.24	203.10	220.012
Ward	10	7.91	9.49	10.28
	50	11.54	13.84	15.00
	100	13.46	16.15	17.49
	1000	22.19	26.62	28.84

Flows were compared against other flow estimation methods including:

- Flood Studies Report 3 variable and;
- Institute of Hydrology Report 124.

The results are stated below in Table 6.4 and compared against the FEM FRAMS flow input.

Table 6.4 Flood Estimation Method Results

Watercourse	Return Period Current Scenario (1:x year)	FSR - 3 Variable	IH124 / ICP IH124	OPW FSU Web Portal Calculations	FEM FRAMs
Broadmeadow	10	33.39	28.27	66.38	35.94
	50	42.40	35.91	93.84	58.19
	100	47.76	40.44	107.77	68.60
	1000	66.77	56.54	169.23	128.13
Ward	10	19.54	16.88	7.91	21.54
	50	24.82	21.44	11.53	36.97
	100	27.96	24.15	13.44	39.58
	1000	39.08462	33.76261	22.21	64.91

The FSR & IH124 estimation flows stated above are significantly lower than the FSU and FEM FRAM generated flows for the Broadmeadow. The FSU and FEM FRAMs used site specific parameters as inputs as well as gauged catchment data. The FSU is a refinement of the FEM FRAMS methodology, as such the FSU flows were selected as the design flow for the River Broadmeadow.

However, for a catchment as large as the River Ward, the FSU generated flows are uncharacteristically low. This can be seen when compared with the other estimation methods including the FEM FRAMs flows. As per the precautionary principle outline in the OPW's The Planning System and Flood Risk Management – Guidelines for Planning Authorities (2009), the existing FEM FRAM flow inputs were selected for the River Wards design flow.

6.2.2 Tidal Level Estimation

An analysis of existing tides at the Malahide Estuary was undertaken using available data from OPW FEM FRAMs, OPW waterlevels.ie and the Irish Coastal Protection Strategy Study. Although tidal flooding does propagate up the Broadmeadow and Ward rivers, the tidal variation seems to be limited by the constriction/weir at the Malahide railway viaduct. The tidal flood levels 200m form the M1 motorway bridge were extracted from the FEM FRAMS hydraulic model, these were subsequently input as the downstream model boundary.

6.2.3 Rainfall Estimation

Rainfall hyetographs were estimated for the 1 in 100 year and 1 in 1000 year rainfall events using the OPW Flood Studies Update Depth Duration Frequency Module. These were then compared with calculations undertaken using the Unit Hydrograph Method. The FSU rainfall hyetographs were seen to be more representative of the catchment characteristics. The effective rainfall levels were used as the model inputs.

6.3 Hydraulic Model

A 1D-2D hydraulic model of the River Broadmeadow and River Ward was developed using the Jacobs Flood Modeller software v4.4. This covered a 2km reach of the Broadmeadow and a 1.2km reach of the Ward. The 1D river sections were created from a topographic survey. An example of a typical cross section from the 1D model is included in Figure 6.2 below.

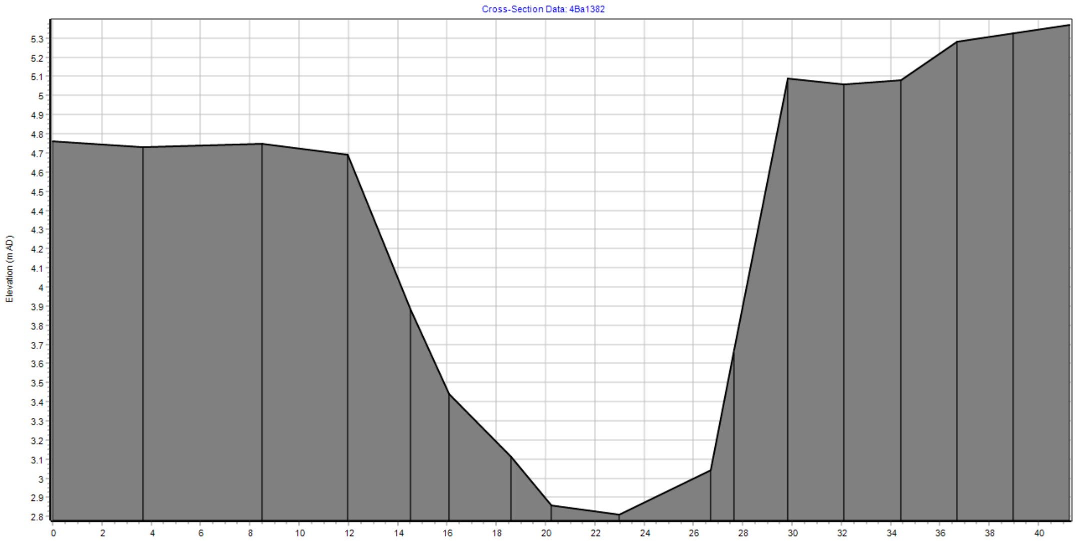


Figure 6.2 Typical 1D Channel Cross Section

A digital terrain model (DTM) of the Rivers Broadmeadow and Ward floodplain was created using LiDAR data. The DTM was linked to the 1D model using a series of link lines that allow water to pass from the 1D domain to the 2D domain when the water level in the channel exceeds the bank levels. The DTM used in the hydraulic model is shown in Figure 6.3 below.

Figure 6.3 LiDAR Derived Digital Terrain Model

A site visit was conducted on 21st November 2018. Significant features within the channel and in the floodplain were recorded. It was noted that the Broadmeadow adjacent to the Estuary West lands was relatively wide and open with varying levels of vegetation ingress into the channel. Vegetated lateral and mid-channel banks were common along the surveyed reach. The site visit aided in determining the manning's roughness values attributable to the reach. A roughness grid shapefile was used in the model to represent the effects of different surfaces on overland flow. Manning's N values ranged from 0.015 for pavement to 0.3 to simulate the permeability of flooded buildings.

6.3.1 Pluvial Flood Modelling

Pluvial flooding was assessed in a 2D model. This comprised topographic LiDAR data as used in the fluvial/tidal model as well as the roughness grid as discussed above. Return periods representing 1 in 100 year and 1 in 1000 year rainfall events for the current, MRFS and HEFS climate scenarios were used as inputs. Flooding less than 50mm in depth was removed from the model outputs which is in line with best practice for pluvial flood mapping.

6.4 Hydraulic Modelling Summary

The findings from the hydraulic model are that critical flooding and flood levels within Estuary West Masterplan lands are driven by fluvial flooding with tidal inundation having a lesser though nonetheless significant effect.

Out of Bank flooding occurs along the Broadmeadow inundating the riparian corridor and adjacent Balheary Industrial park. The Balheary industrial park also receives flood waters from out of bank flooding emanating from the River Ward. In extreme events floodwaters cross the Balheary road and enter the eastern portion of the Estuary West site. Out of bank flooding from the Broadmeadow also effects the north west corner of the Estuary West site.

Flood extent and flood depth mapping generated as part of this Hydraulic assessment are shown in the Estuary West Masterplan - Storm Water Management Plan Part 1: Strategic Flood Risk Assessment Appendix G and Appendix H respectively.

There is an increasing likelihood that Irelands climate will be similar to that depicted in the High End Future climate change scenario by the year 2100. Therefore, it is prudent to consider the HEFS parameters when planning for vulnerable infrastructure and developments.

The masterplan lands are also susceptible to flooding from pluvial sources. Pluvial flooding should be managed through appropriate surface water management strategies incorporating Sustainable Drainage Systems (SuDS). Refer to *Estuary West Masterplan Surface Water Management Plan: Part 2: Sustainable Drainage Systems (SuDS)* Strategy for detailed SuDS implementation protocol.

Although great care and modern widely-accepted methods have been used in the preparation and interpretation of the hydraulic model, there is inevitably a range of inherent uncertainties and assumptions made during the estimation of design flows and the construction of flood models. The inherent uncertainty necessitates a precautionary approach when interpreting the flood extent and flood depth mapping.

Flood risk is detailed for the Estuary West Masterplan lands in Section 7 below.

6.5 Development Land Use Zoning Review

This review will look at the development land use zoning for the areas within the Estuary West Masterplan and comment on the flood risk in each area.

The entire Estuary West Masterplan lands are zoned as ME Metro Economic Corridor – “Facilitate opportunities for high density mixed use employment generating activity and commercial development, and support the provision of an appropriate quantum of residential development within the Metro Economic Corridor”. As per the Guidelines (OPW, 2009), development on the site would be a mix between “highly vulnerable” and “less vulnerable” developments.

Several portions of the Estuary West Masterplan lands are impacted by potential fluvial and tidal flooding from the Broadmeadow and Ward Rivers. It is recommended that the lands subject to the 0.1% AEP (HEFS) fluvial flood extent shown in Appendix G Drawing 18.164-EW-107 be designated for appropriate uses such as amenity space. This will ensure that Natural Floodplain Management and floodplain protection & enhancement principles are implemented in accordance with Estuary West Masterplan Surface Water Management Plan Part 2: Sustainable Drainage Systems (SuDS) Strategy section 3.4 and FDP 2017-2023 chapter 7.2. Water Services & chapter 9.2 biodiversity.

Developments within the Estuary West lands will require a justification test for development management as per The Guidelines. (OPW, 2009).

7. FLOOD RISK ASSESSMENT CONCLUSIONS

The SFRA for the Estuary West Masterplan lands has been carried out in accordance with the requirements of the OPW “The Planning System and Flood Risk Management Guidelines for Planning Authorities”, 2009. It was determined that the most significant source of flooding within the Masterplan area is from fluvial and tidal inundation from the Broadmeadow and Ward Rivers. There are several other minor areas of pluvial flooding within the Masterplan boundary.

The majority of the Masterplan area is within Flood Zone C where the probability of flooding from rivers and the sea is low (<1 in 1000 year) and is therefore appropriate for highly vulnerable developments.

8. RECOMMENDATIONS

1) It is recommended that the drainage channels, watercourses and floodplains within the developed and undeveloped areas of the Masterplan boundary be maintained and protected.
2) Riparian corridors should be provided in accordance with the requirements of the Fingal Development Plan 2017-2023 to protect and enhance watercourses and their natural regimes including: ecological, biogeochemical and hydromorphological.
3) Sustainable Drainage Systems should be incorporated in all new developments within the Estuary West Masterplan lands.

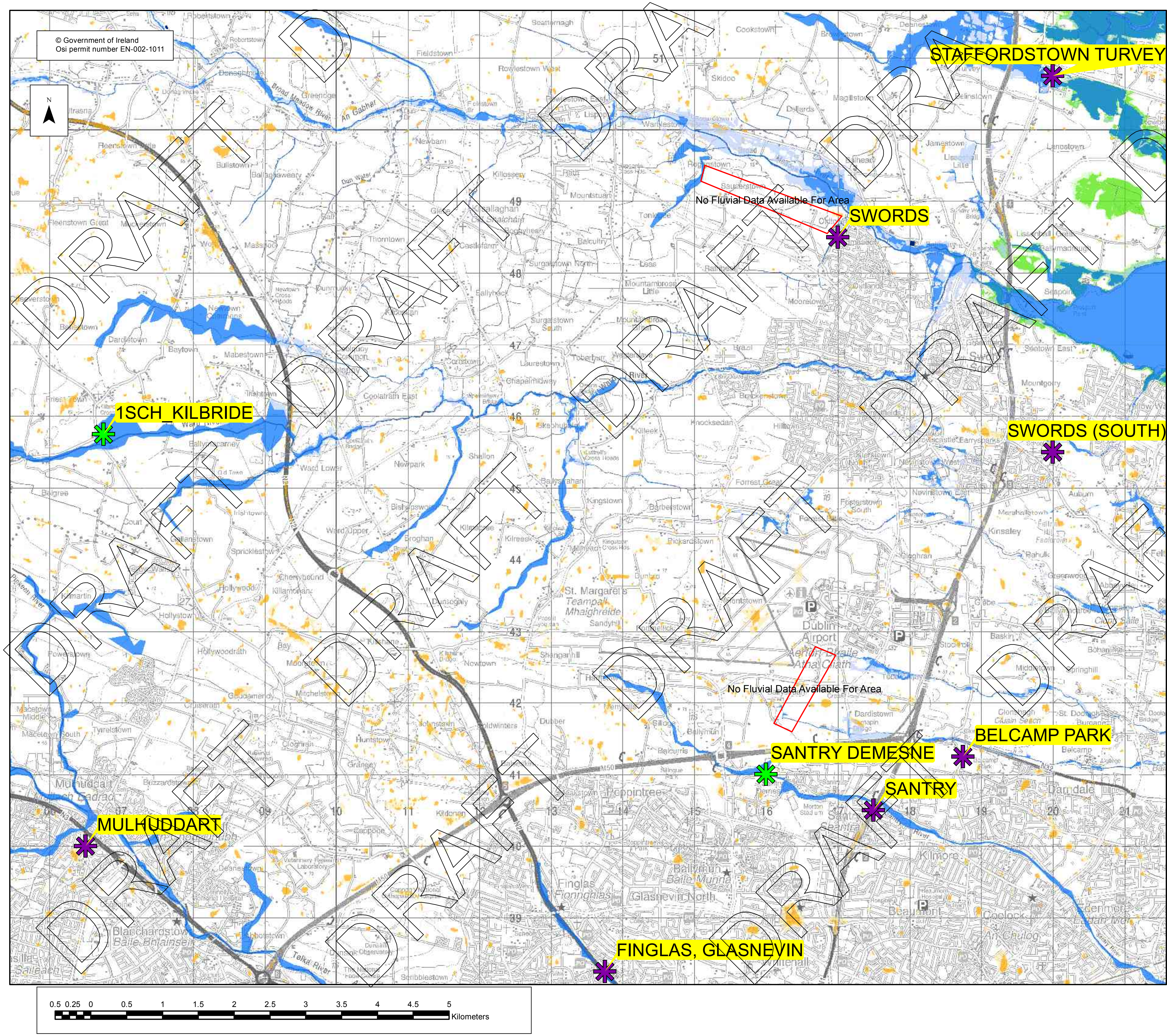
4) Future developments within Estuary West Masterplan should be designed and constructed in accordance with the “Precautionary Principle” detailed in The Guidelines. It is recommended that the flood zoning within the Masterplan is based on the High-End Future Scenario (HEFS) for climate change, shown in Drawing 18.164-EW-107 Appendix G.

5) There is an increasing likelihood that Irelands climate will be similar to that depicted in the High-End Future climate change scenario by the year 2100. Therefore, it is prudent to consider the HEFS parameters when planning for vulnerable infrastructure and developments. Development will generally be prohibited within the HEFS fluvial Q1000 flood extents.

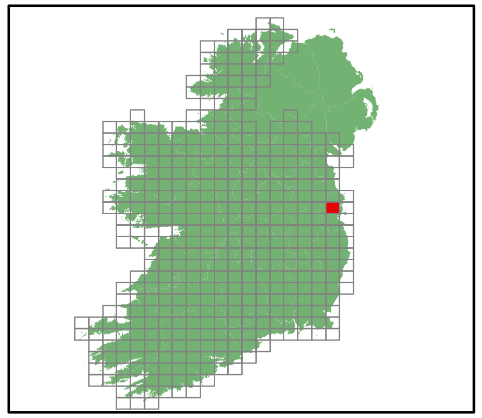
6) To address the risk of pluvial flooding in new developments in the Masterplan area, the Estuary West Masterplan Surface Water Management Plan Part 2: Sustainable Drainage Systems (SuDS) Strategy should be adopted. This will ensure a consistent approach to the management of flood risk and water quality within Estuary West Masterplan. Implementing these measures and complying with the GDSDS will ensure the risk of flooding downstream of any new developments is minimised.

7) Site specific flood risk assessments shall be undertaken for all new developments within Estuary West Masterplan in accordance with The Planning System and Flood Risk Management – Guidelines for Planning Authorities (2009). Detailed topographical surveys and site development plans should be used to provide a more accurate estimation of the flood extents and aid in deciding the location of various development types.

APPENDIX A
PFRA MAPS



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).

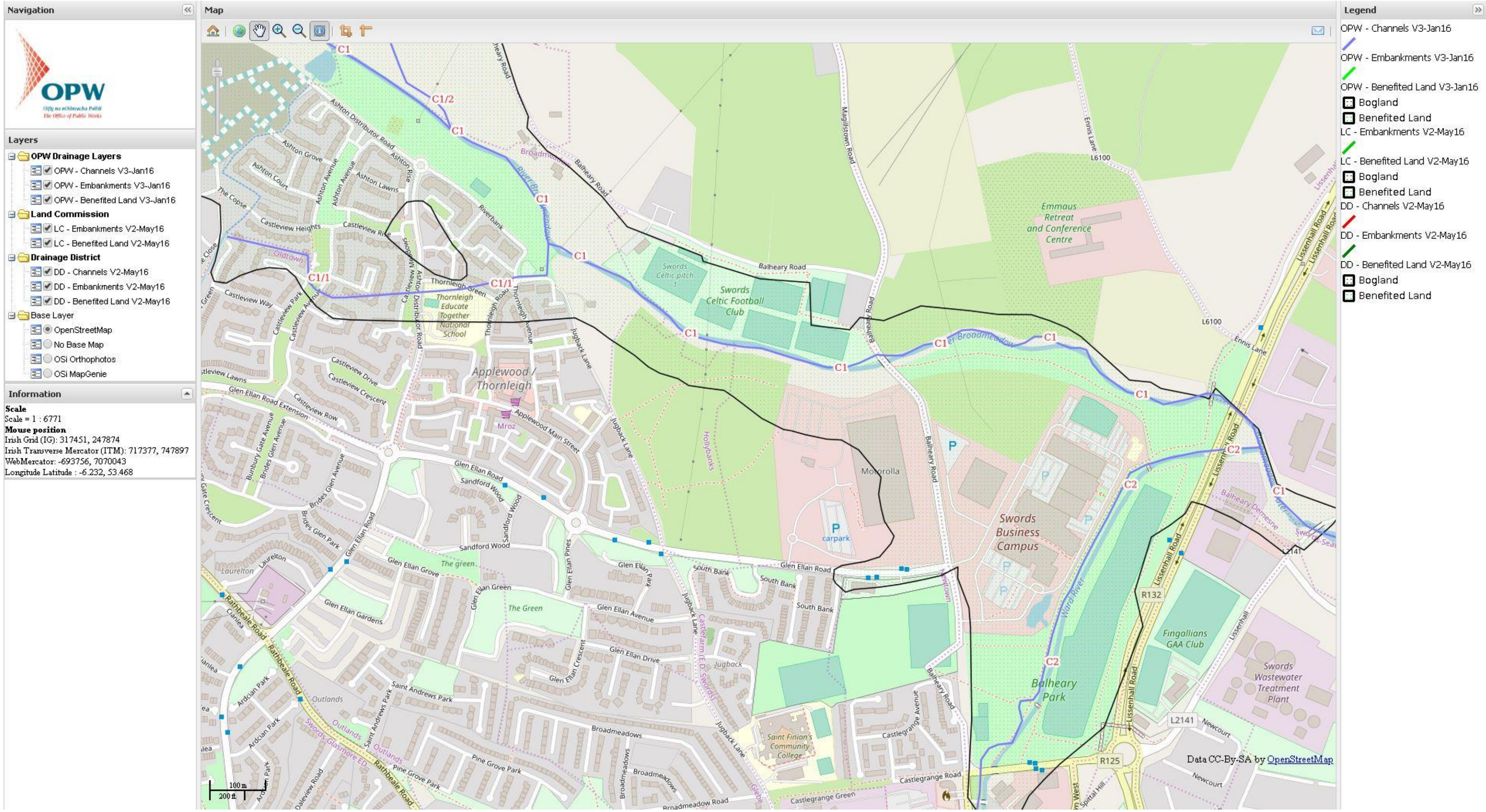
Office of Public Works
Jonathon Swift Street
Trim
Co Meath
Ireland

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 / 256 / A	Revision	0
Drawing Scale :	1:50,000	Plot Scale :	1:1 @ A3

APPENDIX B
OPW BENEFITTING LAND MAPS


Navigation
OPW
Layers
OPW Drainage Layers
OPW - Channels V3-Jan16
OPW - Embankments V3-Jan16
OPW - Benefited Land V3-Jan16
Land Commission
LC - Embankments V2-May16
LC - Benefited Land V2-May16
Drainage District
DD - Channels V2-May16
DD - Embankments V2-May16
DD - Benefited Land V2-May16
Base Layer
OpenStreetMap
No Base Map
OSi Orthophotos
OSi MapGenie
Information
Scale
Scale = 1 : 6771
Mouse position
Irish Grid (IG): 317451, 247874
Irish Transverse Mercator (ITM): 717377, 747897
WebMercator: -693756, 7070043
Longitude Latitude : -6.232, 53.468
Map
Legend
OPW - Channels V3-Jan16
OPW - Embankments V3-Jan16
OPW - Benefited Land V3-Jan16
Bogland
Benefited Land
LC - Embankments V2-May16
LC - Benefited Land V2-May16
Bogland
Benefited Land
DD - Channels V2-May16
DD - Embankments V2-May16
DD - Benefited Land V2-May16
Bogland
Benefited Land
C1
C1/2
C1/1
C2
Balheary Road
Swords Celtic Football Club
Emmaus Retreat and Conference Centre
Applewood / Thornleigh
Thornleigh Educate Together National School
Motorola
Swords Business Campus
Balheary Park
Fingallians GAA Club
Swords Wastewater Treatment Plant
Saint Finian's Community College
Glen Ellan Road
Rathbeale Road
Broadmeadows
R132
R125
L2141
L6100
100 m
200 ft
Data CC-By-SA by OpenStreetMap

APPENDIX C
OPW FLOOD RECORDS

OPW *National Flood Hazard Mapping*

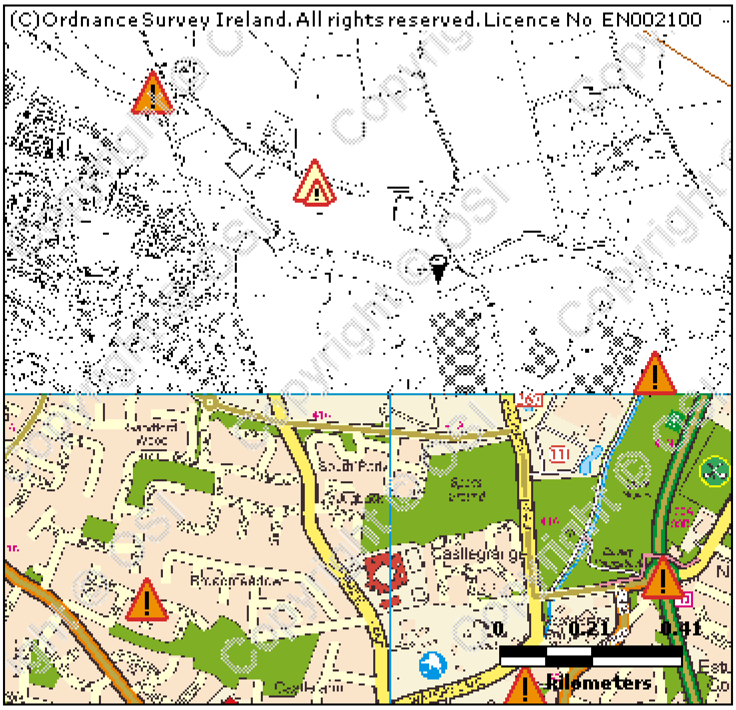
Summary Local Area Report

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

The map centre is in:

County: Dublin

NGR: O 179 480



Map Scale 1:17,055

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

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

12 Results

1. Estuary Road Swords Feb 2002 — Start Date: 01/Feb/2002
County: Dublin — Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

2. Broadmeadow Swords August 1986 — Start Date: 25/Aug/1986
County: Dublin — Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

3. Ward Swords Co.Dublin August 2008 — Start Date: 09/Aug/2008
County: Dublin — Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

4. Pinnock Hill Nov 2002 — Start Date: 14/Nov/2002
County: Dublin — Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

5. Ward North Street Swords Nov 2002 — Start Date: 13/Nov/2002
County: Dublin — Flood Quality Code:3

Additional Information: Reports (3) Press Archive (3) More Mapped Information

---

6. N1 at Roundabout at Fingallions Nov 2002 — Start Date: 13/Nov/2002

County: Dublin — Flood Quality Code:3

Additional Information: Reports (1) More Mapped Information

---

7. Pinnock Hill October 2002 — Start Date: 20/Oct/2002

County: Dublin — Flood Quality Code:3

Additional Information: Reports (3) More Mapped Information

---

8. Gartan Court Swords Feb 2002 — Start Date: 01/Feb/2002

County: Dublin — Flood Quality Code:3

Additional Information: Reports (1) More Mapped Information

---

9. Pine Grove Park Swords Nov 1982 — Start Date: 05/Nov/1982

County: Dublin — Flood Quality Code:3

Additional Information: Reports (1) More Mapped Information

---

10. Seatown Villas Swords Nov 1982 — Start Date: 05/Nov/1982

County: Dublin — Flood Quality Code:3

Additional Information: Reports (1) More Mapped Information

---

11. Pinnock Hill Swords Recurring — Start Date:

County: Dublin — Flood Quality Code:3

Additional Information: Reports (6) More Mapped Information

---

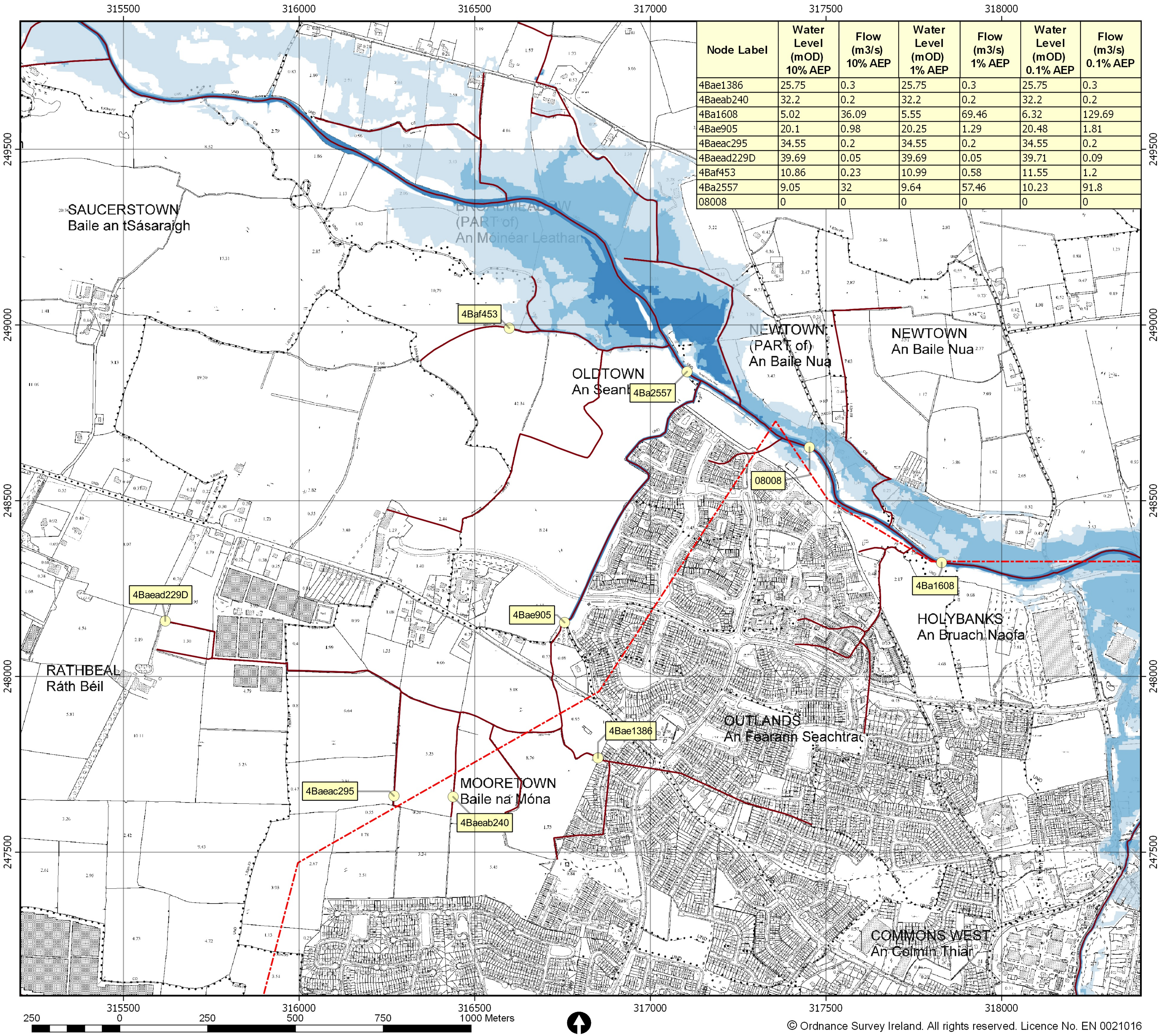
12. Balheary Road Swords Recurring — Start Date:

County: Dublin — Flood Quality Code:4

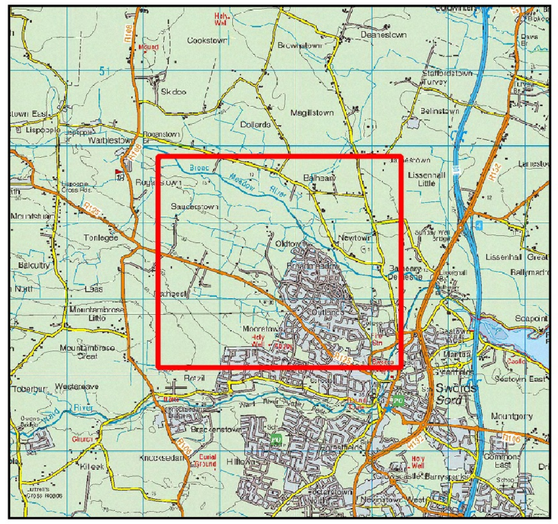
Additional Information: Reports (1) More Mapped Information

APPENDIX D
FINGAL AND EAST MEATH FLOOD RISK ASSSESMSNST AND MANAGAMENT STUDY – FLOOD MAPPING

Node Label	Water Level (mOD) 10% AEP	Flow (m3/s) 10% AEP	Water Level (mOD) 1% AEP	Flow (m3/s) 1% AEP	Water Level (mOD) 0.1% AEP	Flow (m3/s) 0.1% AEP
4Bae1386	25.75	0.3	25.75	0.3	25.75	0.3
4Baeab240	32.2	0.2	32.2	0.2	32.2	0.2
4Ba1608	5.02	36.09	5.55	69.46	6.32	129.69
4Bae905	20.1	0.98	20.25	1.29	20.48	1.81
4Baeac295	34.55	0.2	34.55	0.2	34.55	0.2
4Baead229D	39.69	0.05	39.69	0.05	39.71	0.09
4Baf453	10.86	0.23	10.99	0.58	11.55	1.2
4Ba2557	9.05	32	9.64	57.46	10.23	91.8
08008	0	0	0	0	0	0



Location Plan:



LEGEND

- AFA Boundary
- Defended Area
- Modelled River Centreline
- Node Point
- 10% AEP Fluvial Extent (High Risk)
- 1% AEP Fluvial Extent (Medium Risk)
- 0.1% AEP Fluvial Extent (Low Risk)
- Flood Defence - Embankment
- Flood Defence - Wall
- Gate
- NODE123 — Node Label
- x.x% AEP — Standard of Protection of Flood Defence

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

OPW
Oifig na nOibreacha Poiblí
The Office of Public Works

The Office of Public Works
Jonathan Swift Street
Trim
Co. Meath

Project:
FINGAL EAST MEATH FRAM STUDY

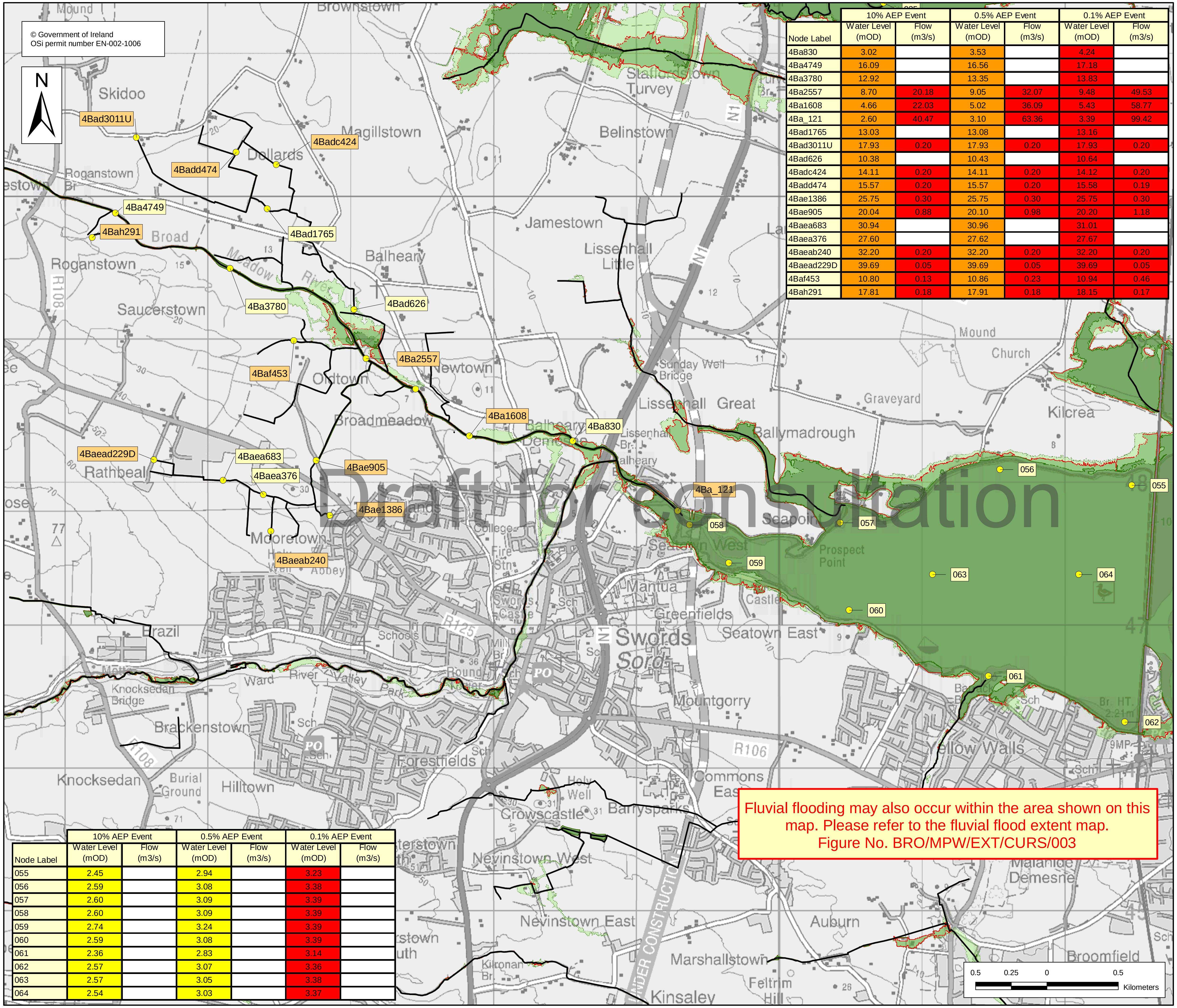
Map: **Broad Meadow Model**
FLUVIAL FLOOD EXTENT MAP

Map Type:	EXTENT		
Source:	FLUVIAL		
Map Area:	HPW		
Scenario:	CURRENT		
Drawn by:	IH	Date:	Sep - 2016
Checked by:	MC	Date:	Sep - 2016
Approved by:	JM	Date:	Sep - 2016

Map No.:
BRO/HPW/EXT/CURS/009

Revision: F0

Map Scale: 1:10,000 Plot Scale: 1:1 @ A3

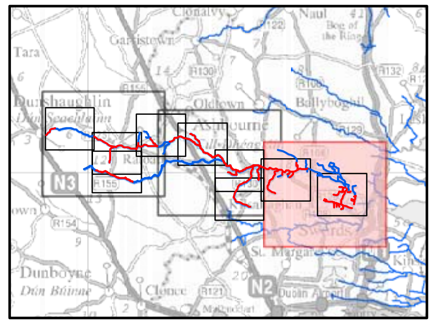


Node Label	10% AEP Event Water Level (mOD)	10% AEP Event Flow (m3/s)	0.5% AEP Event Water Level (mOD)	0.5% AEP Event Flow (m3/s)	0.1% AEP Event Water Level (mOD)	0.1% AEP Event Flow (m3/s)
4Ba830	3.02		3.53		4.24	
4Ba4749	16.09		16.56		17.18	
4Ba3780	12.92		13.35		13.83	
4Ba2557	8.70	20.18	9.05	32.07	9.48	49.53
4Ba1608	4.66	22.03	5.02	36.09	5.43	58.77
4Ba_121	2.60	40.47	3.10	63.36	3.39	99.42
4Bad1765	13.03		13.08		13.16	
4Bad3011U	17.93	0.20	17.93	0.20	17.93	0.20
4Bad626	10.38		10.43		10.64	
4Badc424	14.11	0.20	14.11	0.20	14.12	0.20
4Badd474	15.57	0.20	15.57	0.20	15.58	0.19
4Bae1386	25.75	0.30	25.75	0.30	25.75	0.30
4Bae905	20.04	0.88	20.10	0.98	20.20	1.18
4Baea683	30.94		30.96		31.01	
4Baea376	27.60		27.62		27.67	
4Baeab240	32.20	0.20	32.20	0.20	32.20	0.20
4Baead229D	39.69	0.05	39.69	0.05	39.69	0.05
4Baf453	10.80	0.13	10.86	0.23	10.94	0.46
4Bah291	17.81	0.18	17.91	0.18	18.15	0.17

Node Label	10% AEP Event Water Level (mOD)	10% AEP Event Flow (m3/s)	0.5% AEP Event Water Level (mOD)	0.5% AEP Event Flow (m3/s)	0.1% AEP Event Water Level (mOD)	0.1% AEP Event Flow (m3/s)
055	2.45		2.94		3.23	
056	2.59		3.08		3.38	
057	2.60		3.09		3.39	
058	2.60		3.09		3.39	
059	2.74		3.24		3.39	
060	2.59		3.08		3.39	
061	2.36		2.83		3.14	
062	2.57		3.07		3.36	
063	2.57		3.05		3.38	
064	2.54		3.03		3.37	

Fluvial flooding may also occur within the area shown on this map. Please refer to the fluvial flood extent map.
Figure No. BRO/MPW/EXT/CURS/003

Location Plan :



EXTENT MAP

Legend:

- 10 % AEP Flood Extent (1 in 10 chance in any given year)
- 0.5 % AEP Flood Extent (1 in 200 chance in any given year)
- 0.1 % AEP Flood Extent (1 in 1000 chance in any given year)
- Defended area
- High Confidence (<20m) (10% AEP)
- Medium Confidence (<40m) (10% AEP)
- Low Confidence (> 40m) (10% and 0.1% AEP)
- High Confidence (<20m) (0.5% AEP)
- Medium Confidence (<40m) (0.5% AEP)
- Low Confidence (>40m) (0.5% AEP)
- Modelled River Centreline
- Node Point
- 21Ma237 Node label with level data (refer to table)
- 21Ma237 Node level with flow & level data (refer to table)

High confidence
Medium confidence
Low confidence
refer to table

USER NOTE :

USERS OF THESE MAPS SHOULD REFER TO THE DETAILED DESCRIPTION OF THEIR DERIVATION, LIMITATIONS IN ACCURACY AND GUIDANCE AND CONDITIONS OF USE PROVIDED AT THE FRONT OF THIS BOUND VOLUME. IF THIS MAP DOES NOT FORM PART OF A BOUND VOLUME, IT SHOULD NOT BE USED FOR ANY PURPOSE.

HalcrowBarry
Tramway House
32 Dartry Road
Dublin 6
Tel: +353-1-4975716

Clients :
Fingal County Council
Meath County Council
OPW

Project : FEM FRAMS

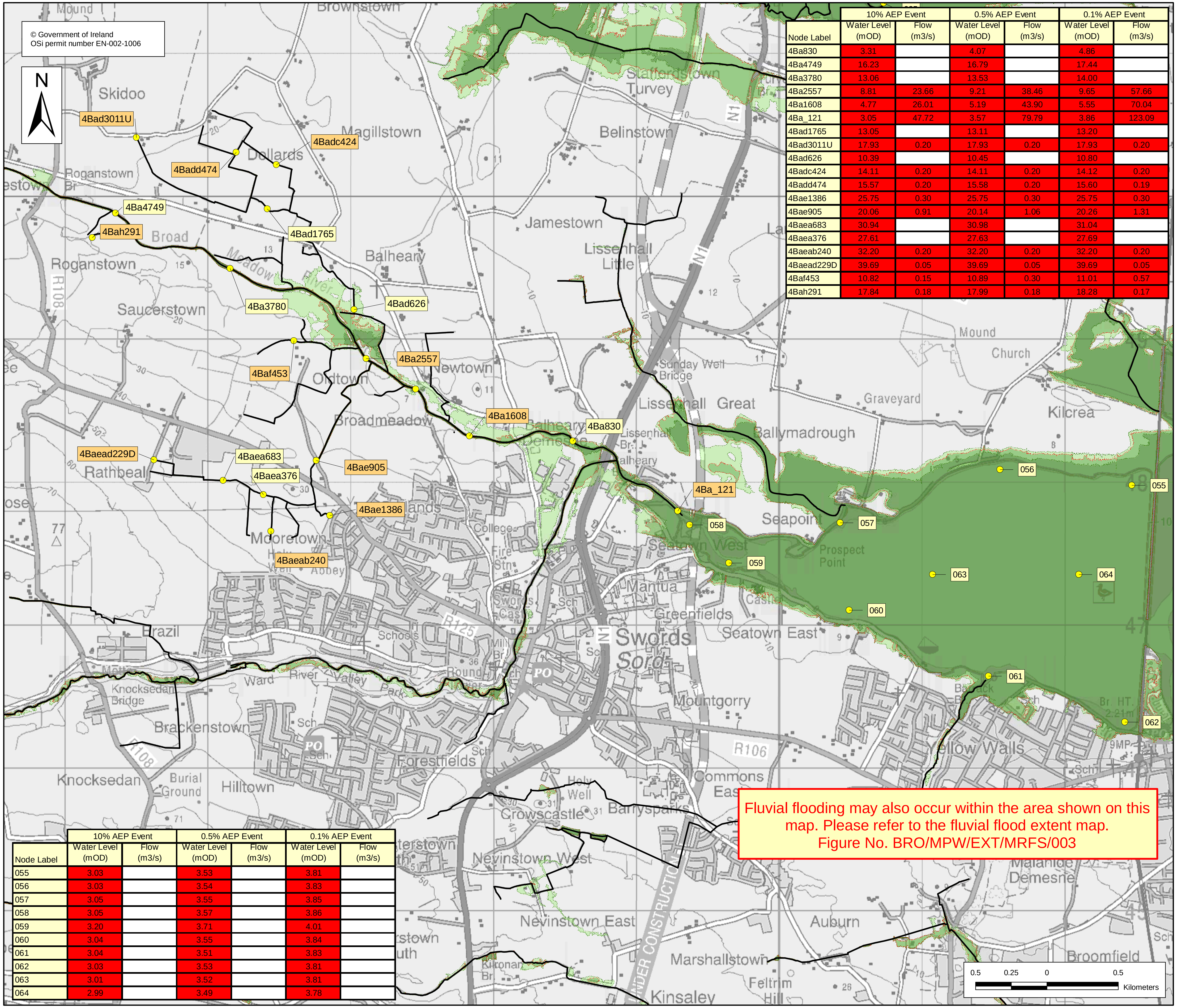
Map : BROAD MEADOW MODEL FLOOD EXTENT

Map Type : FLOOD EXTENT
Source : TIDAL FLOODING
Map area : MEDIUM PRIORITY WATERCOURSE
Scenario : CURRENT

Figure By : Mara Ruiz | Date : 17 January 2011
Checked By : Sergio Herbón | Date : 17 January 2011
Approved By : Clare Dewar | Date : 17 January 2011

Figure No. : BRO/MPW/EXT/CURS/T/003 | Revision 1

Drawing Scale : 1:25,000 | Plot Scale : 1:1 @ A3

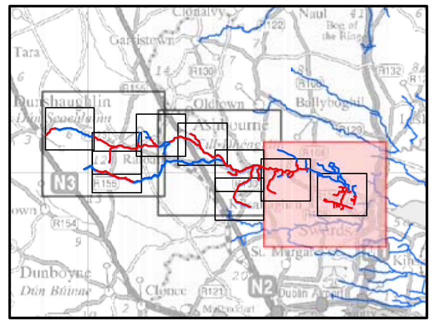


Node Label	10% AEP Event Water Level (mOD)	10% AEP Event Flow (m3/s)	0.5% AEP Event Water Level (mOD)	0.5% AEP Event Flow (m3/s)	0.1% AEP Event Water Level (mOD)	0.1% AEP Event Flow (m3/s)
4Ba830	3.31		4.07		4.86	
4Ba4749	16.23		16.79		17.44	
4Ba3780	13.06		13.53		14.00	
4Ba2557	8.81	23.66	9.21	38.46	9.65	57.66
4Ba1608	4.77	26.01	5.19	43.90	5.55	70.04
4Ba_121	3.05	47.72	3.57	79.79	3.86	123.09
4Bad1765	13.05		13.11		13.20	
4Bad3011U	17.93	0.20	17.93	0.20	17.93	0.20
4Bad626	10.39		10.45		10.80	
4Badc424	14.11	0.20	14.11	0.20	14.12	0.20
4Badd474	15.57	0.20	15.58	0.20	15.60	0.19
4Bae1386	25.75	0.30	25.75	0.30	25.75	0.30
4Bae905	20.06	0.91	20.14	1.06	20.26	1.31
4Baea683	30.94		30.98		31.04	
4Baea376	27.61		27.63		27.69	
4Baeab240	32.20	0.20	32.20	0.20	32.20	0.20
4Baead229D	39.69	0.05	39.69	0.05	39.69	0.05
4Baf453	10.82	0.15	10.89	0.30	11.01	0.57
4Bah291	17.84	0.18	17.99	0.18	18.28	0.17

Fluvial flooding may also occur within the area shown on this map. Please refer to the fluvial flood extent map.
Figure No. BRO/MPW/EXT/MRFS/003

Node Label	10% AEP Event Water Level (mOD)	10% AEP Event Flow (m3/s)	0.5% AEP Event Water Level (mOD)	0.5% AEP Event Flow (m3/s)	0.1% AEP Event Water Level (mOD)	0.1% AEP Event Flow (m3/s)
055	3.03		3.53		3.81	
056	3.03		3.54		3.83	
057	3.05		3.55		3.85	
058	3.05		3.57		3.86	
059	3.20		3.71		4.01	
060	3.04		3.55		3.84	
061	3.04		3.51		3.83	
062	3.03		3.53		3.81	
063	3.01		3.52		3.81	
064	2.99		3.49		3.78	

Location Plan :



EXTENT MAP

Legend:

- 10 % AEP Flood Extent (1 in 10 chance in any given year)
- 0.5 % AEP Flood Extent (1 in 200 chance in any given year)
- 0.1 % AEP Flood Extent (1 in 1000 chance in any given year)
- Defended area
- High Confidence (<20m) (10% AEP)
- Medium Confidence (<40m) (10% AEP)
- Low Confidence (> 40m) (10% and 0.1% AEP)
- High Confidence (<20m) (0.5% AEP)
- Medium Confidence (<40m) (0.5% AEP)
- Low Confidence (>40m) (0.5% AEP)
- Modelled River Centreline
- Node Point
- 21Ma237 Node label with level data (refer to table)
- 21Ma237 Node level with flow & level data (refer to table)
- High confidence / Medium confidence / Low confidence — refer to table

USER NOTE :

USERS OF THESE MAPS SHOULD REFER TO THE DETAILED DESCRIPTION OF THEIR DERIVATION, LIMITATIONS IN ACCURACY AND GUIDANCE AND CONDITIONS OF USE PROVIDED AT THE FRONT OF THIS BOUND VOLUME. IF THIS MAP DOES NOT FORM PART OF A BOUND VOLUME, IT SHOULD NOT BE USED FOR ANY PURPOSE.

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Tramway House
32 Dartry Road
Dublin 6
Tel: +353-1-4975716

Clients :

Project : FEM FRAMS

Map : BROAD MEADOW MODEL FLOOD EXTENT

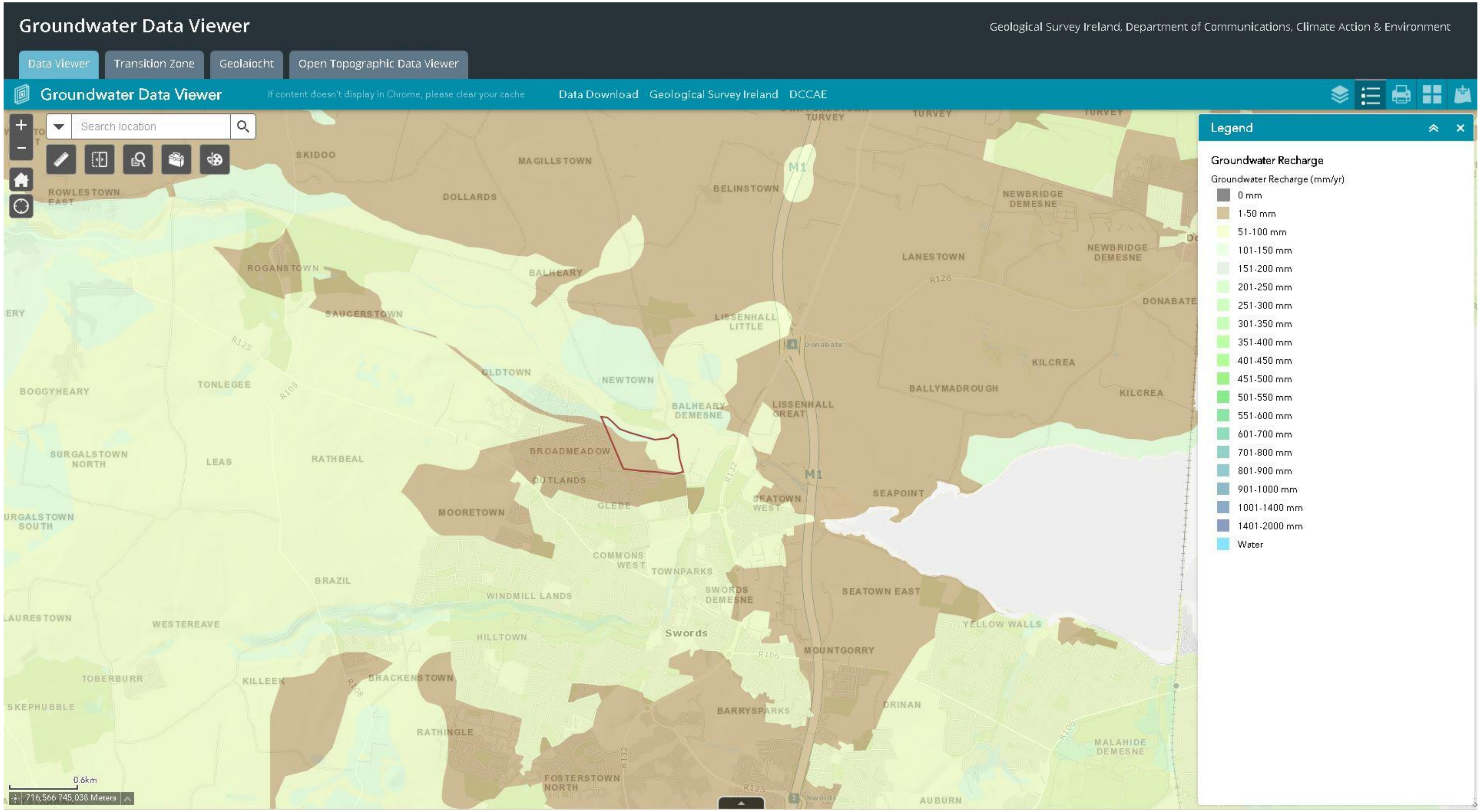
Map Type : FLOOD EXTENT
Source : TIDAL FLOODING
Map area : MEDIUM PRIORITY WATERCOURSE
Scenario : MID RANGE FUTURE SCENARIO

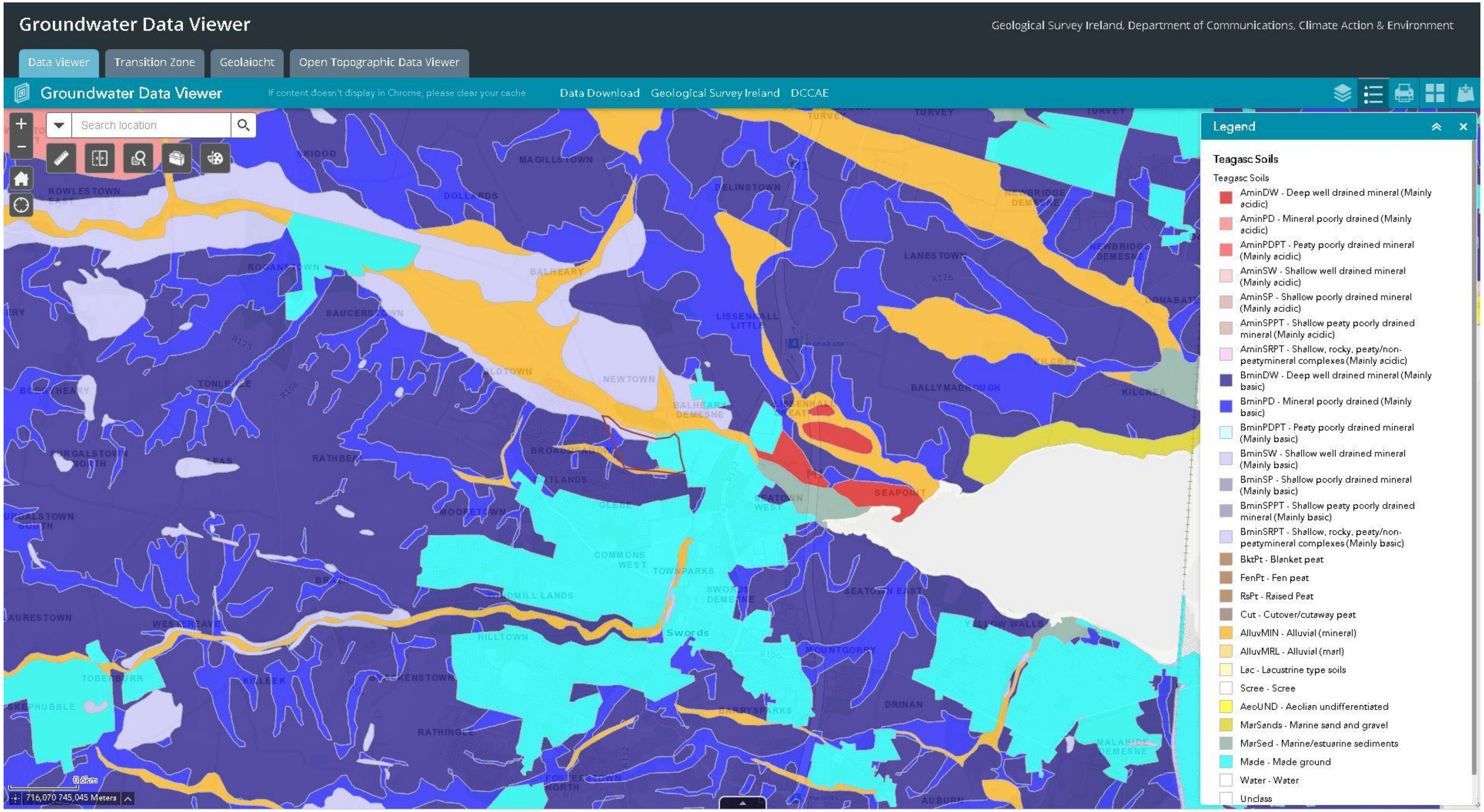
Figure By : Mara Ruiz — Date : 17 January 2011
Checked By : Sergio Herbón — Date : 17 January 2011
Approved By : Clare Dewar — Date : 17 January 2011

Figure No. : BRO/MPW/EXT/MRFS/T/003 — Revision 1

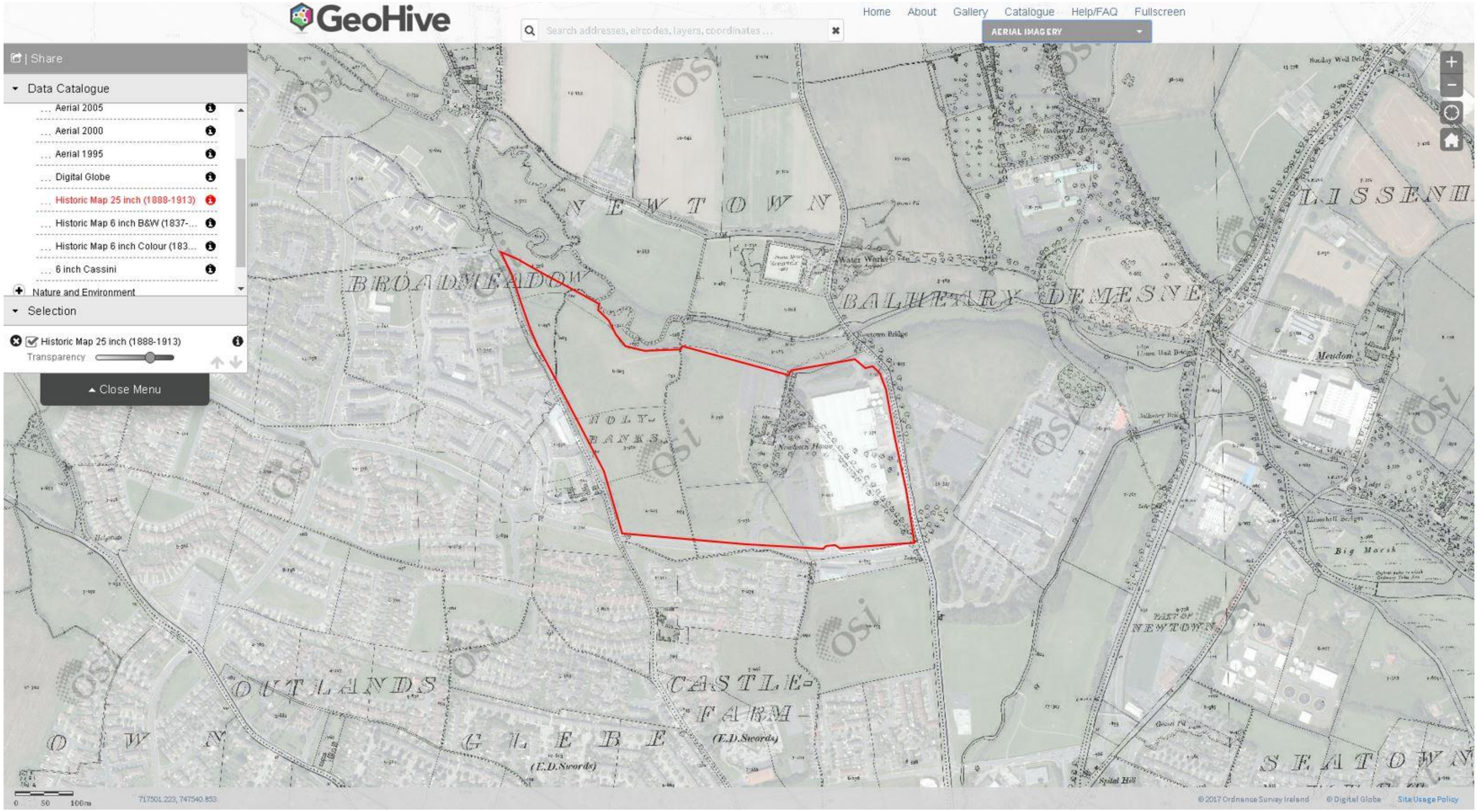
Drawing Scale : 1:25,000 — Plot Scale : 1:1 @ A3

APPENDIX E
GEOLOGICAL SURVEY OF IRELAND (GSI) MAPS


Groundwater Data Viewer
Geological Survey Ireland, Department of Communications, Climate Action & Environment
Data Viewer
Transition Zone
Geolaíocht
Open Topographic Data Viewer
Groundwater Data Viewer
If content doesn't display in Chrome, please clear your cache
Data Download
Geological Survey Ireland
DCCAE
Search location
Legend
Groundwater Recharge
Groundwater Recharge (mm/yr)
0 mm
1-50 mm
51-100 mm
101-150 mm
151-200 mm
201-250 mm
251-300 mm
301-350 mm
351-400 mm
401-450 mm
451-500 mm
501-550 mm
551-600 mm
601-700 mm
701-800 mm
801-900 mm
901-1000 mm
1001-1400 mm
1401-2000 mm
Water
SKIDOO
MAGILLSTOWN
DOLLARDS
BELINSTOWN
TURVEY
NEWBRIDGE DEMESNE
ROWLESTOWN EAST
ROGANSTOWN
BALHEARY
LANESTOWN
SAUCERSTOWN
LISSENHALL LITTLE
DONABATE
KILCREA
BOGGYHEARY
TONLEGEE
OLDTOWN
NEWTOWN
BALHEARY DEMESNE
LISSENHALL GREAT
BALLYMADROUGH
SURGALSTOWN NORTH
LEAS
RATHBEAL
BROADMEADOW
OUTLANDS
M1
SEAPOINT
SEATOWN WEST
MOORETOWN
GLEBE
COMMONS WEST
TOWNPARKS
BRAZIL
WINDMILL LANDS
SWORDS DEMESNE
SEATOWN EAST
LAURESTOWN
WESTEREAVE
YELLOW WALLS
HILLTOWN
Swords
MOUNTGORRY
TOBERBURR
KILLEEK
BRACKENSTOWN
SKEPHUBBLE
BARRYSPARKS
DRINAN
RATHINGLE
MALAHIDE DEMESNE
FOSTERSTOWN NORTH
AUBURN
0.6km
716,566 745,038 Meters


Groundwater Data Viewer
Geological Survey Ireland, Department of Communications, Climate Action & Environment
Data Viewer
Transition Zone
Geolaiocht
Open Topographic Data Viewer
Groundwater Data Viewer
If content doesn't display in Chrome, please clear your cache
Data Download
Geological Survey Ireland
DCCAE
Search location
Legend
Teagasc Soils
Teagasc Soils
AminDW - Deep well drained mineral (Mainly acidic)
AminPD - Mineral poorly drained (Mainly acidic)
AminPDPT - Peaty poorly drained mineral (Mainly acidic)
AminSW - Shallow well drained mineral (Mainly acidic)
AminSP - Shallow poorly drained mineral (Mainly acidic)
AminSPPT - Shallow peaty poorly drained mineral (Mainly acidic)
AminSRPT - Shallow, rocky, peaty/non-peatymineral complexes (Mainly acidic)
BminDW - Deep well drained mineral (Mainly basic)
BminPD - Mineral poorly drained (Mainly basic)
BminPDPT - Peaty poorly drained mineral (Mainly basic)
BminSW - Shallow well drained mineral (Mainly basic)
BminSP - Shallow poorly drained mineral (Mainly basic)
BminSPPT - Shallow peaty poorly drained mineral (Mainly basic)
BminSRPT - Shallow, rocky, peaty/non-peatymineral complexes (Mainly basic)
BktPt - Blanket peat
FenPt - Fen peat
RsPt - Raised Peat
Cut - Cutover/cutaway peat
AlluvMIN - Alluvial (mineral)
AlluvMRL - Alluvial (marl)
Lac - Lacustrine type soils
Scree - Scree
AeoUND - Aeolian undifferentiated
MarSands - Marine sand and gravel
MarSed - Marine/estuarine sediments
Made - Made ground
Water - Water
Unclass
MAGILLSTOWN
DOLLARDS
BALHEARY
NEWTOWN
LANESTOWN
BALLYMADROUGH
SEAPOINT
COMMONS WEST
TOWNPARKS
Swords
SEATOWN EAST
HILLTOWN
MOUNTGORRY
DRINAN
RATHINGLE
716,070 745,045 Meters

APPENDIX F
OSI HISTORICAL MAPS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Home
About
Gallery
Catalogue
Help/FAQ
Fullscreen
AERIAL IMAGERY
Share
Data Catalogue
Aerial 2005
Aerial 2000
Aerial 1995
Digital Globe
Historic Map 25 inch (1888-1913)
Historic Map 6 inch B&W (1837-...
Historic Map 6 inch Colour (183...
6 inch Cassini
Nature and Environment
Selection
Historic Map 25 inch (1888-1913)
Transparency
Close Menu
NEWTOWN
BROADMEADOW
BALHEARY DEMESNE
LISSENH
HOLY-BANKS
OUTLANDS
CASTLE-FARM
GLEBE
(E.D.Swords)
SEATOWN
Big Marsh
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Gallery
Catalogue
Help/FAQ
Fullscreen
AERIAL IMAGERY
Share
Data Catalogue
Aerial 2005
Aerial 2000
Aerial 1995
Digital Globe
Historic Map 25 inch (1888-1913)
Historic Map 6 inch B&W (1837-...
Historic Map 6 inch Colour (183...
6 inch Cassini
Nature and Environment
Selection
Historic Map 6 inch Colour (1837-...
Transparency
Close Menu
N E W T O W N
B A L H E A R Y D E M E S N E
Newtown Ho.
Gate Lodge
Big Marsh
Meudon
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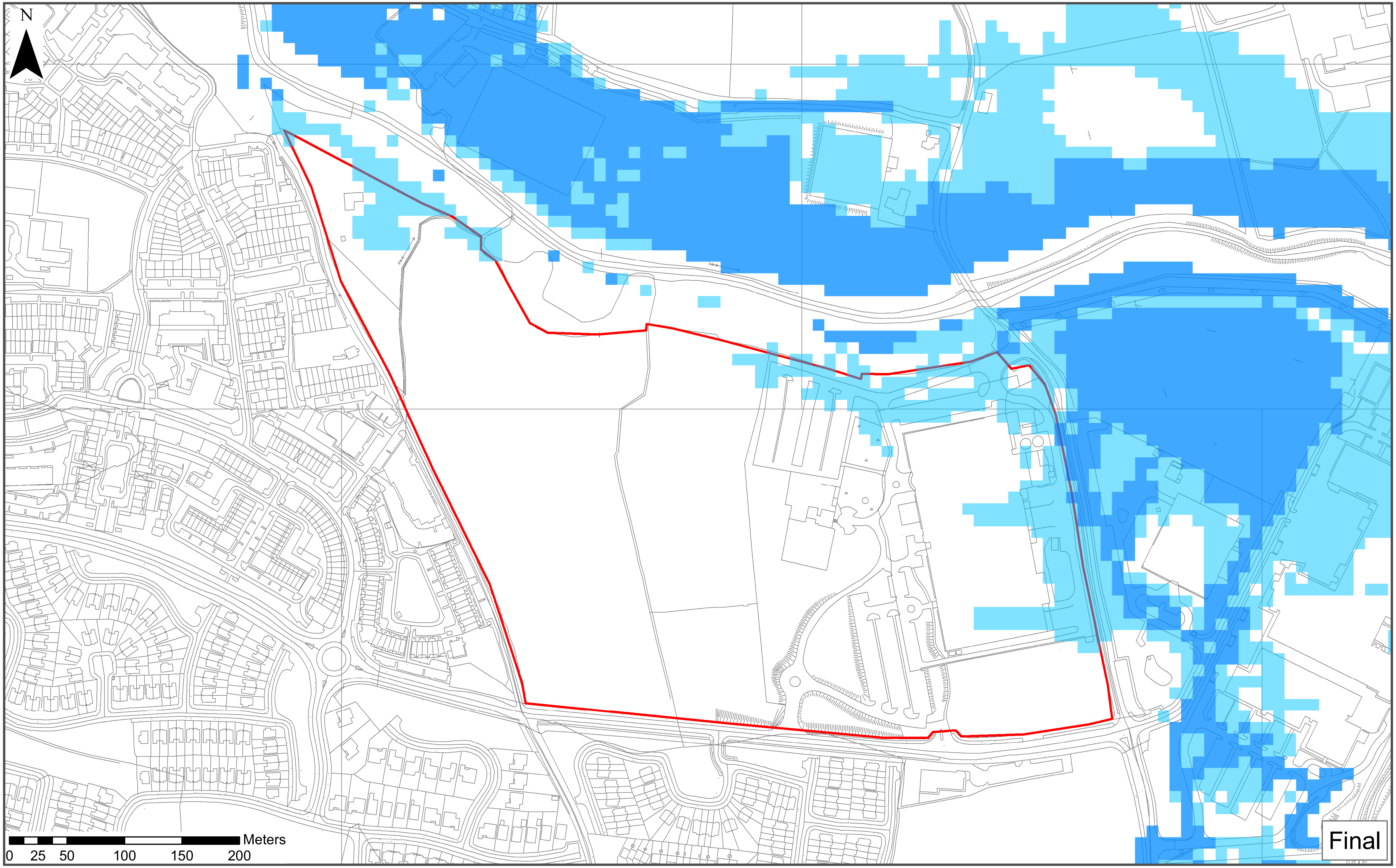
APPENDIX G
STRATEGIC FOOD RISK ASSESSMENT FLOOD EXTENT MAPPING



Legend

- Estuary West - 1 in 100 Year Fluvial Event -Current Scenario
- Estuary West - 1 in 1000 Year Fluvial Event -Current Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	09/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Consulting Engineers
Civil - Structural - Transportation - Environmental

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Sandyford, Dublin 18.
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Fax : +353 1 294 0820
e-mail : info@rod.ie
Website : www.rod.ie

Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Project Title: Estuary West Surface Water Management Plan

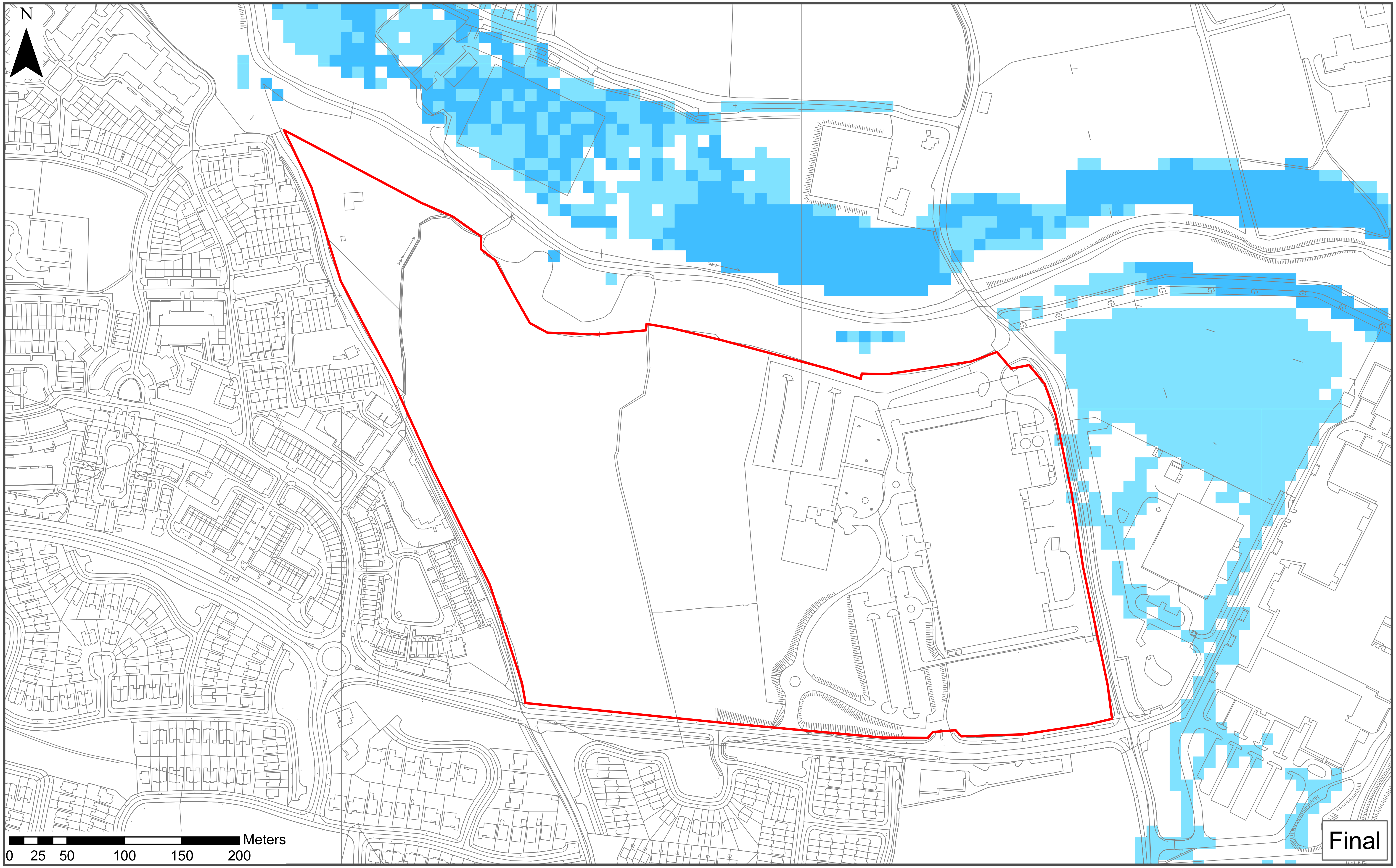
Drawing Title: Fluvial Flood Extents (Current Scenario)

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-101 | Rev: F01

Scale: (A1) 1:3,000 (@ A3) | Date: 31/01/2019

DO NOT SCALE USE FIGURED DIMENSIONS ONLY

09 May 2019 18:11:09 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Extents\Final\Fluvial\18.164-EW-101 Fluvial Flood Extents CS F01.mxd



Legend

- Estuary West - 1 in 200 Year Tidal Event - Current Scenario
- Estuary West - 1 in 1000 Year Tidal Event - Current Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	10/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Tidal Flood Extents (Current Scenario)

Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-102 | Rev: F01

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Legend

- Estuary West - 1 in 100 Year Pluvial Event - Current Scenario
- Estuary West - 1 in 1000 Year Pluvial Event - Current Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	10/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
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APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial Flood Extents (Current Scenario)

Designed:	Checked:	Approved:	Status:	Drawn:	Job No:	Drawing No:	Rev:
BP	WV	JPR	FINAL	BP	18.164	18.164-EW-103	F01

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Date: 31/01/2019

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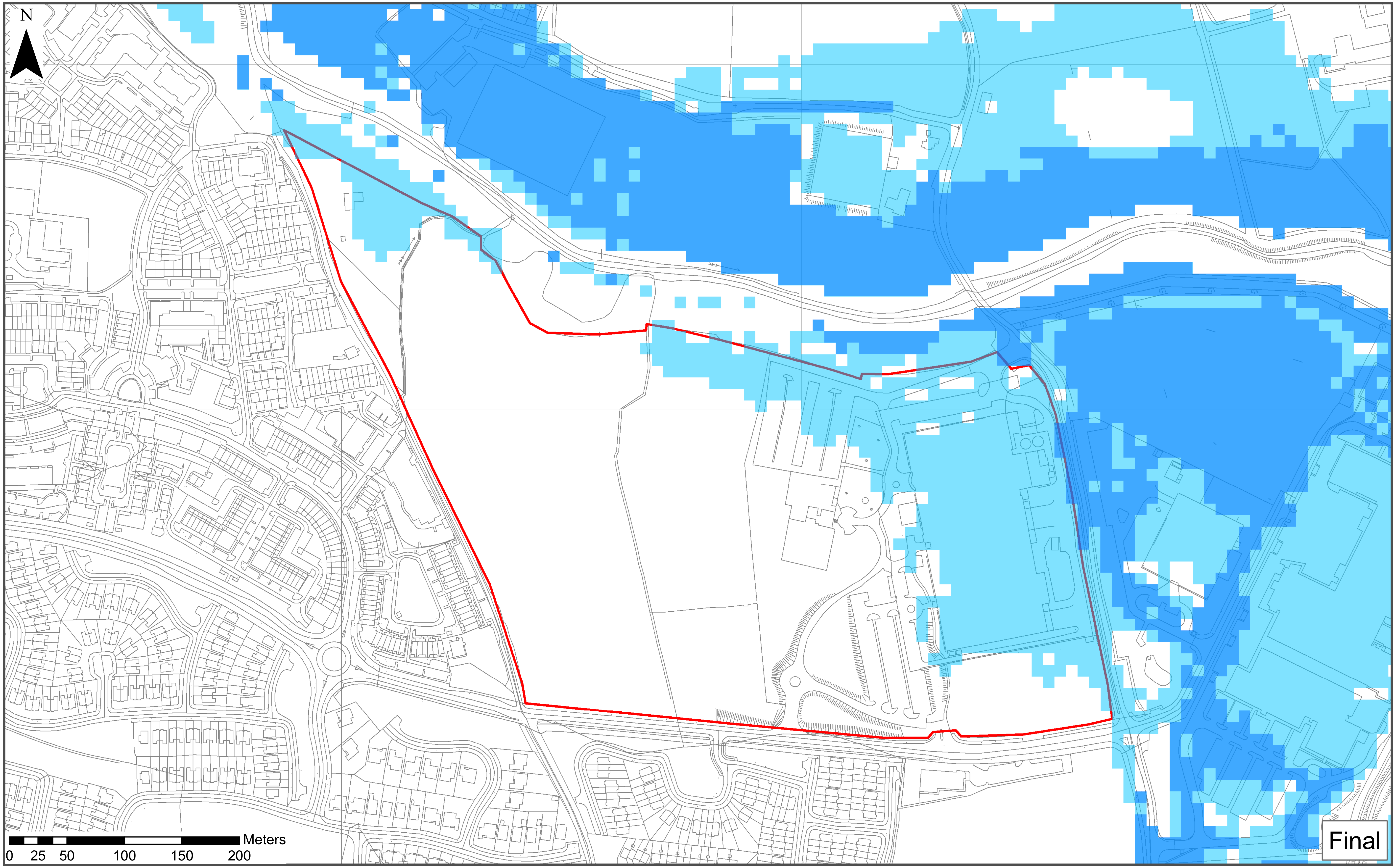

Legend

- Estuary West - 1 in 100 Year Fluvial Event - Mid Range Future Scenario
- Estuary West - 1 in 1000 Year Fluvial Event - Mid Range Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	09/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
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APPROVAL		
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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Fluvial Flood Extents (Mid Range Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL	Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-104	Rev: F01
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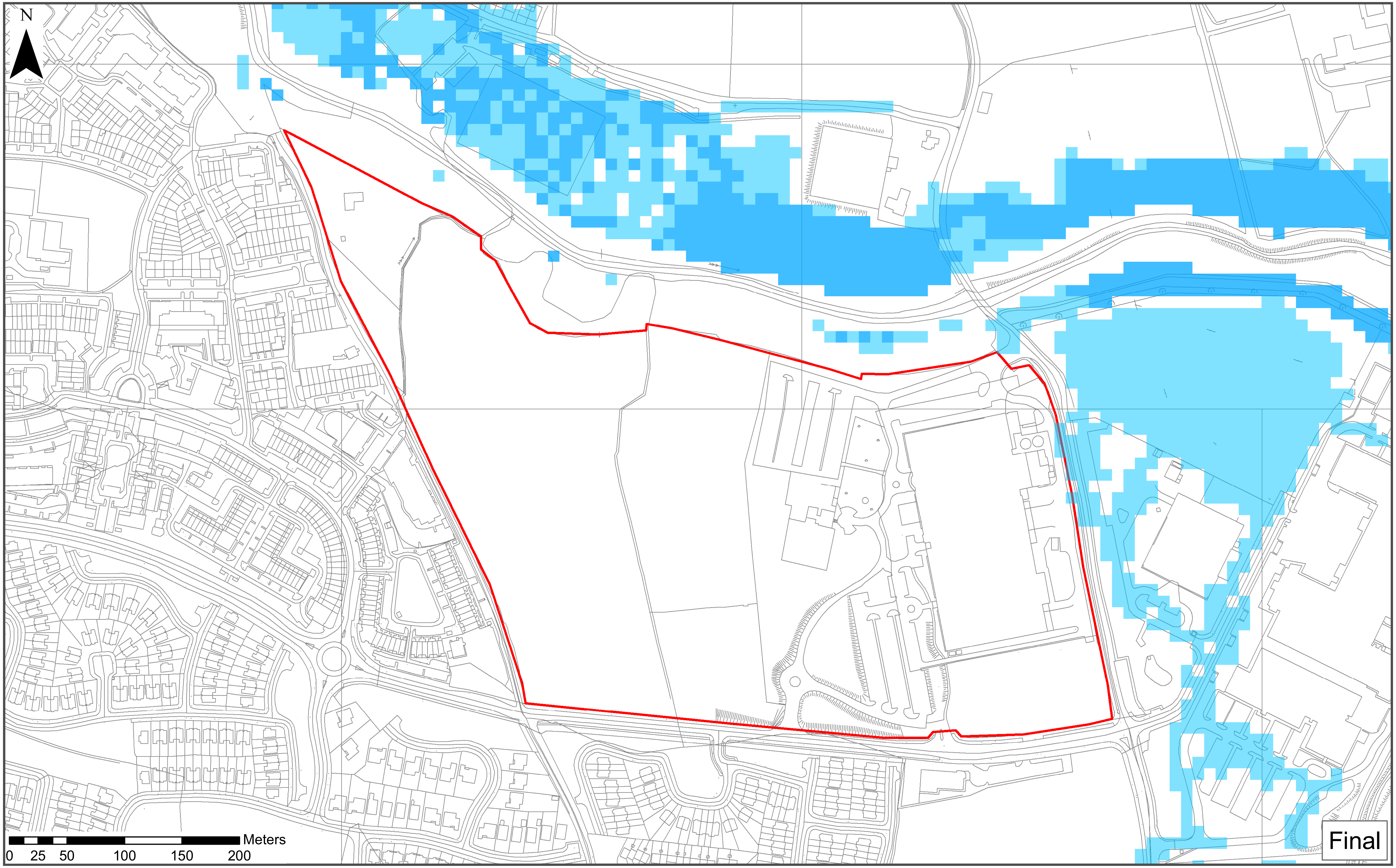
DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

- Estuary West - 1 in 200 Year Tidal Event - Mid Range Future Scenario
- Estuary West - 1 in 1000 Year Tidal Event - Mid Range Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	10/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Tidal Flood Extents (Mid Range Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-105	Rev: F01
Scale: (A1) 1:3,000 (@ A3)	Date: 31/01/2019		

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Legend

- Estuary West - 1 in 100 Year Pluvial Event - Mid Range Future Scenario
- Estuary West - 1 in 1000 Year Pluvial Event - Mid Range Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	10/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial Flood Extents (Mid Range Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL	Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-106	Rev: F01
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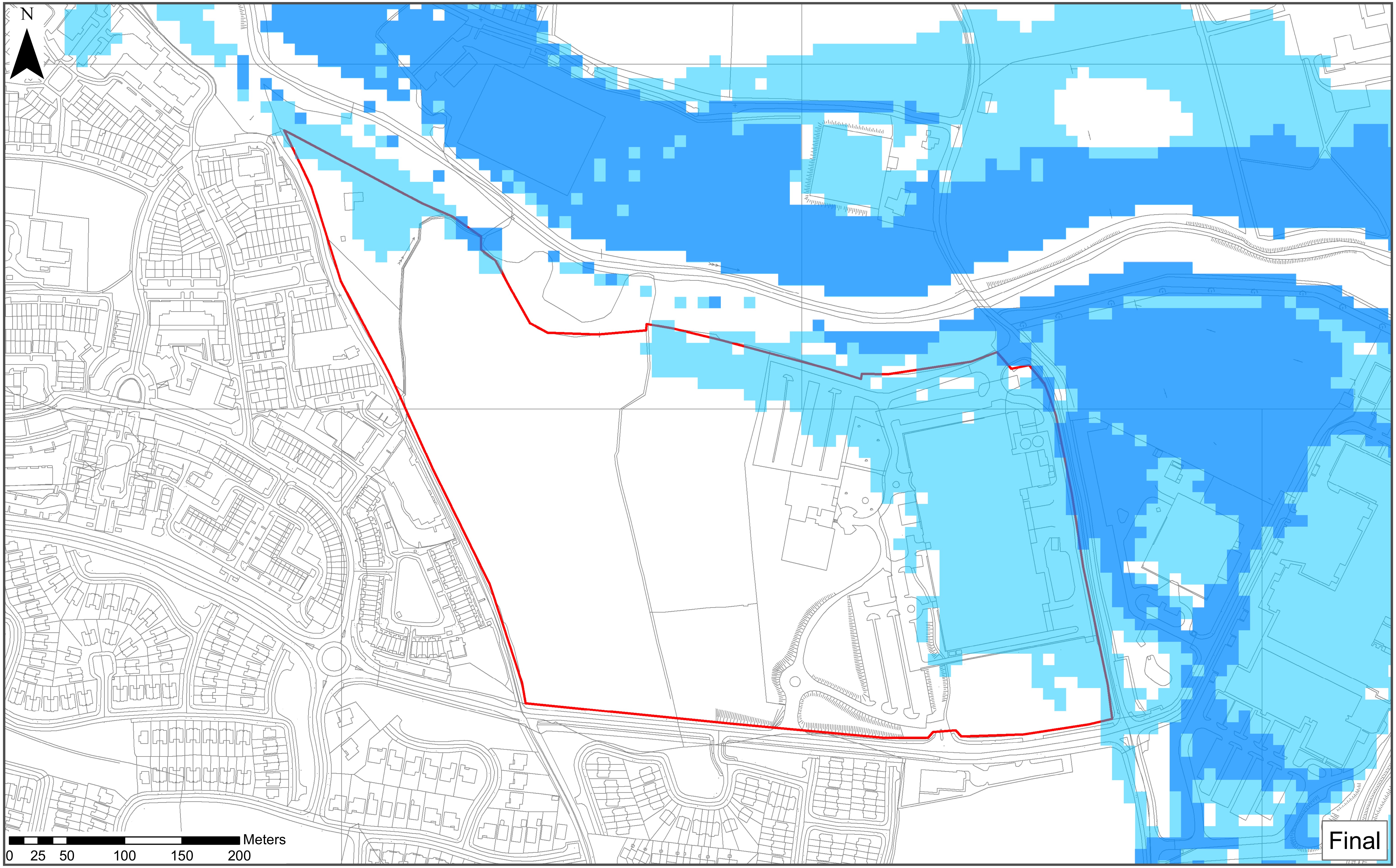

Legend

- Estuary West - 1 in 100 Year Fluvial Event - High End Future Scenario
- Estuary West - 1 in 1000 Year Fluvial Event - High End Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	09/05/2019	BP	WV	JPR
D03	Draft Flood Extents	04/03/2019	BP	WV	JPR
D02	Draft Flood Extents	31/01/2019	BP	WV	JPR
D01	Draft Flood Extents	25/01/2019	BP	WV	JPR

Stage	Date	App'd
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APPROVAL		
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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Fluvial Flood Extents (High End Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-107	Rev: F01
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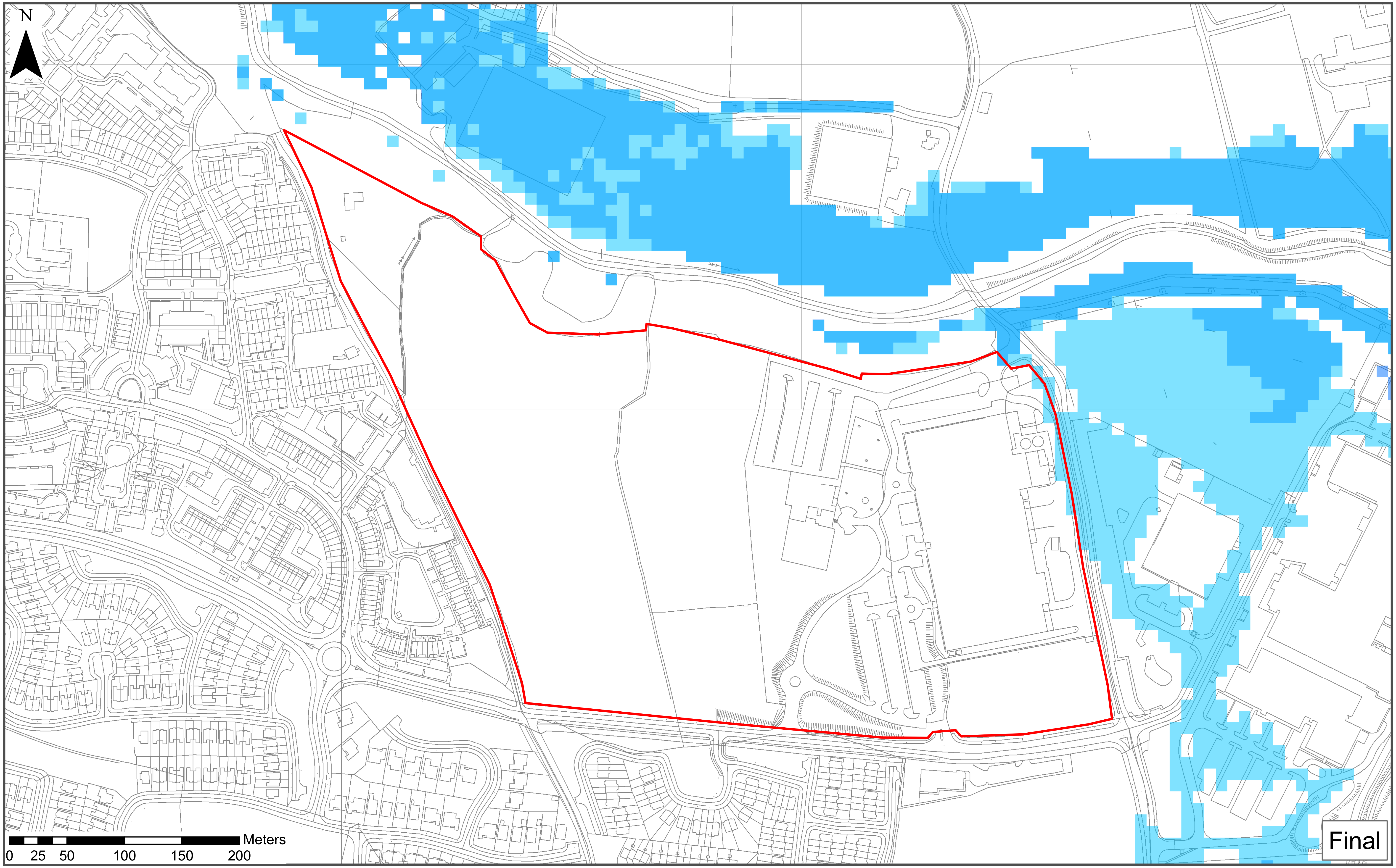

Legend

- Estuary West - 1 in 200 Year Tidal Event - High End Future Scenario
- Estuary West - 1 in 1000 Year Tidal Event - High End Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	10/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
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e-mail : info@rod.ie
Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Tidal Flood Extents (High End Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-108 | Rev: F01

Scale: (A1) 1:3,000 (@ A3) | Date: 31/01/2019

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DO NOT SCALE USE FIGURED DIMENSIONS ONLY

Legend

- Estuary West - 1 in 100 Year Pluvial Event - High End Future Scenario
- Estuary West - 1 in 1000 Year Pluvial Event - High End Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	10/05/2019	BP	WV	JPR
D02	Draft Flood Extents	05/03/2019	BP	WV	JPR
D01	Draft Flood Extents	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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e-mail : info@rod.ie
Website : www.rod.ie

Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial Flood Extents (High End Future Scenario)

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-109 | Rev: F01

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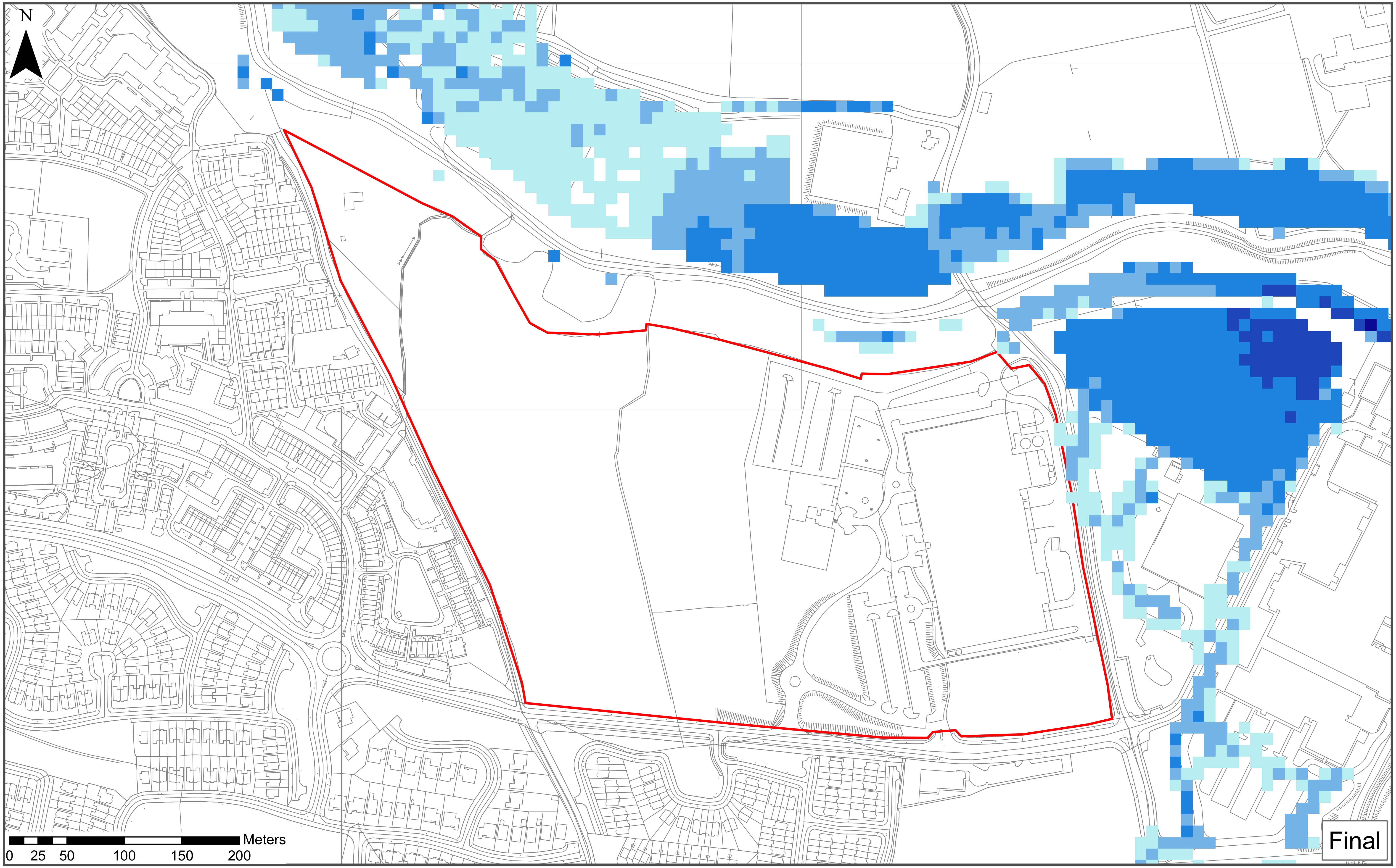
APPENDIX H
STRATEGIC FOOD RISK ASSESSMENT FLOOD DEPTH MAPPING



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Fluvial 1 in 100 Year Flood Depths (Current Scenario)

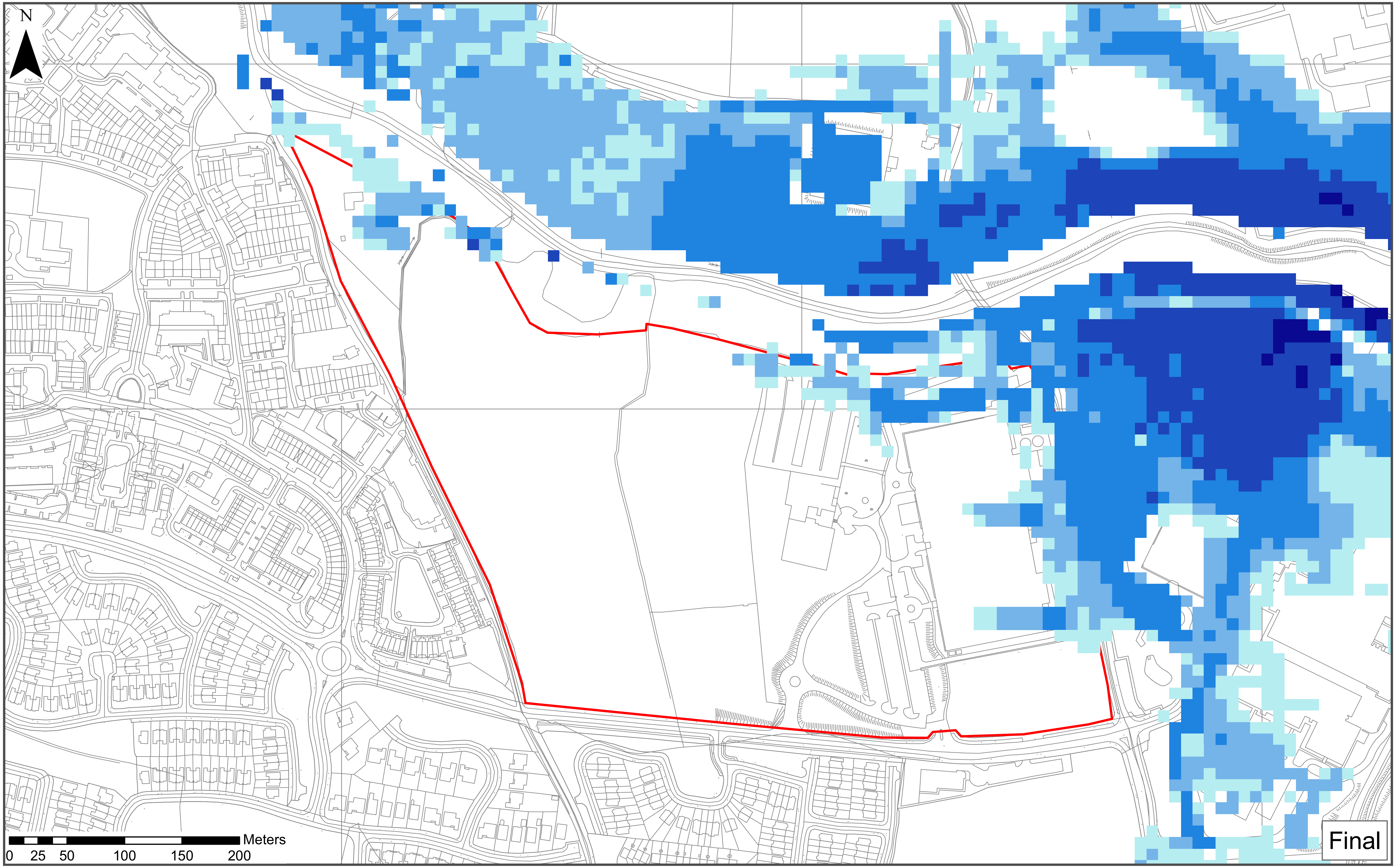
Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-201 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 16:57:44 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Fluvial\18.164-EW-201 Fluvial Flood Depths CS Q100 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

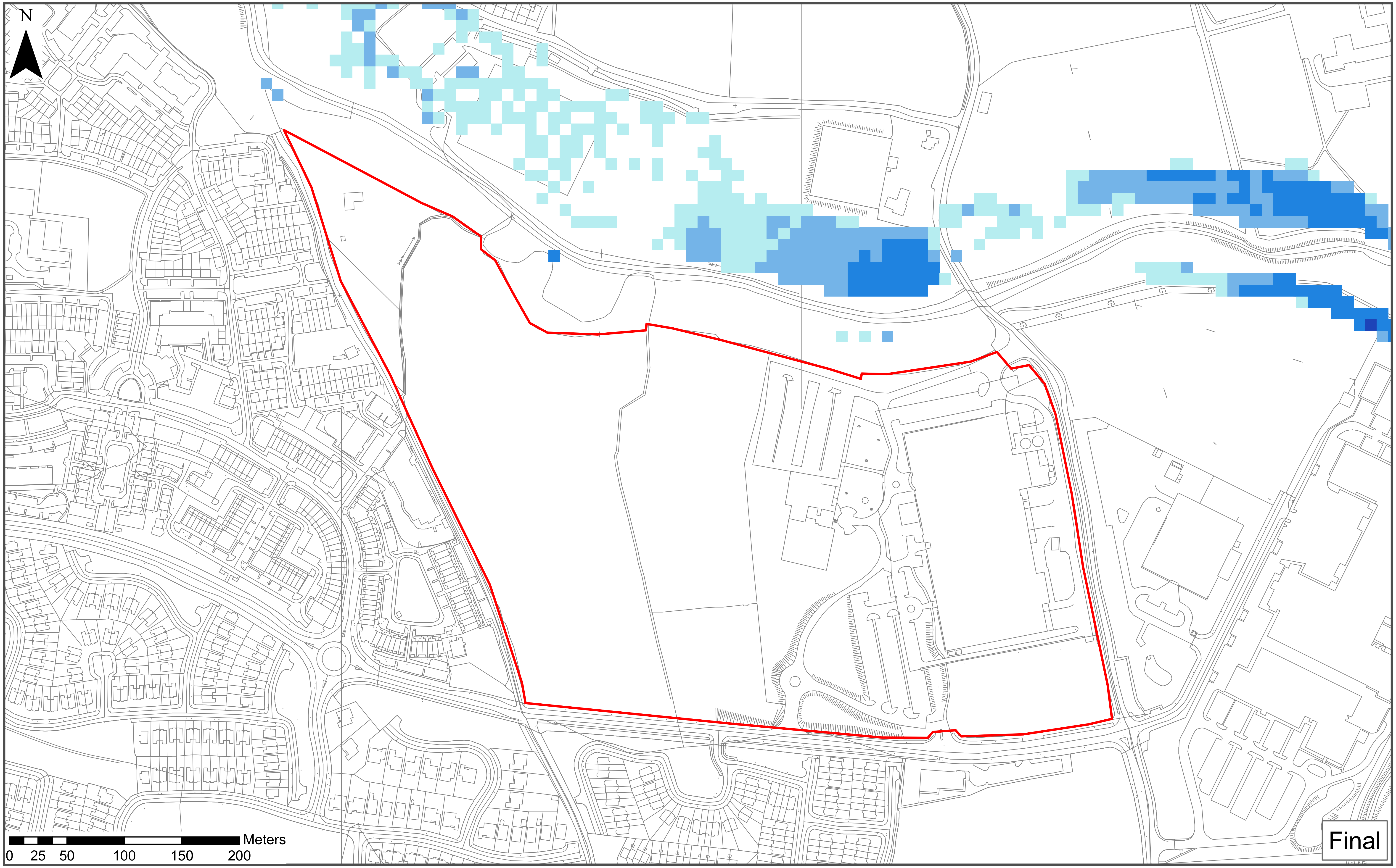
Drawing Title: Fluvial 1 in 1000 Year Flood Depths (Current Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-202	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

09 May 2019 16:58:48 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Fluvial\18.164-EW-202 Fluvial Flood Depths CS Q1000 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

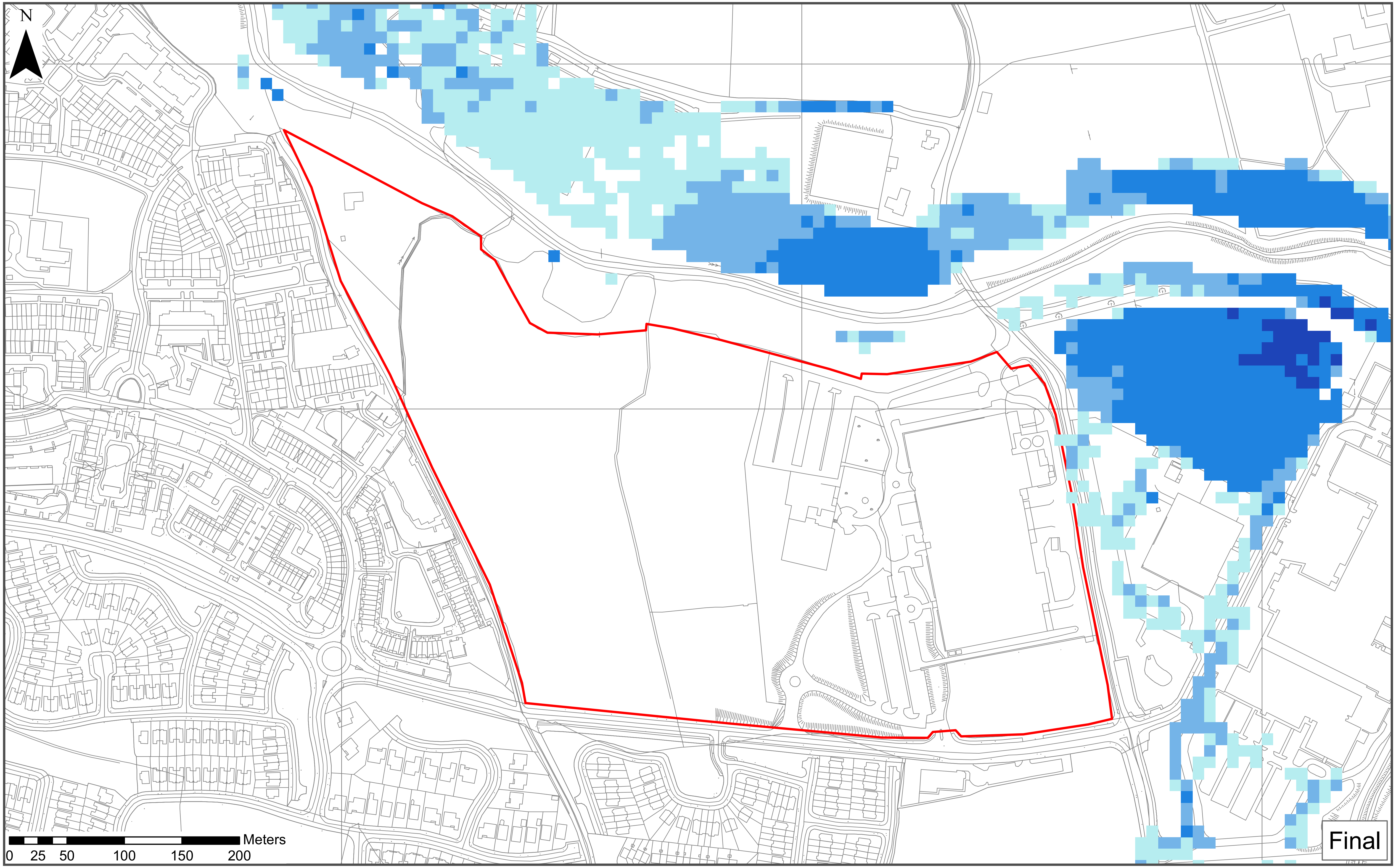
Drawing Title: Tidal 1 in 200 Year Flood Depths (Current Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-203	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

09 May 2019 17:52:55 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Tidal\18.164-EW-203 Tidal Flood Depths CS Q200 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

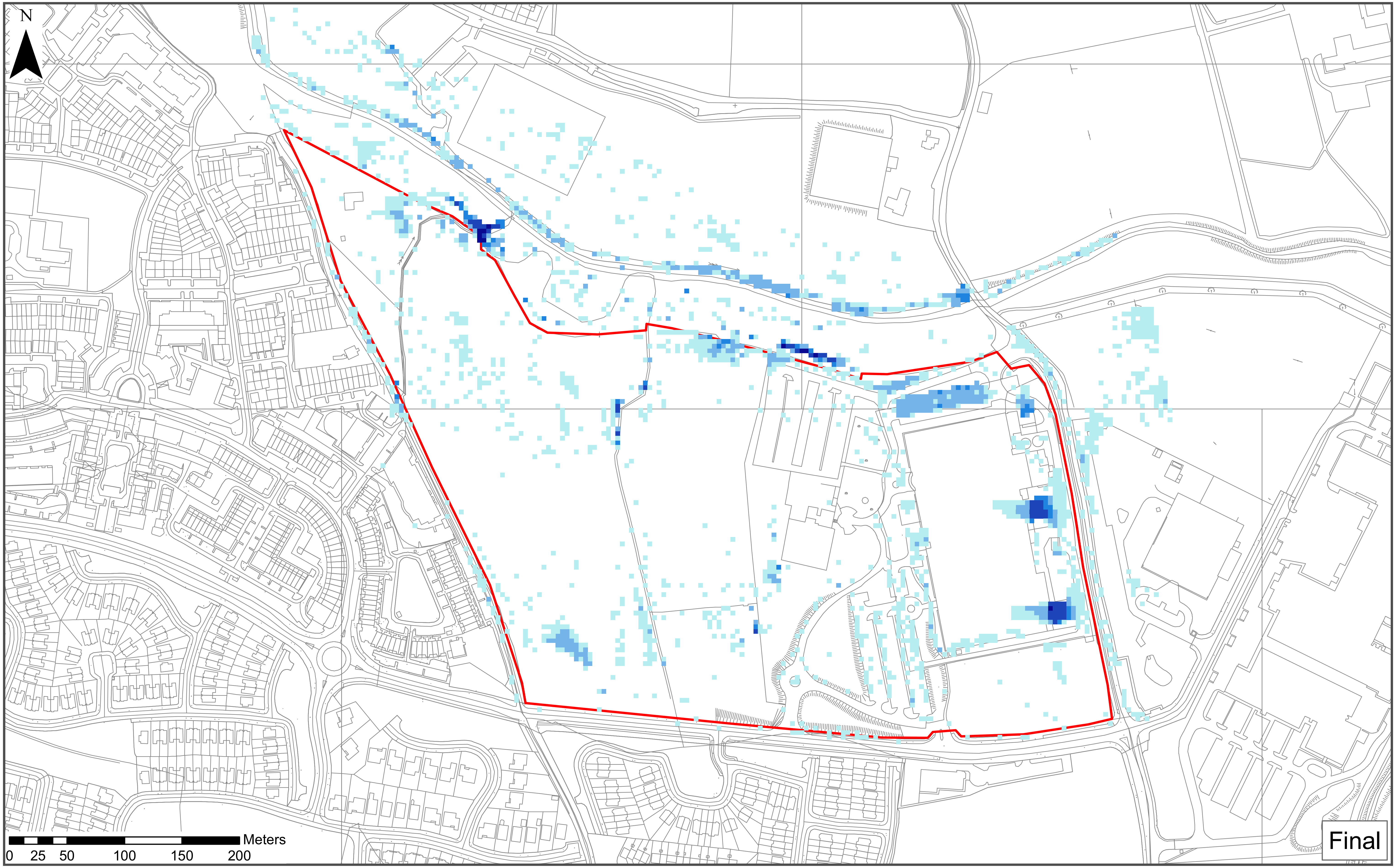
Drawing Title: Tidal 1 in 1000 Year Flood Depths (Current Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-204	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

DO NOT SCALE USE FIGURED DIMENSIONS ONLY

09 May 2019 17:53:58 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Tidal\18.164-EW-204 Tidal Flood Depths CS Q1000 F01.mxd



Legend

Depth (m)

- 0.05- 0.2m
- 0.2 - 0.4m
- 0.4 - 0.6m
- 0.6 - 1m
- 1 - 2m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial 1 in 100 Year Flood Depths (Current Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL	Drawn: BP	Job No: 18.164
Scale: 1:3,000 (@ A3)	Date: 31/01/2019	Drawing No: 18.164-EW-205	Rev: F01		

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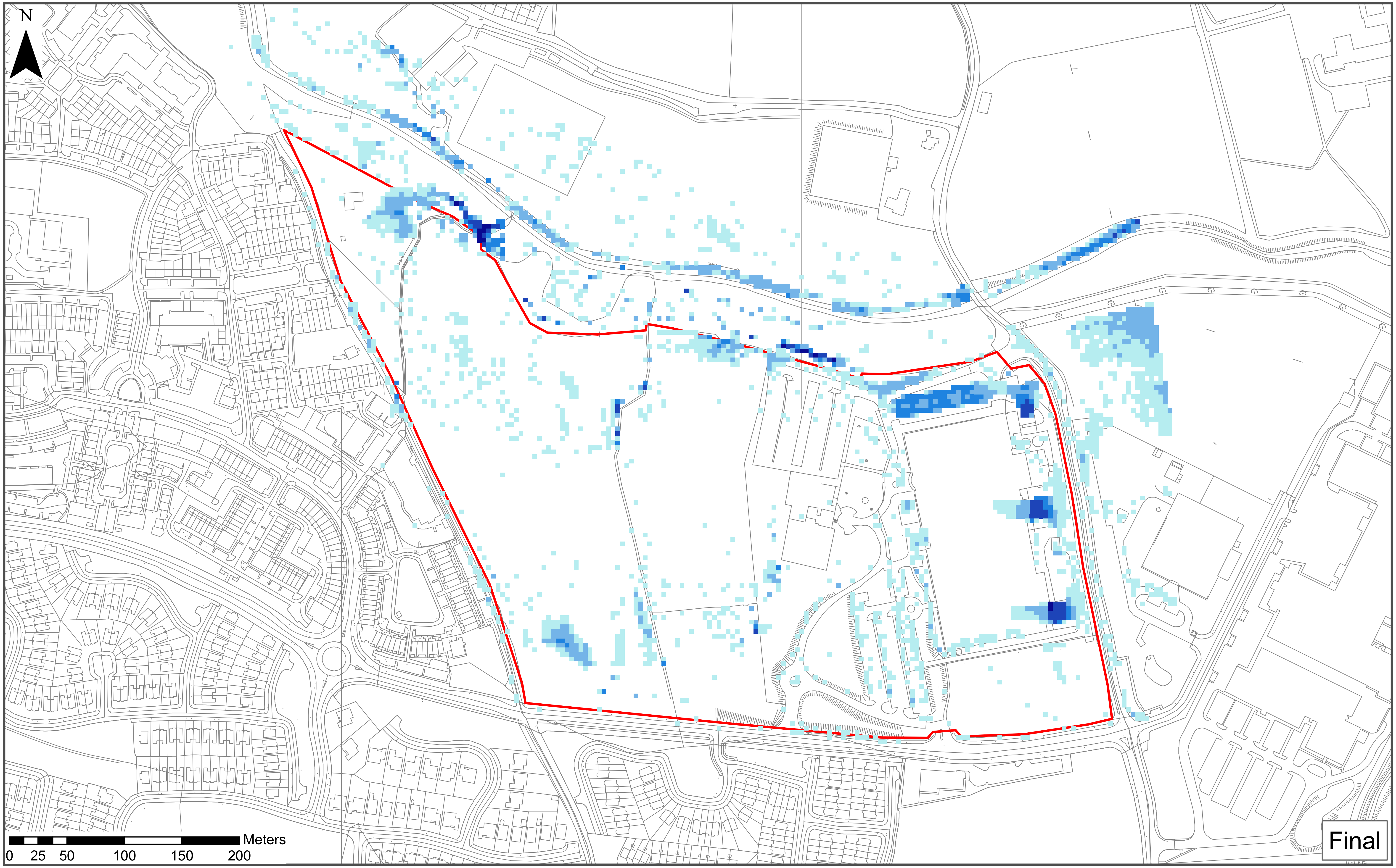
DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.05- 0.2m
- 0.2 - 0.4m
- 0.4 - 0.6m
- 0.6 - 1m
- 1 - 2m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Project Title: Estuary West Surface Water Management Plan

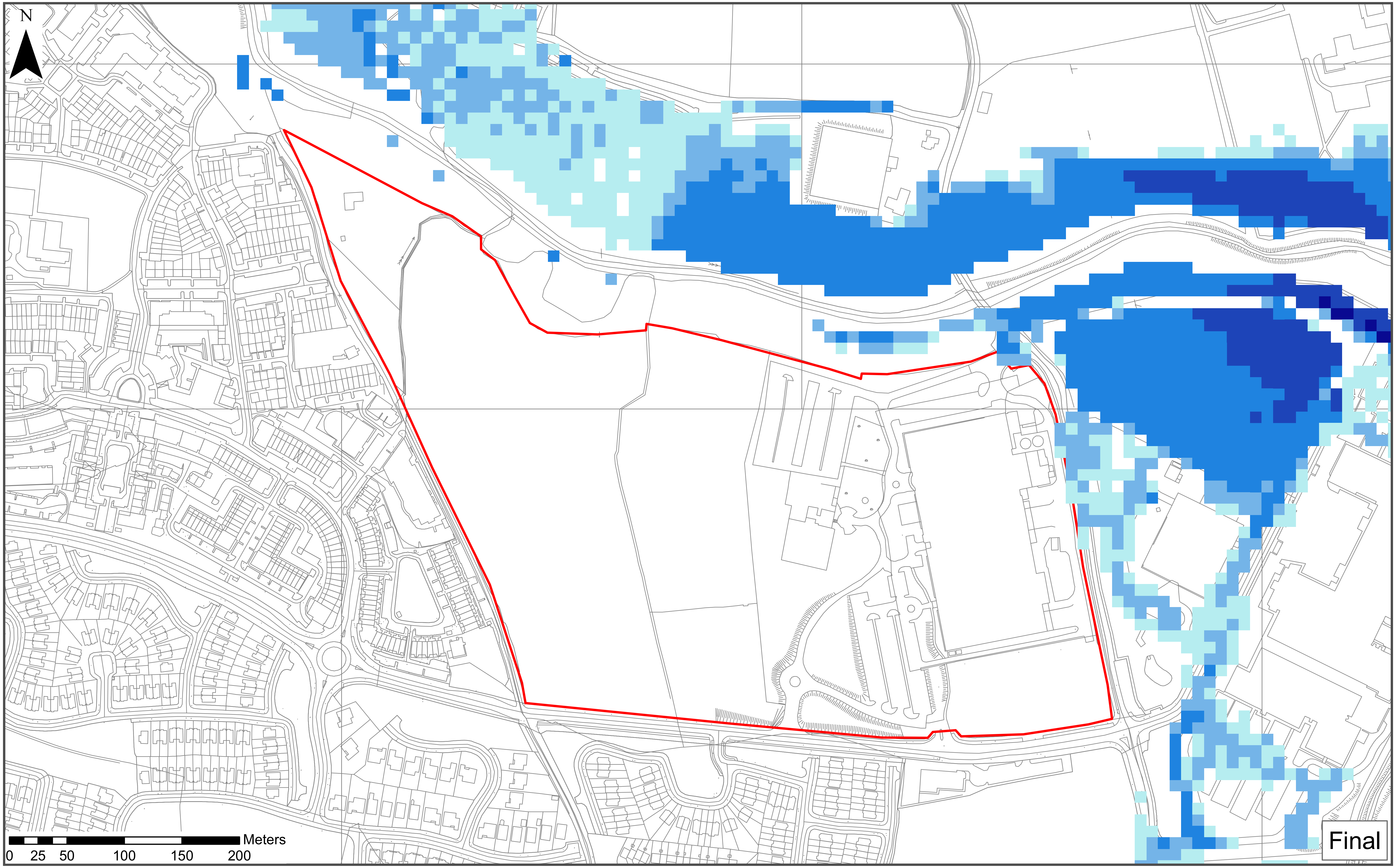
Drawing Title: Pluvial 1 in 1000 Year Flood Depths (Current Scenario)

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-206 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:23:49 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Pluvial\18.164-EW-206 Pluvial Flood Depths CS Q1000 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

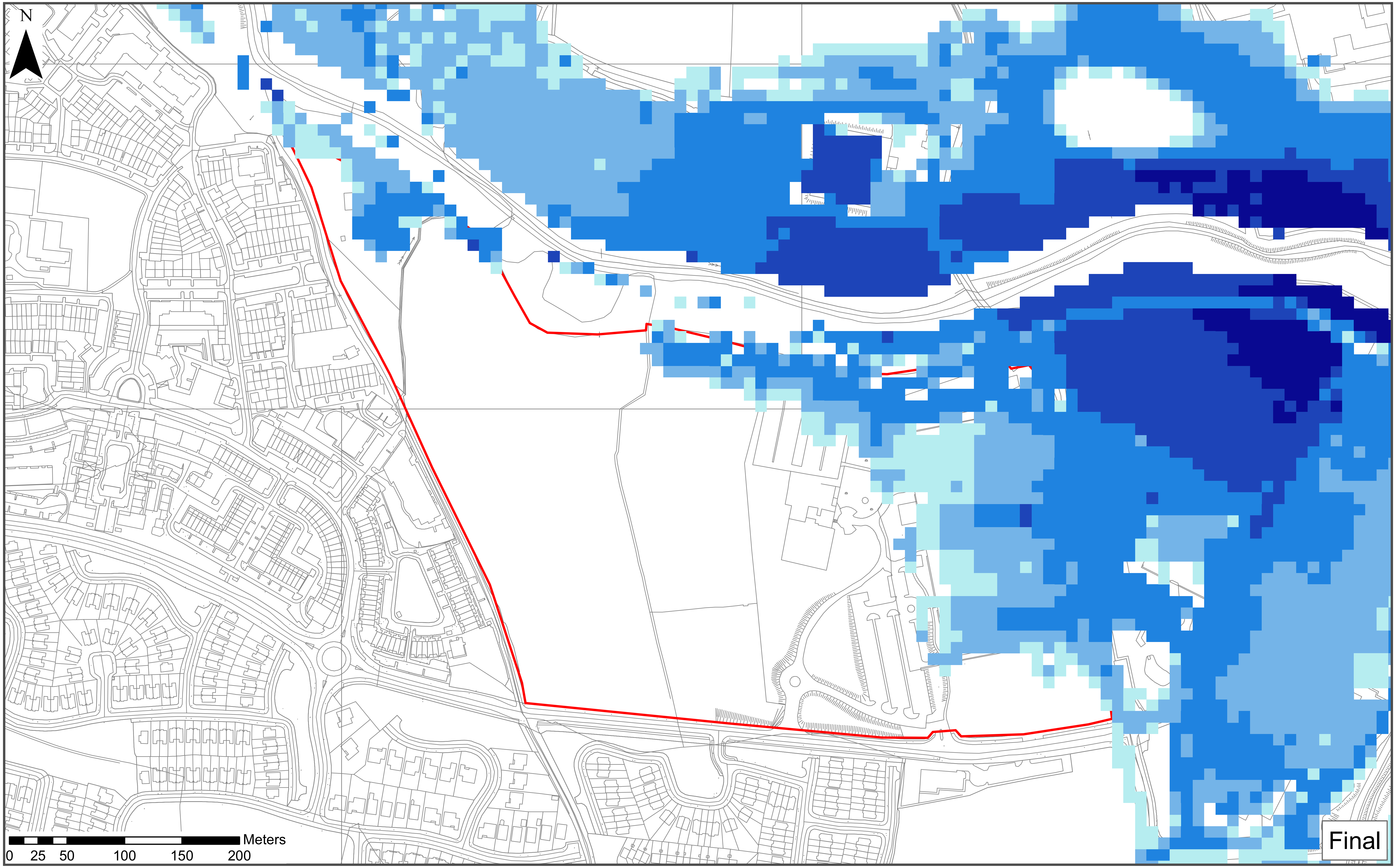
Drawing Title: Fluvial 1 in 100 Year Flood Depths (Mid Range Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-207	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

09 May 2019 16:59:51 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Fluvial\18.164-EW-207 Fluvial Flood Depths MRFS Q100 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

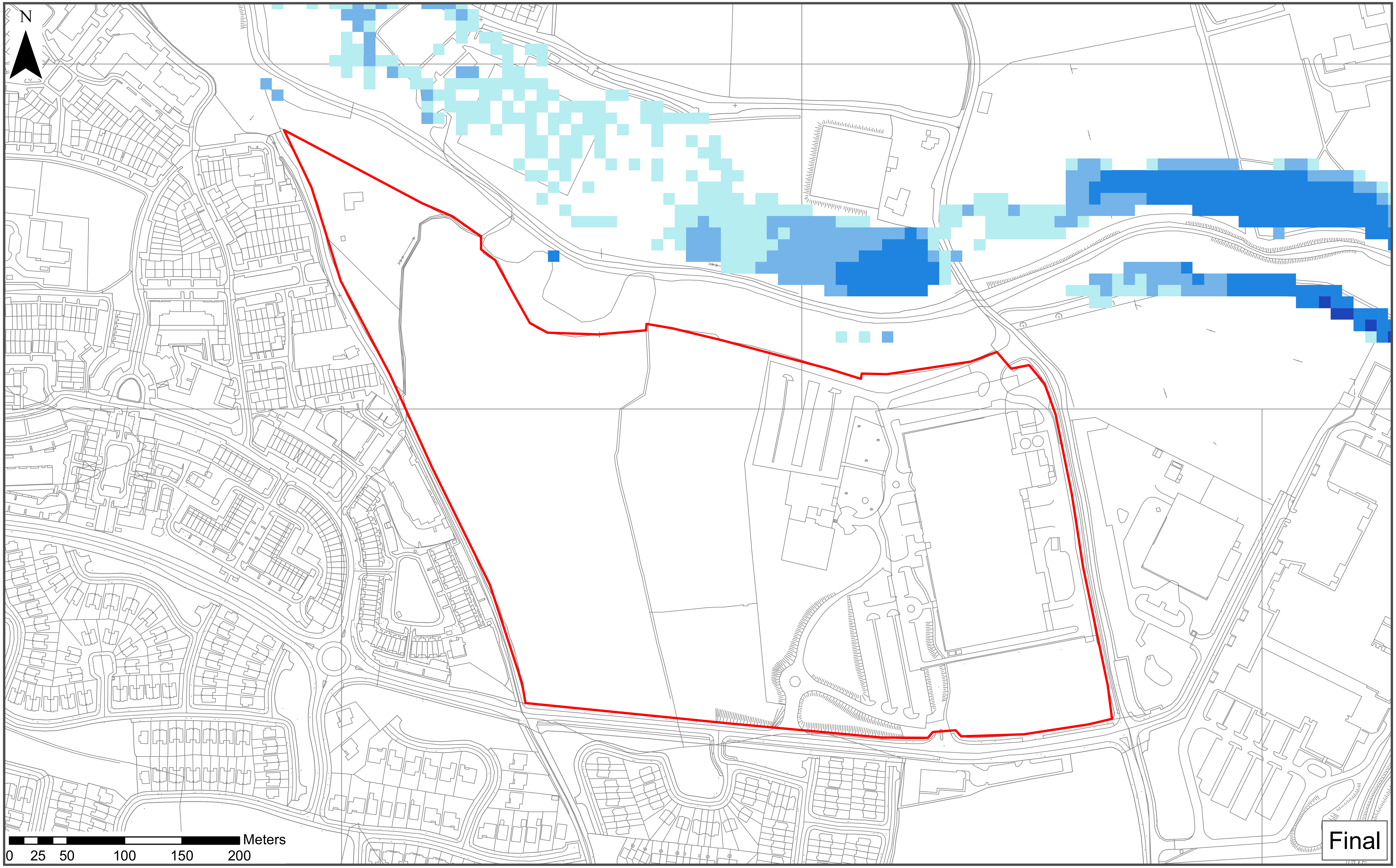
Drawing Title: Fluvial 1 in 1000 Year Flood Depths (Mid Range Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-208	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

09 May 2019 17:00:56 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Fluvial\18.164-EW-208 Fluvial Flood Depths MRFS Q1000 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Tidal 1 in 200 Year Flood Depths (Mid Range Future Scenario)

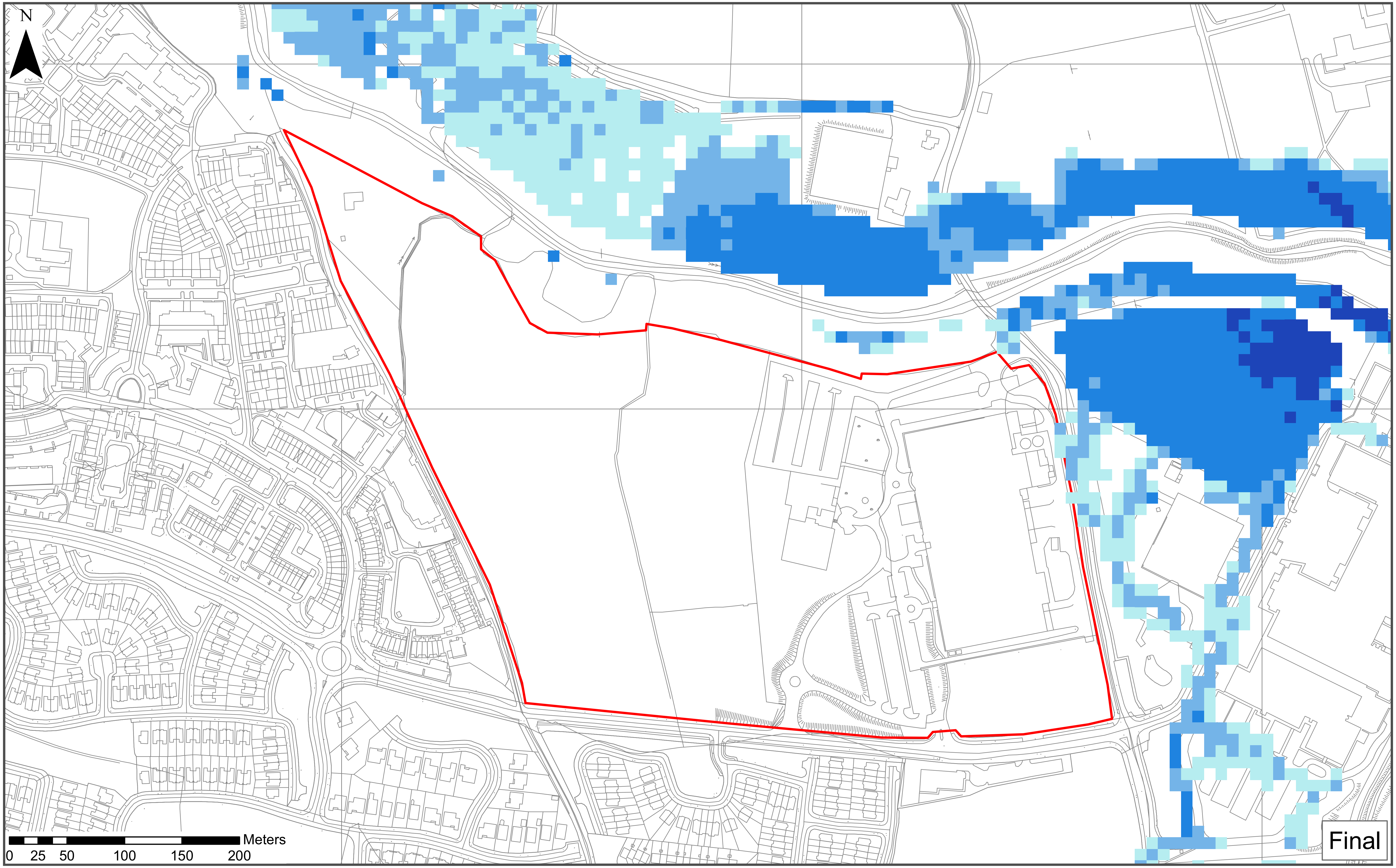
Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-209 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:55:14 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Tidal\18.164-EW-209 Tidal Flood Depths MRFS Q200 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Project Title: Estuary West Surface Water Management Plan

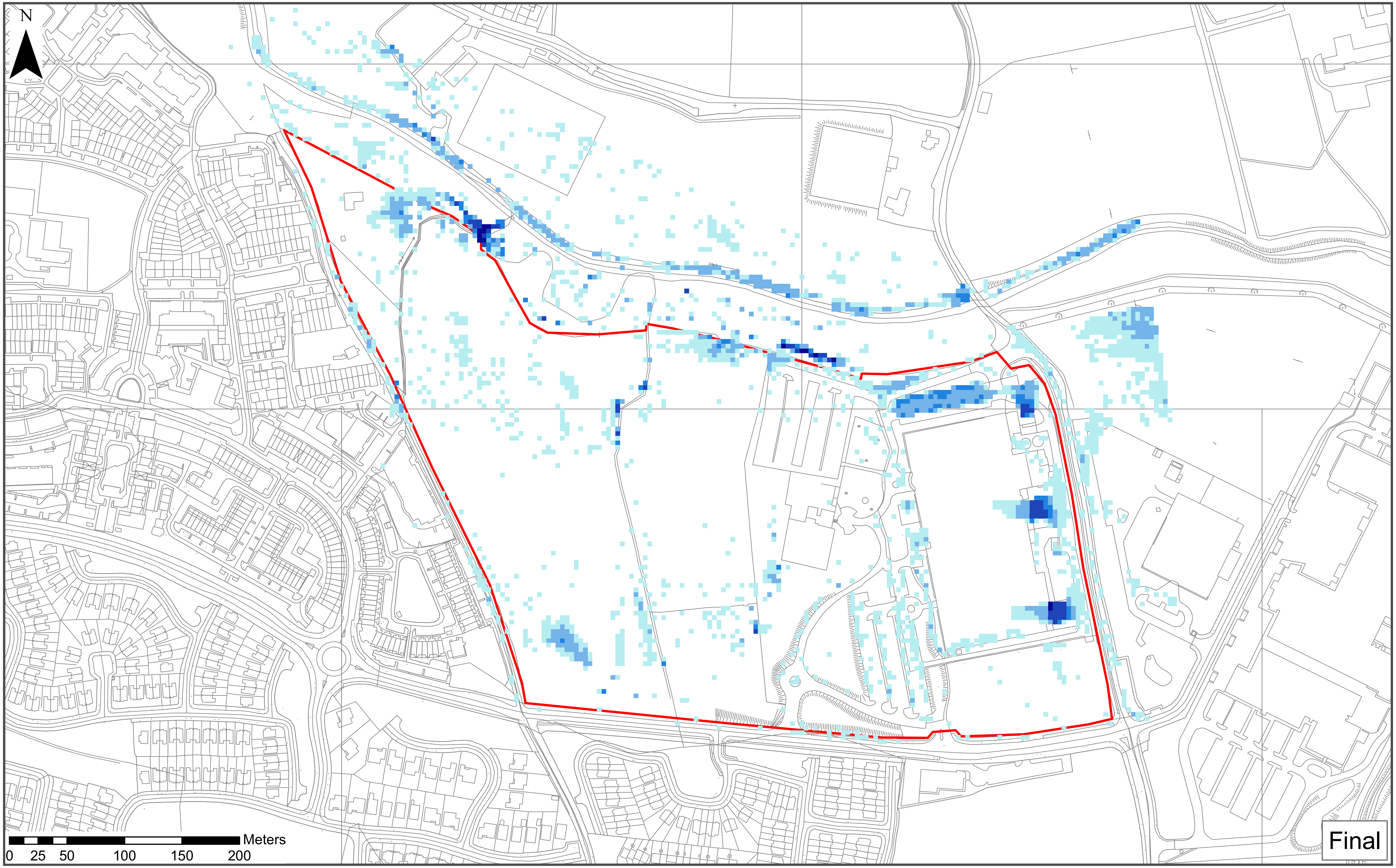
Drawing Title: Tidal 1 in 1000 Year Flood Depths (Mid Range Future Scenario)

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-210 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:58:11 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Tidal\18.164-EW-210 Tidal Flood Depths MRFS Q1000 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.05- 0.2m
- 0.2 - 0.4m
- 0.4 - 0.6m
- 0.6 - 1m
- 1 - 2m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial 1 in 100 Year Flood Depths (Mid Range Future Scenario)

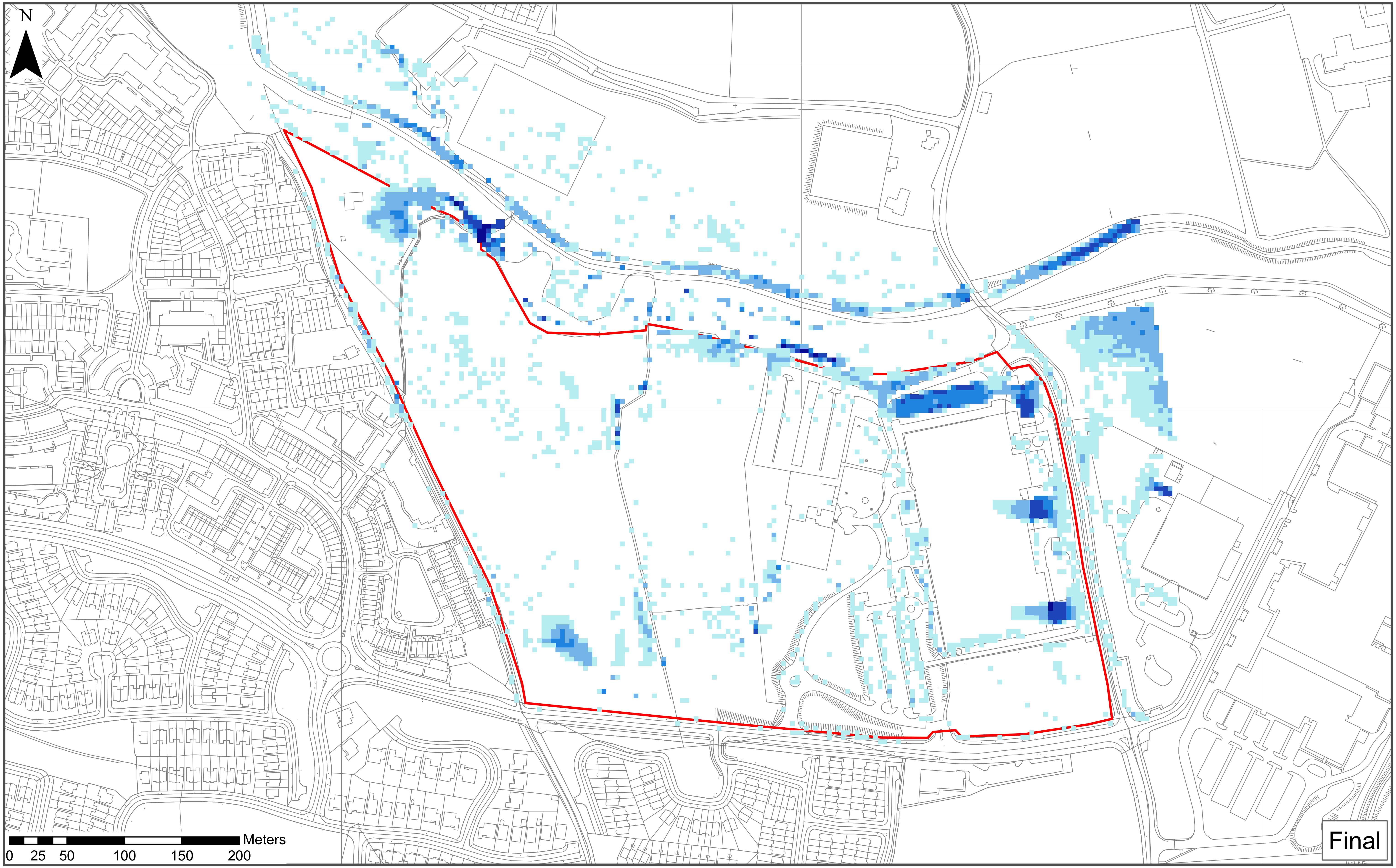
Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-211 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:24:57 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Pluvial\18.164-EW-211 Pluvial Flood Depths MRFS Q100 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.05- 0.2m
- 0.2 - 0.4m
- 0.4 - 0.6m
- 0.6 - 1m
- 1 - 2m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial 1 in 1000 Year Flood Depths (Mid Range Future Scenario)

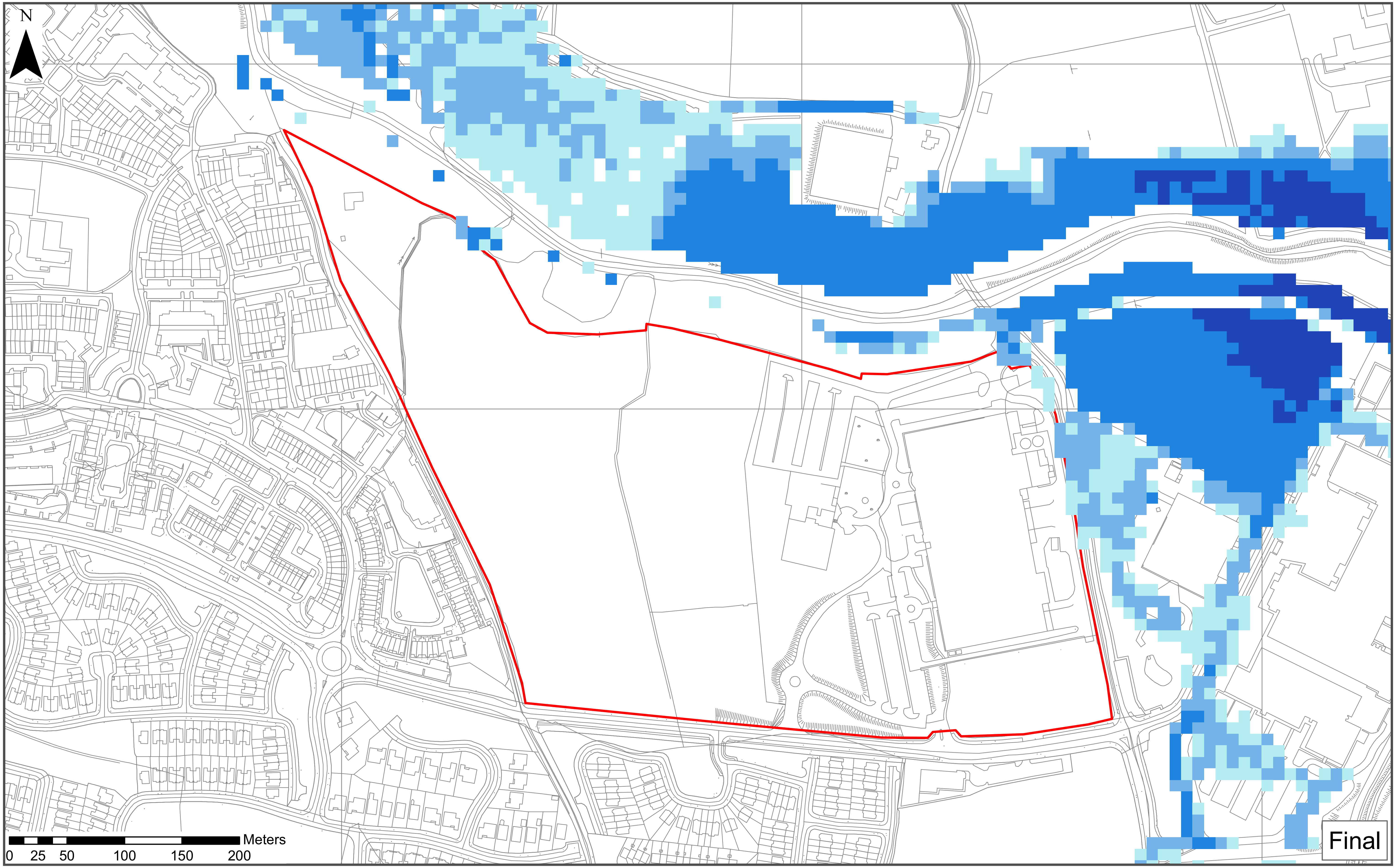
Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-212 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:26:03 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Pluvial\18.164-EW-212 Pluvial Flood Depths MRFS Q1000 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Fluvial 1 in 100 Year Flood Depths (High End Future Scenario)

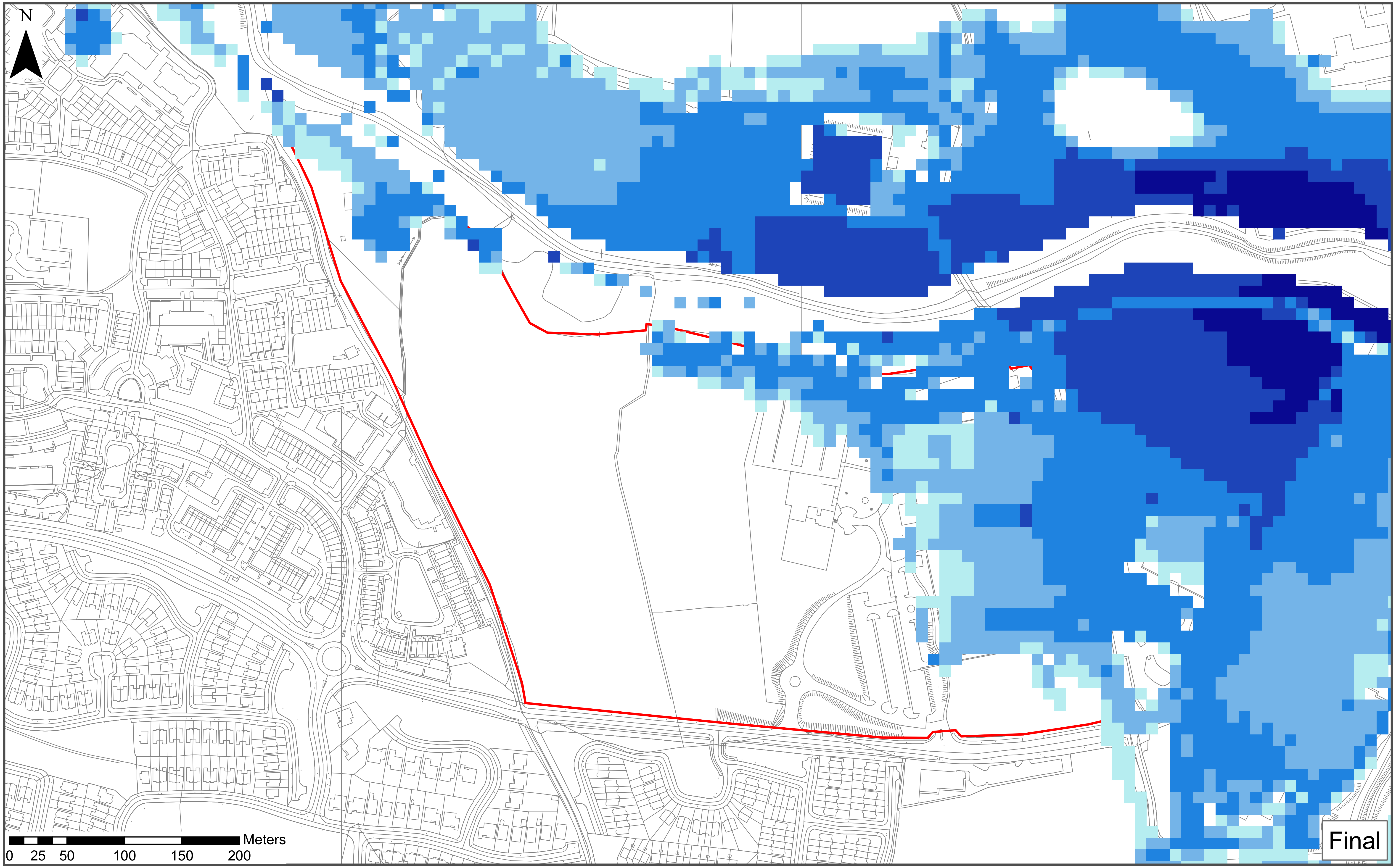
Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-213 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:02:03 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Fluvial\18.164-EW-213 Fluvial Flood Depths HEFS Q100 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

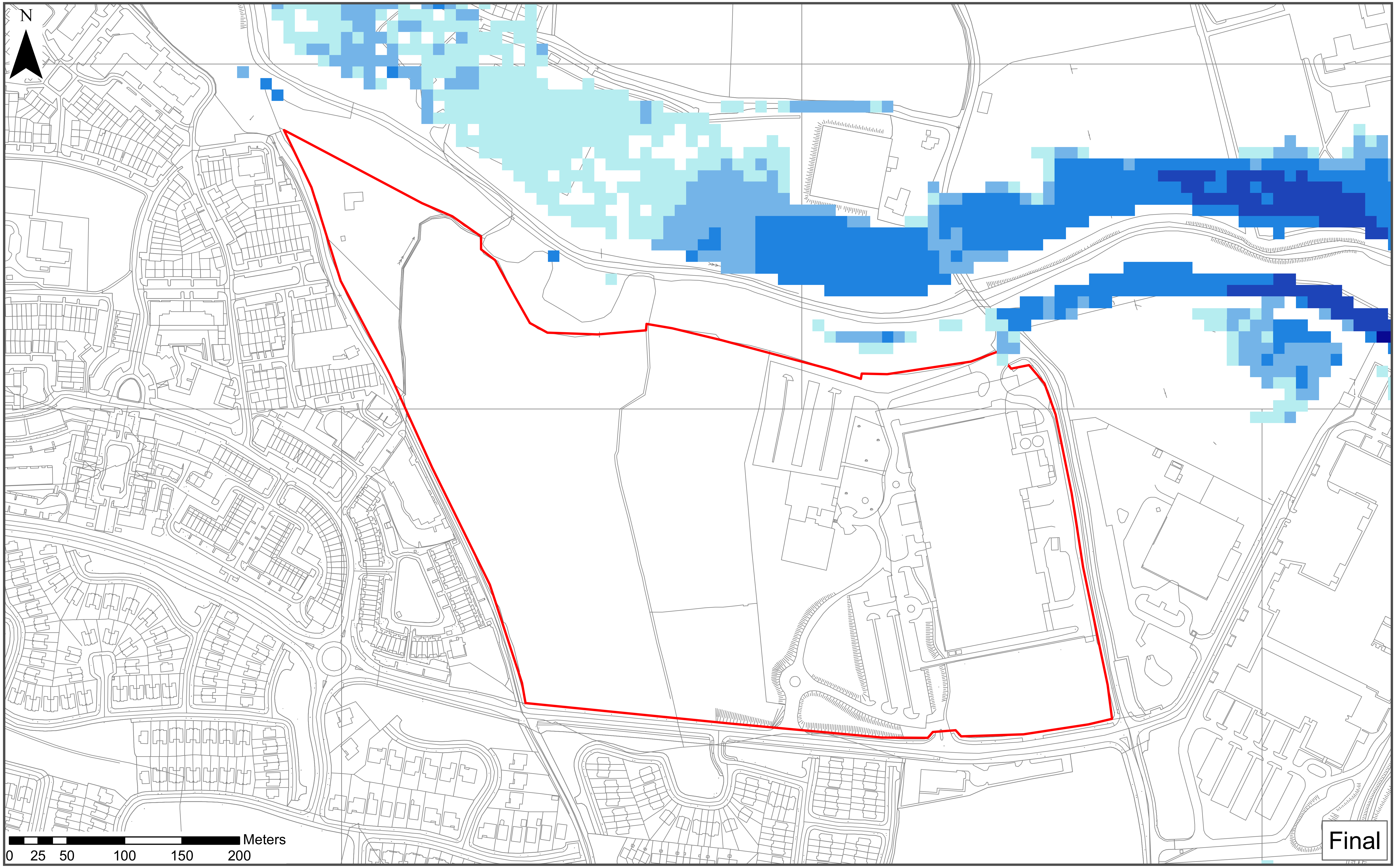
Drawing Title: Fluvial 1 in 1000 Year Flood Depths (High End Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-214	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

09 May 2019 17:03:01 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Fluvial\18.164-EW-214 Fluvial Flood Depths HEFS Q1000 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

- 0.01 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Tidal 1 in 200 Year Flood Depths (High End Future Scenario)

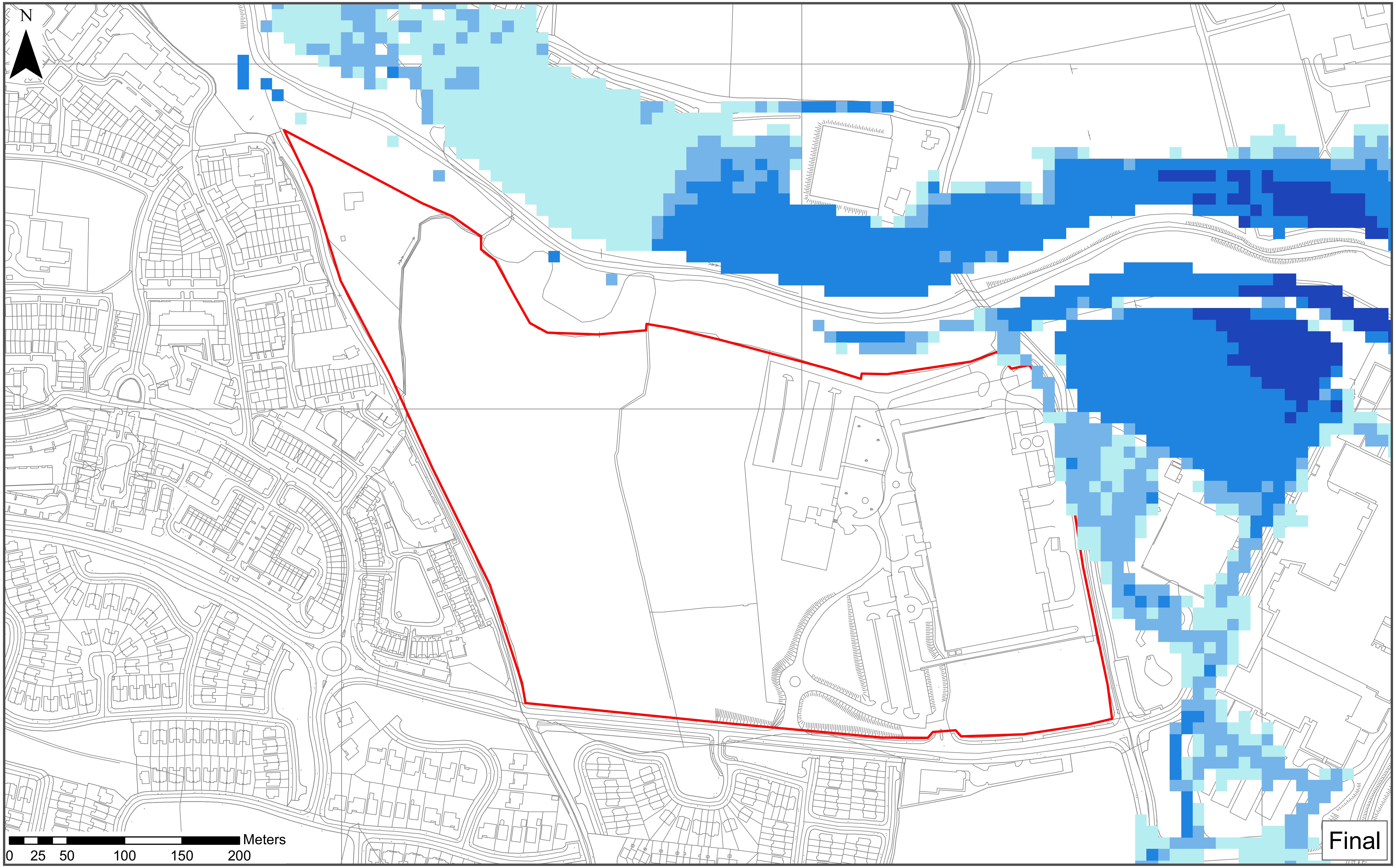
Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-215 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 17:59:47 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Depths\Final\Tidal\18.164-EW-215 Tidal Flood Depths HEFS Q200 F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY



Legend

Depth (m)

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- 0.2 - 0.5m
- 0.5 - 1.5m
- 1.5 - 2.5m
- 2.5 - 5m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D02	Draft Flood Depths	05/03/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Tidal 1 in 1000 Year Flood Depths (High End Future Scenario)

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

Drawn: BP	Job No: 18.164	Drawing No: 18.164-EW-216	Rev: F01
Scale: 1:3,000 (@ A3)	Date: 31/01/2019		

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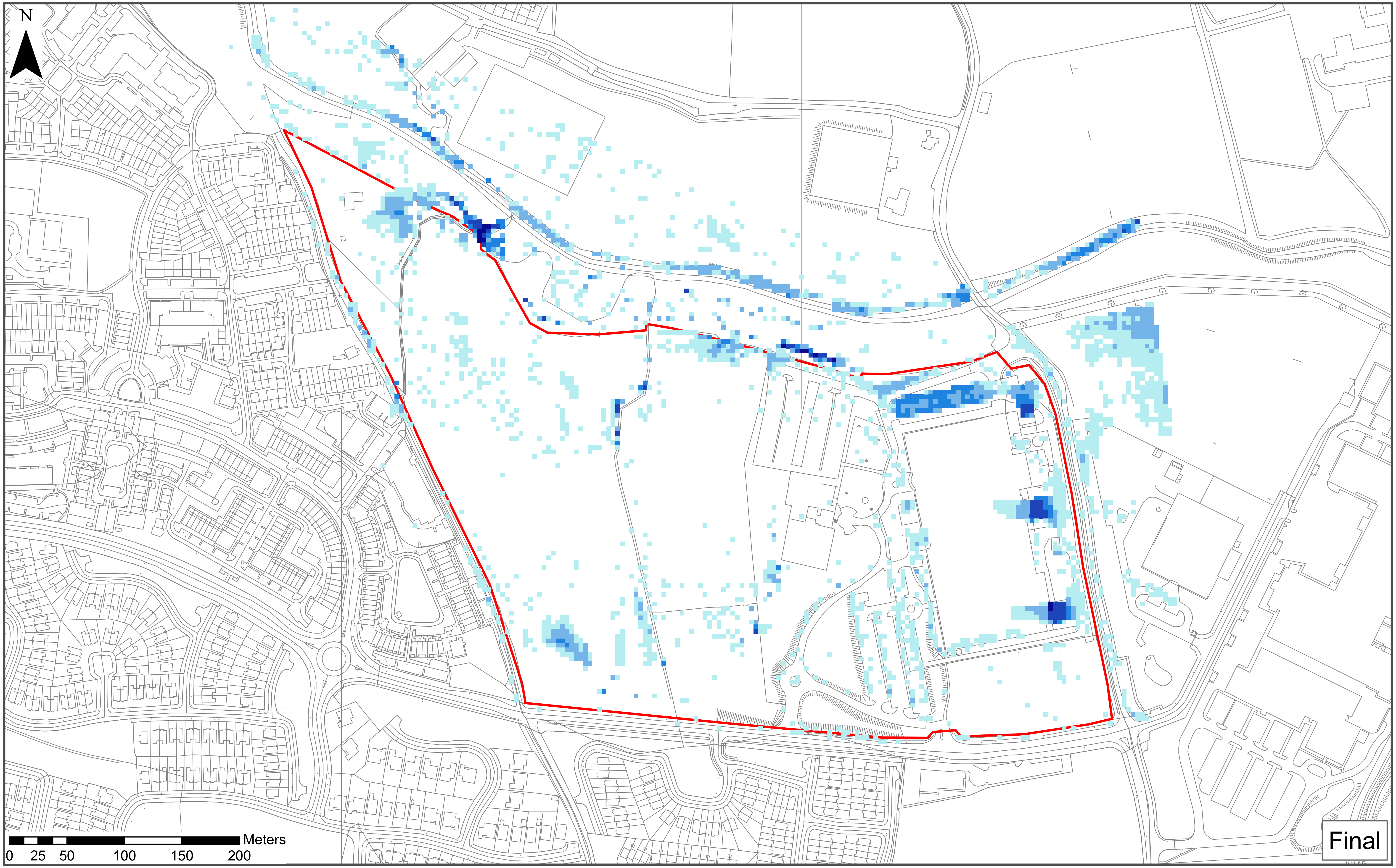

Legend

Depth (m)

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- 0.2 - 0.4m
- 0.4 - 0.6m
- 0.6 - 1m
- 1 - 2m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial 1 in 100 Year Flood Depths (High End Future Scenario)

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Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-217 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

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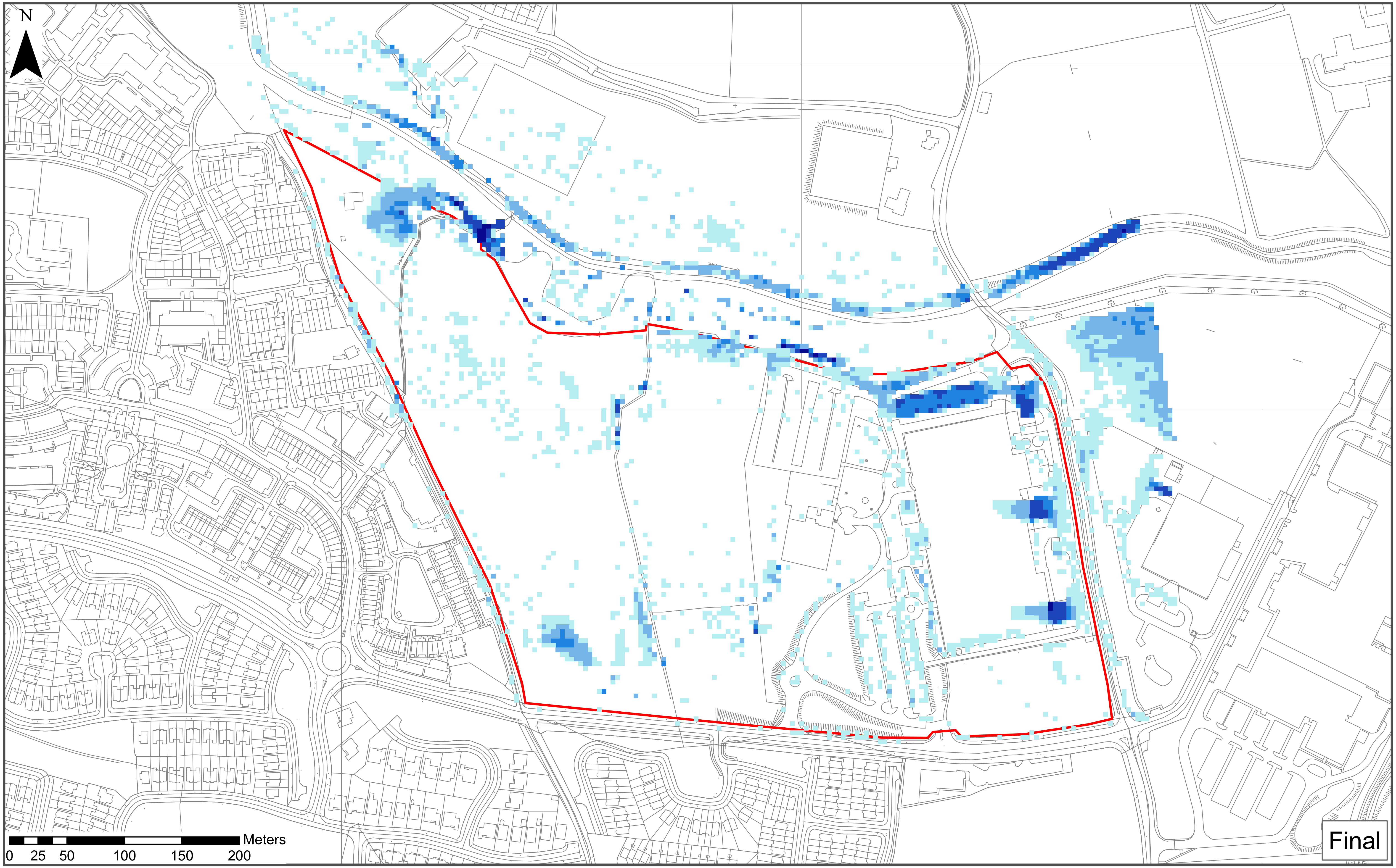

Legend

Depth (m)

- 0.05- 0.2m
- 0.2 - 0.4m
- 0.4 - 0.6m
- 0.6 - 1m
- 1 - 2m
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Depths	09/05/2019	BP	WV	JPR
D01	Draft Flood Depths	31/01/2019	BP	WV	JPR

Stage	Date	App'd
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TENDER		
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Project Title: Estuary West Surface Water Management Plan

Drawing Title: Pluvial 1 in 1000 Year Flood Depths (High End Future Scenario)

Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-218 | Rev: F01

Scale: 1:3,000 (@ A3) | Date: 31/01/2019

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Fingal County Council

Estuary West Masterplan

Surface Water Management Plan Part 2: Sustainable Drainage Systems (SuDS) Strategy

May 2019 (FINAL)

ROD
ROUGHAN & O'DONOVAN

Comhairle Contae
Fhine Gall
Fingal County
Council

Estuary West Masterplan in Swords Co. Dublin
Surface Water Management Plan:
Part 2: Sustainable Drainage Systems (SuDS) Strategy

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Commission

Roughan & O'Donovan Consulting Engineers (ROD) was commissioned by Fingal County Council (FCC) to prepare a Surface Water Management Plan to supplement the Estuary West Masterplan. As part of this commission, a Sustainable Drainage Systems (SuDS) Strategy for the masterplan has been developed. The masterplan will set out the local land use and planning policy and provide a strategy for the future planning and sustainable development of the area.

1.2 Scope

The scope of this report is as follows:

- Review the existing drainage network servicing the lands and provide an assessment of the Masterplan lands in terms of sustainable drainage possibilities, in accordance with the requirements of the GDSDS, CIRIA SuDS Manual C753 and the current Fingal County Development Plan (2017 – 2023).
- Prepare a SuDS Strategy with recommendations regarding appropriate SuDS systems and devices for the implementation of the SuDS strategy for all proposed development within the Estuary West masterplan boundary.
- Incorporate the effects of Climate Change, soil type and groundwater into the SuDS Strategy.
- Determine the effects on and of flooding, groundwater and surface water drainage system in the masterplan area due to the incorporation of the SuDS Strategy.
- Make recommendations on the discharge rate to be applied across the Masterplan lands and as to the future development and sustainable drainage of the Plan lands.
- Liaison with Consultants completing the Strategic Environmental Assessment (SEA), Appropriate Assessment and Fingal County Council.

1.3 Study Area

1.3.1 Overview

The subject area is located at Estuary West, Swords, North County Dublin. The Masterplan lands are located approximately 1.5km west of the M1 motorway, 6.6km north of the M50 motorway and 4.5km north of Dublin Airport. The Masterplan lands are located within an urban environment, consisting predominantly of residential and commercial development. The lands are bounded by residential development to the west and south, commercial developments to the east and the River Broadmeadow to the north. The Glen Ellen Road runs adjacent to the southern boundary of the lands, with the Balheary Road running parallel to the eastern boundary of the lands. Refer to Figure 1.1 below.

Figure 1.1 Estuary West Masterplan

The topography of the Masterplan lands generally falls from south west to north east from a level of approximately 16mOD to 5mOD.

1.3.2 Catchment Description

The masterplan study area lies within the catchment of the Broadmeadow River and the Ward River, which is a tributary to the Broadmeadow River. The confluence of these two watercourses is located approximately 1.4km west of Malahide Estuary, as outlined in Figure 1.2. This river drains to the Malahide Estuary prior to discharging to the Irish Sea.

The River Broadmeadow rises approximately 21km north west of the subject lands in Dunshaughlin. The Ward River rises approximately 16km south west of the Masterplan lands. Both rivers generally flow in an easterly direction towards the Malahide Estuary.

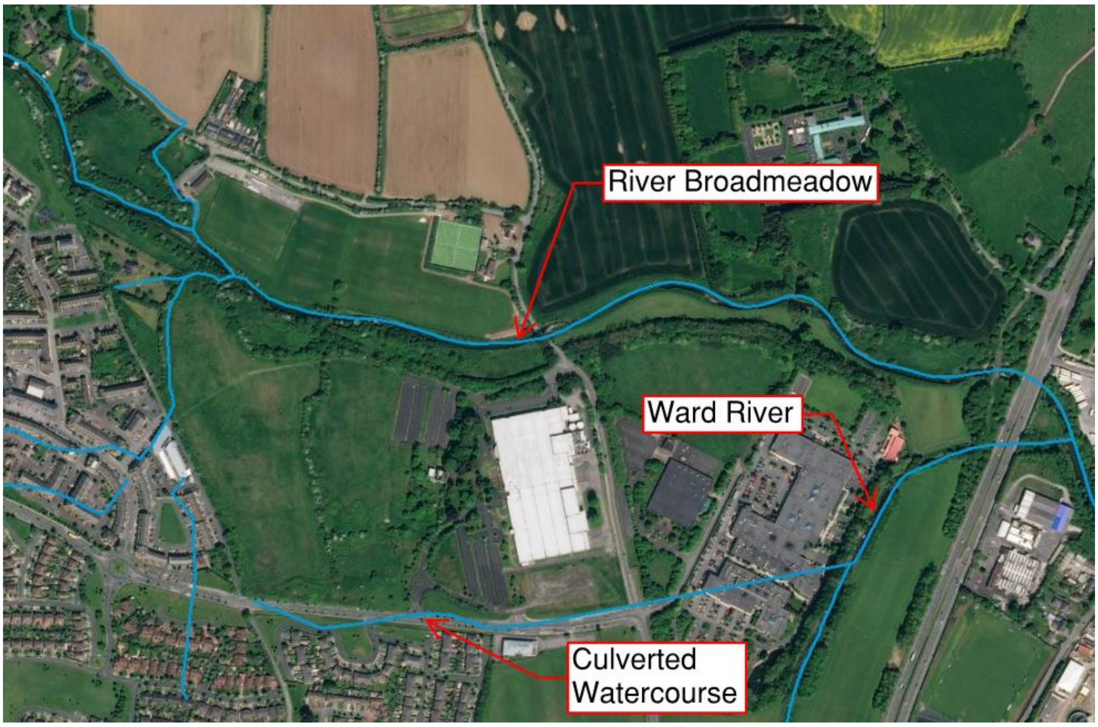


Figure 1.2 Watercourses around the Estuary West masterplan area (EPA Envision)

Irish Water records indicate that there is existing surface water drainage infrastructure within the vicinity of the Masterplan lands. There is also a drainage ditch located at the north western corner of the lands which drains to the River Broadmeadow. Upon inspection on the 21/11/2018, this ditch was found to be dry.

1.3.3 Environment

There are no Natura 2000 sites located within the study area; however, the Natura 2000 sites Malahide Estuary (SPA and SAC) is located 2km east of the Masterplan lands, Rogerstown Estuary (SPA and SAC) is located 4.5km north east of the Masterplan lands and Baldoyle Bay (SPA and SAC) is located 8.00km south east of the Masterplan lands.

Under Article 6(3) of the EU Habitats Directive, an "appropriate assessment" (AA) is required where any plan or project, either alone or 'in combination' with other plans or projects, could have an adverse effect on the integrity of a Natura 2000 site.

Natural Heritage Areas (NHAs) are sites of national importance for nature conservation and are afforded protection under planning policy and the Wildlife Acts, 1976-2012. Proposed NHAs (pNHAs) are published sites identified as of similar conservation interest but have not been statutorily proposed or designated. The nearest NHA/pNHAs to the study area are:

- Malahide Estuary (proposed NHA) ~ 2km east of Estuary West Masterplan lands
- Rogertown Estuary (proposed NHA) ~ 4.50km north-east of the Estuary West Masterplan lands
- Baldoyle Bay (proposed NHA), ~8.00km south-east of the Estuary West Masterplan lands
- Sluice River Marsh (proposed NHA), ~ 7.00km south-east of the Estuary West Masterplan lands

- Feltrim Hill (proposed NHA), ~4km south-east of the Estuary West Masterplan lands
- Portrane Shore (proposed NHA) ~ 8km north-east of the Estuary West Masterplan lands

Therefore, the management of flood risk within the masterplan study area must have regard to potential negative impacts to this environment.

1.4 Proposed Development

The Estuary West Masterplan lands comprises of one main zoning objective in the Fingal Development Plan 2017 – 2023 as outlined in Figure 1.3 and Table 1.1 below.

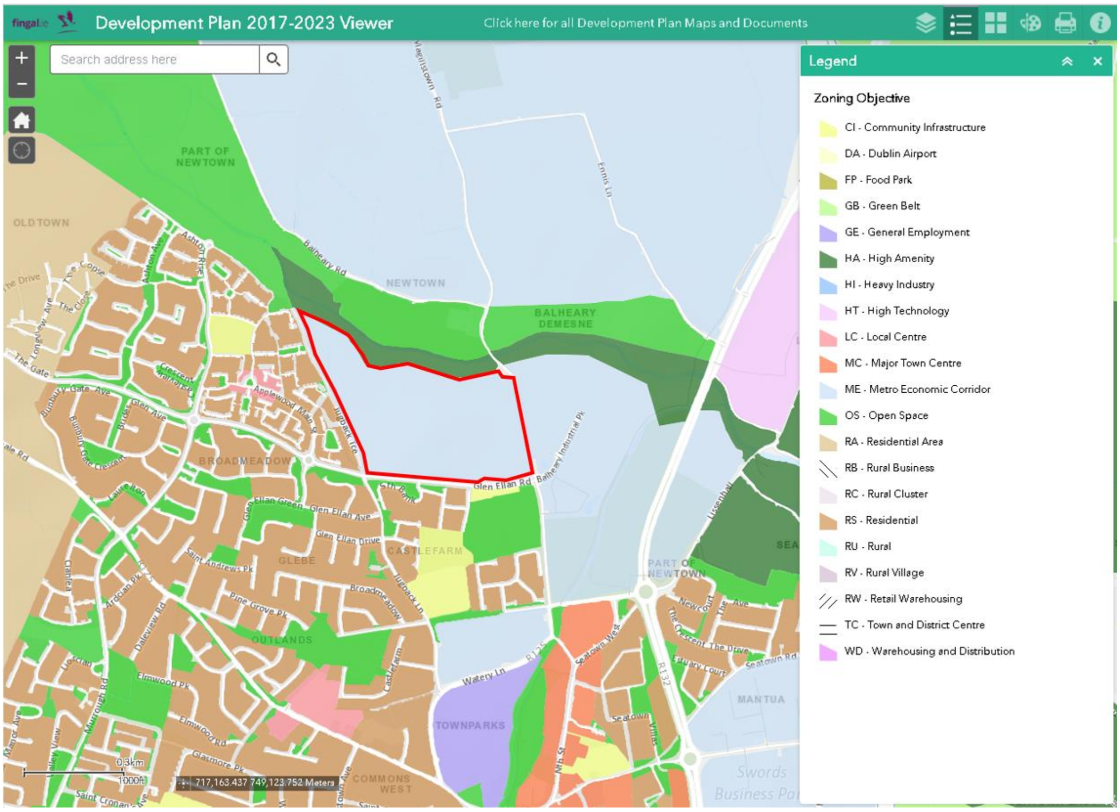


Figure 1.3 Estuary West Zoning Objectives (Fingal Co Co Development Plan 2017 – 2023)

Table 1.1 Estuary West Masterplan lands Current Zoning Objectives

Objective	Description
ME – Metro Economic Corridor	Facilitate opportunities for high density mixed use employment generating activity and commercial development, and support the provision of an appropriate quantum of residential development within the Metro Economic Corridor.

2. SUDS OVERVIEW

2.1 Introduction

The SuDS philosophy is to mimic the natural hydrological cycle by promoting; infiltration, evaporation, evapotranspiration, the harvesting of rainwater at source and the temporary storage of water (ponding), through the construction of a combination or series of components to form a 'management train'. Whilst there is no internationally agreed definition for SuDS – as the understanding of the SuDS philosophy correlates to the extent to which it is embedded in policy and practice over time, the three 'pillars' of sustainable stormwater management practice are generally accepted as;

(i) Reducing the rate and quantity of stormwater discharge,

(ii) Improve the quality of stormwater discharges and receiving water bodies and

(iii) Provide amenity and biodiversity value.

Consideration of the sensitivity of the surrounding environment and downstream water quality is fundamental to the successful implementation of SUDS systems, particularly as we face into the uncertainties of a changing climate.

2.2 Benefits of SuDS

Traditional surface water drainage design is relatively simple, using the Rational method to size pipes to ensure that surface water is removed as quickly as possible to ensure flooding does not take place on the road itself. Unfortunately, this philosophy is flawed as, in more rapidly transferring the surface water downstream, it provides the potential for flooding of other areas. This accelerated run-off gives rise to higher flood levels and the corresponding loss of groundwater recharge results in reduced low flows in rivers thus increasing environmental vulnerability. In addition, the pollution in the run-off is conveyed into the natural environment.

SuDS offer multiple benefits over traditional drainage practices managing discharge rates, volumes and diffuse pollution as well as providing the flexibility for adaption to future drainage needs through a modular implementation. Climate change predictions suggest that some types of extreme events will become more frequent, such as heat waves, flooding caused by extreme rainfall and drought. The SuDS approach is more robust and adaptable than the traditional approach of underground piped drainage systems. In shallow surface-based systems, such as swales, water levels rise gradually and visibly. When the capacity of the SuDS feature is exceeded, the excess water can be directed to safe storage zones. This allows the general public, and road owners and operators to prepare for flood events more effectively. Conversely, flooding from underground piped drainage systems can occur suddenly and rapidly when the design capacity is exceeded. Furthermore, shallow, visible surface-based systems can be designed to offer greater flexibility to adapt to Climate Change. SuDS systems can enhance more readily and cheaply, compared to underground drainage systems. Lower River flows; caused by drought, result in reduced dilution of pollutants following rainfall events. The treatment of surface water runoff, through SuDS, helps to protect and enhance the quality of receiving watercourses.

2.3 Factors Influencing the Design of SuDS

There is no unique solution and each situation has to be evaluated on its own merits and suitable SuDS solutions applied, although the means to achieving these objectives are many and varied. Factors such as site suitability, available space, cost, maintenance regimes and community acceptance must be considered to ensure successful implementation. The various SuDS features can generally be categorised as 'hard' SuDS and 'soft' SuDS. Soft SuDS resemble natural features and include techniques such as swales, ponds and wetlands. Hard SuDS are more similar to traditional drainage methods but incorporate SUDS principles. Examples of these are permeable pavements and proprietary SUDS features such as filtration systems and vortex separators.

2.4 The Management Train

The individual components described above do not constitute SuDS, if applied in isolation. The SuDS philosophy, and effective stormwater management in general, requires a series of SuDS features, linked together, to form a stormwater management system to treat and attenuate surface water runoff as close to the source of runoff as possible, before being conveyed downstream for further treatment and storage.

3. OPPORTUNITIES FOR SUDS SYSTEMS IN A CHANGING CLIMATE

The principal treatment processes in a SuDS system are Sedimentation and Biodegradation.

3.1 Sedimentation

Sedimentation is one of the primary removal mechanisms in SuDS. Most pollution in stormwater runoff is attached to sediment particles and therefore the removal of sediment will achieve a significant reduction in pollution loading to receiving water bodies. Sedimentation is achieved through the reduction in flow velocities to a level at which the sediment particles fall out of suspension.

3.2 Biodegradation

Biodegradation is a natural biological treatment process that is a feature of several SuDS systems - systems that are subject to both wet and dry conditions. In addition to the physical and chemical processes of SuDS systems, biological treatment may also occur. Microbial communities may be established in the ground using the oxygen within the free-draining materials and the nutrients supplied with the inflows, to degrade pollutants such as hydrocarbons and grease.

The level of bioremediation activity will be affected by environmental conditions such as temperature and the supply of oxygen and nutrients. It also depends on the physical conditions within the ground such as the suitability of the materials for colonisation.

'Wet and Dry' SuDS Systems Perform Best

The presence of vegetation adds a physical filtration aspect to SuDS systems in the case of filter strips leading to swale/basins, the majority of hydrocarbons are removed by the first stage. If vegetation has been affected by drought, this element of the treatment train will be absent (in a worst-case scenario or significantly diminished at best). Maintenance of filter strips, swales and detention basins typically involve grass cutting. It is worth noting that hydrocarbons are also broken down by UV light in a process called photolysis, but where increasing levels of contaminants are building up in the soil (in the swale, basin, pond or wetland) the affected soil is likely to require removal and will more than likely be classified as contaminated waste.

The most recent published literature suggests that ponds and wetlands do not seem to benefit from the enhanced biological treatment of hydrocarbons found in the oxygen-rich conditions of the swales and basins (which are not designed to hold a permanent volume of water). Nonetheless, ponds and wetlands have been utilised extensively as the default treatment system serving roads and motorways in Ireland and UK, with little supporting literature to justify such initiatives.

In the selection of the most resilient and enduring suds systems, this fact is important:

Only the suds features that experience <u>*both wet and dry conditions*</u> *benefit from this added biological treatment - ponds and wetlands are proposed as polishing stage options as part of a treatment train.*

The temperature dependence of these aerobic microbes (responsible for this additional layer of treatment) means that the chemical and biological treatment mechanisms found in SuDS systems are enhanced with increasing temperature.

3.2.1 The Benefits of Vegetative Systems

The successful implementation of bioremediation systems requires the establishment of appropriate plants and /or microorganisms at the containment site. Factors to be considered include: (i) selection of appropriate plant species, (ii) the influence of contaminants on seed germination, (iii) the use of native versus non-native plants and (iv) the effectiveness of inoculating contaminated soils with microorganisms. Furthermore, the plant species must be well adapted to the soil and climate of the region, making soil characteristics, length of growing season, average temperature and annual rainfall important considerations in plant-assisted bioremediation / biodegradation planning. The rate of microbial degradation generally doubles for every 10-degree centigrade increase in temperature.

Indirect benefits include enhanced soil quality through improvements in soil structure, increased porosity and therefore water infiltration, providing nutrients, accelerating nutrient cycling and increasing soil organic carbon. The use of plants also stabilises the soil thus preventing erosion and direct human exposure.

3.3 SuDS Objectives

3.3.1 Quantity Control Processes

Several techniques can be implemented to control the quantity of runoff from a development. Each technique presents different opportunities for stormwater control, flood risk management, water conservation and groundwater recharge.

a) Infiltration
- Soaking of water into the ground
- Most desirable solution to runoff management as it restores the natural hydrologic process
- Impacted by groundwater vulnerability and infiltration ability of subsoil

b) Detention / Attenuation
- Slows down surface water flows before their transfer downstream
- Usually achieved through use of a storage volume and constrained outlet
- Should be above ground
- Reduces peak flow rate but total volume of runoff remains the same

c) Conveyance
- Transfer of surface runoff from one place to another
- Through grassed channels/trenches and pipes

- Transfer essential for managing flows and linking SuDS components
- Uncontrolled conveyance to a point of discharge in the environment not considered sustainable

d) Water Harvesting

- Direct capture and use of runoff on site for domestic or irrigation, overflowing/discharging to adjoining SuDS component(s)
- Contributes to Flood Risk Management

3.3.2 Quality Control Processes

A number of natural water quality treatment processes can be exploited within SuDS design. Different processes will predominate for each SuDS technique and will be present at different stages in the treatment train (*Refer to Section 3.5*).

a) Sedimentation – reducing flow velocities to a level at which the sediment particles fall out of suspension;

b) Filtration & Biofiltration – trapping pollutants within the soil or aggregate matrix, on plants or on geotextile layers;

c) Adsorption – pollutants attach or bind to the surface of soil or aggregate particles;

d) Biodegradation – Microbial communities in the ground degrade organic pollutants such as oils and grease;

e) Volatilisation – transfer of a compound from solution in water to the soil atmosphere and then to the general atmosphere;

f) Precipitation – transform dissolved constituents to form a suspension of particles of insoluble precipitates;

g) Plant Uptake – removal of nutrients from water by plants in ponds and wetland;

h) Nitrification – Ammonia and ammonium ions can be oxidised by bacteria in the ground to form nitrate which readily used as a nutrient by plants;

i) Photolysis – The breakdown of organic pollutants by exposure to ultraviolet light.

3.3.3 Amenity & Biodiversity Processes

SuDS provides opportunities to create attractive landscaping features which offer a variety of amenity/biodiversity. The following are the main SuDS components offering aesthetic, amenity and ecological benefits *(Refer to Section 6 for details on each technique).*

Primary Processes:

a) Blue/Green Roofs

b) Grassed channels/Swales

c) Filter strips

d) Bioretention Areas

e) Vegetated swales and detention basins

f) Infiltration Basins

Benefits subject to design:

a) Ponds

b) Wetlands

3.3.4 Water Quality

There is an existing Q-Value monitoring point located on the River Broadmeadow, immediately downstream of the Masterplan lands. The EPA Envision website indicates that the last recorded Q-Value at this location was in 2014, where a value of 2-3 was recorded. Table 3.1 details the biotic indices (Q Values) ranges as per the EPA's website, indicating that a river with a Q value of 2-3 is considered moderately polluted.

The Water Framework Directive Monitoring Programme became operational in 2006. The most recent monitoring period (2010 – 2015) identifies the River Broadmeadow & Ward River as being currently "Poor" status and "at risk" of failing to meet the directives environmental objectives. Groundwater status for the 2010 – 2015 monitoring period identifies as being "good" status. Table 3.1 correlates the Water Framework Directive Status to Q Value readings.

Table 3.1 Surface Water Quality Ranges

Q Value*	WFD Status	Pollution Status	Condition*
Q5, Q4-5	High	Unpolluted	Satisfactory
Q4	Good	Unpolluted	Satisfactory
Q3-4	Moderate	Slightly polluted	Unsatisfactory
Q3, Q2-3	Poor	Moderately polluted	Unsatisfactory
Q2, Q1-2, Q1	Bad	Seriously polluted	Unsatisfactory

Note:

* "Condition" refers to the likelihood of interference with beneficial or potential beneficial uses.

The implementation of SuDS as part of future development within the masterplan area should ensure that the quality and quantity of discharge from future development to the surrounding watercourses will not negatively impact the existing condition of the watercourses, moreover, the adoption of SuDS systems in all new developments, the retrofitting of SuDS and the protection of existing floodplains shall assist in the attainment of our objectives under the Water Framework Directive.

3.4 Effects of Climate Change

The effects of climate change need to be considered when designing and preparing maintenance regimes for SuDS features. Sedimentation is one of the primary removal mechanisms in SuDS. As discussed above in Section 3.1, this is achieved through the reduction in flow velocities to a level at which particles fall out of suspension. However, care must be taken through design and appropriate maintenance regimes to ensure the risk of re-suspension is minimised during extreme rainfall events.

The level of biodegradation activity that occurs within SuDS features will be affected by environmental conditions such as temperature and the supply of oxygen and nutrients. It is also depending on the physical conditions within the ground such as the suitability of the materials for colonisation.

3.5 SuDS Techniques

In addition to the objectives above, in order to replicate the natural drainage system, a 'Management Train' is required. The Management Train sets a hierarchy of SuDS techniques which should be implemented in series as follows:

(iv) Prevention – prevent runoff and pollution

(v) Source Control – control runoff at or close to the source

(vi) Site Control – management of surface water in the site/local area

(vii) Regional Control – management of surface water from a number of sites together

Various SuDS components have different capabilities regarding the objectives outlined above and are more suited to certain stages of the Management Train. The principle of the Management Train is that wherever possible, surface water should be managed locally in small, sub-catchments rather than being conveyed to and managed in large systems further down the catchment. Table 3.1 below contains examples of SuDS techniques for Source, Site and Regional controls. *(Refer to Section 6 for details on each technique).*

Table 3.1 SuDS Techniques for Source, Site & Regional Control

Source Control	Site Control	Regional Control
Rainwater Harvesting	Permeable Paving	Detention Ponds/Basins
Green Roofs	Bioretention Strips	Retention Ponds/Basins
Permeable Paving	Infiltration Trenches	Wetlands
Bioretention Strips	Filter Drains	Infiltration Basins
Filter Drains	Filter Strips	Detention Basins
Infiltration Trenches	Swales	Petrol Interceptors*
Filter Strips	Sand Filters	
Soakaways	Infiltration Basins	
Blue Roofs	Detention Basins	
Swales	Petrol Interceptors*	

*Use of Petrol Interceptors should be avoided except where the potential for hydrocarbons entering the surface water drainage network is particularly high. Treatment of surface water runoff should be provided through the use other SuDS techniques.

3.6 Modular SuDS Components

Management trains for new and existing developments should facilitate the construction of future SuDS components and/or provide for future enhancements to existing SuDS components – to mitigate the risk of flooding caused by more extreme rainfall events and risk of pollution due to lower baseflow in receiving waters.

Modular components can include:

- Additional physical SuDS features e.g. swales, basins and ponds and/or;
- Enhancements to existing SuDS features by upsizing and/or;
- Introducing vegetation and/or;
- Management actions e.g. changing the maintenance regime in response to findings of a monitoring regime.

Subject to the findings of a monitoring regime, it may be found that more frequent maintenance of the SuDS components (e.g. grass cutting, disposal of contaminated soil and planting) may negate the requirement for additional SuDS components.

4. REVIEW OF EXISTING DRAINAGE NETWORK IN RESPECT OF SUDS

This section outlines the various SuDS techniques, existing and proposed in either live planning applications or development proposals, within close proximity to the Estuary West Masterplan lands. Information has been gathered from a review of planning applications in Swords, Fingal Development Plan 2017-2023, and a site visit undertaken on the 31st August 2018 and the 21st November 2018.

Development within the vicinity of the Masterplan lands is predominantly residential to the south and west of the lands, with commercial development to the east and community facilities sports and recreation to the north. Implementation of SuDS techniques by Local Authorities typically began following the publication of the Greater Dublin Strategic Drainage Strategy (GDSDS) in 2005. Given that the majority of development within the vicinity of the Masterplan lands is dated pre 2005, SuDS techniques generally have not been adapted in the areas within the vicinity of the Masterplan lands. There are currently no live planning applications within the vicinity of the Masterplan lands for proposed developments that will implement SuDS techniques.

4.1 Future Scenario – Proposed Development and Infrastructure as per Fingal Development Plan 2017-2023 if built

Proposals for Estuary West Masterplan lands, as identified in the Fingal Development Plan 2017-2023 include the following:

- Future development shall provide a strong urban edge with attractive elevations which address, overlook and provide a high degree of informal supervision of: The Glen Ellan distributor Road; the extended River Broadmeadowside Park and Jugback Lane.
- A mixed-use Local Services Area shall be provided in the centre of the subject lands close to Newtown House and the stand of mature trees.
- Provide for an extension to the River Broadmeadowside Park between Jugback Lane and Balheary Road in conjunction with the first phase of the development of the MP lands.
- Consider a School site as required in consultation with the Department of Education and Skills.
- Provide for pedestrian and cycle routes within the MP lands: in particular, along a west – east access linking the proposed Local Service Area in the MP lands with Applewood to the west; along the extended River Broadmeadowside Park and along Jugback Lane.
- Provide for the retention and protection of the mature stands of trees around Newtown House as part of the development.
- Provide for buildings to be set back in a landscaped setting from the edge of Jugback Lane. Protect the residential amenities of existing property adjoining the subject lands.
- Retain the rural character of Balheary road north of its junction with Glen Ellan Road.
- The Masterplan lands will be subject to a detailed flood risk assessment to address potential flood risk and proposed mitigation measures.
- Consult with Health and Safety Authority (HSA) in relation to the designated Seveso site to the south as part of the MP process

As part of these future proposals, various SuDS techniques can be implemented and a SuDS protocols developed, which will be discussed further in Section 6.

4.2 Sustainable Water Management

It is a specific objective of the current Fingal County Development Plan to require all Masterplans to protect, enhance, provide and manage green infrastructure in an integrated and coherent manner, which includes sustainable water management. This can be achieved through the implementation of the SuDS Protocol, (which will be discussed further in Section 6) along with natural floodplain management. It is a specific objective to establish riparian corridors free from new development along significant watercourses. In line with the current County Development Plan, a 15m wide riparian corridor, measured from the top of the bank to either side of the watercourse, free from development will be provided along the length of the existing watercourses that flow through the Masterplan lands, rather than culverting these watercourses beneath ground. As a minimum, for the Broadmeadow a 30m wide riparian corridor will be required. The provision of such buffer strips will:

- Preserve water quality by filtering sediment from runoff before it enters the river;
- Protect the river bank from erosion;
- Provide an undeveloped flood plain to accommodate flood waters during extreme flooding events (Refer to Estuary West Strategic Flood Risk Assessment Flood Maps);
- Provide food and habitat for fish and wildlife;
- Preserve open space and aesthetic surroundings.

The proposed riparian corridors through the masterplan lands are outlined in Figure 4.1.

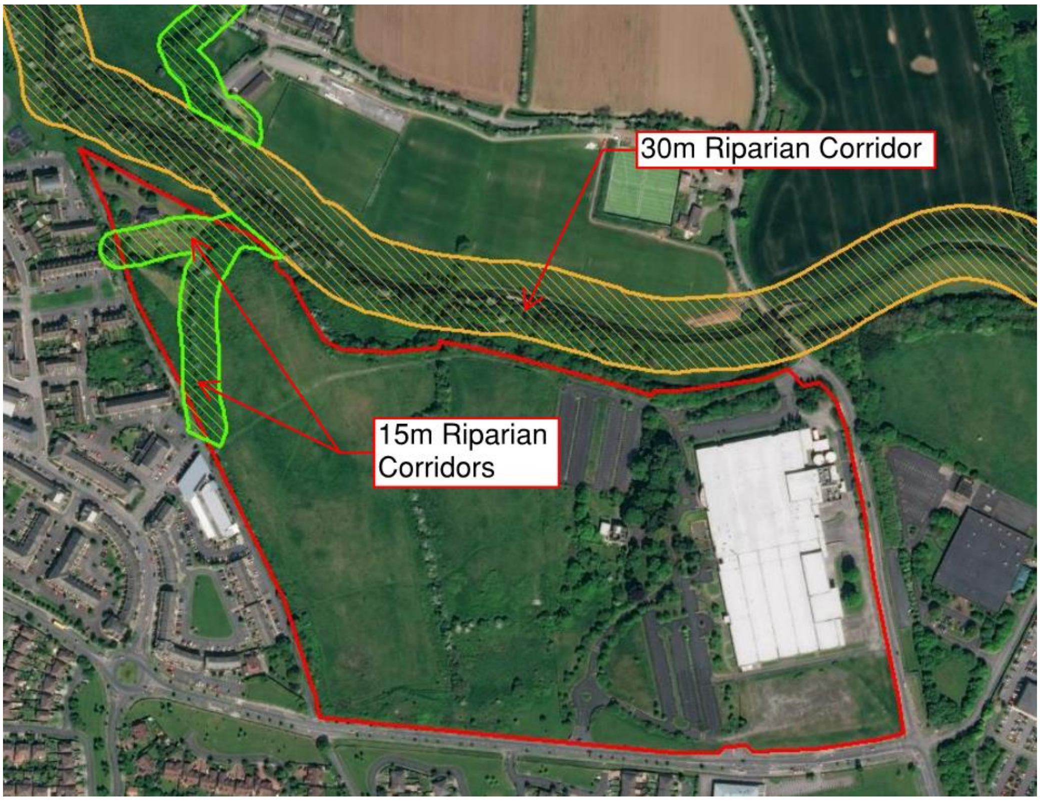


Figure 4.1 Proposed Riparian Corridors

The primary impact on the existing surface water drainage network will be as a result of new development within the masterplan boundary. Integration of SuDS techniques within these new developments will be required to ensure that the capacity of the existing network is not exceeded, and the quality of surface water runoff is not negatively impacted by the development. As discussed further in Section 6, it is recommended that runoff from private developments be managed at source, by limiting discharge to 2l/sec/ha and by providing attenuation for the 1 in 100-year rainfall event, including an allowance for climate change of 20%, in line with regional drainage policy, within the curtilage of all proposed development plots. Runoff from public infrastructure such as roads and landscaped areas should be managed within the public realm, by also limiting discharge to 2l/sec/ha and by providing attenuation for the 1 in 100-year rainfall event, including an allowance for climate change of 20%. These SuDS features should also convey the attenuated flows from individual private plot. As discussed later in Section 6, runoff from roads and parking bays in public areas should be treated by a minimum of two SuDS components prior to discharge to receiving watercourses / sewers.

Based on the existing surface water drainage network and topographic levels obtained from contour mapping provided by FCC, it is likely that the Masterplan lands will drain to the River Broadmeadow. If the new surface water drainage network for the Masterplan lands is to connect to the existing surface water network in places, the capacity of the existing network will need to be established at these locations and discharge from the development limited to acceptable flow rates. The quality of any runoff from any new development will need to be such that the existing water quality and flow regime is not negatively affected.

5. SUDS SELECTION

5.1 Land use

Under the current Final County Development Plan (2017-2013), the Estuary West Masterplan lands are zoned Objective ME – *'Facilitate opportunities for high-density mixed-use employment generating activity and commercial development and support the provision of an appropriate quantum of residential development within the Metro Economic Corridor'*. The extent of the land zoned is outlined in Table 5.1 and Appendix A.

Table 5.1 Estuary West Masterplan lands Zoning Objectives

Zoning Ref	Description	Approximate size (ha)
MC	Facilitate opportunities for high-density mixed-use employment generating activity and commercial development and support the provision of an appropriate quantum of residential development within the Metro Economic Corridor	19.4

5.2 Site Characteristics

The various site characteristics which influence SuDS techniques are outlined below. The site characteristics have been obtained from a desktop study of LiDAR and Contour maps, Ordnance Survey maps and Geological Survey of Ireland (GSI) maps. *Refer to Appendix B for relevant maps.*

5.2.1 Soils

The soil at the Estuary West Masterplan lands generally consists of Limestone Till (Carboniferous), Glaciofluvial sands, gravels with some alluvium in the floodplain of the River Broadmeadow and made ground.

No site specific ground investigations are available for the Masterplan lands. Localised ground investigation will need to be undertaken to determine the depth to bedrock within the Masterplan lands. GSI ground water vulnerability mapping indicates that ground water vulnerability within the Masterplan lands varies. Ground water vulnerability towards the north of the lands is high, spanning from the western to eastern boundaries. Ground water vulnerability towards the centre of the site is low, spanning from the western to eastern boundaries, while ground water vulnerability to the south of the site is moderate, spanning from the western to eastern boundaries. *Refer to Appendix B.*

5.2.2 Area Draining to SuDS Component

The Estuary West Masterplan lands comprise approximately 19.4ha in total, with varying; land uses, ecological characteristics, topography, subsoil permeability, and with some areas at risk of flooding, therefore, a carefully selected Management Train of various SuDS components will be required to effectively manage surface water runoff.

5.2.3 Minimum Depth to Water Table

Typically, some SuDS techniques require a minimum 1m depth of soil between the maximum water Table level and the base of the device (e.g. Soakaways). Localised ground investigation will need to be undertaken to determine the depth to groundwater at each development area.

5.2.4 Site Slope

The slope of the lands within the Masterplan Area is diverse but generally slopes towards the River Broadmeadow. The majority of the masterplan area has gentle slopes less than 5%.

In steeper sections, swales can be routed along contours or fitted with cascades to reduce the effective gradient. Ponds and basins are not usually located in areas with slopes >5%, although tiered systems can be effective in treating runoff but need to be carefully designed.

5.2.5 Available Head

Based on existing levels in the proposed development areas, available head is unlikely to be an issue for any SuDS solutions.

5.2.6 Available Space

Given the extent of undeveloped land within the Masterplan lands, there should be significant available space to incorporate SuDS features as part of any future development.

5.3 Catchment Characteristics

5.3.1 Aquifers used for Public Water supply

The Estuary West site is underlain by Locally Important Aquifer (LI) – Bedrock which is Moderately Productive only in Local Zones. This suggests a reasonable depth to groundwater. This is expected based on the coastal location of the area. There are no GSI or EPA Source Protection Zones in the vicinity of the masterplan area. The GSI groundwater viewer indicates multiple groundwater springs/supplies identified south of Estuary West Masterplan lands. *Refer to Appendix B*.

5.3.2 Surface Waters used for Public Supply

The watercourses within the vicinity of the Masterplan lands do not appear to be used for surface water abstraction.

5.3.3 Coastal / Estuarial Waters

According to the SuDS Manual (2015) and Greater Dublin Strategic Drainage Study (GDSDS), discharge to coastal waters do not typically require attenuation as there will be no deterioration in flood risk as a result of an increase in runoff. However, it will be necessary to provide a combination of source controls, site controls and regional controls as part of the Estuary West surface water drainage system to protect and enhance receiving coastal / estuarine waterbodies. This will help achieve obligations under the Water Framework Directive.

It will be necessary to provide a combination of SuDS systems within the curtilage of all new individual development plots and proposed public areas (to be taken-in-charge) as part of all new developments. This approach should be adopted in tandem with Fingal County Council Policy, to protect and enhance floodplains (as identified in the Strategic Flood Risk Assessment for the Estuary West Masterplan), to ensure high water quality from runoff into these downstream areas.

5.3.4 Receiving Waters that act as Formal Recreational / Amenity Facilities

The following recreational / amenity facilities in receiving waters from Estuary West have been identified:

- Malahide Beach located approximately 6.30km east of Estuary West;
- Donabate Beach located approximately 6.90km east of Estuary West;
- Portmarnock Beach located approximately 8.1km south east of Estuary West;
- Tower Bay Beach located approximately 7.55km north east of Estuary West.

5.3.5 Requirements for Sustainable Water Management / Water Conservation Measures

The provision of rainwater harvesting for landscaping purposes should be provided in all residential developments. Any commercial, retail or institutional buildings should provide rainwater harvesting for non-consumption purposes (eg. flushing toilets).

5.3.6 Habitat – Dependent Flow Regime

As part of any future development within the masterplan boundary, discharging to the existing surface water network shall not exceed 2l/sec/ha. This shall be implemented via SuDS measures and on-site attenuation, ensuring that there is no significant impact on the existing flow regime of the receiving waters which will penultimately be the River Broadmeadow prior to discharging to the Malahide Estuary, and through the protection and enhancement of existing floodplains from the watercourses within the Masterplan lands.

5.3.7 Flood Risk

Proposed surface water drainage networks should be designed such that runoff is limited to 2l/sec/ha. *Refer to Estuary West masterplan Flood Risk Assessment*.

5.4 Quantity and Quality Performance

In selecting suitable SuDS components for a SuDS management train, the quantity of runoff and quality performance for various SuDs techniques should be assessed:

- Source Control techniques are most effective in reducing run off volume
- Open Channels and Detention Basins provide the best hydraulic control for large flows (1% AEP), and water quality benefits.
- Permeable paving, Infiltration and Filtration techniques (filter strips, swales, grassed channels) are most effective for water quality treatment
- Subsurface storage systems offer limited potential for water treatment.

5.5 Community, Environmental and Amenity Performance

Community and environmental factors for various SuDS techniques include Maintenance Regime, Community Acceptability, Construction and Maintenance Costs and Habitat Creation Potential.

Detention Basins and Swales (particularly Conveyance Swales) typically provide the most cost-effective SuDS solution while also incorporating the potential for habitat creation.

The implementation of wetlands will typically promote habitat creation and are generally accepted by communities as they provide valuable open space for visual and recreational enjoyment, however capital and maintenance costs can be relatively high.

There may be some public safety concerns associated with SuDS techniques involving open water, however good design and education can help minimise these concerns. This can be achieved through ‘demonstration projects’ and initiatives to educate local residents of the benefits of SuDS systems and natural floodplain management approaches as a means to tackle flood risk, particularly in response to climate change and the adverse environmental effects of uncontrolled contaminated stormwater runoff from urban developments. The SuDS approach also offers benefits to the health and wellbeing of citizens.

6. SUDS STRATEGY

6.1 SuDS Protocol for New Development

As part of any future development within the Estuary West Masterplan lands, the developing authority should adapt the following protocol. This protocol will provide guidance for assessing the resilience of SuDS to climate change during periods of drought, flash flooding, temperature extremes and periods of persistent rainfall and to propose appropriate resilient SuDS strategies to manage stormwater runoff arising from severe rainfall events now and into the future. An overview of this protocol is outlined in Figure 6.1 below.

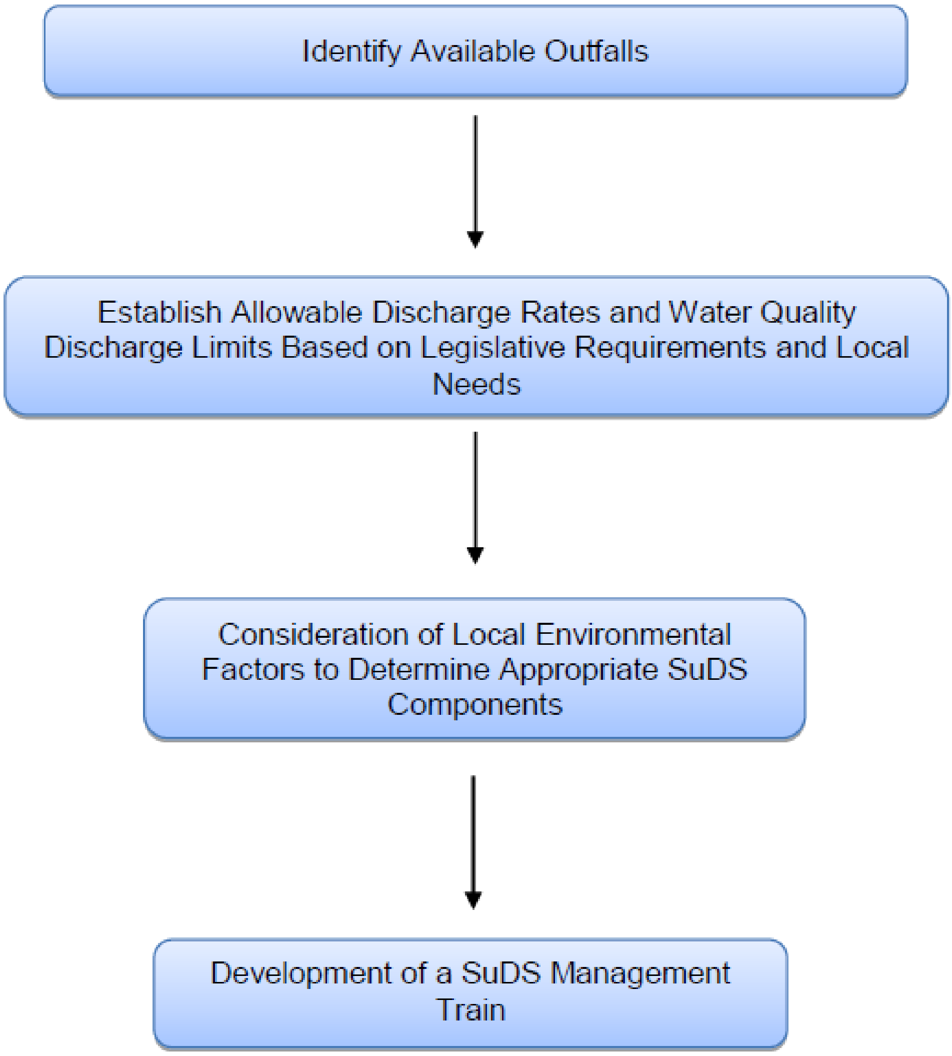


Figure 6.1 Recommended SuDS Protocol to Be Adapted

6.2 Management Train

A Management Train is usually required when developing a SuDS strategy. A Management Train sets a hierarchy of SuDS techniques which are subsequently linked together. Each technique employed contributes in different ways and degrees to the overall drainage network. The scale and number of components required will depend on the respective catchment characteristics and likely concentration of pollutants in the inflow. Considering the scale of proposed developments, a combination of carefully designed and appropriately maintained source controls, site controls and possibly regional controls are required as part of the surface water drainage system to ensure high water quality from runoff into these areas.

Following a review of all the information presented in previous sections, a selection of some SuDS techniques suitable for inclusion in the Estuary West masterplan are described below. Given the extent of potential development land within the masterplan and that source and site control devices should be utilised on these lands, regional control measures may not be required.

6.3 Source Controls

6.3.1 Water Butts

Water Butts are small, offline storage devices designed to collect runoff from roofs. They are the most common means of harvesting rainwater for garden use and have a typical capacity of less than $0.5m^3$. Two-stage devices can provide some storage volume for attenuation using a throttled overflow, however poor maintenance can lead to blockages.

Table 6.1 Advantages of Water Butts

Advantages
Ease of installation (new and retrofit)
Inexpensive
Provides water for non-potable means – typically garden use
Suitable for all developments

Figure 6.2 Domestic Water Butt (Susdrain.org)

Water Butts are recommended for all residential properties.

6.3.2 Rainwater Harvesting

Rainwater harvesting involves collection of rainwater from roofs and hard surfaces, similar in principle to Water Butts but generally on a much larger scale. Collected water is typically used for non-potable purposes such as irrigation, flushing toilets and washing machines. The size of the harvesting tank depends on catchment area, seasonal rainfall pattern, demand pattern and retention time. Stormwater attenuation can also be provided by additional storage capacity in the tank.

Table 6.2 Advantages of Rainwater Harvesting

Advantages
Reduced demand of mains water
Can provide source control of stormwater runoff

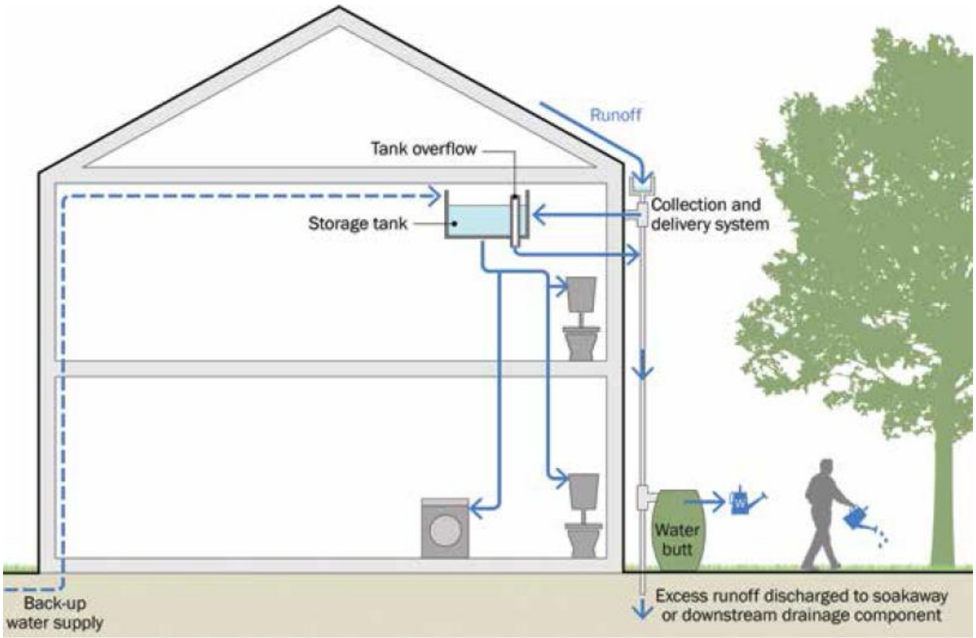


Figure 6.3 Rainwater Harvesting Schematic (CIRIA 753)

Rainwater Harvesting is recommended for use in commercial, retail industrial and educational buildings.

6.3.3 Permeable Pavements

Permeable pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater infiltrate through the surface and into the underlying layers where it is subsequently infiltrates to the ground and/or is collected and conveyed to the drainage network. Permeable pavements are most suitable for areas with light traffic loads and volume. The pavement generally caters for rainwater which lands directly on its surface but in certain cases, can accept runoff from other impermeable areas, such as Water Butts, Modified Planters or directly from rainwater goods and paved areas.

Table 6.3 Advantages of Permeable Paving

Advantages
Peak flow reduction
Runoff volume reduction
Effective in removing urban runoff pollutants
No additional land space requirements
Low maintenance costs
Good community acceptability

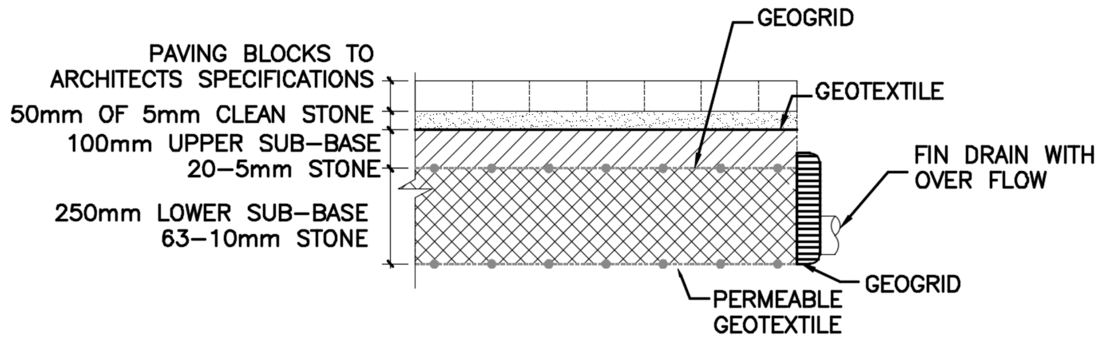


Figure 6.4 Typical Permeable Paving Detail

Permeable paving is recommended for all residential, commercial and retail parking spaces. Lightly trafficked roads should be considered for permeable block paving. Detailed site investigation will be required to determine if total, partial or no infiltration to groundwater is possible.

6.3.4 Green / Blue Roofs

Green Roofs comprise a multi-layered system which covers the roof of a building with vegetation and landscaping over a drainage layer. Blue Roofs comprise a porous surface that is explicitly designed to store water. Both systems are designed to intercept and retain precipitation which reduces the volume and rate of surface water runoff. Both systems can be integrated on a variety of roof types and sizes, although larger roof areas are typically more cost effective. They are particularly suited to flat / gently sloping roofs on commercial buildings, sports centres, schools, apartment blocks and other similar buildings.

Table 6.4 Advantages of Green / Blue Roofs

Advantages
No additional land take
Ecological, aesthetic and amenity benefits
Good removal of atmospherically deposited pollutants
Provides further insulation to buildings
Runoff storage provided at source

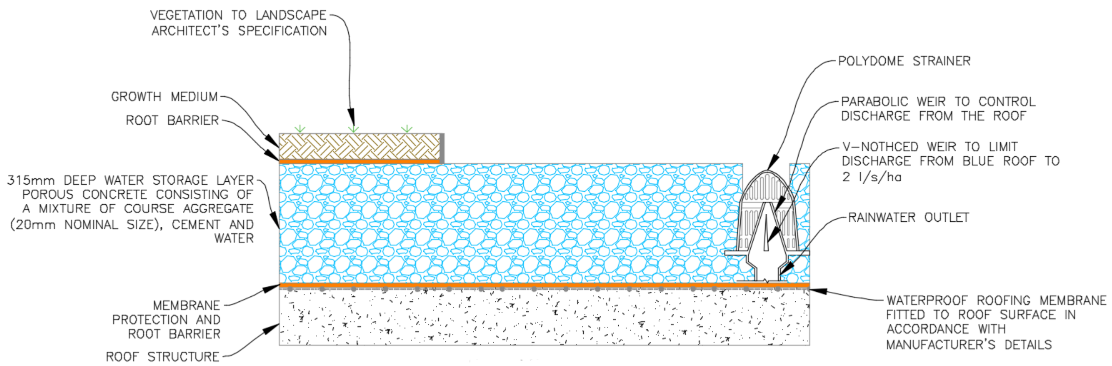


Figure 6.5 Typical Green / Blue Roof Schematic

6.3.5 Green Walls

Green Walls are walls that have plants growing on, or integrated within them, providing a living and self-regenerating cladding system. Green walls can comprise climbing plants supported by the wall, hanging plants which hang from suspended planters or plants growing within them.

Table 6.5 Advantages of Green Walls

Advantages
Can occupy much greater surface area than green roofs
High amenity & biodiversity benefits
Improves thermal efficiency of building
Good removal of atmospherically deposited pollutants

Figure 6.6 Green Wall (CIRIA C644, 2007)

6.3.6 Filter Drains

Filter drains are shallow excavations backfilled with granular material that create temporary subsurface storage for either filtration or infiltration of stormwater runoff. Filter drains can contain a perforated pipe at the base to convey runoff to further SuDS components in the Management Train.

Table 6.6 Advantages of Filter Drains

Advantages
Can reduce runoff rates and volumes
Significant reduction in pollutant load
Easily incorporated into site landscaping

Figure 6.7 Example Filter Drain

Subject to appropriate ground conditions, filter drains are recommended for draining residential back gardens and other small grassed areas where subsoil permeability is low. Filter drains can also be used to drain carriageways. The base of the filter drain should be a minimum 500mm above highest expected groundwater table level.

6.3.7 Soakaways

Soakaways are excavations that are filled with a void-forming material that allows the temporary storage of water before it soaks into the ground. They are generally suited for small catchments, such as within the curtilage of a dwelling. Many soakaways are now constructed with geocellular units, as these units provide good overall storage capacity.

Table 6.7 Advantages of Soakaways

Advantages
Minimal net land take
Provides groundwater recharge
Good volume reduction and peak flow attenuation
Easy to construct and operate

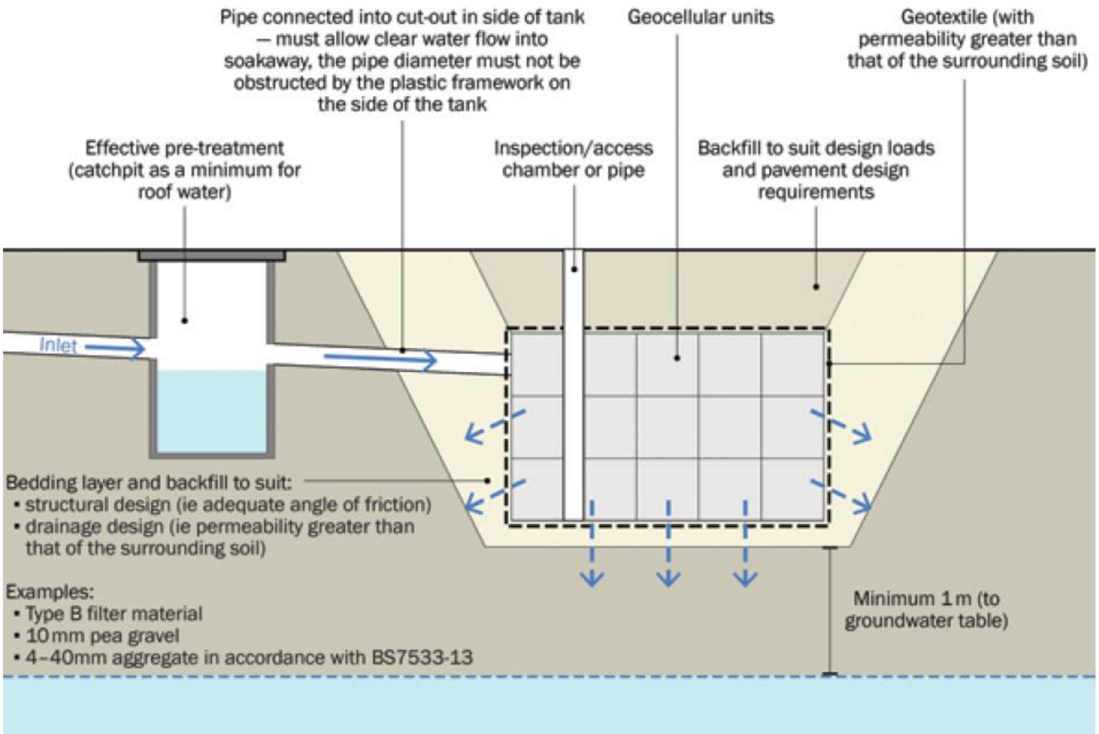


Figure 6.8 Typical Schematic of a Soakaway (SuDS Manual, 2015)

Subject to appropriate ground conditions, soakaways are recommended for draining residential gardens and other small grassed areas where subsoil permeability is low.

6.4 Site Controls

6.4.1 Swales

Swales are broad, shallow, vegetated drainage channels which can be used to convey or store surface water. Swales are generally suited for small catchments with impermeable areas. They are typically provided along roads in grass verges. Swales can be designed for infiltration to subsoil or detention and conveyance to another stage in the management train. Conveyance can be in the open channel or in a perforated pipe within a filter bed below the base of the channel.

Table 6.8 Advantages of Swales

Advantages
Good removal of pollutants
Easy to incorporate into landscaping
Peak flow reduction
Runoff volume reduction (depending on design)

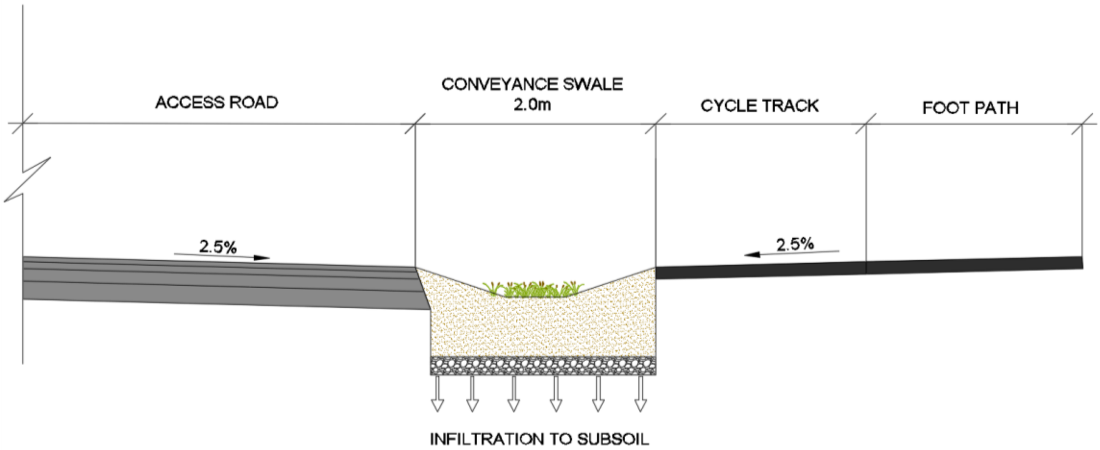


Figure 6.9 Typical Swale Schematic

Figure 6.10 Example Roadside Swale

Swales are recommended to cater for runoff from access roads, providing water treatment and reduction in peak flow. Depending on local subsoil conditions, dry swales are recommended which provide infiltration and further reduce runoff volume. Where vehicle and pedestrian access is required across a swale, a causeway can be provided. The levels at the outer swale banks will be higher than at the centre of the crossing point. This drop-in level acts as an exceedance route for runoff from the swale during extreme rainfall events.

Figure 6.11 Example Causeway for Access Across Swale (Robert Bray Associates)

6.4.2 Bioretention Areas / Modified Planters

Bioretention areas are stormwater controls that collect and treat stormwater runoff. The runoff is treated using soils and vegetation in shallow landscaped basins to remove pollutants. Treated runoff can be collected and conveyed further downstream and/or allowed infiltrate into the subsoil. Part of the runoff volume will be removed by evaporation and plant transpiration.

Table 6.9 Advantages of Bioretention Areas / Modified Planters

Advantages
Very good removal of pollutants
Runoff volume and peak flow reduction
Flexible layouts possible
Can be aesthetic landscaping features

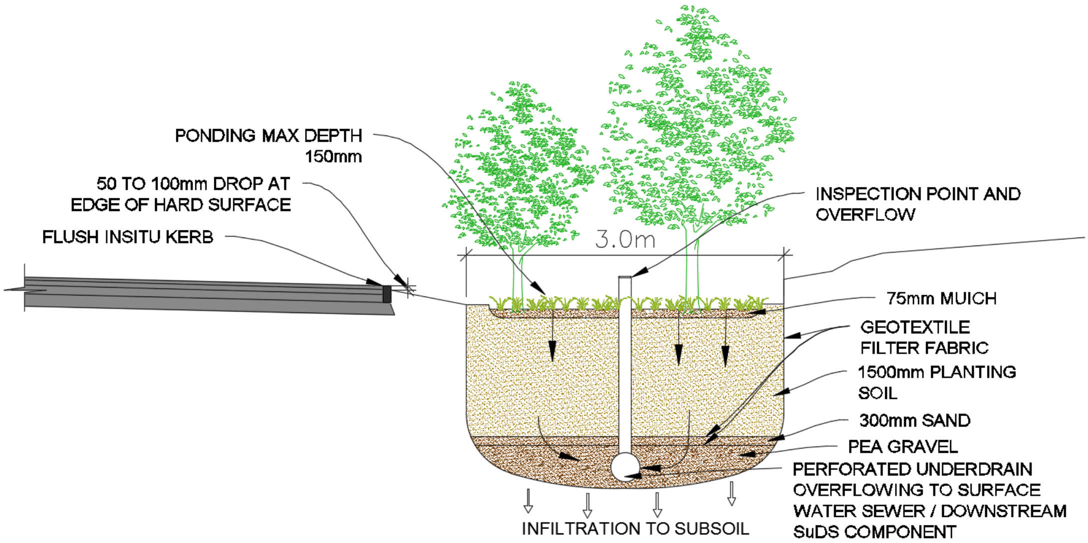


Figure 6.12 Bioretention Area Schematic

Figure 6.13 Example Roadside Bioretention Area (Portlandoregon.gov)

Bioretention areas are recommended to cater for runoff from residential neighbourhoods and car parks.

6.4.3 Detention Basins

Detention Basins are dry basins that attenuate stormwater runoff by providing temporary storage with flow control of the attenuated runoff. Detention basins are generally applicable to most types of developments. In residential areas they are normally dry and often function as a recreational facility, e.g. sports fields or play grounds. They may be constructed such that surface runoff is routed through them during storm events with an outflow restriction (online), or such that runoff typically bypasses the detention basin until a design storm event occurs when runoff is received by a flow diverter or overflow and temporarily stored until the inflow recedes below a design level (offline). Small permanent pools at the outlet can enhance water treatment quality.

Table 6.10 Advantages of Detention Basins

Advantages
Can cater for wide range of rainfall events
Simple to design and construct
Potential for dual use
Easy to maintain

Figure 6.14 Example Detention Basin (SuDS Manual, 2015)

6.5 Regional Controls

6.5.1 Ponds

Ponds are basins which have a permanent depth of water. They can be constructed in an existing depression, by excavating a new depression or by constructing embankments. Runoff which enters the pond is detained and treated by settlement and often biological uptake before out falling. Ponds should contain the following features:

- Sediment Forebay – This may not be required if previous SuDS techniques are implemented upstream
- Permanent pool – This minimum volume of water (excluding losses due to infiltration and evaporation) will remain throughout the year. The main treatment associated with the pond occurs in this pool.
- Temporary Storage Volume – An additional storage volume within the pond to provide flood attenuation for design events.
- Aquatic Bench – A shallow zone around the perimeter of the pool to support wetland planting which provides biological treatment, ecology, amenity and safety benefits.

Table 6.11 Advantages of Ponds

Advantages
Good removal of pollutants
High potential ecological, aesthetic and amenity benefits

Figure 6.15 Example Landscaped Pond

Ponds are recommended at the end of proposed surface water drainage networks following previous SuDS techniques in the Management Train. Outflow from any proposed ponds may be restricted at times due to high tide levels and as such may require additional attenuation volume. Inclusion of several independent cells is encouraged which will enhance biodiversity, improve water quality levels and provide a more environmentally effective management programme.

6.5.2 Constructed Wetlands

Constructed Wetlands comprise of shallow ponds and marshy areas which are designed primarily for stormwater treatment but can also provide some attenuation above the permanent water level. Well designed and maintained wetlands can offer significant aesthetic, amenity and biodiversity opportunities. Constructed wetlands require a continuous baseflow to support a plant-rich community. Wetlands should contain the following features:

- Shallow, vegetated areas of varying depths
- Permanent pools or micropools
- Small depth range overlying permanent pool in which runoff control volumes are stored
- Sediment forebay
- Emergency spillway
- Maintenance access
- Safety bench

Table 6.12 Advantages of Constructed Wetlands

Constructed Wetlands
Good removal of pollutants
High potential ecological, aesthetic and amenity benefits

Figure 6.16 Example Constructed Wetland

Constructed Wetlands are recommended at the end of proposed surface water drainage networks following previous SuDS techniques in the Management Train. Their primary objective should be treatment, not attenuation. Outflow from any proposed ponds may be restricted at times due to high tide levels and as such may require additional attenuation volume. Inclusion of several independent cells is encouraged which will enhance biodiversity, improve water quality levels and provide a more environmentally effective management programme. Permanent pond volume should be provided in accordance with CIRIA C753 'The SuDS Manual'.

6.6 Recommended Management Train for Estuary West Masterplan lands

Recommended SuDS features that should be utilised as part of a management train for undeveloped areas for residential, commercial, industrial and educational uses are outlined below:

SuDS Protocol for Housing Developments:

For all future residential developments:

- Runoff within the curtilage of the property boundary shall pass through at least one SuDS component prior to discharging to downstream SuDS components within the public realm.
- Storage for the 100-year event (as a minimum) including a 20% increase in rainfall intensity for climate change shall be provided within the curtilage of the property boundary, with a maximum discharge rate of 2l/s/ha.
- Runoff from public areas (such as roads, parking bays, hard and soft landscaped areas and footpaths) shall pass through at least two SuDS components prior to discharging to the final downstream detention/retention/polishing SuDS components within the public realm.
- The Final SuDS Components located in the public realm shall comprise basins/ponds/wetlands (as appropriate), prior to discharge to the River Broadmeadow or local surface water sewer. The location of such basins, ponds and wetlands shall be outside the high-end future scenario fluvial flood extents.

- Storage for the 100-year event (as a minimum) including a 20% increase in rainfall intensity for climate change shall be provided for runoff from the public realm, with a maximum discharge rate of 2l/s/ha.

  In addition, a 15m wide riparian buffer strip shall be provided from top of bank to either side of the minor watercourses present on the Masterplan lands. A 30m wide riparian corridor shall be provided along the River Broadmeadow.

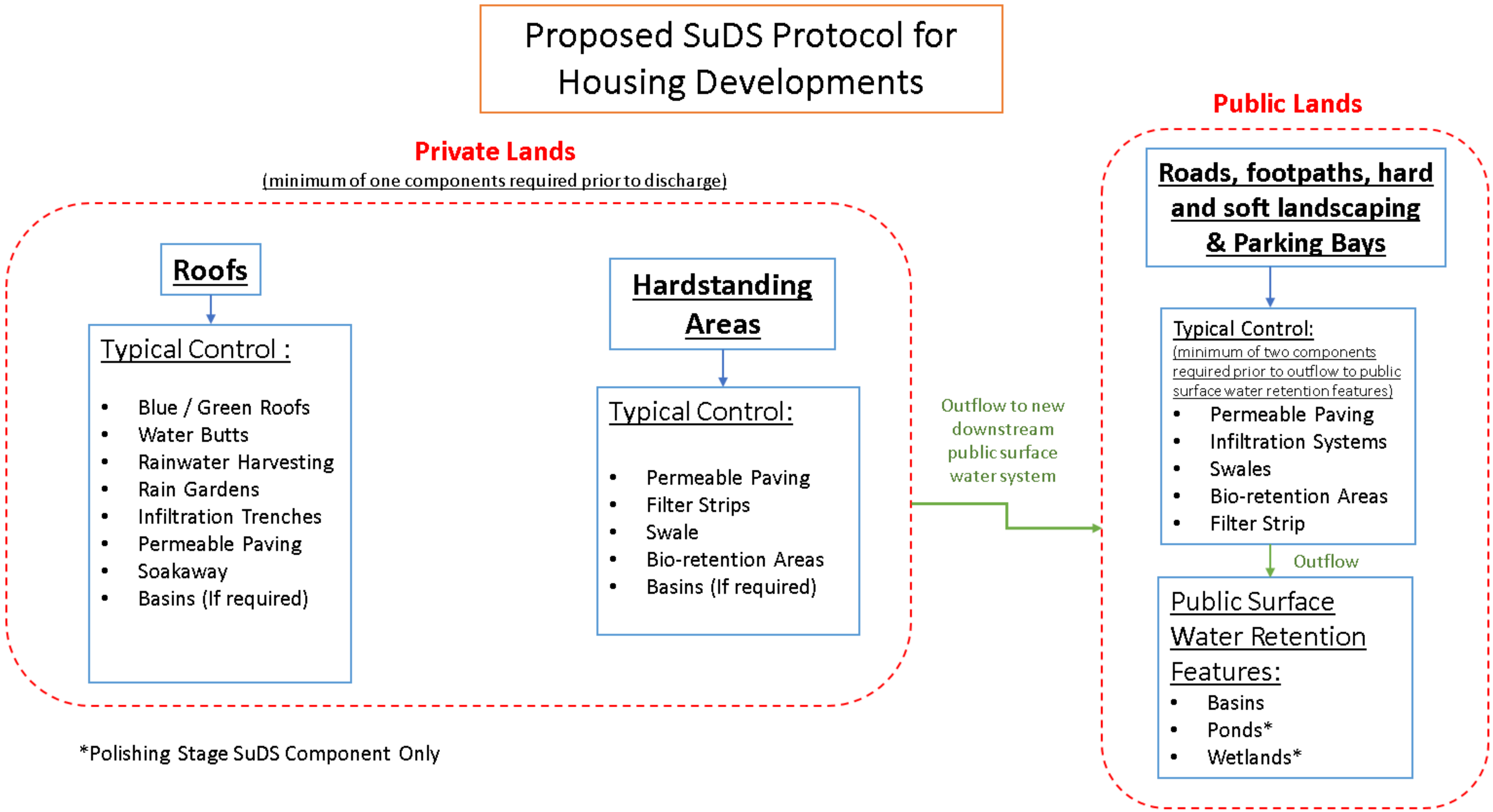


Figure 6.17 Proposed SuDS Features to Be Utilised for Housing Development Management Train

Commercial, Retail, Industrial, Educational and Apartment Developments:

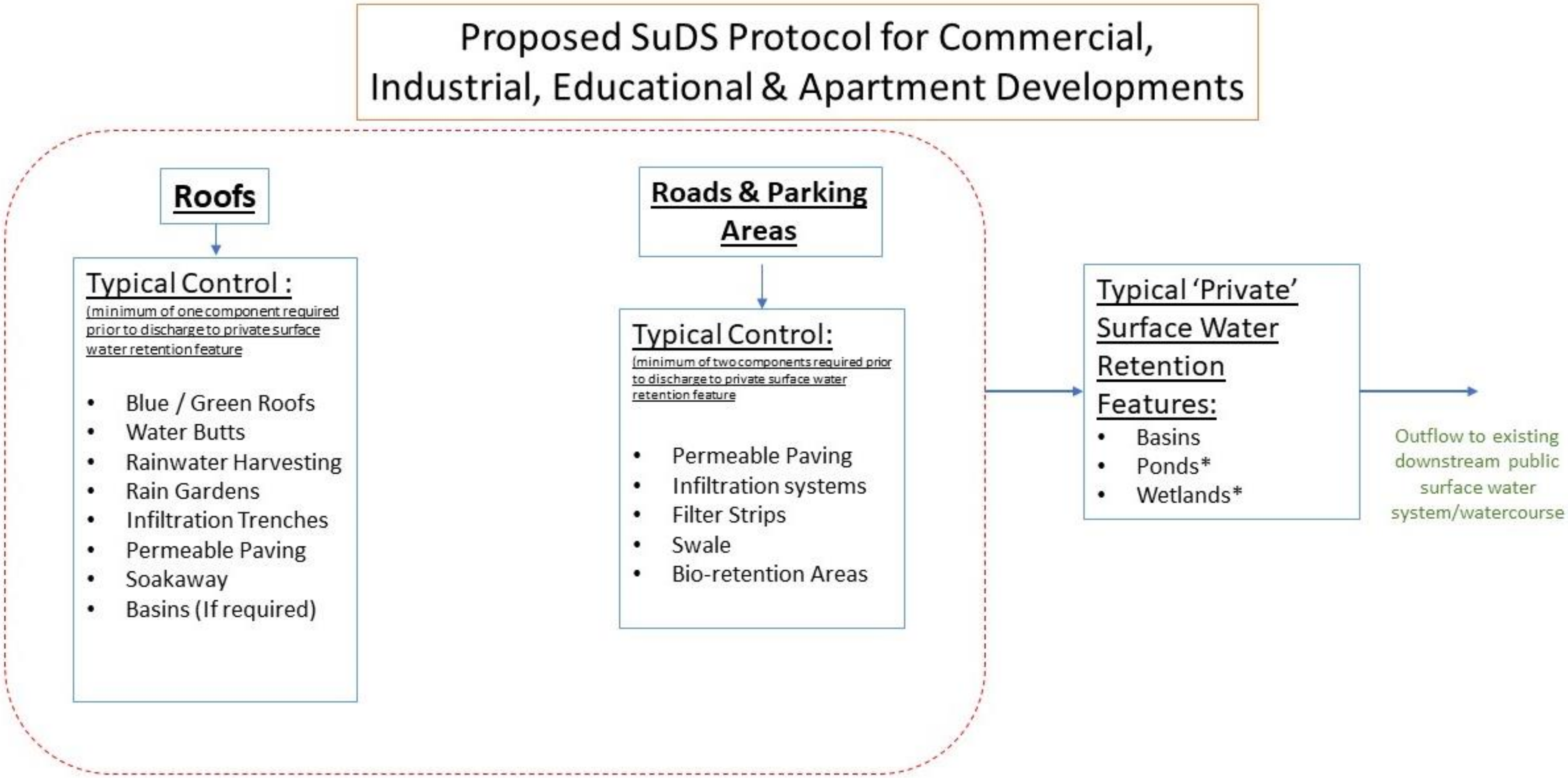
For all future commercial, retail, industrial, educational and apartment developments:

- Runoff from roofs shall pass through at least one SuDS feature prior to discharge to on-site surface water retention features.
- Blue/green roofs shall be provided to store the 100-year event with an allowance for Climate Change.
- Runoff from roads and parking areas shall past through at least two SuDS features prior to discharge to the final on-site surface water retention features.

The final ‘Private’ surface water retention features shall comprise basins/ponds/wetlands (as appropriate), prior to discharge to the local surface water sewers/watercourses. The location of such basins, ponds and wetlands shall be outside the high-end future scenario (HEFS) fluvial flood extents.

Storage for the 100-year event (as a minimum) including a 20% increase in rainfall intensity for climate change shall be provided for runoff from the developments, with a maximum discharge rate of 2l/s/ha.

In addition, a 15m wide riparian buffer strip shall be provided from top of bank to either side of the minor watercourses present on the Masterplan lands. A 30m wide riparian corridor shall be provided along the River Broadmeadow.



*Polishing Stage SuDS Component Only

All new industrial/commercial and apartment developments shall incorporate blue / green roofs to attenuate the 1 in 100 year (incl. climate change) rainfall event.

Figure 6.18 Proposed SuDS Features to Be Utilised for Industrial, Commercial, Educational & Apartment Development Management Train

7. IMPACT OF SUDS STRATEGY

7.1 Runoff Quantity

Increase in the area of hardstanding within the development areas will result in an increase in the total runoff quantity due to reduced infiltration of surface water to ground. This increase will be minimised through the use of rainwater harvesting and evaporation and transpiration from open channels / ponds and vegetation respectively.

7.2 Runoff Quality

Management of runoff quality is important in order to protect existing water quality in receiving waters. The proposed SuDS Strategy implements a Management Train whereby runoff will pass through a series of SuDS techniques prior to outfall. Each technique will provide different treatment processes – settlement, filtration, removal of nutrients, removal of heavy metals and biological treatment through vegetation.

7.3 Amenity and Biodiversity

The Masterplan lands available for new development are currently predominantly greenfield plots and an existing structure with parking facilities (due to be demolished). The proposed SuDS Strategy will introduce a variety of features to promote and enhance amenity and biodiversity in the area. Tree plantings will be incorporated within Bioretention Areas. Ponds/Wetlands should be designed with an emphasis on ecology. Ponds should contain multiple pools fed by cleaner surface water runoff from surrounding grassland or scrub. This will allow a wider range of plants and animals to exploit the overall pond development. A variety of local (c.30km) pond plants should be included to maximise habitat structural diversity. A mix of open, lightly shaded and densely shaded areas will also add to the diversity of habitats available.

7.4 Flooding

Implementation of the SuDS Strategy will reduce peak flow runoff of the proposed development and minimise the risk of flooding. Ponds located in low lying areas will need to be designed to provide additional attenuation volume as it may not be possible to outfall during periods of extreme tidal events. *Refer to Estuary West Masterplan Strategic Flood Risk Assessment*.

7.5 Groundwater

It is expected that the infiltration capacity of the soil within the masterplan will be generally good as the masterplan land are within Soil Class 2, as identified in the Flood Studies Report. Infiltration SuDS techniques may be favourable as part of this SuDS Strategy. As a result of the proposed development, there will be a significant increase in the area of hardstanding within the Masterplan lands, resulting in a loss of surface water infiltration to the underlying subsoil. Where possible, infiltration SuDS techniques should be implemented to minimise the effect of the development and replicate the natural hydrological process. Site specific ground investigations should be undertaken when determining the infiltration capacity for future development sites.

7.6 Surface Water Drainage Network

The majority of land zoned for new development will require construction of new surface water drainage networks. It is recommended that the SuDS Protocol described above is adapted for all sites and that a SuDS Management Train is developed for all future development sites, prior to discharging from the lands to the downstream watercourse.

8. CONCLUSIONS

- As part of new development in the Masterplan lands, new surface water drainage networks will be required.
- SuDS measures will be required as part of this developments to ensure the quantity, quality and ecological/biodiversity value of downstream water bodies are protected and enhanced, to assist in achieving our obligations under the WFD.
- The protocols outlined in this report for the various land uses should be adopted as a minimum, in accordance with Fingal County Council policy, and overarching national and EU legislation.

9. RECOMMENDATIONS

1) New surface water drainage networks will be required as part of the land available for development. These networks should be designed in accordance with this SuDS Strategy, CIRIA C753 ‘The SuDS Manual’ and the Greater Dublin Strategic Drainage Systems (GDSDS).

2) Provide an undeveloped flood-plain to accommodate flood waters during extreme flooding events through the provision of a riparian corridor along the River Broadmeadow and the existing drainage channel at the north western corner of the Masterplan lands – refer to the Strategic Flood Risk Assessment for the Estuary West masterplan.

3) For all future housing developments:
   - Runoff within the curtilage of the property boundary shall pass through at least one SuDS component prior to discharging to downstream SuDS components within the public realm.
   - Storage for the 100-year event (as a minimum) including a 20% increase in rainfall intensity for climate change shall be provided within the curtilage of the property boundary, with a maximum discharge rate of 2l/s/ha.
   - Runoff from public areas (such as roads, parking bays, hard and soft landscaped areas and footpaths) shall pass through at least two SuDS components prior to discharging to the final downstream detention/retention/polishing SuDS components within the public realm.
   - The Final SuDS Components located in the public realm shall comprise basins/ponds/wetlands (as appropriate), prior to discharge to the River Broadmeadow watercourse or local surface water sewers. The location of such basins, ponds and wetlands shall be outside the high-end future scenario fluvial flood extents.
   - Storage for the 100-year event (as a minimum) including a 20% increase in rainfall intensity for climate change shall be provided for runoff from the public realm, with a maximum discharge rate of 2l/s/ha.

4) For all future commercial, industrial, retail, educational and apartment developments:
   - Runoff from roofs shall pass through at least one SuDS feature prior to discharge to on-site surface water retention features.
   - Blue/green roofs shall be provided to store the 100-year event with an allowance for Climate Change.
   - Runoff from roads and parking areas shall past through at least two SuDS features prior to discharge to the final on-site surface water retention features.
   - The final 'Private' surface water retention features shall comprise basins/ponds/wetlands (as appropriate), prior to discharge to the local surface water sewers/watercourses. The location of such basins, ponds and wetlands shall be outside the high-end future scenario (HEFS) fluvial flood extents.
   - Storage for the 100-year event (as a minimum) including a 20% increase in rainfall intensity for climate change shall be provided for runoff from the developments, with a maximum discharge rate of 2l/s/ha.

5) A Management Train should be incorporated during the design stage whereby surface water should be managed locally in small sub-catchments rather than being conveyed to and managed in large systems further down the catchment.

6) Water Butts, Rainwater Harvesting, Rain Gardens and Permeable Paving are recommended for use in all residential developments.

7) Any Industrial, Commercial, Retail and Educational developments and Apartment blocks should incorporate rainwater harvesting for re-use and should incorporate blue / green roof structures.

8) Subject to subsoil permeability, filter drains may be required to drain residential gardens and other small green areas within future developments. Runoff from green areas should, where possible, infiltrate directly to groundwater.

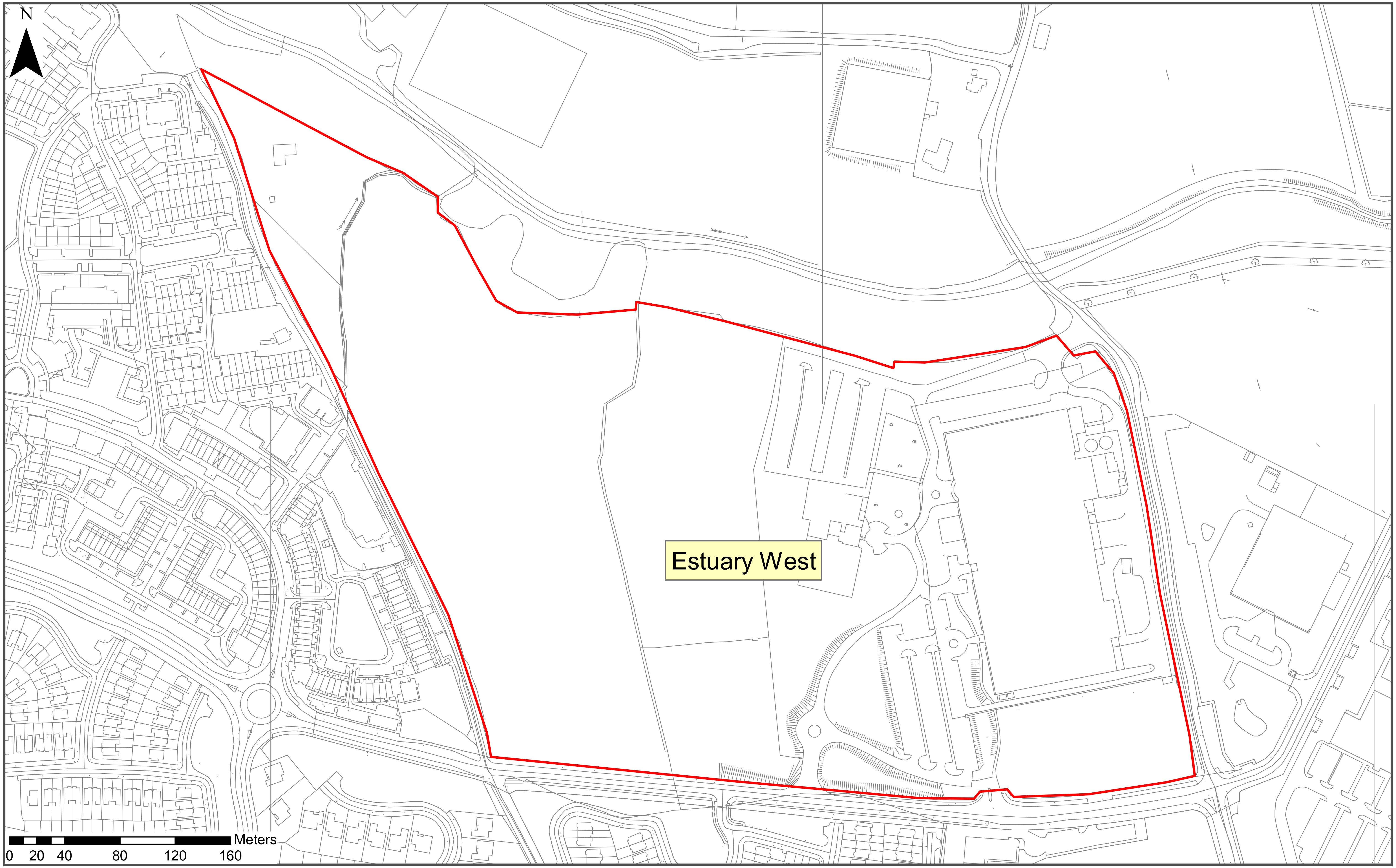
9) Runoff from development lands should be limited to 2l/sec/ha. Attenuation should be provided for the 1% AEP rainfall event plus an allowance for Climate Change in accordance with regional drainage policy. The siting of all future SuDS components shall be outside the high-end future scenario fluvial flood extents. Refer to the Estuary West Masterplan Flood Risk Assessment for flood extent mapping.

10) The relevant authorities should promote the benefits of SuDS retrofitting to the general public.

11) Development will generally be prohibited within the 0.1% AEP Fluvial or Tidal Flood Extent, including defended areas. Refer to Estuary West Masterplan Flood Risk Assessment for flood extent mapping.

12) Management trains for new and existing developments should facilitate the construction of future SuDS components – to mitigate the risk of flooding caused by more extreme rainfall events and risk of pollution due to lower baseflow in receiving waters.

APPENDIX A
SITE LOCATION MAP



Masterplan lands

No.	Revision	Date	By	Chk'd	App'd
F01	Site Layout - Final	10/05/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

ROD
ROUGHAN & O'DONOVAN
Consulting Engineers
Civil - Structural - Transportation - Environmental

Arena House, Arena Road,
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Project Title: Swords Surface Water Management Plan

Drawing Title: Estuary West Site Layout

Designed: BP	Checked: WV	Approved: JPR	Status: FINAL

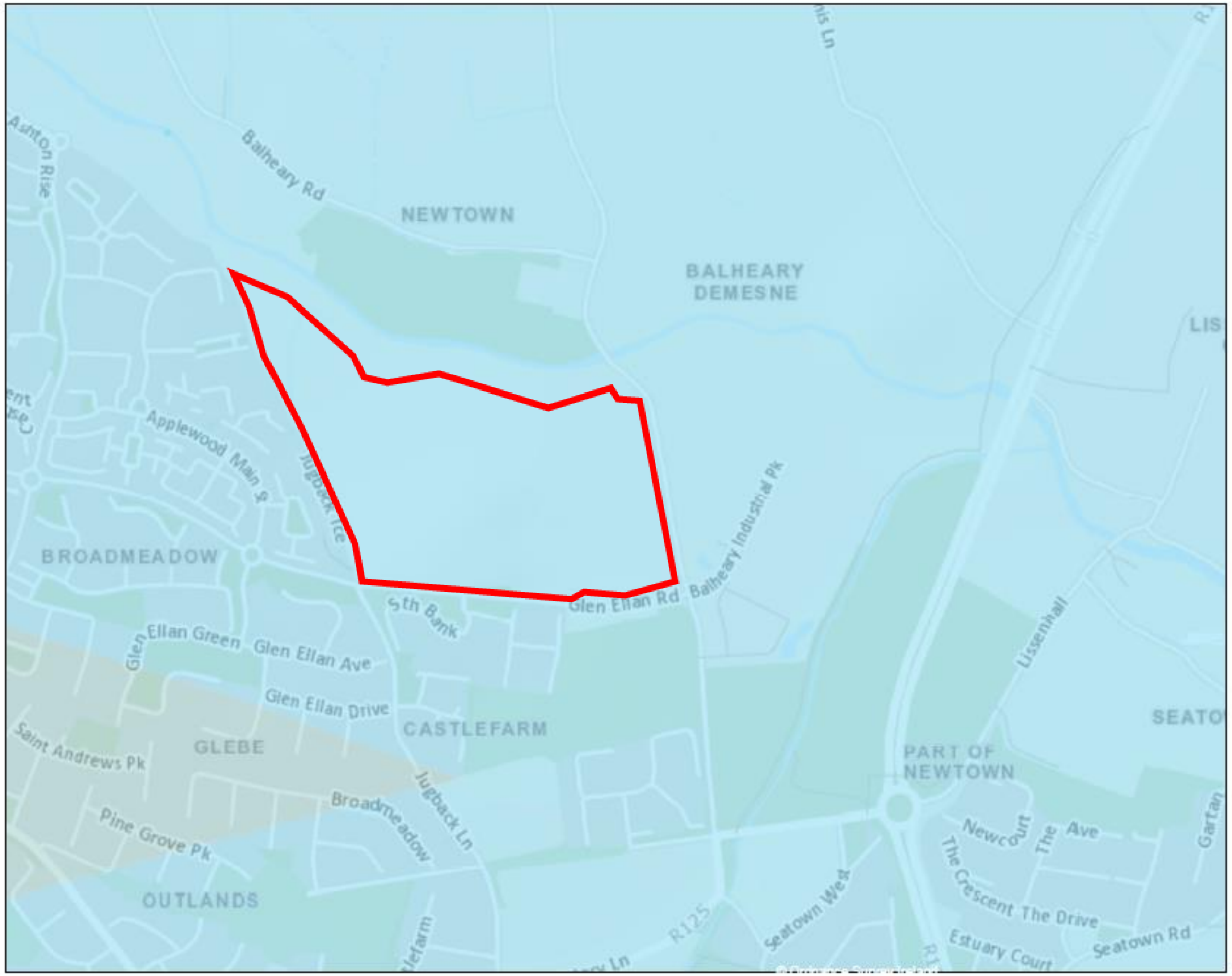
Drawn: BP	Job No: 18.164	Drawing No: 18.164-003	Rev: F01
Scale: 1:2,500 (@ A3)	Date: 29/11/2018		

10 May 2019 09:47:22 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Final\18.164-003 Swords Masterplan Estuary West F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY

APPENDIX B
GSI MAPS

Bedrock Data



Legend

Bedrock Rock Units

- Malahide Formation
- Tober Colleen Formation

Scale: 1:10,000

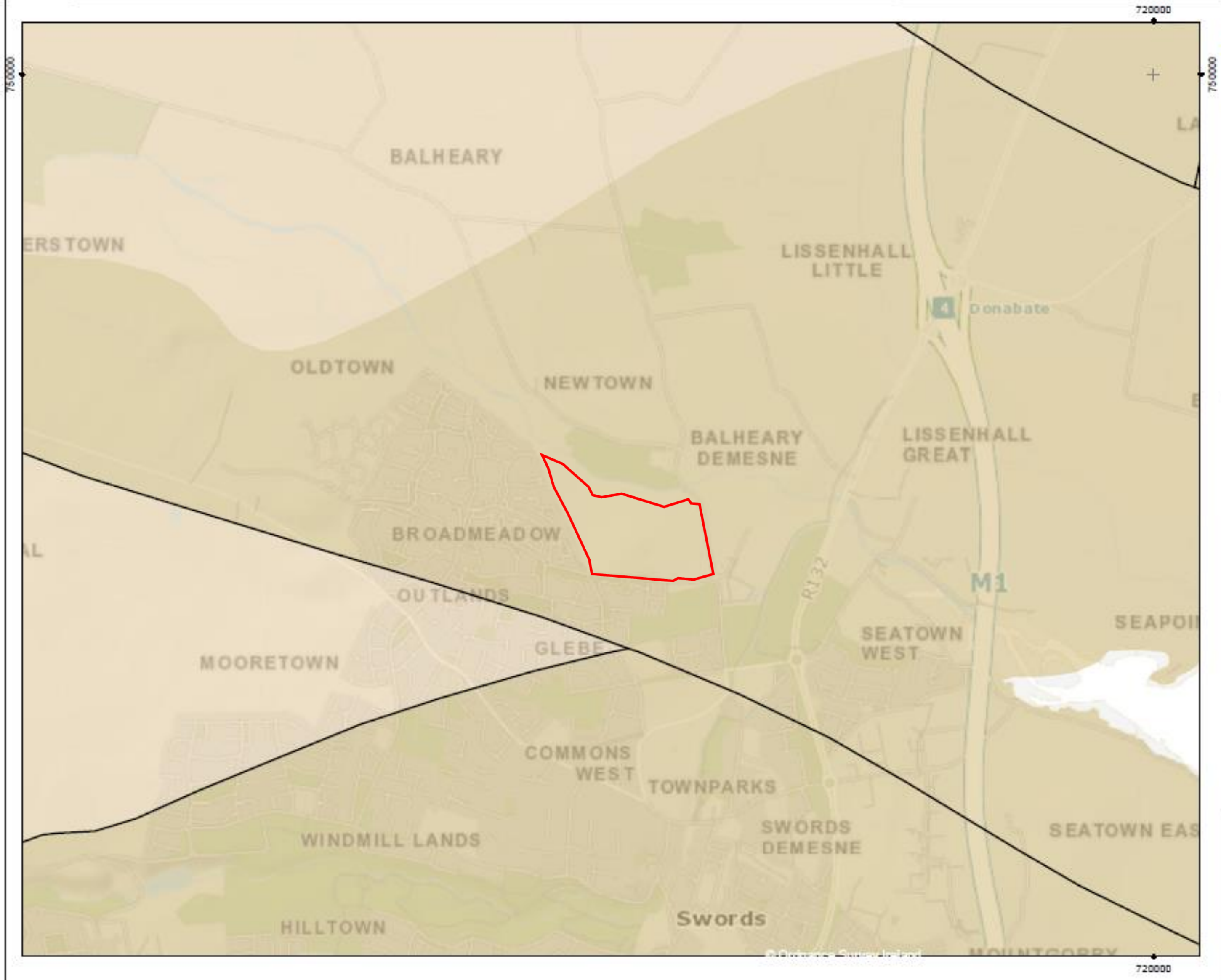
Geological Survey Ireland

0 0.05 0.1 0.2 mi
0 0.1 0.2 0.4 km

Map Centre Coordinates (ITM) 718,094 748,113
10/31/2018, 9:27:56 AM

Groundwater Data

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann



Scale: 1:25,000

Geological Survey Ireland

0 0.175 0.35 0.7 mi
0 0.275 0.55 1.1 km

Map Centre Coordinates (ITM) 717,780 748,304
10/31/2018, 12:05:28 PM

Legend

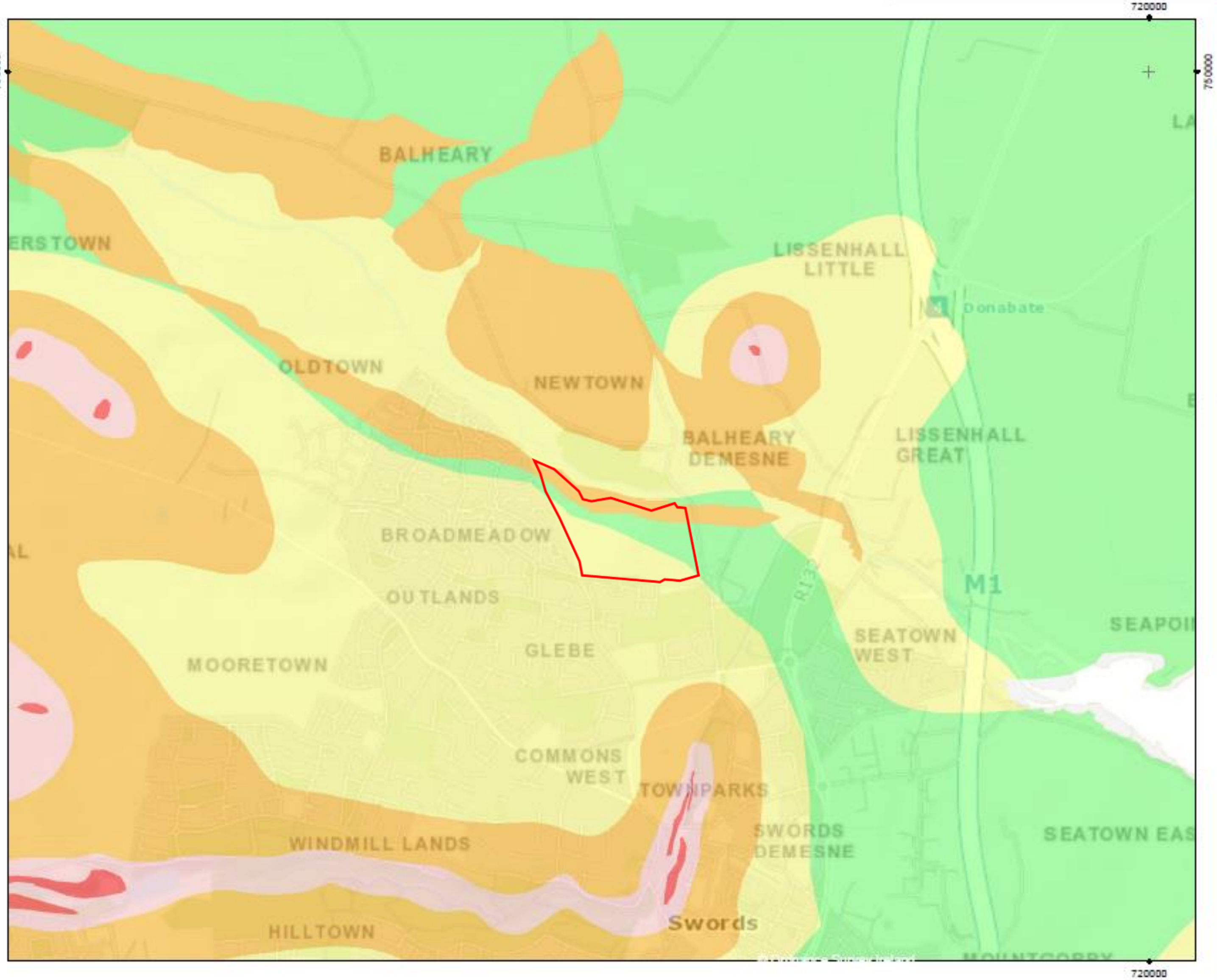
Bedrock Aquifer Faults

— Bedrock Aquifer Faults

Bedrock Aquifer

- Lm - Locally Important Aquifer - Bedrock which is Generally Moderately Productive
- Ll - Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- Pl - Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones

Groundwater Data



Legend

Groundwater Vulnerability

- X - Rock at or near surface or Karst
- E - Extreme
- H - High
- M - Moderate
- L - Low

Scale: 1:25,000

Geological Survey Ireland

0 0.175 0.35 0.7 mi
0 0.275 0.55 1.1 km

Map Centre Coordinates (ITM) 717,780 748,304
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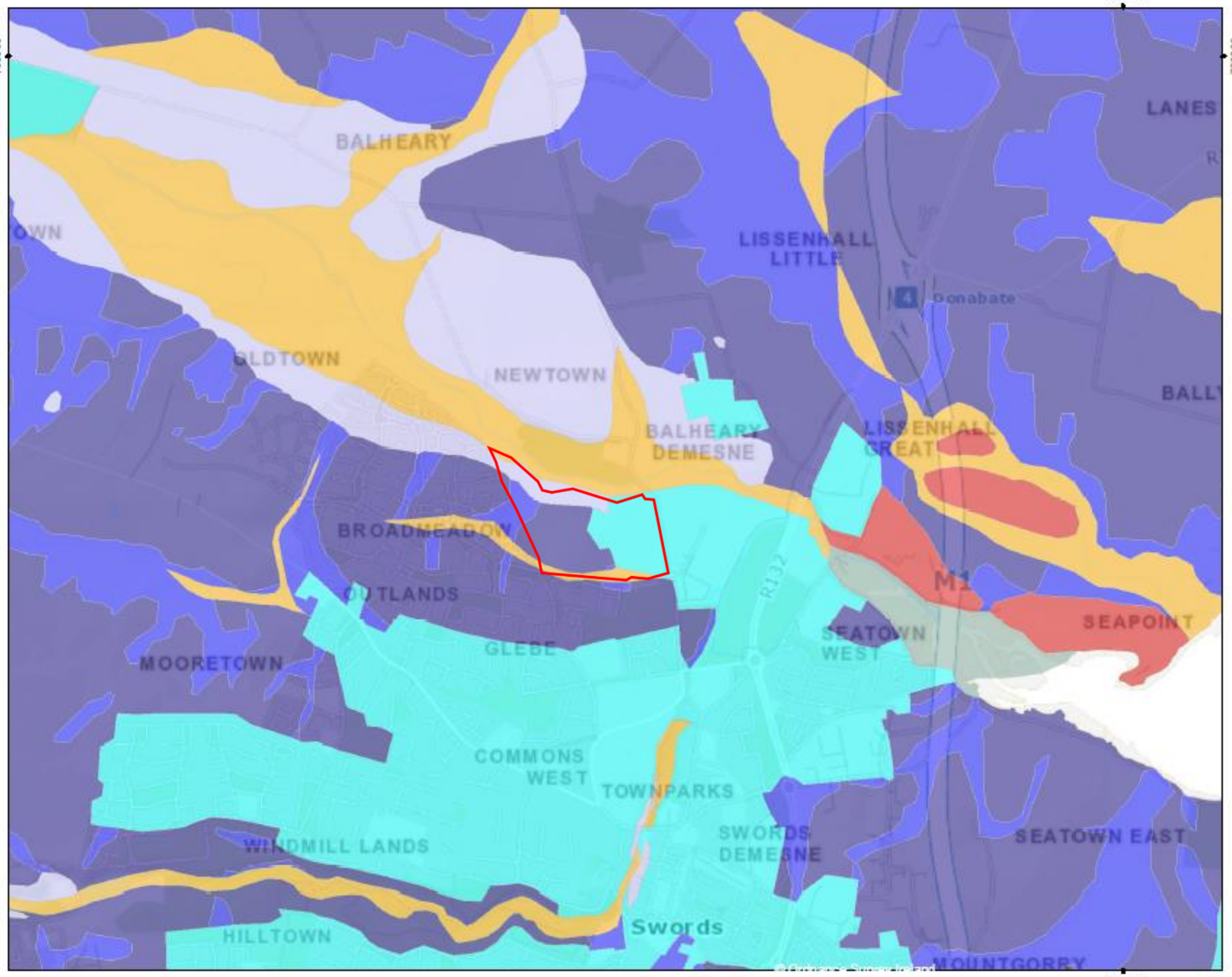
Subsoil Data



Legend

- AminDW - Deep well drained mineral (Mainly acidic)
- BminDW - Deep well drained mineral (Mainly basic)
- BminPD - Mineral poorly drained (Mainly basic)
- BminSW - Shallow well drained mineral (Mainly basic)
- AlluvMIN - Alluvial (mineral)
- MarSed - Marine/estuarine sediments
- Made - Made ground

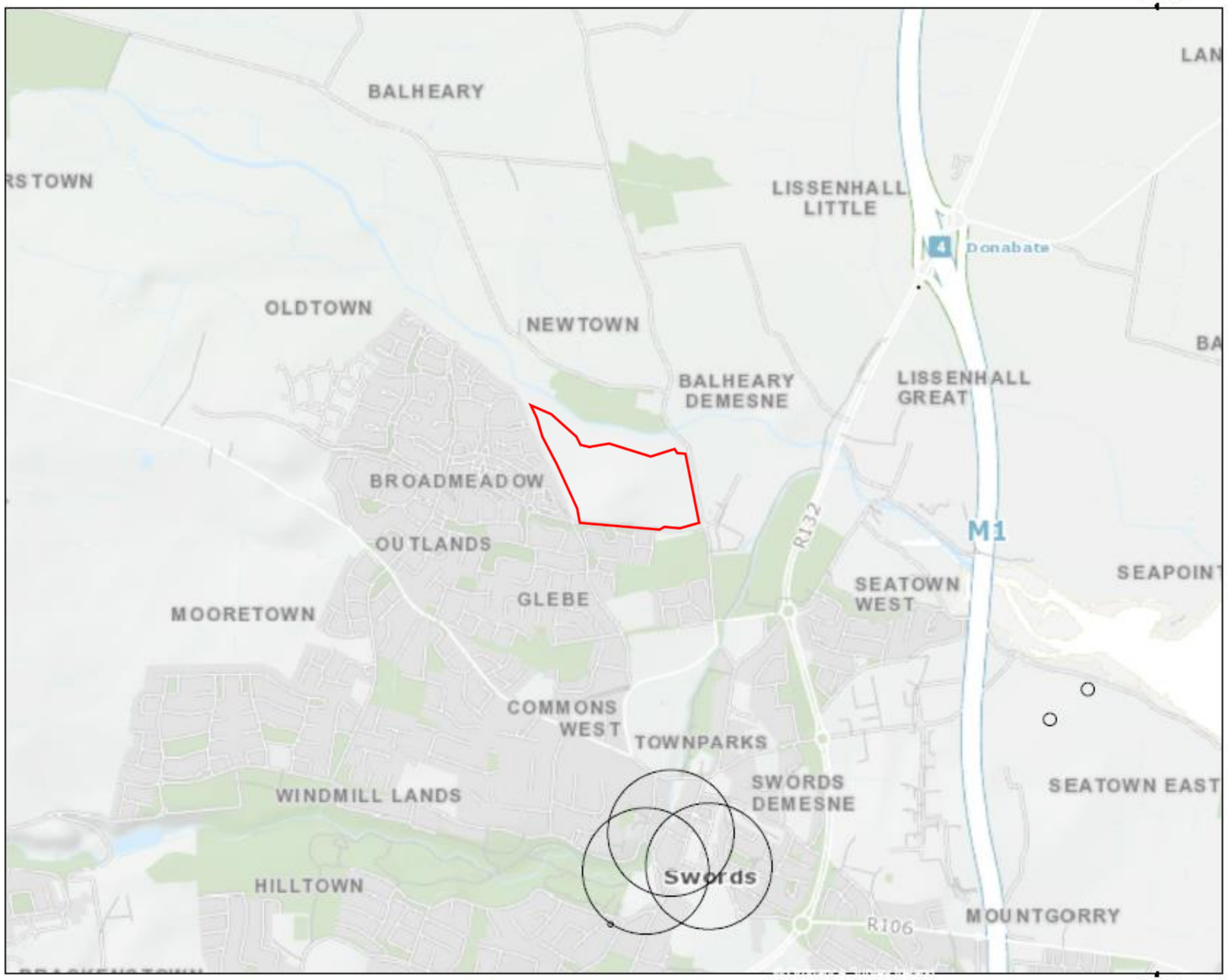
Scale: 1:25,000

Geological Survey Ireland

0 0.175 0.35 0.7 mi
0 0.275 0.55 1.1 km

Map Centre Coordinates (ITM) 717,987 748,285
10/31/2018, 12:13:03 PM

Groundwater Data



Legend

Groundwater Wells and Springs

Groundwater Wells and Springs

Scale: 1:25,000

Geological Survey Ireland

0 0.175 0.35 0.7 mi
0 0.275 0.55 1.1 km

Map Centre Coordinates (ITM) 717,850 748,080
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