Hydro Environmental Ltd

Strategic Flood Risk Assessment Of Variation No. 1 to Galway County Development Plan 2015 - 2021

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Galway County Council

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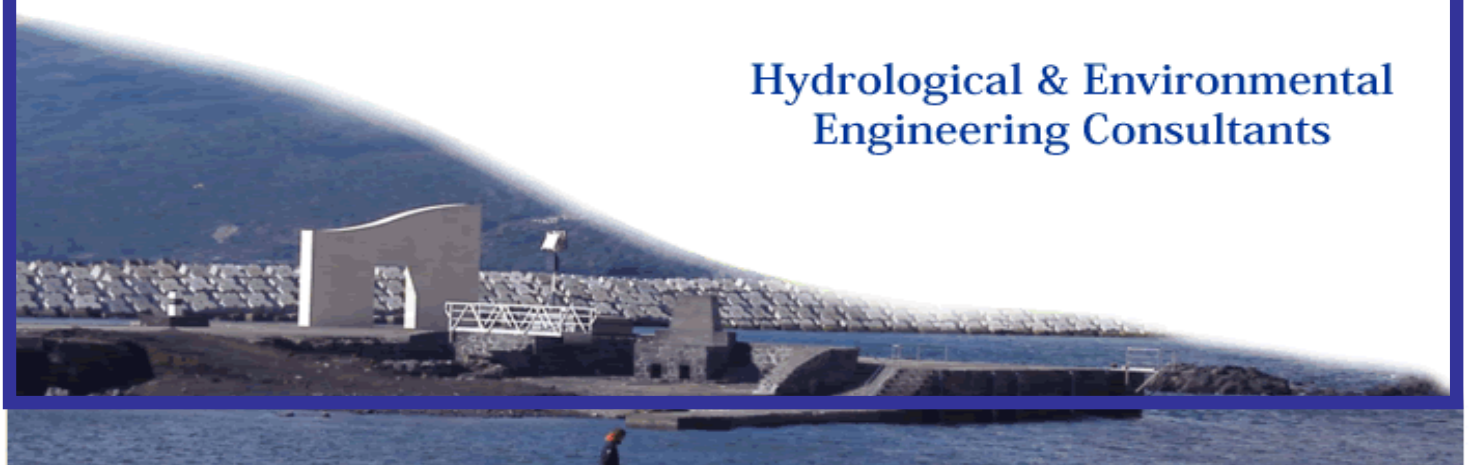
Hydrological & Environmental Engineering Consultants



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Hydro Environmental Ltd
No. 4 Caiseal Riada,
Clarinbridge,
Galway,
Ireland.
Tel/Fax: 091 796734

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Prepared by:	Anthony Cawley BE, M.EngSc, CEng MIEI
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Table of Contents

Appendices

1. INTRODUCTION

Galway County Council varied the Galway County Development Plan 2015-2021 to incorporate where relevant the measures of the Galway Transport Strategy (GTS). The preparation of the GTS was also subject to a standalone Strategic Flood Risk Assessment (SFRA). Hydro Environmental Ltd in association with Arup was appointed by Galway County Council to carry out a Strategic Flood Risk Assessment (SFRA) for the Variation No. 1 to the Galway County Development Plan 2015-2021, hereafter referred to as the Variation.

It was determined by Galway County Council that a Strategic Flood Risk Assessment (SFRA) is required in order to assess and manage flood risk in accordance with the Office of Public Works (OPW) Flood Risk Management Planning Guidelines (FRMPG). This document presents the current findings of the SFRA of the Variation to the Galway County Development Plan 2015-2021. The purpose of this document is to detail the findings of the Stage 2 SFRA.

The SFRA has been undertaken in accordance with *The Planning System and Flood Risk Management – Guidelines for Planning Authorities (Dept. of the Environment, Heritage and Local Government and The Office of Public Works, Nov 2009)*.

Chapter 2 of this report outlines the flood risk management policies and guidelines used for this assessment. Chapter 3 includes an overview of the Galway Transport Strategy and the measures which are assessed in respect to the Variation to the Galway County Development Plan 2015-2021. Finally chapter 4 documents the Stage 1 Flood Risk Identification, and then follows with Stage 2 Initial Flood Risk Assessment of these identified locations and finally recommends where Stage 3 Detailed Flood Risk Assessment will be required.

Figures with the GTS measures overlaid on PFRA and CFRAM mapping are included in Appendix A of this report. Figure GCOB-SK-D-729 includes pluvial and groundwater indicative flooding, GCOB-SK-D-730 includes coastal and fluvial indicative flooding and GCOB-SK-D-731 to 733 includes CFRAM Flood Risk Mapping.

2 FLOOD RISK MANAGEMENT POLICY

2.1 EU Floods Directive

The European Floods Directive 2007/60/EC on the assessment and management of flood risk aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. This directive applies to both inland waters and coastal waters across the whole territory of the EU.

The directive requires all member states to undertake a national preliminary flood risk assessment in order to identify areas where significant flood risk exists or might be considered likely to occur and to prepare flood hazard and flood risk maps for such areas by December 2013. The Directive requires the preparation of catchment-based Flood Risk Management Plans (FRMPs) by 2015, which will set out flood risk management objectives, actions and measures. These Flood Risk Management Plans are to include measures to reduce the probability of flooding and its potential consequences. Implementation of the EU Floods Directive is required to be coordinated with the requirements of the EU Water Framework Directive and current River Basin Management Plans.

2.2 National Flood Policy review

2.2.1 Background

Historically management of flooding was implemented by drainage commissioners and focused on the protection and improvement of land for agricultural purposes and this is reflected in the various Drainage Acts passed (1842, 1867, 1925, 1928, and 1945).

The Brown Commission (Report of the Drainage Commission 1938-1940) which examined flooding and improvement of land through drainage resulted in the development of the Arterial Drainage Act, 1945. The Brown Commission recommended the establishment of a single national drainage authority with a remit to embark on a national drainage programme. The Office of Public Works (OPW) became the Statutory Authority responsible for implementing arterial drainage schemes nationally.

The emphasis of the 1945 act was improvement of agricultural land and following the act a priority list of river basins was set out and a programme of drainage works commenced and continued up until the early 1990's. This drainage act was amended in 1995 to allow the OPW to implement localised flood relief schemes for reliving flooding in urban areas. This amendment recognised that urban flooding had become

a significant problem and signalled a departure away from arterial drainage of lands with no new arterial drainage schemes being implemented.

The various drainage districts and arterial drainage schemes, local flood relief schemes carried out under the drainage act continue to be maintained today by the OPW and Local Authorities.

2.2.2 Report of the Flood Policy Review Group

In 2003 a review of the National Flood Policy was carried out by a review group of relevant stakeholders. The review focuses on fluvial (river) and tidal flooding and concentrates on the roles of the state agencies in these areas. The scope of the review included the following:

- Causes, extent and impacts of the flooding problem
- Current roles and responsibilities of the main state bodies
- International best practice
- Future flood policy
- Proposals for future organisational structures and responsibilities
- Resource requirements and strategic programme

The review group prepared a report by December 2003 that was approved by government and published in September 2004. The adopted policy has many specific recommendations, including:

- Minimise the national level of exposure to flood damages through identification and management and future flood risks in an integrated, proactive and river basin based approach
- The Office of Public Works is to be the lead agency in delivering this policy
- All future expenditure in the area of flood relief will need to satisfy strict prioritisation criteria
- A two-pronged approach to flood management is to be pursued with a greater level of importance attributed to non-structural flood relief measures supported where necessary by traditional structural flood relief measures

- River basin flood management plans to be developed along with comprehensive Flood Hazard Maps and all information made available to the Dept. of the Environment, Heritage and Local Government to inform future planning and development processes

- Programmes of necessary hydrological research were identified and included the update of the Flood Studies Report and river basin (hydrological) modelling, analysis of potential impact of climate change on flood frequency and severity and Meteorological forecasting

2.3 National CFRAM

The OPW is the lead agency for flood risk management and part of its responsibility is the coordination and implementation of Government Policy on the management of flood risk in Ireland. The SI No. 122 on the European Communities (Assessment and Management of Flood Risks) 2010 identifies the Commissioners of Public Works as the competent authority with overall responsibility for the implementation of the Floods Directive (2007/60/EC).

In order to comply with the Floods Directive (2007) and the National Flood Policy Review Group (2004) a national Catchment Flood Risk Assessment and Management (CFRAM) programme commenced in 2011 and flood risk and hazard mapping completed in 2015 and the catchment management plans and the Strategic Environmental Assessment (SEA) process completed in 2016. This followed preparatory studies involving the Preliminary Flood Risk Assessment mapping and AFA (areas for further assessment) identification and followed a number of Pilot Catchment studies including the Lee Catchment FRAMs (commenced 2006), the River Dodder FRAMS (commenced 2007) and the Fingal East Meath FRAMS (commenced 2008) to refine the approach and methodologies to be adopted. The areas deemed to be at significant risk are identified as AFAs and more detailed assessment on the extent and degree of flooding was under taken in the CFRAM studies and involved detailed survey hydrological and hydraulic modelling, flood mapping, flood risk management plans and supporting Strategic Environmental Assessments.

2.4 Planning Guidelines Concerning Flood Risk Management

2.4.1 Background

In November 2009, the OPW and DoEHLG jointly published the Planning System and Flood Risk Management - Guidelines for Planning Authorities which are aimed at ensuring a more consistent, rigorous and systematic approach to fully incorporate flood risk assessment and management into the planning system.

The core objectives set out in these guidelines are to:

- Avoid inappropriate development in areas of flood risk
- Avoid new developments that may increase flood risk elsewhere
- Ensure effective management of residual risks for developments permitted in floodplains
- Avoid unnecessary restriction of national, regional or local economic growth
- Improve the understanding of flood risk among the relevant stakeholders
- Ensure that the requirements of EU and National law in relation to the natural environment and nature conservation are compiled with at all stages of flood risk management.

The key principles to be adopted by regional and local authorities, developers and their agents are to:

- Avoid the risk, where possible
- Substitute less vulnerable uses, where avoidance is not possible
- Justify that the need for the development is a strategic need, where avoidance and substitution are not possible
- Mitigate and manage the risk

Decision Making Process

Management of flood hazard and potential risks in the planning system is based on:

1. Sequential Approach
2. Justification Test

2.4.2 Sequential Approach

The aim of the sequential approach is to guide new development away from areas at risk from flooding into areas at low risk of flooding. The approach makes use of flood risk zones and classifications of vulnerability of property to flooding but ignores the presence of flood protection structures. The sequential approach should be applied to all stages of the planning process, particularly at the plan making stage.

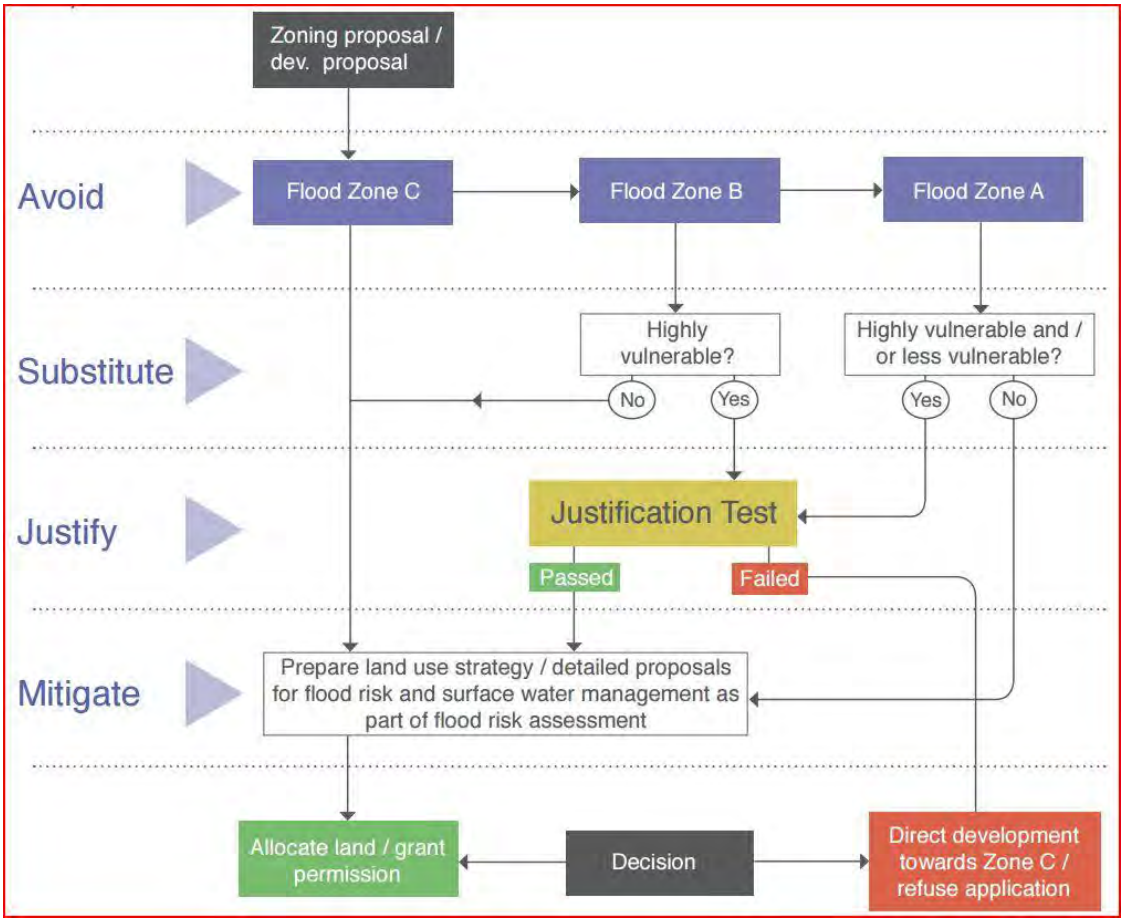


Figure 1 Sequential approach mechanism in the planning process (Fig. 3.2 from the Flood Risk Management Planning Guidelines)

The Sequential Approach is based on the following principles:

AVOID
Preferably choose lower flood risk zones for new developments

SUBSTITUTE
Ensure proposed development type is not especially vulnerable to the adverse impacts of flooding

JUSTIFY
Ensure that the development being considered is for strategic reasons

MITIGATE
Ensure that flood risk is reduced to acceptable levels

PROCEED
Only where Justification Test passed. Ensure emergency planning measures are in place.

2.4.3 Flood Risk Zones

Definitions of flood risk zones in the planning guidelines are based on probability of occurrence with three flood risk zones (High, Moderate and Low) defined. These flood zones are as follows:

- Zone A High Probability – Highest risk of flooding: More than 1% probability of river flooding and more than 0.5% probability of tidal flooding. Development should be avoided and/or only considered through application of a justification test. Most types of development would be considered inappropriate in this zone. Development in this zone should be avoided and/or only considered in exceptional circumstances, such as in city and town centres, or in the case of essential infrastructure that cannot be located elsewhere, and where the justification test has been applied.

- Zone B Moderate Probability: Between 1 and 0.1% probability of river flooding or between 0.5 and 0.1% probability of coast flooding. Development should only be considered in this zone if adequate land or sites are not available in Zone C or if development in this zone would pass the Justification Test. Highly vulnerable development would generally be considered inappropriate in this zone, unless the requirements of the Justification Test can be met. Less vulnerable development and water-compatible development might be considered appropriate in this zone. In general however, less vulnerable development should only be considered in this zone if adequate lands or sites are not available in Zone C and subject to a flood risk assessment to the appropriate level of detail to demonstrate that flood risk to and from the development can or will adequately be managed.

- Zone C Low Probability: Less than 0.1% probability of river or coastal flooding. Development in this zone is appropriate from a flood risk perspective (subject to assessment of flood hazard from sources other than rivers and the coast) but would need to meet the normal range of other proper planning and sustainable development considerations.

These flood zones are determined on the basis of the probability of river and coastal flooding only and should be prepared by suitably qualified experts with hydrological experience. The derivation of these zones is broadly in line with those in common usage internationally. They are based on the current assessment of the 1% and the 0.1% fluvial events and the 0.5% and 0.1% tidal events, without the inclusion of climate change factors.

The provision of flood protection measures in appropriate locations, such as in or adjacent to town centres, can significantly reduce flood risk. However, the presence of flood protection structures should be ignored in determining the flood zones. This

is because areas protected by flood defences still carry a residual risk of flooding from overtopping or breach of the defences and the fact that there may be no guarantee that the defences will be maintained in perpetuity. The likelihood and extent of this residual risk needs to be considered, together with the potential impact on proposed uses, at both development plan and development management stages, as well as in emergency planning. In particular, the finished floor levels within protected zones will need to take account of both urban design considerations and the residual risk remaining.

2.4.4 Development Type Vulnerability Classification

In determining the suitability of the Development within the various flood zones the vulnerability class of the development is taken into consideration. Three categories of vulnerability are considered as described in Table 1 and 2 below:

Table 1 Classification of Vulnerability of Different Types of Development

Vulnerability Class	**Land uses and types of development which include*:**
Highly Vulnerable development (including essential infrastructure)	• Garda, ambulance and fire stations and command centres required to be operational during flooding • Hospitals • Emergency access and egress points • Schools; • Dwelling houses, student halls of residence and hostels • Residential institutions such as residential care homes, children's homes and social services homes • Caravans and mobile home parks • Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility • Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding
Less Vulnerable development	• Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions • Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans • Land and buildings used for agriculture and forestry • Waste treatment (except landfill and hazardous waste) • Mineral working and processing • Local transport infrastructure

Vulnerability Class	**Land uses and types of development which include*:**
Water Compatible development	• Flood control infrastructure • Docks, marinas and wharves • Navigation facilities • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation) • Lifeguard and coastguard stations • Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms • Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan)
	• Uses not listed here should be considered on their own merits

Table 2 Requirement for Justification Test based on Vulnerability group and Flood Zone Category

Vulnerability Class	**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

2.4.5 Justification Test

Further sequentially based decision making should be applied when undertaking the Justification Test for development that needs to be in flood risk areas for reasons of proper planning and sustainable development:

1 within zone or site, development should be directed to areas of lower flood probability
2 where impact of the development on adjacent lands is considered unacceptable the justification of the proposal or zone should be reviewed

3 where the impacts are acceptable or manageable, appropriate mitigation measures within the site and if necessary elsewhere should be considered.

A justification test is required where a planning authority is considering the future development of areas at a high or moderate risk of flooding, for uses or development vulnerable to flooding that would generally be inappropriate as set out above within the flood zones. In such cases the planning authority must be satisfied that it can clearly demonstrate on a solid evidence base that the zoning or designation for development will satisfy the justification test outline in Box 4.1 of the guidelines as presented below in Plate 1.

Box 4.1: Justification Test for development plans

Where, as part of the preparation and adoption or variation and amendment of a development/local area plan[1], a planning authority is considering the future development of areas in an urban settlement that are at moderate or high risk of flooding, for uses or development vulnerable to flooding that would generally be inappropriate as set out in Table 3.2, all of the following criteria must be satisfied:

1 The urban settlement is targeted for growth under the National Spatial Strategy, regional planning guidelines, statutory plans as defined above or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act, 2000, as amended.

2 The zoning or designation of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in particular:

- (i) Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement[2];
- (ii) Comprises significant previously developed and/or under-utilised lands;
- (iii) Is within or adjoining the core[3] of an established or designated urban settlement;
- (iv) Will be essential in achieving compact and sustainable urban growth; and
- (v) There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.

3 A flood risk assessment to an appropriate level of detail has been carried out as part of the Strategic Environmental Assessment as part of the development plan preparation process, which demonstrates that flood risk to the development can be adequately managed and the use or development of the lands will not cause unacceptable adverse impacts elsewhere.

N.B. The acceptability or otherwise of levels of any residual risk should be made with consideration for the proposed development and the local context and should be described in the relevant flood risk assessment.

Plate 1 Justification Test for development plans

2.4.6 Strategic Flood Risk Assessment

A staged approach to flood risk assessment that covers both the likelihood of flooding and the potential consequences is recommended in carrying out a Strategic Flood Risk Assessment (SFRA). The stages of appraisal and assessment are:

Stage 1 Flood Risk Identification

Stage 2 Initial Flood Risk Assessment

Stage 3 Detailed Flood Risk Assessment

Stage 1 Flood risk identification – to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and local area plans (LAPs) or a proposed development site that may warrant further investigation at the appropriate lower level plan or planning application levels.

Stage 2 Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the requirements of the detailed assessment should be scoped.

Stage 3 Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

All stages may not be needed in the SFRA in order to inform the decision making process and often a Stage 2 assessment is sufficient at the strategic level to inform the decision making process. This will depend on the level of risk, the level of conflict with the proposed development and the scale of mitigation measure being proposed. For the purposes of applying the sequential approach, once a flood risk has been identified it can be avoided. Where development is planned in flood risk areas, a detailed assessment may be carried out within the SFRA, so that the potential for development of the lands and their environmental impact can be assessed.

A SFRA is individually designed to match the availability of data, scale and nature of the flood risk issues, the type of development and any focus on regeneration. The SFRA should provide sufficient information to make sound planning decisions,

including an identification and assessment of the impacts and mitigation strategies for development options.

The Stage 1 SFRA of the Variation will:

- Identify the broad nature of flood risk (type and source) within the study area
- Outline the flood risk management objectives to be included in the Variation
- Outline development management standards to be included in the Variation

The Stage 2 SFRA of the Variation will:

Provide an improved understanding of flood risk management issues associated with the Variation

- Provide more detailed assessment and management strategy for the transport infrastructure within the identified flood risk areas

Chapter 4 of this report describes the methodology of the stage 1 and 2 assessments and documents the findings of the SFRA for the Variation to the County Development Plan 2015 – 2021.

2.5 Climate Change Recommendations

The biggest threat to coastal flood risk areas is from sea level rise. Global mean sea levels are predicted to increase from a combination of thermal expansion of the water column and melt from the glaciers and reduction of liquid water storage on land. The Intergovernmental Panel on Climate Change Third Assessment Report (*IPPC TAR)* that preceded the published *IPCC Fourth Assessment Report* (2007) has been used as the basis of future sea level projections for Ireland. A best estimate increase of 480 mm to year 2100 has been suggested by Sweeney et al (2003) and used in the *Greater Dublin Strategic Drainage Study* (GDSDS 2005). This value was not directly challenged in the 2007 *IPCC* report, with a range of 0.2 - 0.51 m given for the prudent Medium-High A2 emission scenario.

The UK DEFRA (2006) publication suggests for the UK and globally that significantly higher rates of sea level rise, particularly towards the end of the century, than the 500mm allowance that is currently considered.

Table 3 **The UK Flood and Coastal Defence Appraisal Guidance (DEFRA, 2006) Regional Net Sea Level Rise Allowances**

Region	Assumed vertical land movement (mm/yr)	Net Sea-Level Rise (mm/yr)				Previous Allowances
		1990-2025	2025-2055	2055-2085	2085-2115	
East of England	-0.8	4.0	8.5	12.0	15.0	6mm/yr constant
South West and Wales	-0.5	3.5	8.0	11.5	14.5	5mm/yr constant
NW & NE England, Scotland	+0.8	2.5	7.0	10.0	13.0	4 mm/yr constant

The latest IPCC fifth Assessment Report (2014) has investigated the current and future trends in global mean sea level rise (GMSLR) and have concluded with a high level of confidence under various emission scenarios considered (four modelled RCPS (Representative Concentration Pathways) that thermal expansion of the sea due to warming will increase Global mean sea level by between 0.15 to 0.3m by 2100. This report predicts at medium confidence the contribution of glacier mass loss to GMSLR for the four RCP scenarios. The global glacier volume is projected to decrease by 15 to 55% for RCP2.6, and by 35 to 85% for RCP8.5 and in between these rates for the other two RCP scenarios. RCP2.6 is representative for scenarios leading to very low greenhouse gas concentration level, it is a so called “peak” scenario with radiative forcing reaching a peak level of 3.1 W/m^2 mid-century and returning back to 2.6W/m^2 by 2100. RCP8.5 is characterised by increasing greenhouse gas emissions overtime leading to high greenhouse gas concentrations by 2100.

Projections of GMSLR by 2100 under the high RCP8.5 scenario are 0.53 to 0.98m with rises of 8 – 16mm/annum during 2081 to 2100 and under the low RCP2.6 scenario are a rise is 0.28 to 0.61mm.

Observations of GMSLR show that from 1901 to 1990 1.5mm per annum mean rise and from 1993 to 2010 the mean rise was 3.2mm per annum.

The IPCC concluded that it is very likely that sea level will rise in more than about 95% of the ocean area. About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change. GMSLR during 1901–2010 can be accounted for by ocean thermal expansion, ice loss by glaciers and ice sheets, and change in liquid water storage on land. It is very likely that the 21st-century mean rate of GMSLR under all RCPs will exceed that of 1971–2010, due to the same processes. It is virtually certain that global mean sea level rise will continue

for many centuries beyond 2100, with the amount of rise dependent on future emissions.

The Irish Coastal Protection Strategy Study prepared by RPS on behalf of the OPW (RPS, 2010) uses a Mid-Range Future Scenario (MRFS) reflecting changes that are within the typical range projected for mean sea level rise of 500mm. The glacial isostatic adjustment for land movement along the west coast is projected to be very minor. An allowance of 500mm mean sea level rise to the year 2100, which accounts for a 500mm increase in mean sea level and no increase for isostatic land movement adjustment was included in that study to simulate a potential mid-range future climate change scenario.

The Flood Risk Planning Guidelines recommends a precautionary approach to climate change effects in respect to flooding due to the high level of uncertainty in predicting its effects. It recommends the following in this respect:

- Caution in zoning lands in these potential transitional areas that would be impacted if climate change predictions occur
- Ensuring that the level of structures designed to protect against flooding are sufficient over the lifetime of the design to cope with the effects of climate change
- Ensuring that structures to protect against flooding and the development are capable of adaption to the effects of climate change when there is more certainty as to the effects

Notwithstanding the above precautionary principle the flood risk zones defined in the Flood Risk Planning Guidelines are based on the present day assessment of the 100 year (1%) and 1000 year (0.1%) return period for fluvial flooding and the 200 (0.15%) year and 1000 (0.1%) year for tidal flooding. The OPW provide specific guidance as to the allowances in their publication entitled "Assessment of Potential Future Scenarios, Flood Risk Management Draft guidance, 2009 and these allowances are summarised in Table 4.

Table 4 Climate Change Allowances for Future Scenarios 100 year

Criteria	**Mid-Range Future Scenario MRFS**	**High-End Future Scenario HEFS**
Mean Sea Level Rise	+500mm	+1000mm
Land Movement	-0.5mm/year	-0.5mm/year
Extreme Rainfall Depths	+20%	+30%
Flood Flows	+20%	+30%

3. GALWAY TRANSPORT STRATEGY OVERVIEW

3.1 Introduction

Variation No. 1 to the County development Plan 2015 – 2021 is to incorporate where relevant the measures of the Galway Transport Strategy (GTS). The Galway Transport Strategy examines the transportation issues facing Galway City and surrounding areas at present, and aims to underpin future growth by establishing a long-term strategy for transport to, within and around the city. The GTS will facilitate Galway with an opportunity to grow both physically and economically, offering better transport choices and creating a public realm to be enjoyed by residents and visitors alike. This transport strategy will in turn underpin the objectives of the current and future Galway City and County Development Plans.

The overall vision is:

"to create a connected city region driven by smarter mobility."

To address the current and future transport needs of the city, it is concluded in the strategy that a fundamental shift is needed towards sustainable travel, reducing the dependency on the private car and taking action to make Galway City and its environs more accessible and connected, enhancing quality of life within the city for all. In order to achieve this vision the guiding principles underpinning the development of the Galway Transport Strategy are as follows:

- To promote and encourage sustainable transport, and in particular to make it convenient and attractive to walk, cycle or use public transport
- To improve accessibility and permeability to and within the city centre for pedestrians, cyclists and public transport users, while also maintaining an appropriate level of access for vehicular traffic for commercial and retail purposes
- To maximise the safety and security of pedestrians, cyclists and other transport users, particularly within the core city centre
- To manage and increase transport capacity, where necessary, for the efficient movement of people and goods into and within the city
- To provide opportunities to enhance the city centre Public Realm through traffic management and transport interventions
- To maintain and develop transport infrastructure and services to a high degree of quality and resilience
- To adopt a 'smarter technology' approach to all transport interventions, whereby transport infrastructure and services are future-proofed

The Galway Transport Strategy considers all transport modes, including but not limited to public transport, smarter mobility, cycling, walking, and road/street infrastructure. It assesses each in turn to establish its viability and suitability for a particular transport demand. It also includes assessment of transport linkages between the city and surrounding settlements. The various projects that are proposed to be implemented through the GTS can be grouped under the following headings:

- The pedestrian network
- The cycle network which includes the Bearna Greenway, the Galway to Dublin Cycleway (Galway City to Oranmore)[1], the Galway to Oughterard Greenway[2] and non-greenway elements
- The public transport network including increased frequency of buses and a new cross city access link
- The road network which includes the N6 Galway City Ring Road (GCRR) and modifications to the existing road infrastructure

3.2 Pedestrian Network

The proposed strategy provides for pedestrian priority within the city centre. A proposed cross-city link initiative will seek to reinforce the pedestrian at the top of the hierarchy of transport modes and underpin the planned transformation of the city centre. The limited number of crossings of the River Corrib within the city centre has been identified as a barrier to walking, in particular the poor quality pedestrian facilities at the bridges which are compounded by the heavy traffic flow across these bridges. It is proposed to provide a new pedestrian bridge crossing of the River Corrib downstream of the Salmon Weir Bridge and thereby remove pedestrians from the Salmon Weir Bridge. Other supporting measures for walking include an upgrade of road junction layouts and where appropriate provision of dedicated pedestrian crossings, provision of permeable pedestrian environments in residential areas, review of speed limits in the core city centre, removal of unnecessary street clutter to facilitate ease of movement along streets and the implementation of the Greenway Network, including the Bearna Greenway, the Galway to Dublin Cycleway (Galway City to Oranmore)[3], the Galway to Oughterard Greenway[4] (the extension of the Dangan Greenway to Oughterard via Maigh Cuilinn) so as to enhance leisure walking facilities. In terms of flood vulnerability the primary pedestrian routes within the city centre would be considered to be “less vulnerable development” and the amenity / greenway routes to be “water compatible development”.

[1] The GTS includes that portion of the Galway to Dublin Cycleway between Galway City and Oranmore.
[2] The GTS includes that portion of the Galway to Oughterard Greenway between Galway City and Moycullen.
[3] The GTS includes that portion of the Galway to Dublin Cycleway between Galway City and Oranmore.
[4] The GTS includes that portion of the Galway to Oughterard Greenway between Galway City and Moycullen.

3.3 Cycling Network

The overall aspiration of the proposed cycle network is to provide a safe and comfortable environment for cyclists in the city and surrounding areas which will encourage a greater modal shift from the private car to cycling. The existing cycling facilities in the city and surrounding areas are limited and discontinuous. The proposal in the strategy is to provide high quality dedicated cycling facilities and improve measures giving priority to cyclists with the objective of encouraging a greater uptake in cycling both for commuting and as a leisure activity in the city and surrounding areas.

The overall cycle plan has been formulated on three levels of network (Primary, Secondary and Feeder) which support each other and reinforce connections across the study area as shown in Figure 2 below. The primary network comprises two greenways providing connectivity for cyclists from nearby towns and villages (Bearna, Oranmore and Maigh Cuilinn), a cross city route and some key north south links. Primary routes are generally either segregated, off-road cycle only paths, or dedicated cycle lanes along new or existing roads. As part of the primary route network and greenways a bridge crossing is proposed over the River Corrib downstream of Wolfe Tone Bridge from the Claddagh Quay to the Spanish Arch.

The secondary network provides connections from residential areas and areas of employment to the primary network, accessing key destinations. Secondary links are a combination of off-road cycle paths, cycle lanes along existing roads, shared bus and cycle lanes and traffic calmed roads, with feeder links connecting residential areas to these facilities, generally in the form of traffic management on these routes.

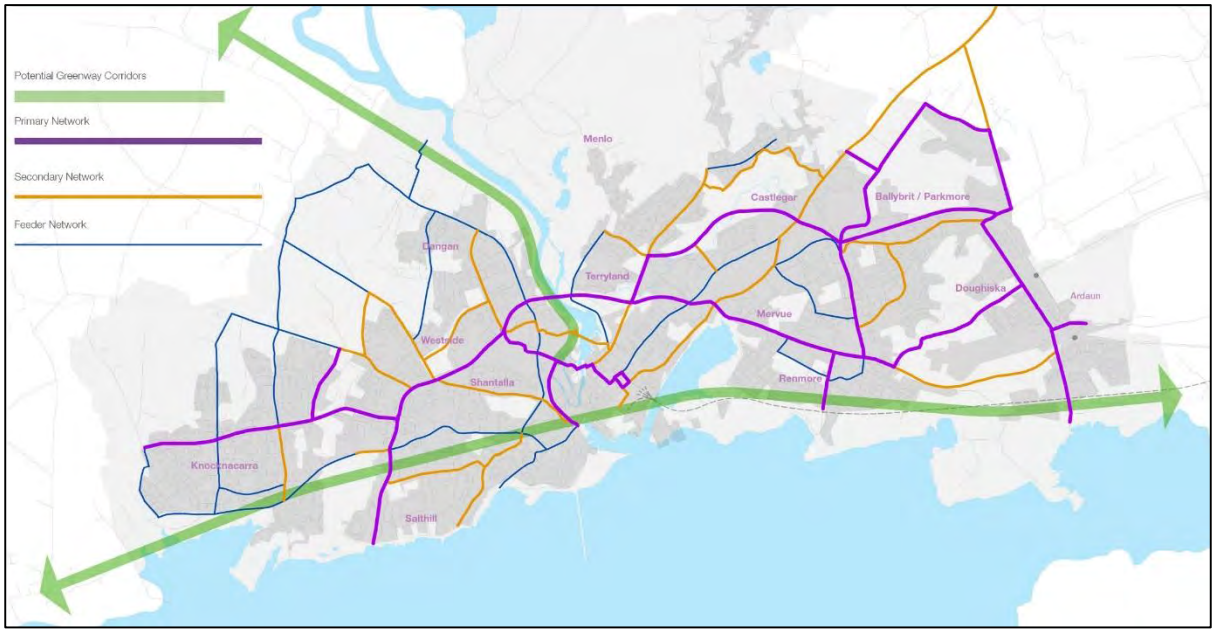


Figure 2 Proposed Cycle Routes and Greenways

In terms of flood vulnerability the primary and secondary cycle routes within the city centre would be considered to be “less vulnerable development” or even “water compatible development” and the amenity / greenway routes to be “water compatible development”.

3.4 Public Transport

A bus network is proposed which will be characterised by the provision of reliable high frequency services, and will operate cross-city and thus improve east-west connectivity to include Bearna, Parkmore and Oranmore. Certain areas of the proposed bus network will be the focus of implementation of significant infrastructural priority measures (through the provision of new bus lanes, removal of pinch points and delays and maximising the efficiency and reliability of services on the network) so as to make this mode more attractive than the private car.

The regional/intercity/commuter bus and coach network will for the most part avail of the bus network infrastructure proposals within the city area, in addition to other proposals outside the city, including, for example, the Tuam Road Bus Corridor scheme which is currently under development.

The bus network can be considered to be an essential transport infrastructure for the city and therefore is classified as high vulnerable development in respect to flood risk. The proposed bus network may be augmented by localised services over time; however these are considered to represent less vulnerable development.

Figure 3 Proposed Public Transport Network

3.5 Road Network

A defined "City Centre Access Network" is proposed to enable traffic to access and move around the core city centre area. This will involve revisions to road access, junctions and changes to flow direction.

Figure 4 Galway City Centre Access Network

The existing wider road network is crucial to the operation of the city and surrounding region. Even with the anticipated increased uptake in walking, cycling and public transport use, the regional and national road network within the study area is likely to suffer from increased congestion. In order to enhance Galway's function as a regional city and permit continued growth an additional river crossing is required. The N6 Galway City Ring Road project has identified the most suitable corridor for an orbital road scheme for Galway. In addition to the orbital route a number of ancillary, localised road links are proposed to improve connectivity at the local level.

It is considered that the existing national primary, secondary and regional roads (R446, R339, R336, N6, N17, N84 and N59) entering the city, the proposed N6 Galway City Ring Road and the proposed City Centre Access Network and Inner City Access Route are high vulnerability development given their strategic nature in terms of conducting traffic to, from and around the city and should ideally avoid flood risk areas (i.e. Zones A and B). Avoidance as a measure for the existing network may not be possible as such roads are existing and integral to the road network system.

Figure 5 N6 Galway City Ring Road and national routes linking to the City Centre Access Network

3.6 Park & Ride

It is proposed to provide Park & Ride sites on multiple approaches to the city which will be serviced by normal scheduled bus services. This will offer financial viability and offer a wider range of destinations with passengers being able to interchange between routes on the core bus network. This will provide alternatives to the private car for those accessing the city and thereby reduce traffic flows to and from the city.

The general areas for potential Park & Ride facilities have been identified in the vicinity of the M6, N17, and western approaches to the city.

4. STRATEGIC FLOOD RISK ASSESSMENT OF THE GTS

4.1 Overview of Sources of Flooding in Study Area

The SFRA has reviewed the potential for flood risk from fluvial coastal, pluvial and groundwater flooding as a result of the Variation and involved consulting:

- the OPW National Preliminary Flood Risk Assessment (pFRA) Mapping
- the OPW CFRAM (Catchment Flood Risk Assessment and Management) mapping for the Areas for Further Assessment (AFA) of Galway City and Oughterard Village and associated hydrological reports
- the Irish Coastal Protection Strategic Study - Western Coast and other relevant mapping including historical OSI mapping
- the OPW River Corrib Benefiting Lands mapping (developed as part of the River Corrib-Clare Arterial Drainage Scheme)
- known historical flooding areas and extents

The web portal floodmaps.ie provides a national archive of information on historical flood events including locations, reports, photographs, drawings and newspaper archives, which assists in the compilation of historical flood information. Other sources consulted as reference information are the SFRAs for the various development plans including the Galway County and Galway City Development Plans and various LAPS including Bearna and Oranmore and the Galway Transport Strategy.

The sources of information on flood risk along the proposed infrastructure routes are summarised in Table 3 below.

Table 3 Flood Risk Source Evaluation

Title	Description	Quality	Confidence
OPW – Arterial Drainage Land benefitting maps	Mapping of lands identified through walkover and consultation by OPW of lands	medium	Low to medium
Historical flood records including photos and reports	Various sources including various local authority records, reports, photos, archives and the floodmaps.ie repository	Variable	Low to high
OPW pFRA Mapping	The Preliminary Flood Risk Assessment (PFRA) national screening exercise to identify areas at flood risk and includes, pluvial, fluvial, groundwater and tidal.	Medium	Medium

Title	Description	Quality	Confidence
Irish Coastal Protection Strategy Study	Prediction of tidal events under storm surge events for the western region which includes tidal levels and coastal erosion of soft shoreline areas	High	High
Walkover Survey	Specific visits to selected locations and key structures and flood defences	medium	Low
Western CFRAM (draft)	Draft Western CFRAM maps	High	High
SFRA for Development Plans	Stage 1 / 2 SFRA undertaken for Local Area and city and county Plans (Bearna, Oranmore, Moycullen, Spiddal, Galway City and Galway County)	Medium	Medium

The study area is located principally within Hydrometric Area 30 (River Corrib System) but also to the west within Hydrometric Area 31 and to the southeast in Hydrometric Area 29.

The pFRA mapping is generally used in Ireland in combination with other information as a coarse screening tool for identifying potential flood hazard and the requirement for further more detailed stage 2 and stage 3 flood risk assessments. This pFRA national mapping was produced from simplified river, pluvial and tidal surge hydraulic models using relatively coarse lidar data for flood routing purposes. Historical mapping and aerial flood photos were also relied upon in respect to groundwater and pluvial flooding. The pFRA mapping can only be treated as coarse, indicative mapping of potential flood hazards in an area and should be combined with other information sources.

The more detailed CFRAM study, carried out for identified AFA's (relevant to this strategy are Galway City, Oranmore, and Claregalway), involve more detailed channel and floodplain survey, AFA lidar topographical survey, hydrological analysis and hydraulic flood modelling and provides more accurate and refined mapping for fluvial and coastal flood processes. It should be noted that the villages of Maigh Cuilinn and Bearna were not identified as AFA's and therefore do not have detailed CFRAM mapping available.

4.1.1 Tidal and Coastal Flooding

The main flood risk areas within the study area are the shoreline areas from Bearna to Oranmore and in particular low-lying lands below 4.2m O.D. Malin, namely the White Strand Area and the Bearna Pier, Salthill Promenade, Whitestrand, Claddagh, Southpark, Flood street, Docks area and the Oranmore Coast road (R338) at Oranmore (near Green Island, St. Mary's Quay, Bohernasup, and Innplot). These areas are at risk from flooding by tidal inundation during storm surge events. To date the highest storm event recorded reached a flood level of c. 3.6m O.D. in the Claddagh Basin and a similar level at the Oranmore tidal gauge.

The existing R336 Spiddal Road is sufficiently elevated as not to be at risk from Coastal Flooding with the lowest road elevation (in the vicinity of the Bearna Stream crossing) above 6m O.D. Malin. Therefore the indicative corridor for the Bearna Greenway, proposed cycle network and bus network are not subject to coastal flood risk. The proposed route of the N6 Galway City Ring Road is located well outside of the Coastal Flood Risk Zone. The proposed Park & Ride facility location has not been specified and therefore the selection of a suitable site should avoid areas identified as flood risk zones.

4.1.2 Fluvial Flooding

The study area falls within hydrometric areas 29, 30 and 31 (29 Galway Bay Southeast Catchment, 30 The Corrib Catchment, 31 The Galway Bay North
The principal rivers/streams within the study area are:

- Sruthán na Líbeirtí
- Trusky Stream
- Bearna River
- Knocknacarra Stream
- River Corrib
- The Oranmore River

The River Corrib represents the largest watercourse having a catchment area of some 3,135 km^2 to Salmon Weir in Galway City. The Office of Public Works (OPW) regulate water levels in the River Corrib and Lough Corrib through gated control at the Salmon Weir Barrage. The regulation level range for the lake is set at 28ft to 30ft Poolbeg (5.8 to 6.4m OD Malin) for navigation and flooding control. Gates are opened and closed by the OPW depending on existing and forecasted rainfall conditions. The canals and mill races through the city are fed by the River Corrib upstream of the Salmon Weir Barrage and outfall into the River Corrib Estuary. The Eglington Canal is prone to siltation as the flow through this is restricted by lock gates, weirs and turbines. The other rivers/streams have catchments that are very minor in area in comparison and do not represent a significant source of flood risk with only localised flooding along their reaches.

The Oranmore River which flows through Oranmore Village has a catchment area of approximately 58km^2, it drains a karst groundwater region and is subject to winter flooding when the groundwater table is elevated. The river system drains through extensive wetland areas upstream of Oranmore Village (Carrowmoneash, Mallynageeha and the Moneymore marshes) which attenuate flood flows. Fluvial flood risk from this river applies to a section of the existing N18 road, a section of residential development and the Old N6 Dublin Road Bridge (R336). OPW have carried local flood relief works on the Oranmore River to protect a number of properties from flooding.

In the Bearna area there are a number of minor coastal streams that cross the R336 at An Báile Nua, and at Bearna Village including the Liberty and Trusky Stream crossings.

The pFRA mapping shows relatively narrow linear flood risk zones running longitudinally adjacent to the stream channels. The pFRA mapping indicates for the Trusky Stream a flood risk to the R336 in Bearna Village is associated with the existing culverted road crossings. Refer to Figures 4 and 5 below.

Figure 5 presents the available flood risk indicative mapping for the Trusky Stream based on the OPW PFRA mapping, the ICPSS mapping and the JBA sFRA mapping for the Bearna Local Area Plan. This indicate a relatively wide zone of potential flood risk along both west and east tributaries of the Trusky Stream and the flood risk potential at the R336 Road crossing.

As part of the N6 GCRR project the above tributaries where intercepted by the proposed road development have been assessed for flood risk and return period flows and flood levels have been estimated.

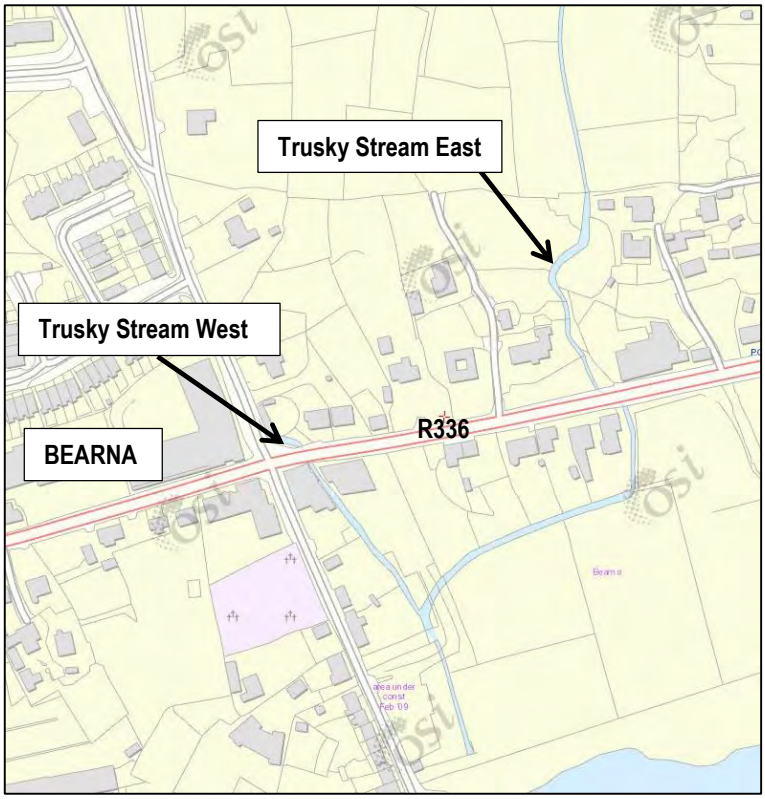


Figure 4: Trusky Stream at Bearna

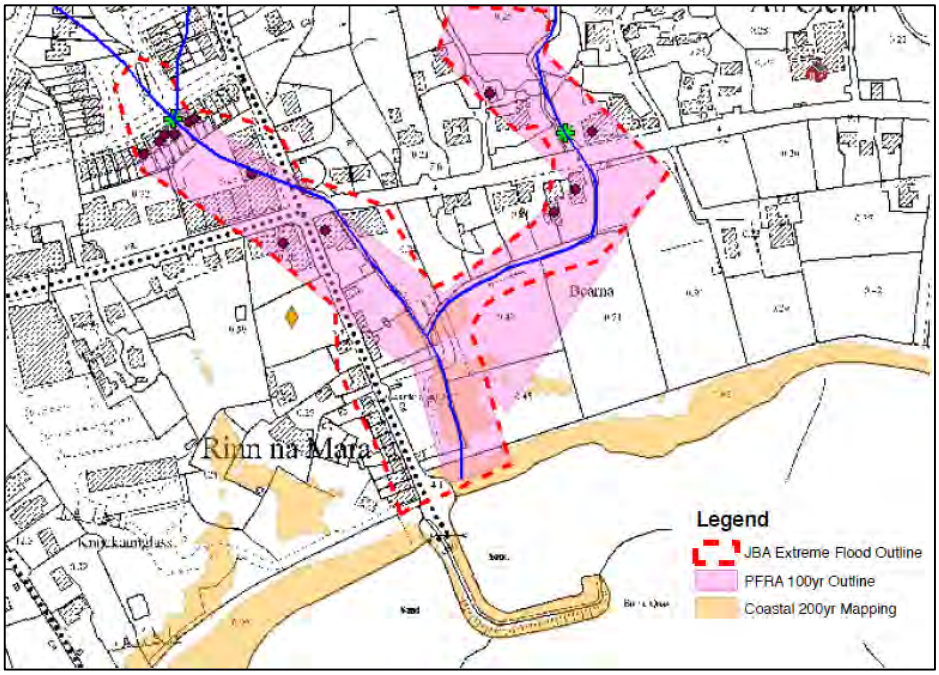


Figure 5 OPW pFRA and JBA extreme flood mapping for Trusky Stream at Bearna

4.1.3 Pluvial Flooding Sources

Pluvial Flooding results in the filling and ponding of runoff waters with within local depression topography areas which can result when rainfall intensity and duration exceed the infiltration capacity of the underlying soil causing temporary (over a few hours) building up of flood waters in such areas. In the national PFRA study a simplified model for pluvial flooding was developed which identified from aerial lidar data local depressions and their surrounding contributing catchment area. The potential for ponding and the extent of ponding was determined for these depressions using Met Eireann storm rainfall statistics and soil infiltration characteristics based on soil, subsoil and groundwater aquifer maps. These pluvial flood areas were mapped and presented in the PFRA Maps refer to Appendix A.

Potential pluvial Flood Risk Areas are shown scattered throughout the Galway City and County and are generally small and of limited consequence for the proposed transport network.

An area of pluvial flood risk that potentially could impact the transport network is the existing N17 Tuam Road section at Twomileditch. Regular flooding occurs during intense rainfall events with runoff from the steep hill slopes at Ballybrit flooding the N17 Tuam Road and adjoining properties (Ryan Hanley Report (2004) N17 Flood Relief Project for Galway City Council). The N17 Tuam Road in times of severe flood acts almost as a streambed over its 1800m length conveying flood water along the road to discharge to groundwater to the northeast of the N17 Tuam Road near Parkmore. This groundwater discharge zone is potentially linked to the Castlegar area and the Terryland River Basin.

4.1.4 Groundwater

Groundwater flooding is associated with areas of high water table levels which can generally result in small areas of winter ponding of lands gradually filling and empting between autumn and spring. These flood areas are generally referred to as seasonal lakes or turloughs. They are generally slow to fill and often slower to recede and within the study area are associated with the karst limestone bedrock to the east of the River Corrib. Turlough Features are also present in the Moycullen, Oranmore and Claregalway areas. The N59 Moycullen Road generally represents the boundary between granite and limestone bedrock. The limestone areas to the east of the city give rise to small turlough features, karst springs and swallow-hole systems and areas vulnerable to flooding are the Doughiska, Ardaun and Glennascaul and the Carnmore areas. A flood relief culvert has been provided to relieve flooding in Doughiska area taking the pluvial and groundwater flows and discharging to the sea via a 1500mm diameter storm pipe.

The Bearna area is located in a granite bedrock formation which is a poor aquifer and generally not associated with the formation of turloughs and associated karst features. Due to the undulating and impervious nature of the bedrock, perched water tables are present which are often associated with peatland bog areas.

The Oranmore and Claregalway areas are located in karst limestone bedrock areas and the underlying bedrock aquifer is a regionally important karst conduit flow bedrock aquifers. Both locations have numerous turlough, swallow hole and spring features which give rise to winter flooding.

4.1.5 Urban Stormwater Drainage

In Galway City the urban storm water drainage system varies between new separated storm sewers and older separated and combined storm sewers. The storm water sewer system in places has been upgraded so as to reduce flash storm water flooding. The design standard varies but generally for the more recent storm water sewers a 30year surcharge capacity is provided. Storm water gullies are prone to blockage which can give rise to localised flooding issues as can storm water outfalls. The use of attenuation tanks for housing developments, hard paved areas and roadways as part of SUDS (Sustainable Urban Drainage System) with storage and restricted outfall discharge can give rise to flood hazards where the outfall is blocked through lack of maintenance or its storage capacity has been exceeded.

There is no indication of any urban storm water drainage flooding issues within the Bearna Village area. The recent new developments involved the laying of a large trunk storm sewer which discharges to the Trusky Stream as it enters Galway Bay. There are also no historical flooding issues with the storm drainage network in the Oranmore urban area, except for minor flooding in the vicinity of the N6 / N18 and N17 roundabouts and at N6 dual carriageway overpass at Gurrane South.

Generally urban drainage investigation and analysis is more typical of stage three flood risk assessment requiring the link between the sewer network model and the 2d model of the urban topography to determine the flow pathways and the flood zone mapping.

4.1.6 Climate Change

The biggest threat to coastal flood risk areas is from sea level rise. Global mean sea levels are predicted to increase from a combination of thermal expansion of the water column and melt from the glaciers and reduction of liquid water storage on land. The Intergovernmental Panel on Climate Change Third Assessment Report (*IPPC TAR)* that preceded the published *IPCC Fourth Assessment Report* (2007) has been used as the basis of future sea level projections for Ireland. A best estimate increase of 480 mm to year 2100 has been suggested by Sweeney et al (2003) and used in the

Greater Dublin Strategic Drainage Study (GDSDS 2005). This value was not directly challenged in the 2007 *IPCC* report, with a range of 0.2 - 0.51 m given for the prudent Medium-High A2 emission scenario.

The UK DEFRA (2006) publication suggests for the UK and globally that significantly higher rates of sea level rise, particularly towards the end of the century, than the 500mm allowance that is currently considered.

Table 4 **The UK Flood and Coastal Defence Appraisal Guidance (DEFRA, 2006) Regional Net Sea Level Rise Allowances**

Region	Assumed vertical land movement (mm/yr)	Net Sea-Level Rise (mm/yr)				Previous Allowances
		1990-2025	2025-2055	2055-2085	2085-2115	
East of England	-0.8	4.0	8.5	12.0	15.0	6mm/yr constant
South West and Wales	-0.5	3.5	8.0	11.5	14.5	5mm/yr constant
NW & NE England, Scotland	+0.8	2.5	7.0	10.0	13.0	4 mm/yr constant

The latest IPCC fifth Assessment Report (2014) has investigated the current and future trends in global mean sea level rise (GMSLR) and have concluded with a high level of confidence under various emission scenarios considered (four modelled RCPS (Representative Concentration Pathways) that thermal expansion of the sea due to warming will increase Global mean sea level by between 0.15 to 0.3m by 2100. This report predicts at medium confidence the contribution of glacier mass loss to GMSLR for the four RCP scenarios. The global glacier volume is projected to decrease by 15 to 55% for RCP2.6, and by 35 to 85% for RCP8.5 and in between these rates for the other two RCP scenarios. RCP2.6 is representative for scenarios leading to very low greenhouse gas concentration level, it is a so called “peak” scenario with radiative forcing reaching a peak level of 3.1 W/m^2 mid-century and returning back to 2.6W/m^2 by 2100. RCP8.5 is characterised by increasing greenhouse gas emissions overtime leading to high greenhouse gas concentrations by 2100.

Projections of GMSLR by 2100 under the high RCP8.5 scenario are 0.53 to 0.98m with rises of 8 – 16mm/annum during 2081 to 2100 and under the low RCP2.6 scenario are a rise is 0.28 to 0.61mm.

Observations of GMSLR show that from 1901 to 1990 1.5mm per annum mean rise and from 1993 to 2010 the mean rise was 3.2mm per annum.

The IPCC concluded that it is very likely that sea level will rise in more than about 95% of the ocean area. About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change. GMSLR during 1901–2010 can be accounted for by ocean thermal expansion, ice loss by glaciers and ice sheets, and change in liquid water storage on land. It is very likely that the 21st-century mean rate of GMSLR under all RCPs will exceed that of 1971–2010, due to the same processes. It is virtually certain that global mean sea level rise will continue for many centuries beyond 2100, with the amount of rise dependent on future emissions.

The Irish Coastal Protection Strategy Study prepared by RPS on behalf of the OPW (RPS, 2010) uses a Mid-Range Future Scenario (MRFS) reflecting changes that are within the typical range projected for mean sea level rise of 500mm. The glacial isostatic adjustment for land movement along the west coast is projected to be very minor. An allowance of 500mm mean sea level rise to the year 2100, which accounts for a 500mm increase in mean sea level and no increase for isostatic land movement adjustment was included in that study to simulate a potential mid-range future climate change scenario.

The Flood Risk Planning Guidelines recommends a precautionary approach to climate change effects in respect to flooding due to the high level of uncertainty in predicting its effects. It recommends the following in this respect:

- Caution in zoning lands in these potential transitional areas that would be impacted if climate change predictions occur
- Ensuring that the level of structures designed to protect against flooding are sufficient over the lifetime of the design to cope with the effects of climate change
- Ensuring that structures to protect against flooding and the development are capable of adaption to the effects of climate change when there is more certainty as to the effects

Notwithstanding the above precautionary principle the flood risk zones defined in the Flood Risk Planning Guidelines are based on the present day assessment of the 100 year (1%) and 1000 year (0.1%) return period for fluvial flooding and the 200 year and 1000 year for tidal flooding. The OPW provide specific guidance as to the allowances in their publication entitled “Assessment of Potential Future Scenarios, Flood Risk Management Draft guidance, 2009 and these allowances are summarised in Table 5.

Table 5 Climate Change Allowances for Future Scenarios 100 year

Criteria	Mid-Range Future Scenario MRFS	High-End Future Scenario HEFS
Mean Sea Level Rise	+500mm	+1000mm
Land Movement	-0.5mm/year	-0.5mm/year
Extreme Rainfall Depths	+20%	+30%
Flood Flows	+20%	+30%

4.2 Stage 1 Flood Risk identification

As stated previously the aim of Variation No. 1 to the Galway County Development Plan 2015-2021 is to incorporate where relevant the measures of the GTS.

The proposed transport measures and transport networks were provided digitally and overlaid in GIS with OSI background mapping and relevant flood risk mapping for flood hazard identification and flood risk quantification purposes.

The indicative routes of the proposed networks for the various Galway Transport Strategy measures (walking, cycling, bus and road networks) which are the subject of the Variation to Galway County Development Plan 2015-2021 have been superimposed onto the OPW pFRA and draft CFRAM Flood Risk mapping which is included in Appendix A to this report. This mapping demonstrates at numerous locations the close proximity and potential encroachment of the various transport measures to various flood risk areas.

4.2.1 GTS Walkway Network

The greenway areas which will facilitate walking are shown in many locations to be in the high flood risk zone from generally coastal and fluvial flood risk.

4.2.2 GTS Cycle Network

The cycle network is shown to be at risk from coastal, fluvial and pluvial flood sources with the path of primary cycle network along the Galway City coastline situated within the extreme and indicative coastal flooding extents at various locations, particularly along Salthill Promenade, the Claddagh area, the Galway Docks area, Lough Atalia and the Oranmore Coast Road area near Oranmore. The proposed cycle network also has a potential fluvial flood risk from the River Corrib floodplain. A number of smaller streams to the west towards Bearna are also crossed by the proposed cycle network including the Knocknacarra Stream, the Bearna Stream, the Trusky Stream and the Sruthán na Líbeirtí Stream. Local pluvial flood risk sources (ponding within topographical depressions) have also been identified at a number of locations within

the proposed cycle network. The proposed Galway to Oughterard Greenway crosses a number of tributaries of the River Corrib along its indicative route. It also traverses through and adjacent to the flood plain of the River Corrib and Lough Corrib and the Owenriff River Floodplain at Oughterard along its proposed indicative route. The current draft CFRAM mapping also confirms these sources of potential coastal and fluvial flood risk to the proposed cycle network. The OPW Benefitting Lands mapping (used as an indicator of fluvial Flood risk also identifies fluvial flood risk) from the River Corrib catchment.

4.2.2 GTS Road Network

The proposed N6 GCRR and its various road linkages and junction upgrades are shown, from the various flood risk mapping sources, to have the potential to intercept fluvial, groundwater and pluvial flood risk sources. The proposed N6 GCRR corridor crosses the River Corrib at the townlands of Menlough and Dangan where it has the potential to encroach the river channel and its floodplain. The proposed road development also crosses a number of smaller streams to the west towards Bearna including the the Bearna Stream, the Trusky Stream and the Sruthán na Líbeirtí Stream. A potential source of groundwater flooding is identified adjacent to its corridor at Doughiska, Coolagh and Castlegar areas and potential pluvial sources at a number of locations along its corridor. Coastal flood risk has generally not being identified for the other proposed road links and junction upgrades within the county.

4.2.3 GTS Bus Network

The proposed bus network including new bus routes and bus corridors is shown to potentially have flood risk from various coastal, groundwater, pluvial and fluvial sources based on the pFRA mapping and also historical information.

4.2.4 Summary of Stage 1 Flood Risk Identification

It is important to note that the information relied on for the Stage 1 screening assessment (particularly the pFRA mapping, the OPW land benefitting mapping and the Irish Coastal Protection Strategic Study mapping) is only indicative and may both exaggerate or underestimate and possibly miss out altogether potential flood hazards. Nevertheless, there is sufficient information available for the screening assessment to conclude that the various measures outlined in the Galway Transport Strategy, which is the subject of Variation No. 1 to the County Development Plan 2015 - 2021 have potential flood risk from the following sources coastal, fluvial, pluvial, groundwater and urban drainage. It is therefore concluded that a Stage 2 Flood Risk Assessment for Variation No. 1 to the County Development Plan 2015 – 2021 is required in order to assess and manage flood risk in accordance with the Flood Risk Management Planning Guidelines.

4.3 Stage 2 Initial Flood Risk Assessment

4.3.1 Introduction

This Stage 2 assessment investigates in more detail the flood risk implications and management options associated with the various modes of transport and associated measures in the GTS that are relevant to the Variation to the County Development Plan 2015 - 2021.

The draft CFRAM maps were used to inform the Stage 2 assessment in respect to fluvial and coastal sources. Although the CFRAM mapping is currently in draft format this mapping has undergone public consultation and full review and is now considered to be finalised mapping. It is expected that this mapping and the CFRAM assessments will be regularly updated and reviewed into the future.

By the nature of transport infrastructure crossing of watercourses (rivers estuaries and floodplains) are often unavoidable as the purpose is to link lands that are likely to be separated by a number of watercourses. A sequential approach may be adopted in respect to a route selection process for a project which takes into account many environmental factors which include flood risk and hydrology to select the most suitable route. The N6 GCRR will also cross other minor water courses which are small and of limited floodplain area and will only require culverting of the channel to facilitate the proposed road.

4.3.2 Greenway and Primary Cycle and Bus Network

The existing R336 Spiddal Road has associated residual flood risk from the existing culverted stream crossings. This risk is a residual risk whereby the relatively small existing culverts have a potential to become blocked either through a lack of maintenance and inspection, vegetation growth (very aggressive within these stream catchments) and by floating debris carried during floods. In such cases there is a potential for the streams to overtop across the R336 continuing in their southerly direction towards Galway Bay. In such cases the flood depth across the road will be relatively shallow and given the small catchment size and associated short storm duration such potential flooding will only occur for a number of hours before receding.

The Western CFRAM flood risk review of potential AFAs (Area for Further Assessment) that included Bearna concluded that in respect to the Bearna area a relatively low flood risk exists due to the recent upgrades to the urban storm drainage in Bearna Village. The review identified that the Trusky Stream eastern branch was a very small and overgrown watercourse having a small culvert under the R336 and risk from this watercourse is very limited. Blockage of R336 culvert may result in localised flooding but water would likely flow over the R336 and only cause limited property impact.

In the Oranmore area the flood risk to the potential greenway and primary cycle and bus network is from the coastal inundation of relatively low-lying lands which includes;

the R338 road near Green Island, St. Mary's Quay and the R338 road bridge over the Oranmore River. Groundwater and pluvial flooding do not pose a significant flood risk to the greenway and primary cycle network. Fluvial flood risk to the existing N18 road exists at Oranmore from the Oranmore River. Pluvial storm water flood risk also exists for a short section of the existing N6 dual carriageway as does pluvial storm water flood risk of the Dublin Road and the Claregalway roundabouts which would subject the bus network to flood risk. Extensive turlough and surface flooding of low lying wetlands exists in the Oranmore area but this flooding is generally isolated to low-lying lands and away from the potential greenway and road routes.

The proposed green way and cycle networks would be considered less vulnerable to almost water compatible development and suitable for development within Flood Zone A. The proposed bus network would also be considered to be less vulnerable development in respect to flooding and therefore may on occasion be disrupted. However, fluvial flooding of the R336 will be infrequent and limited in extent and duration. Currently the R336 road is a regional Bus Route and disruption of this route within the Bearna Local Area through fluvial flooding is not evident. Coastal flooding of the R338 road at Oranmore would be infrequent and of short duration for a number of hours approaching highwater during tidal storm surge combining with high spring tides.

4.3.3 N6 Galway City Ring Road

By the nature of transport infrastructure crossing of watercourses and thus high flood risk zones is generally unavoidable as the purpose of such a road development is to linearly traverse lands that are likely to be separated by watercourses and flood prone areas. A sequential approach is adopted in respect to a route selection process for such road projects including the N6GCRR which takes into account many environmental, social, engineering and economic factors, which includes flood risk and hydrology to select the most suitable route.

The N6 GCRR within the study area for the Bearna LAP crosses a number of minor watercourses, all of which have very limited contributing catchments and floodplain extents. A total of nine watercourse crossings are proposed for the N6 GCRR development within the study area for the Bearna LAP and these crossings are summarised below in Table 6.

A detailed flooding assessment will be carried out for all of stream crossings to inform the road design in terms of flood risk and flood impact.

The N6 GCRR is subject to Section 50 approval from the OPW under the 1945 arterial drainage act for all of these watercourse crossings requiring new or upgraded or extended culverts and bridges and such an assessment will include for a robust design flow of the 100 year plus statistical error plus 20% increase for climate change allowance and a freeboard allowance for clearance between the proposed road culvert soffit and the design flood level.

Generally west of the River Corrib the proposed N6 GCRR corridor passes through pockets of wet, marshy ground due to the poor draining peaty / silty nature of the quaternary and the shallow, undulating impermeable granite bedrock. These characteristics give rise to sections of wet grassland and to a lesser extent wet heath along the road alignment. These sections of poor draining land do not present a flood risk to the proposed road as the road can be adjusted both horizontally and vertically to minimise the flood risk and impact on such wetland systems.

To the east of the River Corrib the route passes through karst limestone terrain that is generally free draining and of low flood risk. Exceptions to this are at Doughiska and Twomileditch on the N17 Tuam Road. At Doughiska flooding has previously occurred. Flood relief allowing the urban development of Doughiska involved the laying of a large 1500mm diameter storm drainage pipe to convey storm water and winter groundwater /pluvial flood water away from this area and discharge it to the sea at Renmore. A significant flood risk area crossed by the N6 GCRR is the existing N17 Tuam Road at Twomileditch which has seen regular flash flooding and winter flooding of the N17 Tuam Road between the site of the Kenny Garage and the Roadstone Quarry entrance. A drainage solution is required for this area to ensure that the proposed N6 GCRR does not exacerbate flooding in this area and where possible improve the drainage of this area.

4.3.4 Proposed Park & Ride Facilities

It is proposed to provide Park & Ride facilities on multiple approaches to Galway City which will be serviced by roads, cycle and bus network routes. The general areas for potential Park & Ride facilities have been identified in the vicinity of the existing N6, N17, and western approaches to the city. Flood risk avoidance measures are proposed as follows:

Table 9 SFRA for the Proposed Park & Ride Facilities

Site Description	The general area for such Park & Ride facilities has been identified but not the specific sites locations. Potential Park & Ride sites are proposed off the M6, N17 and west of the city.
Development Considerations and Flood Risk Management	Given that these are new proposed facilities, the siting of these facilities should be located within Flood Zone C with climate change scenarios considered and away from any potential coastal erosion areas and sensitive ecological areas that include wetlands. Sustainable urban drainage systems will be used to mitigate flood risk and impact associated with runoff from large urban pavement areas.

5. CONCLUSION

A strategic flood risk assessment (SFRA) was carried out for the GTS measures relevant to Galway County Council and which are the subject of the Variation No. 1 to the County Development Plan 2015 – 2021. In this respect the SFRA investigated potential flood risk issues for the N6 Galway City Ring Road (GCRR) corridor, the indicative corridor for the greenways, Park & Ride facilities and proposed pedestrian, cycle and bus network routes within the study area.

The principal source of flood risk to these elements is fluvial flood risk from the River Corrib at the proposed crossing point for the N6 GCRR and from a number of small streams to the west of the River Corrib. The SFRA concludes that the proposed N6 GCRR development can be suitably designed in terms of culvert sizes, vertical alignment and storm water attenuation so as not to be at flood risk and not to cause any significant impact on flooding and flood risk elsewhere.

A significant pluvial flood risk was identified for the Twomileditch section of the N17 Tuam Road within the corridor of the N6 GCRR. A drainage solution for this section is required to protect the existing N17 road from flooding and the adjacent low-lying dwellings and properties fronting the existing N17 Tuam Road. This drainage solution should be incorporated in the N6 GCRR road drainage design so that there is no potential for the N6 GCRR to exacerbate flooding as crosses this flood zone and potentially discharge to it.

In respect to the proposed greenway, cycle network and the bus networks the principal sources of flood risk to these elements are coastal flood risk along the R338 road in the Oranmore area, fluvial flood risk to the N18 road from the Oranmore River near Oranmore, fluvial flood risk from the River Clare to the N17 road in the Claregalway area, and pluvial flood risk to the N17 road at Twomileditch Galway.

Such flood risk will only impact a very limited sections of existing roadway that may potentially facilitate the proposed greenway, cycle network and/or bus network routes. The greenway and cycle transport modes could be considered to be less vulnerable development to almost water compatible development and suitable for development within Flood Zone A or in flood protected lands where a residual flood risk remains. The bus network would be considered to be less vulnerable development in respect to flooding and therefore may on occasion be disrupted without suffering significant impact.

No specific site has been identified for a proposed Park & Ride facilities and therefore the siting of such should avoid the high and moderate flood risk zones A and B. The surface water drainage from such facilities should be attenuated to greenfield runoff rates so as not to impact on the flood regime in receiving watercourses or groundwater systems.

By the nature of transport infrastructure crossing of watercourses (rivers, estuaries and floodplains) and avoidance of fluvial, coastal, pluvial, groundwater and urban drainage flood risk sources and zones is often unavoidable as the purpose is to link lands that are likely to be separated by a number of flood hazards. This strategic flood risk assessment has for the various elements of the Variation identified the principal sources of flood risk, evaluated the flood risk from these sources in respect to the flood vulnerability of the various infrastructure measures and has set out specific flood risk management strategies to mitigate such potential impacts, principally through avoidance, design, protection and management of the flood hazard.

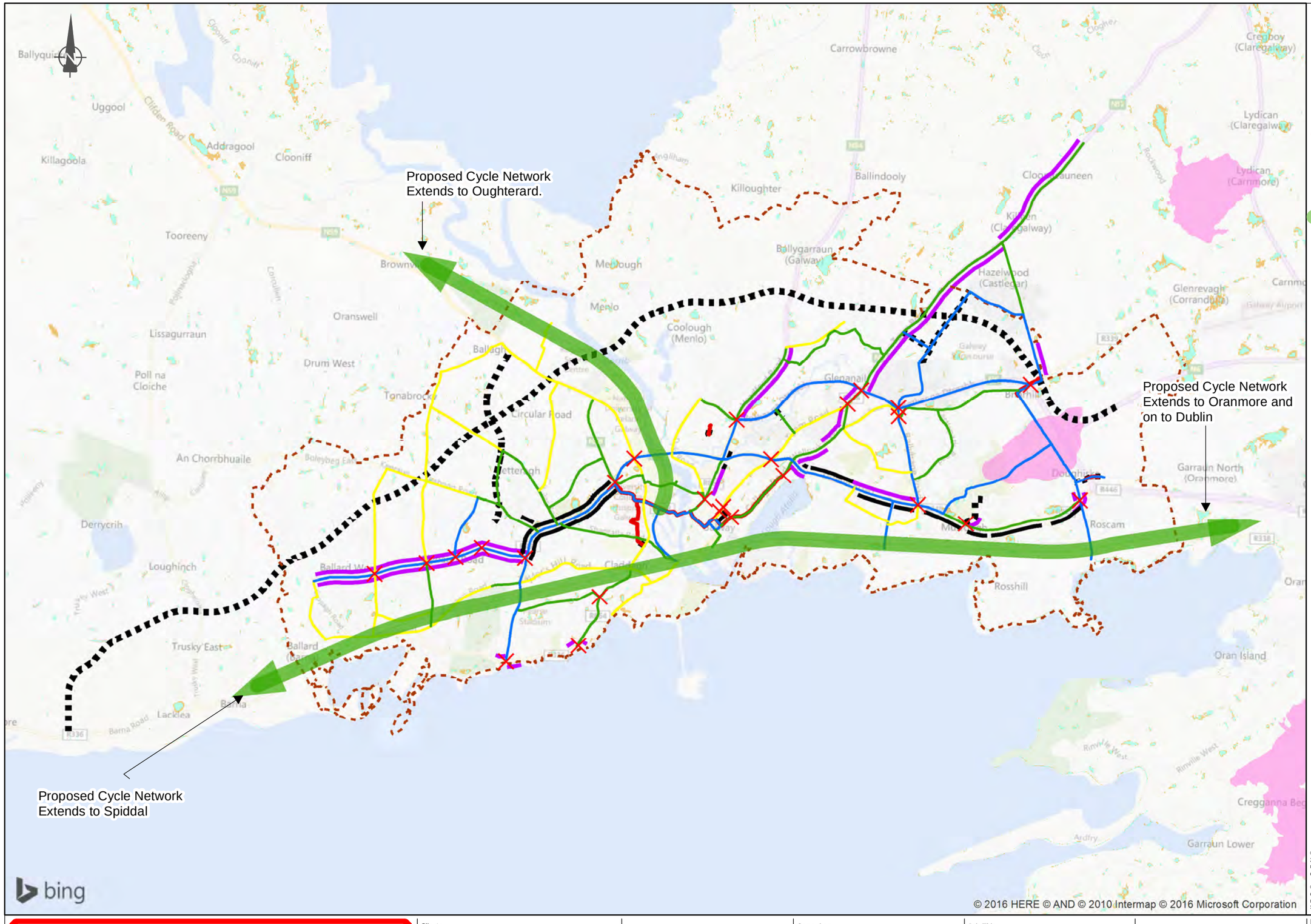
The SFRA has taken cognisance to the potential for future increases in flood risk caused by climate change factors, in particular sea level rise, increased storm activity increased fluvial and rainfall intensities as per the current adopted climate change guidance have been assessed.

In a number of cases where the transport measure has to rely on the existing road infrastructure it is not possible to avoid high and moderate flood risk zones and consequently active management of the flood hazard through existing defences and flood risk warnings will be required and which may become more challenging in the future if predicted sea level rise and storm rainfall increases are realised.

It is concluded that the GTS measures relevant to Galway County Council and which are the subject of Variation No. 1 to the County Development Plan 2015-2021 are sustainable in respect to the Flood Risk Management Planning guidelines and can be implemented so as to minimise flood risk to the GTS measures and potential flood impacts arising from such measures.

Appendix A

A3



FOR INFORMATION

Legend

- City Boundary

GTS Measures

- Proposed Bus and Local Access only
- Proposed Bus Lane
- Existing Bus Lane
- Potential Greenway Corridors
- Primary Cycle Network
- Secondary Cycle Network
- Feeder Cycle Network
- Junction Upgrades
- Road Links

PFRA Flood Risk

- Groundwater
- Pluvial Indicative
- Pluvial Extreme

Disclaimer Note:
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Clients

Consultant
ARUP
Corporate House
City East Business Park
Ballybrit, Galway, Ireland
Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

Job Title
Variation No. 1 to Galway County Development Plan 2015 -2021

Scale: **1:50,000**

Date: January 2017

Issue	Date	By	Chkd	Appd
I1	12/01/2017	NOR	MH	EMC

Drawing Title
GTS Measures with PFRA Flood Risk Mapping - Pluvial & Groundwater

Drawing Status
For Information

Job No	Drawing No	Issue
233985	**GCOB-SK-D-729**	**I1**

A3

'Insert A'

Proposed Cycle Network Extends to Oughterard.

Proposed Cycle Network Extends to Oranmore and on to Dublin

Proposed Cycle Network Extends to Spiddal

FOR INFORMATION

Legend

- City Boundary

GTS Measures

- Proposed Bus and Local Access only
- Proposed Bus Lane
- Existing Bus Lane
- Potential Greenway Corridors
- Primary Cycle Network
- Secondary Cycle Network
- Feeder Cycle Network
- Junction Upgrades
- Road Links

PFRA Flood Risk

- Coastal Indicative
- Coastal Extreme
- Fluvial 100
- Fluvial 1000

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Clients

Consultant

ARUP
Corporate House
City East Business Park
Ballybrit, Galway, Ireland
Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

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Scale: **1:50,000**

Date: January 2017

Issue	Date	By	Chkd	Appd
I1	12/01/2017	NOR	MH	EMC

Drawing Title
GTS Measures with PFRA Flood Risk Mapping - Coastal & Fluvial

Drawing Status
For Information

Job No	Drawing No	Issue
233985	GCOB-SK-D-730	I1

A3

'Insert A'

Proposed Cycle Network Extends to Oughterard.

Proposed Cycle Network Extends to Oranmore and on to Dublin

Refer to GCOB-SK-D-733 for further detail of this area

Proposed Cycle Network Extends to Spiddal

FOR INFORMATION

Legend

- City Boundary

GTS Measures

- Proposed Bus and Local Access only
- Proposed Bus Lane
- Existing Bus Lane
- Potential Greenway Corridors
- Primary Cycle Network
- Secondary Cycle Network
- Feeder Cycle Network
- Junction Upgrades
- Road Links

CFRAM Flood Risk

- 0.5% AEP Wave Overtopping
- 0.1% AEP Wave Overtopping

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Clients

Consultant
ARUP
Corporate House
City East Business Park
Ballybrit, Galway, Ireland
Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

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Scale: **1:50,000**

Date: January 2017

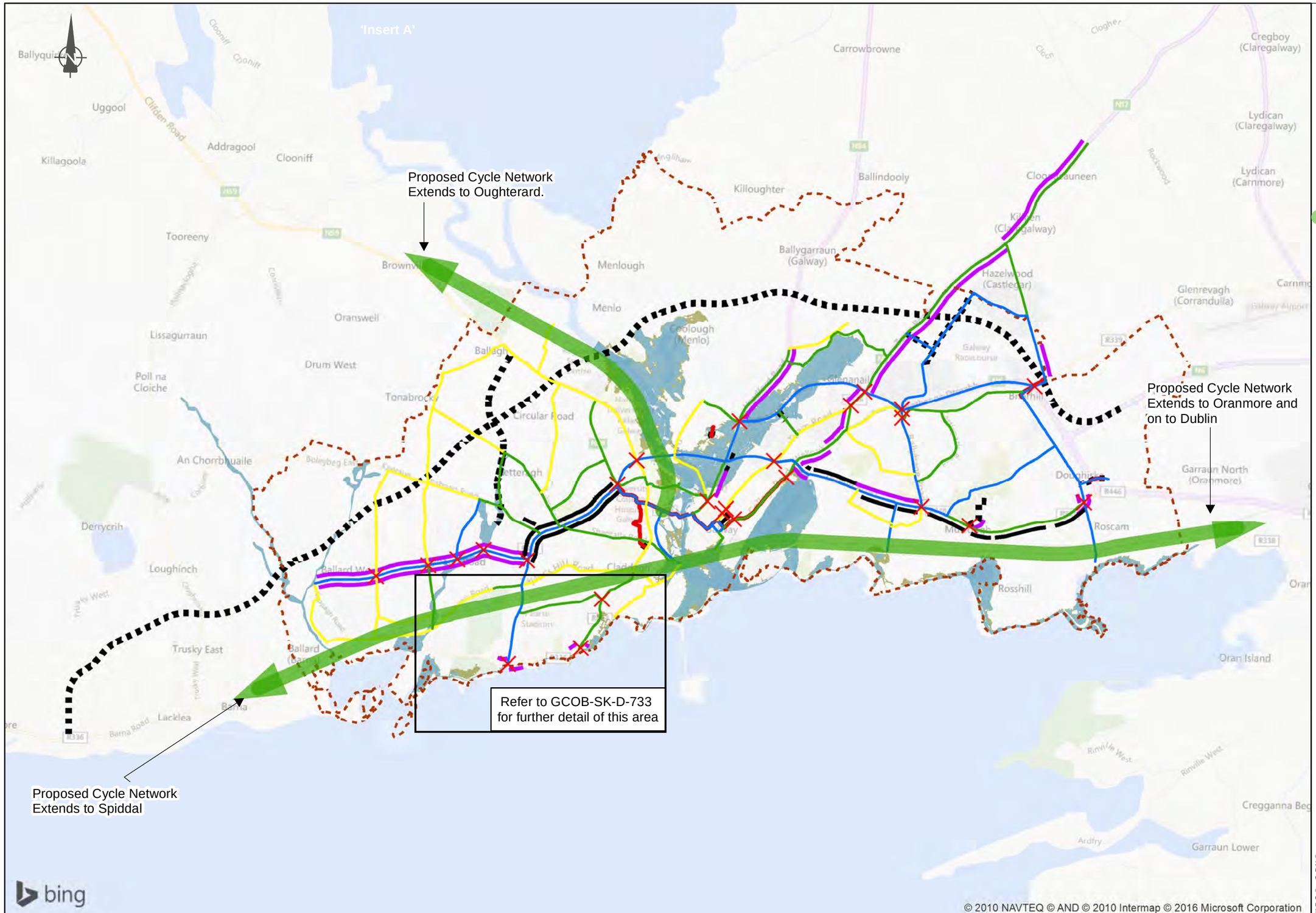
Issue	Date	By	Chkd	Appd
I1	12/01/2017	NOR	MH	EMC

Drawing Title
GTS Measures with CFRAM Flood Risk Mapping - Wave Overtopping

Drawing Status
For Information

Job No	Drawing No	Issue
233985	**GCOB-SK-D-731**	**I1**

A3



FOR INFORMATION

Legend

- City Boundary

GTS Measures

- Proposed Bus and Local Access only
- Proposed Bus Lane
- Existing Bus Lane
- Potential Greenway Corridors
- Primary Cycle Network
- Secondary Cycle Network
- Feeder Cycle Network
- Junction Upgrades
- Road Links

CFRAM Flood Risk

- Flood Zone A
- Flood Zone B

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Clients

Consultant
ARUP
Corporate House
City East Business Park
Ballybrit, Galway, Ireland
Tel +353 (0)91 460675
www.N6GalwayCity.ie
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Scale: **1:50,000**

Date: January 2017

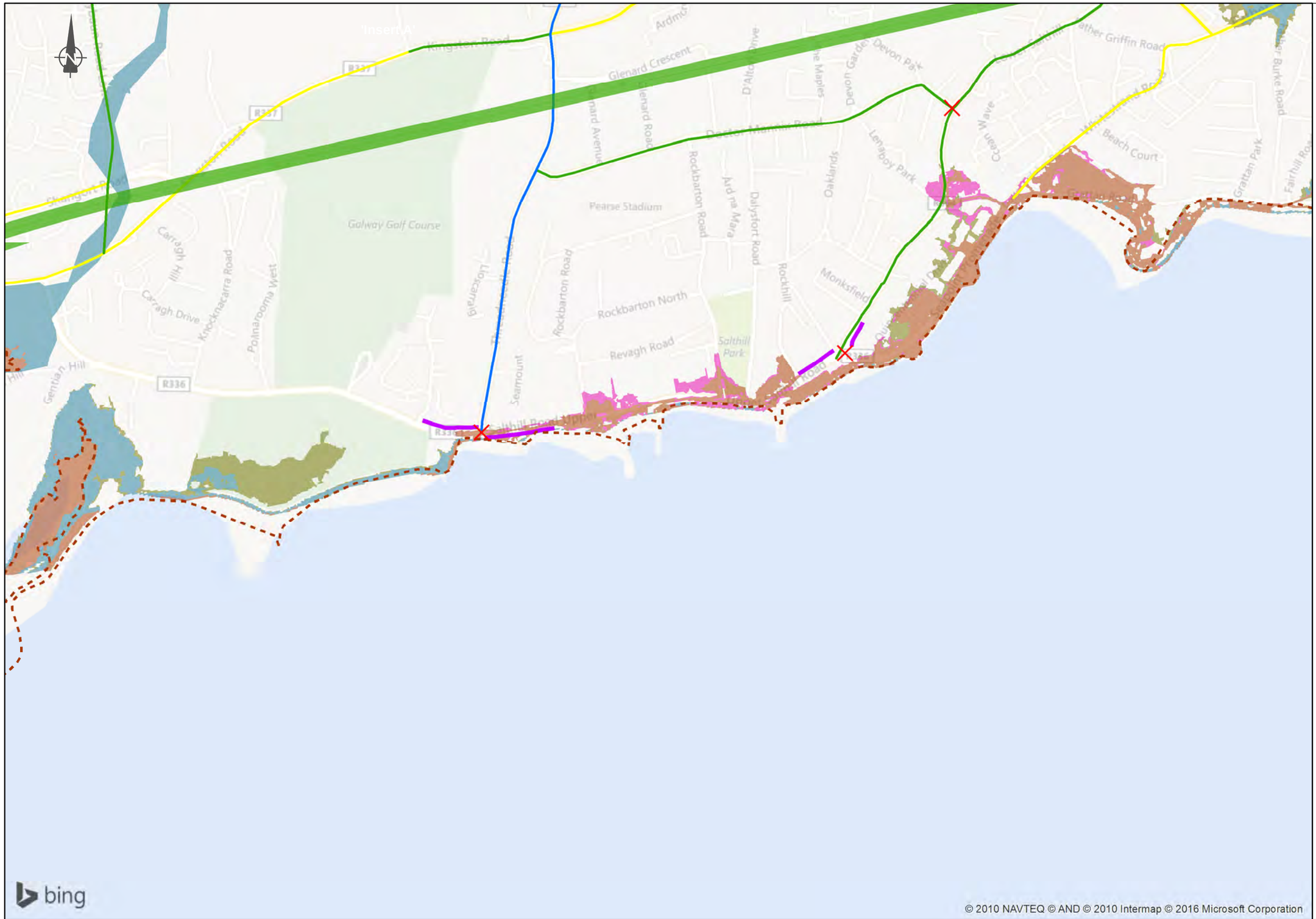
Issue	Date	By	Chkd	Appd
I1	12/01/2017	NOR	MH	EMC

Drawing Title
GTS Measures with CFRAM Flood Risk Mapping - Flood Zones

Drawing Status
For Information

Job No	Drawing No	Issue
233985	**GCOB-SK-D-732**	**I1**

A3



FOR INFORMATION

Legend

- City Boundary

GTS Measures

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- Proposed Bus Lane
- Existing Bus Lane
- Potential Greenway Corridors
- Primary Cycle Network
- Secondary Cycle Network
- Feeder Cycle Network
- Junction Upgrades
- Road Links

CFRAM Flood Risk

- 0.5% AEP Wave Overtopping
- 0.1% AEP Wave Overtopping
- Flood Zone A
- Flood Zone B

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Consultant

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Corporate House
City East Business Park
Ballybrit, Galway, Ireland
Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

Job Title
Variation No. 1 **to Galway County Development Plan 2015 -2021**

Scale: **1:10,000**

Date: January 2017

Issue	Date	By	Chkd	Appd
I1	12/01/2017	NOR	MH	EMC

Drawing Title
GTS Measures Salthill Area with CFRAM Flood Risk Mapping

Drawing Status
For Information

Job No	Drawing No	Issue
233985	**GCOB-SK-D-733**	**I1**