Annex 13.1

Flood Risk Assessment and Drainage Strategy

(JBA Consulting)

ABLE Marine Energy Park

Flood Risk Assessment and Drainage Strategy

Final Report

August 2011

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Revision History

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Contract

This report describes work commissioned by ABLE UK Ltd under Purchase Order No. 73441 dated 9 September 2010. ABLE UK Ltd's representative for the contract was Richard Cram. David Stark of JBA Consulting carried out this work.

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Purpose

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Executive Summary

Introduction

ABLE UK Ltd proposes to develop Able Marine Energy Park (AMEP) at Killingholme on the south bank of the Humber Estuary. AMEP comprises a site for manufacturing marine energy components (specifically wind turbines) and includes a new quay and deep water channel; the project includes raising existing ground levels on Killingholme Marshes.

The proposals have to be submitted to the Infrastructure Planning Commission (IPC) for approval. A formal consultation exercise was undertaken between 31 January and 19 March 2011. This Final Flood Risk Assessment and Drainage Strategy Report accompanies the formal submission to the IPC. This report identifies all relevant flood risk and drainage issues, presents appropriate solutions, and addresses all relevant comments mentioned in the IPC Scoping Opinion and consultation responses.

This low-lying site is in Flood Zone 3 (the high risk zone) and is currently protected by a coastal defence embankment and wave wall. The most significant flood risk to the proposed development is the risk from breach or overtopping of tidal defences. This study has focused on:

- Obtaining information about tidal and fluvial flood risks and developing a robust Flood Warning and Evacuation Plan.
- Clarifying planning issues in relation to PPS25 and the local SFRA.
- Ensuring that the development has minimal impact upon tidal flood risks to adjacent land, development and installations and developing any required mitigation measures.
- Gathering information for an application for a Flood Defence Consent (to formalise the alterations to the existing Environment Agency tidal defences).
- Developing a surface water drainage strategy in liaison with the North East Lindsey Drainage Board.
- Developing a foul water drainage strategy in liaison with Anglian Water.

Consultations

Flood risk information was obtained from the Environment Agency and meetings were held with them in late 2010. The Environment Agency accepted that the site will inevitably flood in the event of severe breaches of tidal defences, advised that onshore site levels do not need to be raised (for the purpose of reducing flood depths), emphasised that flood risks needed to be managed in a robust manner, and confirmed that compensatory storage is not required (to compensate for the impact of any raised ground levels on the tidal floodplain).

The site lies within the district of the North East Lindsey Drainage Board (NELDB). A meeting was held with the Board and drainage information was obtained from their consulting engineers (Hannah Reed). The Board already have a proposed scheme for improving the local Killingholme Marshes drainage system, comprising the installation of an outfall pumping station and associated channel widening (with an adaptive strategy to ensure that the 100-year plus climate change flows will be contained within the channels of the IDB watercourses).

North Lincolnshire Council were consulted about the proposed Flood Warning and Evacuation Plan.

Tidal Flood Risks and the Design of the Quay

Key design features of the quay are:

- The proposed quay will effectively replace a length of the existing tidal defences. The quay will initially be set at a level of 6.38 mAOD so that it is above the crest level of the existing tidal defence wave wall (6.2 mAOD) to maintain continuity of tidal defences.
- The level of the quay could be raised by 0.2 m, if required in the future, as an adaptive mitigation measure in response to potential rising sea levels which may be caused by climate change. With that measure in place, the effective defence level of the quay would rise to 6.58 mAOD, which would provide a freeboard of 0.34 m above the maximum predicted 200-year still water level of 6.24 mAOD (which includes an allowance of 1.19m to represent 100 years of climate change).
- A 28 metre width of quay frontage will slope at 1:100 down to a front level of 6.1 mAOD. With the quay raised to 6.3 mAOD, this quay front level will limit wave overtopping discharges to 5.3 l/s/m in a 2-year event after 100 years of climate change, to limit port downtime in bad weather, and any associated risks to workers and users.
- With the quay raised to 6.3 mAOD, the maximum overtopping rate at the quay face is 61.6 l/s/m in the 200-year event including 100 years of climate change (which is within the EurOtop recommended limit of 200 l/m/s for structural damage). The sloping stone pavement adjacent to the quay face will shed the majority of any overtopping floodwaters back into the sea. Any overtopping floodwaters which spill beyond the 28m frontage will be intercepted by the quay drainage system and discharged back to the sea (i.e. they will not spill inland).

Impact of the Quay on Adjacent Tidal Defences

Key results of the hydraulic modelling studies are:

- Spring tide flooding and ebbing currents are predicted to reduce significantly in the wake of the quay and increase slightly in the main Humber channel locally to the development (from 1.31 m/s to 1.40 m/s).
- Negligible increases in high water levels are predicted.
- It is estimated that wave reflection from the quay will adversely impact on the existing defences to the north of the quay in 2033 (the end of the current Humber Strategy timeline). The increase in wave height at the northern coastal defences adjacent to the quay is 25 cm, which decreases to zero within a distance of 60 m along the defences. It is proposed to mitigate this adverse impact by placing rock armour in front of the existing defences, at a 1 in 3⅓ slope, extending from the defence crest level for a distance of 12.3 m towards the sea. The predicted mean overtopping rate in 2033 with the rock armour in place is 1.9 l/s/m in a 1 in 200-year event. This mitigation measure is consistent with the Humber Strategy and associated Environment Agency requirements.
- In the longer term (up to 2114, 100 years after construction of the quay) climate change will lead to the potential for increased wave overtopping risk along the existing defences. The potential impacts of the quay were investigated, ignoring the beneficial effect of the proposed rock armour to the north of the quay. An increase in wave height of 10 cm is predicted to the south of the quay, and a localised increase in wave height of 40 cm is predicted to the north of the quay (200-year event including 100 years of climate change). The predicted overtopping rate assuming the quay is not built is 581 l/s/m. With the quay in place overtopping rates would increase to 631 l/s/m along the southern defences and to 794 l/s/m along the northern defences. However, it is predicted that any such increased wave heights will more than offset by wave limitation effects due to increased sedimentation.

Tidal Breach Modelling

The Environment Agency provided flood hazard mapping based on modelled breaches in tidal defences and flood outlines based on modelled overtopping. These maps show that the site is at significant risk of inundation. It was agreed with the Environment Agency that additional breach modelling should be undertaken by JBA Consulting as part of this study, particularly to assess:

- The speed and depth of inundation on the site (based on the post-development raised site levels) in relation to the flood warning and evacuation plan.
- Whether the proposed raised site levels result in an increase in flood risk elsewhere (e.g. by reducing the available storage volume for floodwaters or blocking floodwater flowpaths).

Tidal breach modelling was undertaken using the Environment Agency model for the 200-year event for the present day conditions and including 100 years of climate change. The analysis considered a breach just to the north of the proposed quay and a breach just to the south of the proposed quay (modelled separately). The key results of the modelling are:

- The raised site levels tend to obstruct the route of floodwaters adjacent to the development in the vicinity of a breach, thus increasing flood risk on land near a breach but reducing flood risk on land beyond the site.
- Outside the site, flood depths increase by a maximum of 350 mm.
- Within the site itself flood depths and velocities are reduced.
- The site is flooded rapidly (floodwater reaches the first building within 30 minutes of a breach, the flood depth at that building increases to 1 m within the next 15 minutes, and floodwaters cross the whole site in 90 minutes. Flood velocity within the site peaks at 0.75 m/s.

As regards land outside the site, the impact of the raised site is mixed, depending upon the location of the breach and the land in question. The main adverse impact is the predicted increase in flood depths of 350 mm adjacent to a breach. However, flood depths in the affected areas would, in any event, be over 2.0 m without the development. Details of the impacts upon the following adversely affected properties are included in this report:

- Hazel Dene on Marsh Lane.
- The coal and ore terminal to the south of the site.
- Industrial buildings near the junction of Rosper Road and Marsh Lane.

It is therefore considered that the development will have limited adverse and beneficial impacts on flooding to property outside the site.

Flood Risk Management Strategy

- All buildings will have mezzanine floors or upper storeys to provide safe refuges above the flood level. The minimum floor level of the safe refuges should be set with a freeboard of 600 mm above the 200-year maximum still water level including 100 years of climate change (6.24 mAOD). Thus the recommended minimum safe refuge floor level is 6.84 mAOD.
- Finished floor levels of all buildings will be set 300 mm above surrounding yard storage levels to prevent ingress of exceedance floodwaters when drainage systems are overloaded.
- All buildings are to incorporate flood-resilient construction measures (e.g. electrical wiring at a high level).
- A robust Flood Warning and Evacuation Plan will be implemented, based on the Environment Agency's new Flood Warning for Infrastructure service. All site occupants and visitors will evacuate the site when the risk of flooding (particularly due to breach of the tidal defences) is judged to have reached a pre-determined level. Any people stranded on the site are to make their way off site or to the safe refuges on the upper floors of the buildings and await rescue by the emergency services.
- The three proposed electricity substations will be located on higher ground adjacent to Rosper Road outside Flood Zone 3.

Surface Water Drainage Strategy

The North East Lindsey Drainage Board's proposed scheme for improving the drainage of the Killingholme Marshes system is designed to cater for unrestricted surface water discharges from all potential development sites in the catchment area. Surface water runoff from the onshore development will therefore be discharged to the improved local watercourse system in compliance with the Board's requirements.

The existing tidal outfall and proposed pumping station are located in the centre of the proposed quay. The outfall and pumping station therefore need to be relocated to accommodate the development. A feasibility study has been undertaken which presents various options for relocating the proposed NELDB pumping station. ABLE have decided to progress a relocation of the pumping station to the south of the site with the NELDB. Proposals for a pumping station are included in the development proposals to cover for the eventuality that the NELDB scheme is not taken forward.

Surface water runoff from the quay will be discharged to the sea. Precautions will be taken to avoid pollution of watercourses and the sea. Drawings of an indicative surface water drainage system for a factory plot are included in Appendix E.

Foul Water Drainage Strategy

There are no public sewers within or adjacent to the site and a new foul drainage connection will have to be made direct to the South Killingholme WWTW. In essence, Anglian Water will need to upgrade South Killingholme WWTW. There will be a small Customs House near the quay, which may be remote from the proposed foul drainage system in the inland manufacturing area (a private foul treatment package plant is currently proposed with a direct discharge to the sea). A preliminary layout of the proposed foul water drainage system is included in Appendix F. Correspondence from Anglian Water is included in Appendix K.

Contents

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Abbreviations

ABP	Associated British Ports
AMEP	Able Marine Energy Park
COMAH	Control of Major Accident Hazards Regulations
EA	Environment Agency
HEPS	Humber Emergency Planning Service
IDB	Internal Drainage Board
IPC	Infrastructure Planning Commission
LPA	Local Planning Authority
mAOD	Metres Above Ordnance Datum
MMO	Marine Management Organisation
NELC	North East Lincolnshire Council
NELDB	North East Lindsey Drainage Board
NFCDD	National Flood and Coastal Defence Database
NLC	North Lincolnshire Council
PPS25	Planning Policy Statement 25: Development and Flood Risk
SCP	Supply Chain Park
SFRA	Strategic Flood Risk Assessment
SPMT	Self-propelled Mobile Transporters
SUDS	Sustainable Drainage Systems
WWTW	Waste Water Treatment Works

Definitions

Annual Exceedance Probability / Return Period	The severity of a flood event is now described in terms of its annual probability of exceedance. A 1% annual exceedance probability (AEP) flood has a 1 in 100 chance of being exceeded in a given year. Descriptions using 'return period' are now regarded as being misleading, but the two may be related by taking the inverse of the AEP. For example, a 1% AEP event may be equated to a '100-year' return period flood.

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1. Introduction

1.1 Development Proposals

1.1.1 ABLE UK Ltd proposes to develop Able Marine Energy Park (AMEP) that will provide manufacturing facilities for the emerging renewable energy sector. AMEP comprises:

- A new quay and deep water approach channel.
- An adjacent onshore area for manufacturing marine energy components.
- A Supply Chain Park (SCP) for associated supply chain industries.

1.1.2 Yorkshire Forward commissioned various preliminary studies for a new quay facility along the Killingholme Marshes frontage in 2010. The local authority (North Lincolnshire Council) is known to be supportive of the proposals in principle (the proposals are compliant with their Local Development Framework Core Strategy Development Plan Document). The proposal will be submitted to the Infrastructure Planning Commission (IPC) for approval.

1.1.3 The majority of the onshore development will consist of open areas for the storage and transportation of fabricated marine energy components. The Indicative Site Plan envisages substantial raising of ground levels to enable the use of heavy-lift Self-propelled Mobile Transporters (SPMTs) to transport the components around the site and to the quay. Ground raising will comprise

- The placement of approx 1m depth of compacted stone to form the storage areas.
- The formation of a 1:100 slope from the elevated quay down to the storage areas.

1.1.4 The Indicative Site Plan and other drawings of the development are included in Appendix A.

1.1.5 The construction of the quay will result in a loss of intertidal habitat. The design of a scheme for the provision of compensatory intertidal habitat at Sunk Island on the north bank of the Humber Estuary is being undertaken by Black & Veatch and is beyond the scope of this report.

1.2 Site Description

1.2.1 The proposed site is located on the south bank of the Humber Estuary to the north west of Immingham Docks and is surrounded on three sides by industrial facilities. The Environment Agency (EA) Flood Map indicates that the site is within Flood Zone 3 (High Risk). Flood defences are in place at the site and currently provide a standard of protection that varies between 1:50 years and 1 in 150 years. This will reduce over time as sea levels rise.

1.2.2 The northern part of the site has recently been partly developed for use as an imported vehicle storage and distribution complex: these facilities will be redeveloped as part of the Marine Energy Park. The southern part of the site is currently in use as agricultural land.

1.3 Purpose of this Report

1.3.1 The proposals for the Marine Energy Park have to be submitted to the Infrastructure Planning Commission (IPC) for approval. A formal consultation exercise was undertaken in February/March 2011. This report identifies all relevant flood risk and drainage issues, presents appropriate solutions, and addresses all relevant comments mentioned in the IPC Scoping Opinion and consultation responses. This assessment has been carried out in accordance with Planning Policy Statement 25 – Development and Flood Risk (PPS25).

1.3.2 An Environmental Statement has been prepared to accompany the application.

1.3.3 This report also makes reference to the following related reports prepared by JBA Consulting for this project and which are included in the Environmental Statement accompanying the application :

- Humber Modelling Report (covering short term hydrodynamic and sediment impacts).
- Humber Geomorphology Review (covering long term geomorphological impacts).

1.4 Discussions with the Environment Agency

1.4.1 Flood risk information was obtained from Environment Agency and a series of three meetings was held with them in late 2010. The Environment Agency accepted that the low-lying site would inevitably flood in the event of severe breaches of tidal defences and advised that onshore site levels do not need to be raised (for the purpose of reducing flood depths), but emphasised that flood risks needed to be managed in a robust manner. In addition the Environment Agency confirmed that compensatory storage is not required (to compensate for the impact of any raised ground levels on the tidal floodplain).

1.5 Discussions with the North East Lindsey Drainage Board

1.5.1 The site lies within the Killingholme Marshes drainage catchment, which is administered by the North East Lindsey Drainage Board and discharges to the Humber Estuary via a gravity outfall with a tidal flap valve. A meeting was held with the Board and details of their general requirements and their proposed scheme for improving the drainage of the Killingholme Marshes system were obtained from their consulting engineers (Hannah Reed). The Board's proposed improvement scheme comprises the installation of a pumping station at the existing outfall point and associated channel widening (designed to cater for unrestricted surface water discharges from all potential development sites in the catchment area). The Board's scheme incorporates an adaptive strategy to ensure that the 100-year plus climate change flows will be contained within the channels of the IDB watercourses.

1.5.2 Further details of the proposed surface water drainage arrangements are included in Chapter 6. Information on the existing and proposed IDB drainage system is included in Appendix D.

1.6 Discussions with North Lincolnshire Council

1.6.1 Initial contact was made with the Humber Emergency Planning Service (HEPS), who provide high-level emergency planning advice to four local authorities. HEPS advised that they are not involved with individual planning applications and North Lincolnshire Council should be contacted regarding emergency planning for the Marine Energy Park. Contact was subsequently made with North Lincolnshire Council and further details are given in Chapter 4.

1.7 Discussions with Anglian Water (Foul Drainage)

1.7.1 An initial meeting was held with Anglian Water to discuss foul drainage arrangements. There are no public sewers within or adjacent to the site and a new foul drainage connection will have to be made direct to the South Killingholme WWTW. In essence, Anglian Water will need to upgrade South Killingholme WWTW. Further details of the foul drainage arrangements are included in Chapter 7.

2. Planning Issues

2.1 SFRA

2.1.1 The May 2010 Review of the North East Lincolnshire Council / North Lincolnshire Council Strategic Flood Risk Assessment (SFRA) was downloaded from the North Lincolnshire Council (NLC) website and reviewed. This document provides an overview of flood risk issues and associated planning guidance in the area covered by these two local authorities.

2.1.2 It is understood that, at the time of writing this report, there are unresolved issues between North Lincolnshire Council (NLC) and the Environment Agency concerning the Review of the SFRA and the document has therefore not yet been formally adopted by NLC. The Environment Agency has acknowledged the current situation and advised that the unresolved issues are not particularly relevant to AMEP. The site-specific flood risk information supplied by, and the discussions held with, the Environment Agency as part of this study effectively supersede the general guidance outlined in the SFRA.

2.2 PPS25 Sequential Test

2.2.1 AMEP has to be located on the coast in order to serve its purpose: this inevitably results in the site being mainly within Flood Zone 3a (see Flood Map in Appendix C.1). The Marine Energy Park comprises a new quay and deep water channel, and an adjacent onshore area for manufacturing marine energy components. Under Table D.2 of PPS25 such uses are classified as "Less Vulnerable" and/or "Water-compatible Development". Under Table D.3 of PPS25 both these uses are appropriate in Flood Zone 3a.

2.2.2 Initial contact was made with NLC regarding the PPS25 Sequential Test. NLC advised that the site is allocated for port-related activity, the proposal is considered to be water-compatible, and it is unlikely that the development could be sited anywhere else that is at a lesser risk of flooding. Accordingly, the Sequential Test is deemed to have been passed.

2.3 The PPS25 Sequential Approach

2.3.1 Annex D6 of PPS25 promotes the "sequential approach" to site layout (i.e. higher vulnerability uses should be located on those parts of a site at lowest probability of flooding). Most of the site is within Flood Zone 3a and only a small part of the site near Rosper Road and Haven Road is in Flood Zone 1. The lowest part of the site is immediately behind the tidal defences (at a level in the region of 2.5 mAOD), and the highest part of the site is adjacent to Rosper Road along the western boundary of the site (at a level in the region of 6.0 - 7.0 mAOD). However, a sequential approach to the site layout is not practical or appropriate, bearing in mind that most of the site is within Flood Zone 3a and the scheme inevitably involves quayside development.

2.4 PPS25 Exception Test

2.4.1 Under PPS25, the Exception Test is not required for "Less Vulnerable" or "Water-compatible Development" in Flood Zone 3a.

2.5 200m Buffer Zone Behind Tidal Defences

2.5.1 Section 2.17 of the IPC Scoping Opinion refers to a 200m buffer strip behind defences where new development should be prohibited. Similarly, Section 6.17 of the May 2010 Review of the NELC/NLC SFRA recommends that permanent buildings should not be erected in this zone in case coastal erosion results in a need to set back the existing tidal defences. The EA have confirmed that this requirement is not relevant to new port development.

2.6 IDB Byelaw Strips

2.6.1 Seven-metre wide maintenance strips are generally required abutting the banks of the IDB watercourses. However, in several locations the proposed widened IDB watercourses will consist of two-stage channels incorporating a wide berm. It is intended that the Board will use these berms as maintenance access strips. In these locations the usual IDB maintenance strip abutting the banks of watercourses will not be required (although Natural England may wish to see a smaller ecological strip beside any watercourse).

3. Flood Risks & Mitigation Measures

3.1 Introduction

3.1.1 Flood risk information was obtained from the Environment Agency (see Appendix C). This low-lying site is in Flood Zone 3 (the high risk zone): see Map 1 in Appendix C.1. The only significant recorded tidal flooding of the site occurred in 1953, when major flooding occurred at numerous locations on the east coast of England: see Map 2 in Appendix C.1. Environment Agency modelling indicates that the site is at risk of flooding due to overtopping of coastal defences: see Maps 5a and 5b in Appendix C.1. Environment Agency modelling indicates that the site is also at risk of flooding due to breach of coastal defences: see Flood Hazard Mapping in Appendix C.2. The most significant flood risk to the proposed development is the risk from breach or overtopping of tidal defences. This study has focused on obtaining information about this flood risk and developing a robust Flood Warning and Evacuation Plan.

3.1.2 Modelling has been undertaken to investigate the impact of construction of the quay and the dredged deepwater approach channel on tidal flood risks and sediment transportation. These studies have informed the design of the quay.

3.1.3 The proposed raised site levels inevitably obstruct the route of floodwaters in the event of a breach of tidal defences to either side of the development, thus potentially increasing flood risk elsewhere. Breach modelling was undertaken to assess this aspect and to assess the speed and depth of inundation on the site in relation to the flood warning and evacuation plan.

3.2 Existing Topography & Flood Defences

3.2.1 There are tidal flood defences in place along this stretch of the south bank of the Humber Estuary. The existing defences at the proposed development site consist of an earth embankment topped by a concrete flood wall, currently owned and maintained by the Environment Agency. The crest level of the tidal defence embankment is in the region of 5.4 mAOD and the crest level of the flood wall is in the region of 6.2 mAOD. See Map 4 and preceeding NFCDD information in Appendix C.1.

3.2.2 Rosper Road runs along the western boundary of the site at a level in the region of 6.0 - 7.0 mAOD. The land immediately behind the tidal defences is at a level in the region of 2.5 mAOD. The site slopes gently down from Rosper Road to the low-lying land behind the tidal defences.

3.2.3 A railway line runs through the site parallel to the coast. The railway is generally on a low embankment (which would tend to temporarily limit the spread of tidal floodwaters in the early stages of a flood event (until the floodwaters overtop the railway line).

3.2.4 The Environment Agency have confirmed that the defences are in a good to fair condition and provide a current standard of protection of 1 in 150 years (see their letter dated 29 October 2010 in Appendix C.1). The Environment Agency have also advised that:

- The Humber Strategy identifies the flood cell (Flood Area 23 – Halton and Killingholme Marshes) for the site to have a Standard of Protection that varies from 2% to 0.6% (1 in 50yr to 1 in 150yr).
- A review of the existing Environment Agency defences is probably due within the next 4 years.
- Bearing in mind the constraints imposed by the Government's October 2010 Comprehensive Spending Review, any proposed works are likely to be limited to revetment repairs and raising crest levels to combat rises in sea levels due to climate change.

3.3 Tidal Flood Risks and the Design of the Quay

3.3.1 JBA Consulting have undertaken preliminary modelling studies of the impact of construction of the quay and the dredged deepwater approach channel on tidal flood risks and sediment transportation for Yorkshire Forward, and have undertaken further more detailed studies for ABLE UK Ltd which have informed the design of the quay. See the following appendices for drawings of the proposed quay and a summary of the hydraulic modelling studies:

- Appendix A.6: Schematic Section through Quay.
- Appendix A.7: Quay General Arrangement.
- Appendix A.8: Quay Sections.
- Appendix H: Quay Design Modelling.

3.3.2 The design lifetime of AMEP is 60 years, but the level of the quay has been designed to cater for 100 years of climate change. Key design features are as follows, as illustrated on the Schematic Section through the Quay (Appendix A.6):

- The main quay area will be set at a level of 6.38 mAOD, which is 0.18 m above the existing crest level of the tidal defence wall (6.2 mAOD).
- There will be a stone pavement, 28 metres wide around the perimeter of the quay. This pavement will slope at a gradient of 1:100 from the general quay level of 6.38 mAOD to the quay face level of 6.1 mAOD.
- Provision has been made to raise the level of the stone pavement by 0.2 m, if required in the future, as an adaptive mitigation measure in response to potential rising sea levels which may be caused by climate change. With that measure in place, the effective defence level of the quay would rise to 6.58 mAOD, which would provide a freeboard of 0.34 m above the maximum predicted 200-year still water level of 6.24 mAOD (which includes 100 years of climate change).
- With the quay face raised by 0.2 m (to 6.3 mAOD), the maximum overtopping rate at the quay face is 61.6 l/s/m in the 200-year event including 100 years of climate change (which is within the EurOtop recommended limit of 200 l/m/s for structural damage). The sloping pavement adjacent to the quay face will shed the majority of any overtopping floodwaters back into the estuary. Any overtopping floodwaters which spill beyond the pavement will be intercepted by the quay drainage system and discharged back to the estuary (i.e. they will not spill inland).
- With the quay face raised by 0.2 m (to 6.3 mAOD), the maximum overtopping rate at the quay face is 5.3 l/s/m in the 2-year event after 100 years of climate change (which is within the EurOtop recommended limit of 1-10 l/m/s for trained staff). Thus port downtime in bad weather, and any associated risks to workers and users will be controlled within acceptable limits.

3.4 Impact of the Quay on Adjacent Tidal Defences

3.4.1 Key results of the hydraulic modelling studies are outlined below and a summary of the calculations is included in Appendix H:

- Spring tide flooding and ebbing currents are predicted to reduce significantly in the wake of the quay and increase slightly in the main Humber channel locally to the development (from 1.31 m/s to 1.40 m/s).
- Negligible increases in high water levels are predicted.
- The impact of the quay on the adjacent tidal defences was discussed with the Environment Agency in the context of their Humber Strategy, which currently covers a period up to 2033. In order to be consistent on the Humber, the Environment Agency requested an improvement to the defences that are affected by the additional impacts from the AMEP quay to provide a 0.5% standard of protection until 2033 (based on limiting overtopping to 2 l/s/m). It is estimated that wave reflection from the quay will adversely impact on the existing defences to the north of the quay for a distance of 60 metres. There will be no increased wave heights along the sea defences to the south of the quay due to greater depth-limitation effects determined by the shallower foreshore gradient. The increase in wave height at the northern coastal defences adjacent to the quay is 25 cm, which decreases to zero within a distance of 60 m along the defences It is proposed to mitigate this adverse impact by placing rock armour in front of the existing defences, at a 1 in 3⅓ slope, extending from the defence crest level for a distance of 12.3 m towards the sea. The predicted mean overtopping rate with the rock armour in place is 1.9 l/s/m. Thus the rock armour will reduce overtopping to the north of the quay in 2033 for a 1 in 200-year wave height/water level event to less than the 2 l/s/m specification.
- In the longer term (up to 2114, 100 years after construction of the quay) water levels are predicted to rise, reducing depth-limitation effects, leading to the potential for increased wave overtopping risk along the existing defences. The potential impacts of the quay were investigated, ignoring the beneficial effect of the proposed rock armour to the north of the quay. An increase in wave height of 10 cm is predicted to the south of the quay, and a localised increase in wave height of 40 cm is predicted to the north of the quay (200-year event including 100 years of climate change). The predicted overtopping rate assuming the quay is not built is 581 l/s/m. With the quay in place overtopping rates would increase to 631 l/s/m along the southern defences and to 794 l/s/m along the northern defences. However, in these potentially vulnerable areas to the south and north of the quay, increased sedimentation is predicted to occur. This would cause a reduction in flood risk due to increased depth-limitation effects and is predicted to be locally significant within 20 years of the quay construction. It is therefore likely that, in the long term, any potential increase in flood risk due to wave reflection from the quay will be more than offset by this increase in bed elevation around the affected areas.

3.5 Breach & Overtopping Modelling

3.5.1 The Environment Agency have provided flood hazard mapping based on modelled breaches in tidal defences and flood outlines based on modelled overtopping: see Appendix C.2. These maps show that the site is at significant risk of inundation. The predicted flooding encroaches onto parts of Rosper Road which are at a level of about 6.0 mAOD. Thus the predicted flood level appears to be in the region of 6.0 mAOD. In such a scenario the lowest parts of the existing site behind the tidal defences (which are at a level of about 2.5 mAOD) would be subject to significant floodwater depths of about 3.5 metres. The Environment Agency also advised that:

- Their draft breach inundation maps show that parts of the site are inundated within the first hour.
- Speed of inundation maps are not available at present.

3.5.2 It was therefore agreed with the EA that additional breach modelling should be undertaken by JBA Consulting as part of this study, particularly to assess:

- The speed and depth of inundation on the site (based on the post-development raised site levels) in relation to the flood warning and evacuation plan.
- Whether the proposed raised site levels result in an increase in flood risk elsewhere (e.g. by reducing the available storage volume for floodwaters or blocking floodwater flowpaths).

3.5.3 Tidal breach modelling was undertaken using the Environment Agency model for the 200-year event for the present day conditions plus 100 years of climate change. The methodology was agreed with the Environment Agency and includes several conservative assumptions; the detailed results are presented in Appendix I (including a suite of maps showing flood depth, flood velocity and flood hazard). The analysis considered a breach just to the north of the proposed quay and a breach just to the south of the proposed quay (modelled separately). Four animations were produced (in .avi format) showing flood depth and velocity for the two breach scenarios - these were supplied to the Environment Agency.

3.5.4 The key results of the modelling are:

- The raised site levels tend to obstruct the route of floodwaters adjacent to the development in the vicinity of a breach, thus increasing flood risk on land near a breach but reducing flood risk on land beyond the site.
- The southern breach produced the greatest adverse impacts.
- Outside the site flood depths increased by a maximum of 350 mm, there was an increase in flood extents, and the pattern of peak flood velocities remained largely unchanged or reduced.
- Within the site itself flood depths and velocities are reduced.
- The site is flooded rapidly (floodwater reaches the first building within 30 minutes of a breach, the flood depth at that building increases to 1 m within the next 15 minutes, and floodwaters cross the whole site in 90 minutes. Flood velocity within the site peaks at 0.75 m/s.

3.5.5 As regards land outside the site, the impact of the raised site is mixed, depending upon the location of the breach and the land in question. The main adverse impact is the predicted increase in flood depths of 350 mm adjacent to a breach. However, flood depths in the affected areas would be over 2.0 m without the development (see Environment Agency Flood Hazard Maps in Appendix C.2).

3.5.6 The three residential properties on Station Road are to be vacated and the only residential property to remain in the vicinity of the site is Hazel Dene on Marsh Lane, near the southern boundary of the site. The speed of inundation at Hazel Dene is fast (within 15 mins of the breach occurring). However this is the case with and without the development in place. The development site therefore does not increase the onset of flooding to this property. The maximum depth of breach floodwaters predicted at Hazel Dene is approximately 2.7m. This property has three storeys and therefore safe refuge would be available on the second floor above flood levels.

3.5.7 With the development in place, the flood extent and flood depth is increased at the coal and ore terminal to the south of the site.

3.5.8 In addition to this, there are a number of industrial buildings located on the western side of Rosper Road, at the junction with Marsh Lane, that flood with the development site in place (floodwater depths of 0.25 m – 0.50 m in the 0.5% AEP with climate change scenario).

3.5.9 It is therefore considered that the development will have limited adverse and beneficial impacts on flooding to property outside the site.

3.5.10 The site is obviously at risk of rapid inundation. A robust flood warning and evacuation plan will therefore be developed, based on evacuating the site in advance of a breach, and providing safe refuges in upper storeys of buildings in case anyone is stranded.

3.5.11 The construction of the proposed quay will have a beneficial impact on local tidal flood risk because it will effectively prevent a breach forming along the site frontage.

3.6 Fluvial Flood Risks

3.6.1 The Internal Drainage Board's proposed scheme for improving the drainage of the Killingholme Marshes system is designed to contain the 1:100-year rainfall event flows within the channels of the IDB watercourses with an adaptive approach to climate change. Thus the existing fluvial floodplain will be eliminated and there will be no fluvial flood risk to the site (unless one or more of the pumps fail).

3.6.2 The proposed NELDB pumping station may fail due to electrical or mechanical breakdown. Such failure of the pumping station would result in rising water levels in the watercourses possibly leading to flooding of parts of the site and land elsewhere. Such flooding would only occur during periods of high tide (when the pumps are designed to operate) and any associated flooding would tend to occur slowly and result in shallow floodwater depths. The risk of such breakdown is low and the worst case potential impact on people and buildings is not likely to be significant. The proposed raised site levels will reduce associated flood risks to the site itself.

3.6.3 The design of the pumping station will seek to reduce foreseeable risks, such as power failures, to as low as reasonably practicable (e.g. by using multiple pumps, alarms, and back-up generators, etc.).

3.7 Safe Refuges in Buildings

3.7.1 All buildings will have mezzanine floors or upper storeys to provide safe refuges above the flood level. The minimum floor level of the safe refuges should be set with a freeboard of 600 mm above the 200-year maximum still water level including 100 years of climate change (6.24 mAOD). Thus the recommended minimum safe refuge floor level is 6.84 mAOD.

3.7.2 All such refuges should have staff welfare facilities (e.g. toilets, wash basins, drinks and food) and provision for stranded staff to issue distress messages (e.g. sirens and flares).

3.8 Building Resilience

3.8.1 All buildings should incorporate flood-resilient construction measures (e.g. electrical wiring at a high level).

3.9 Electricity Substations

3.9.1 There will be three new electricity substations on the site, all located along Rosper Road outwith Flood Zone 3 (see the EIA Masterplan in Appendix **Error! Reference source not found.**). The minimum floor/yard level of the substations should be set with a freeboard of 600 mm above the 200-year maximum still water level including 100 years of climate change (6.24 mAOD). Thus the recommended minimum floor/yard level for the substations is 6.84 mAOD.

3.10 Construction Phase

3.10.1 The main flood risk impacts to be addressed during the construction phase are:

- Ensuring that continuity of tidal defences is maintained.
- Ensuring that the operation of the Killingholme Marshes Drainage System and tidal outfall is maintained.

4. Flood Warning and Evacuation Plan

4.1 Introduction

4.1.1 The low-lying site is inevitably at risk of rapid inundation in the event of severe breaches of tidal defences. It is proposed to manage these flood risks by means of a robust Flood Warning and Evacuation Plan, based on the Environment Agency's new Flood Warning for Infrastructure service. The Agency aim to give 6 hours warning of possible flooding but the occurrence of breaches in tidal defences cannot be accurately predicted. All site occupants and visitors will evacuate the site when the risk of flooding is judged to have reached a pre-determined level. Any people stranded on the site will make their way off site or to the safe refuges on the upper floors of the buildings and await rescue by the emergency services. The main elements of the proposed Flood Warning and Evacuation Plan are outlined below.

4.1.2 As reported in Section 3.5 tidal breach modelling indicates that the site would be flooded rapidly (floodwater reaches the first building within 30 minutes of a breach, the flood depth at that building increases to 1 m within the next 15 minutes, and floodwaters cross the whole site in 90 minutes. Flood velocity within the site peaks at 0.75 m/s. It is therefore essential to evacuate the site before a breach in tidal defences occurs, if at all possible.

4.2 Initial Contact with North Lincolnshire Council

4.2.1 Initial contact was made with the Humber Emergency Planning Service (HEPS), who provide high-level emergency planning advice to four local authorities, including North Lincolnshire Council. HEPS advised that they are not involved with individual planning applications and North Lincolnshire Council should be contacted regarding emergency planning for the Marine Energy Park. Contact was subsequently made with North Lincolnshire Council.

4.2.2 North Lincolnshire Council advised that the Environment Agency are the primary authority regarding emergency planning issues for this development. However the Environment Agency's view is that North Lincolnshire Council are the primary authority regarding emergency planning issues. Emergency planning might also link to the COMAH Plan (Control of Major Accident Hazards Regulations), but that aspect is beyond the scope of this report.

4.2.3 Section 7.31 of the PPS25 Practice Guide (December 2009 Update) states that:

There is no statutory requirement on the Environment Agency or the emergency services to approve evacuation plans. The LPA is accountable via planning condition or agreement to ensure that plans are suitable. This should be done in consultation with local authority emergency planning staff.

4.3 Objectives of the Flood Warning and Evacuation Plan

4.3.1 The objectives of the Flood Warning and Evacuation Plan are to:

- Promote awareness and preparedness measures.
- Outline the conditions that will necessitate evacuation.
- Outline the evacuation procedures.

4.4 Outline Contents of the Flood Warning and Evacuation Plan

4.4.1 A formal Flood Warning and Evacuation Plan will be prepared in due course. The main elements of the plan will be:

- Establish a Port Control Centre.
- The Port Control Centre will manage the Flood Warning and Evacuation Plan.
- A team of named Senior Managers at the Port Control Centre will be appointed as Flood Marshalls, one of whom must be on site at any one time.
- The Port Control Centre will keep a register, which will ensure that a list (or lists) is (are) maintained of all the employees, visitors and contractors that are present on site at any given time.
- An up-to-date Site Layout Plan will be displayed on notice boards around the site giving information to all employees and visitors, showing the layout of the site, the Evacuation Assembly Point and the evacuation route.
- The Flood Marshall will conduct an annual training event for all employees to inform them of the Flood Evacuation Procedure and shall maintain a record of each training event, including a full list of attendees. All employees shall be instructed at the start of their employment with respect to the procedures of this plan. Likewise, visitors and contractors shall be informed of tidal flood risks and evacuation procedures.
- Regular flood warning and evacuation drills will be undertaken.
- The Port Control Centre will receive flood warnings from the Environment Agency via their Flood Warning for Infrastructure service.
- The Port Control Centre will relay warnings to all site occupants and visitors (e.g. by telephone, flashing lights, sirens or tannoy).
- A Flood Marshall will inspect the areas around the site to check if flooding is occurring and if so, to what extent. He shall also ensure that the emergency egress route is clear and any perimeter gates unlocked.
- If significant waves are frequently overtopping the defences the Flood Marshall will evacuate the site. All site workers will be required to vacate as quickly as possible along the route detailed and to congregate at the Evacuation Assembly Points. If there are no waves overtopping the defences site personnel will be advised to:-
    - Note that conditions could deteriorate and become dangerous.
    - Be prepared to comply with the requirements of the Flood Evacuation Plan.
    - Keep clear of the rapid inundation zone behind the sea walls.

4.5 Consultation Response

4.5.1 The draft Flood Warning and Evacuation Plan was sent to North Lincolnshire Council for comment and their response is included in Appendix J.

4.5.2 More detailed plans are to be produced by tenants prior to occupation.

5. Flood Defence Consent

5.1 Introduction

5.1.1 A "Flood Defence Consent" is required for the proposed alterations to the existing tidal defences, comprising:

- The construction of the new quay.
- The formal abandonment of the corresponding section of the existing tidal defence embankment and wave wall (which will be buried beneath the new quay in a similar manner to the adjacent ABP facility).
- Alterations to the means of vehicular access to the remaining short adjacent sections of Environment Agency tidal defences to the north and south of the Marine Energy Park.
- The proposed rock armour protection to the existing northern defences.

5.1.2 A formal application for Flood Defence Consent will be submitted subsequent to the IPC application being accepted.

5.2 Land Drainage and Sea Defence Byelaws

5.2.1 Under their Land Drainage and Sea Defence Byelaws, the consent of the Environment Agency is required for any alteration of the existing tidal defences. Part 2 of the Byelaws refers to Sea and Tidal Defences and there are a number of byelaws which cover the works such as 26, 27, 28, 29, etc. The Environment Agency has two months to determine an application.

5.2.2 The "Flood Defence Consent" relates to any works between the Low Water Mark and 9 metres on the landward side of the existing defences. Any alterations to land levels behind the adjacent northern retained defences will need discussion with the Environment Agency. The proposed relocation of the NELDB pumping station would also require a "Flood Defence Consent".

5.2.3 A similar consent may also be required from the Marine Management Organisation (MMO) for works in the estuary below the level of mean high water springs.

5.3 Alterations to Environment Agency Vehicular Access

5.3.1 The Environment Agency currently track vehicles from North Killingholme Haven southwards along the defences to the junction with the ABP defences (where there is a vehicle turnaround facility). Thus construction of the new quay will interrupt access to the retained lengths of EA defences to the north and south.

5.3.2 The possible use of Station Road as a means of access to the southern defences has been discussed with the Environment Agency. ABLE UK Ltd proposes to replace and improve the westerly part of Station Road as part of their scheme but a private substandard section would remain approaching the coast. ABLE currently envisage that:

- An Environment Agency access route will be provided to the southern retained defences via the extension to Station Road within the Marine Energy Park.
- A turnaround facility will be provided within the ABLE site at the southern end of the northern retained defences.

See Appendix A.4 for a plan of the proposed access arrangements.

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6. Surface Water Drainage Strategy

6.1 Surface Water Drainage - General Considerations

6.1.1 Annex F6 of PPS25 states that surface water arising from a developed site should, as far as is practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development. Developers are encouraged to use sustainable drainage systems (SUDS) (particularly infiltration drainage) for surface water disposal. For infiltration drainage to operate satisfactorily the ground must be sufficiently permeable, the water table must be relatively deep, the ground should be uncontaminated, the percolating water must not cause ground instability or problems elsewhere, and there must be sufficient open space to accommodate the infiltration facilities. Ground investigations undertaken on parts of the site indicate that the ground generally consists of:

- Made ground up to 3 metres deep in some locations.
- Alluvium and clay to depths exceeding 15 metres.
- Groundwater strikes at various levels in some boreholes.
- Groundwater levels which may be influenced by tide levels in the Humber Estuary.

6.1.2 These impermeable clay ground conditions are not suitable for infiltration drainage. The existing site is drained by the Killingholme Marshes Drainage System: a network of open watercourse channels under the control of the North East Lindsey Drainage Board. It is therefore appropriate and consistent with PPS25 to discharge surface water from the development to the Killingholme Marshes Drainage System.

6.2 Discharge to the Killingholme Marshes Drainage System

6.2.1 A meeting was held with the North East Lindsey Drainage Board on 11 October 2010 and discussions focused on the proposal by the Board to implement the Killingholme Marshes Drainage Improvement Scheme. The Board's scheme involves constructing a pump-assisted outfall structure to replace the existing gravity (tidal doors) outfall and widening the watercourse channels. The existing tidal outfall is located in the centre of the proposed quay and ABLE UK propose that the pumping station should be relocated to the north of the quay. Details of the Board's general requirements and their proposed scheme were obtained from their consulting engineers (Hannah Reed): see Appendix D.

6.3 Killingholme Marshes Drainage System

6.3.1 The Killingholme Marshes Drainage System drains virtually all the land between the North Killingholme Drain and the South Killingholme Drain.

6.3.2 The watercourse leading from the Lindsey Oil Refinery and the South Killingholme WWTW used to discharge northwards into the North Killingholme Drain. ABLE has already diverted these flows southwards into the Killingholme Marshes Drainage System in accordance with the Board's strategy. The purpose of this flow diversion was to release spare capacity within the North Killingholme Drain to serve developments by Humber Sea Terminals and reduce the environmental risk to North Killingholme Haven Pits arising from any pollution incident at the Lindsey Oil Refinery. The Board agreed to this flow diversion in 2004 as a temporary arrangement with an intended lifespan of two years, pending construction of the Board's pumping station and improvement scheme.

6.3.3 The southerly leg of the Killingholme Marshes Drainage System used to flow southwards into the South Killingholme Drain. The Board reversed the flow in this watercourse several years ago so that it now flows northwards into the Killingholme Marshes Drainage System.

6.4 The Board's Proposed Improvement Scheme

6.4.1 The main elements of the Board's preferred scheme are as follows:

- The scheme is based on pumping and storage within widened open watercourse channels.
- The scheme is designed to contain the 1:100-year rainfall event flows within the channels of the IDB watercourses with an adaptive approach to climate change (i.e. the existing fluvial floodplain will be eliminated).
- 3 pumps to deal with the existing situation.
- 3 extra pumps to deal with all potential future development within the catchment.
- The Board's scheme is designed to serve the proposed Drax Heron Renewable Energy Plant to the south of the ABLE UK site.
- Discharges from future developments are to be "unrestricted" (based on an assumed 80% impermeability factor).
- The outfall will typically be tide-locked for about 4 hours during a tidal cycle and the pumps will operate during this period if required.

6.5 Feasibility Study - Relocation of NELDB Pumping Station

6.5.1 JBA Consulting have carried out a feasibility study to investigate the possibility of relocating the proposed NELDB pumping station, using elements of the Hannah-Reed hydraulic model. A copy of the Feasibility Report is in Appendix G. The report presents 4 options:

- Route A: being a feasible scheme to relocate the pumping station to the north of the site.
- Route B: being a feasible scheme to relocate the pumping station to the north of the site (with an additional intermediate booster station).
- Route C: Pumping Station relocated to the north of the site using a different watercourse configuration. This option has been discarded because it conflicts with the E.ON power station cooling water pipelines.
- Route D: being a feasible scheme to relocate the pumping station to the south of the site.

ABLE have decided to progress a relocation of the pumping station to the south of the site with the NELDB (i.e. Route D).

6.6 NELDB Advice on Surface Water Drainage Arrangements

6.6.1 General advice on the NELDB surface water drainage requirements is contained in the Hannah Reed document "Standard Criteria for Drainage of Development Land" (see Appendix D.4). The following criteria are particularly relevant to the Marine Energy Park:

- Permeable surfacing should be adopted for storage areas and non-essential hardstanding areas to reduce the burden on the drainage system wherever practicable unless otherwise agreed with the Board.
- Where large impermeable surfaces are implemented the level and drainage strategy should be designed to avoid rapid and concentrated sheet run-off with shallow gradients and extended longitudinal runs used. The risk of surcharging at the outfalls will dictate the need for shallow surface drainage methods.
- Unless otherwise agreed the on-site surface water infrastructure should generally be designed to contain no more than the 1 in 30 annual storm frequency in accordance with current practice. The design should include provision for exceedence to avoid overland flood paths impacting on buildings or adjacent properties.

6.7 Outline Surface Water Drainage Arrangements

6.7.1 The following surface water drainage arrangements are proposed:

- The NELDB outfall and proposed pumping station will be relocated to the south of the quay with associated realignment of the IDB open watercourse channels, as described in the Feasibility Report in Appendix G.
- The Marine Energy Park will be a secure private facility with private roads and sewers.
- Each plot on the Marine Energy Park will have its own independent surface water drainage system with outfalls to an open watercourse. The tenant of each plot will be responsible their surface water drainage system.
- The roads within the Marine Energy Park will be served by a network of highway drains with outfalls to the open watercourses. These highway drains will be maintained by ABLE UK Ltd as port operator. Roads may need an artificial undulating longitudinal profile to achieve effective drainage and the use of hollow kerbing (e.g. Beany Blocks) may be appropriate. Oil interceptors will be provided subject to an assessment of the risk of oil contamination.

6.7.2 The flat topography dictates the use of shallow surface drainage methods wherever possible. Outfalls should be above the normal water level in the open watercourses (at least during periods of low tide). Flapvalves should be provided on all outfalls to prevent water backing up the drainage system when water levels are high in the watercourses and the outfalls are submerged. Penstocks will be installed on surface water outfalls to prevent polluted runoff from discharging into the watercourses where there is an identified risk of this occurring.

6.8 Plot Drainage

6.8.1 Each plot on the Marine Energy Park will have its own independent surface water drainage system with outfalls to an open watercourse. Plot drainage will comprise:

- A piped system of drains to accept runoff from roofs of buildings.
- Concrete service yards are proposed around the perimeters of buildings. Runoff from these areas should pass through oil interceptors. High capacity slot drains may be appropriate for these areas.
- Tarmac parking and traffic circulation areas within each plot could be drained by large capacity slot drainage channels laid to very slack falls (e.g. 1:1,000). Oil interceptors may be required in employee parking areas.

6.8.2 External yard areas within each plot will be provided with a compacted stone pavement suitable for tracking by SPMTs. This would effectively provide a permeable surface and avoid rapid runoff in accordance with the Board's requirements. However, to suppress dust, the surface will be finished with a skim of tarmac chippings or similar: this will tend to provide an impermeable coating on the surface of the yard which will tend to generate surface water runoff. There is a need to positively drain these areas to ensure they are useable by SPMTs in wet or icy weather. The following yard drainage arrangements are proposed (see the drawings in Appendix E):

- Yards to have an inclined ridge and furrow profile to promote drainage towards the nearest watercourse, as shown on Drg. No. AME-04001D in Appendix A.3.
- Land drains to be installed along valley lines with 1,200 mm cover, consisting of perforated or porous pipes with granular backfill, discharging to the IDB ditch system. For a typical valley catchment the indicative pipe size at an outfall point is estimated to be 500 mm diameter, based on a 50% impermeability factor for the yard surface and 50 mm/hour flat rate of rainfall. The structural design of any such shallow drains will require careful consideration as they may be vulnerable to damage by the heavy SPMTs.
- Low bunds to be formed beside watercourses to prevent any potentially polluted overland runoff from rapidly spilling into the watercourses.

- Periodic raking of the yard surface may be required to maintain sufficient permeability.

6.8.3 Finished floor levels (FFLs) of buildings to be set at least 300mm above adjacent yard and storage areas to prevent ingress of exceedance floodwaters when drainage systems are overloaded and external ponding of surface water runoff is occurring.

6.9 Supply Chain Park

6.9.1 The majority of the Supply Chain Park (SCP) area currently has a tarmac finish that was designed for use by light vehicles only. It is anticipated that this will be unsuitable for most tenants. Accordingly the tarmac will be removed as required and the bearing capacity of the pavement layer will be improved to tenant requirements by the addition of imported stone fill and, if required, geogrid. Within the main SCP site, the existing drainage system was installed in 2006 and comprises high capacity slot drains that discharge into the open ditches running around its perimeter. These drains will be retained where possible.

6.10 Drainage of the Quay - Surface Water Runoff

6.10.1 Surface water runoff from the quay will be discharged to the sea. A piled concrete relieving slab will be constructed behind the front wall of the quay to enable a range of heavy plant to operate anywhere on the quay. The quay will have a compacted stone surface to provide a heavy duty pavement for operational plant including SPMTs. The slope of the quay will not exceed 1:100 (to accommodate SPMTs). The Environment Agency have advised that a consent is not required to discharge surface water runoff from the quay direct to the sea providing that:

- Oil interceptors are installed where there is a sufficient risk that runoff might be contaminated.
- Wash-down areas are connected to the foul drainage system.

6.11 Drainage of the Quay - Wave Overtopping

6.11.1 The surface profile of the quay has been designed in relation to wave overtopping. Any overtopping floodwaters will be intercepted by the quay and/or its drainage system and discharged back to the sea (i.e. they will not spill inland).

6.11.2 The zone adjacent to the quay face will slope gently towards the sea to shed overtopping floodwaters back into the sea, and precautions will be taken to prevent polluted discharges to the sea (e.g. careful siting and bunding of oil tanks).

6.12 Pollution Incidents

6.12.1 The management of pollution incidents has been discussed with the Environment Agency and the following measures are proposed:

- Excavation of contaminated hardcore surfacing and transportation to a licensed tip.
- Penstocks will be installed on surface water outfalls to prevent polluted runoff from discharging into the watercourses where there is an identified risk of this occurring.
- Installation of oil interceptors to serve paved areas.
- Bunding of oil tanks etc. and careful siting of such facilities well away from the quay face.

6.13 Drainage Strategy for Climate Change

6.13.1 The proposed NELDB Improvement Scheme is designed for the 1% (100-year) AEP event. See Appendix D.4 for Document 2-C204032 (NELDB Standard Criteria for Drainage of Development Land - Able Marine Energy Park). This document includes the statement "An adaptive approach to climate change is promoted in the strategy". Hannah Reed have explained that this approach is partly to allow for flexibility in the development timings, and the take-up of contributing area; if significant use of permeable surfacing can be made there may not be a need for additional measures. The identified corridors for flood mitigation include zones where additional flood storage might be provided in the future. Corridors for flood mitigation infrastructure/ecology are coloured blue on Drg. No. 2-C204032-SK13. Provision of additional pumping capacity might be another option for mitigating the impact of climate change, but this is not preferred on cost grounds.

6.14 IDB Consent for Outfalls

6.14.1 Any proposed surface water outfall structures on the banks of IDB watercourses will require the specific consent of the Board under their Byelaws.

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7. Foul Water Drainage Strategy

7.1 Initial Contact with Anglian Water

7.1.1 Extracts from the Statutory Sewer Map were obtained from Anglian Water and an initial meeting was held with them to discuss the proposed foul drainage strategy. There are no public sewers within or adjacent to the site and a new foul drainage connection will have to be made direct to the South Killingholme WWTW. In essence, Anglian Water will upgrade South Killingholme WWTW and will subsequently carry out the necessary improvement works. Any potential effects of the discharge from the WWTW on the receiving water body will be controlled by other consents to be obtained by Anglian Water as part of their upgrading of the WWTW. The EA would be concerned about any potential delays in the WWTW upgrade that might result in the need for temporary tankering of foul effluent. Correspondence from Anglian Water is reproduced in Appendix K.

7.2 Outline Foul Drainage Arrangements

7.2.1 Foul flows from individual plots will be relatively small resulting in a need for small size pipes at minimum self-cleansing gradients where flows are under gravity (typically 150mm pipes at a minimum gradient of 1:150). The site is so large and drain runs so long that gravity foul drains would become excessively deep. It is advisable to avoid the difficulties of constructing deep drains in poor or waterlogged ground. It is therefore proposed that a shallow pumped foul drainage system will be installed due to the flat topography. AMEP will be a secure private facility with private roads and sewers. The foul drainage system will therefore consist of:

- A network of private inter-connected satellite pumping stations and rising mains within the Marine Energy Park.
- A terminal on-site foul pumping station with an offsite rising main discharging direct to the South Killingholme WWTW. It is intended that this pumping station and rising main would form part of the public sewerage system. These facilities could be provided by Anglian Water under the sewer requisition procedure or constructed by ABLE and subsequently taken over by Anglian Water under the sewer adoption procedure.

7.3 Supply Chain Park

7.3.1 The existing Supply Chain Park site has two package foul treatment plants that discharge into the NELDB drain running through the site; these units will be retained. However all new buildings will be provided with a connection to the adopted foul water drainage system operated and maintained by Anglian Water.

7.4 Detailed Design Considerations

7.4.1 Foul drainage matters to be resolved at the detailed design stage include:

- Avoidance of shallow drains under hardcore yard areas (to minimise risk of damage to drains by heavy SPMTs).
- Final calculation of foul flow rates. ABLE UK Ltd have provided the following preliminary foul flow rates:
    - Domestic sewage: 13 l/s.
    - Trade effluent: 25 l/s.
- There will be a small Customs House near the quay, which may be remote from the proposed foul drainage system in the inland manufacturing area. A private foul treatment package plant is currently proposed with a direct discharge to the sea. The outfall point would have to be below the low tide mark.

Appendices

A. Plans of the Development

A.1 Drg. No. AME-02001B: Site Location Plan

A.2 Masterplan

A.3 Drg. No. AME-04001D: Finished Ground Levels

A.4 Drg. No. AME-01151A: Proposed Access Arrangements to Retained Environment Agency Defences

A.5 Drg. No. AME-06038: Typical Cross Section through Site

A.6 Drg. No. AME-02045A: Schematic Section Through Quay

A.7 Drg. No. AMEP_P1D_D_001: Quay General Arrangement

A.8 Drg. No. AMEP_P1D_D_003: Quay Sections 1 of 2

A.9 Drawing of Rock Armour Protection to Existing Northern Defences

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KEY

Site Boundary

Rev	Date	Description	By	Chk	App
E	03/11/11	Boundary Amended	JH	RC	RC
D	05/07/11	Boundary Amended	JH	RC	RC
C	21/04/11	Boundary Amended	JH	RC	RC
B	20/12/10	Boundary Amended	JH	RC	RC
A	21/09/10	Preliminary Issue	RK	RC	RC

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email: info@ableuk.com
www.ableuk.com

Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

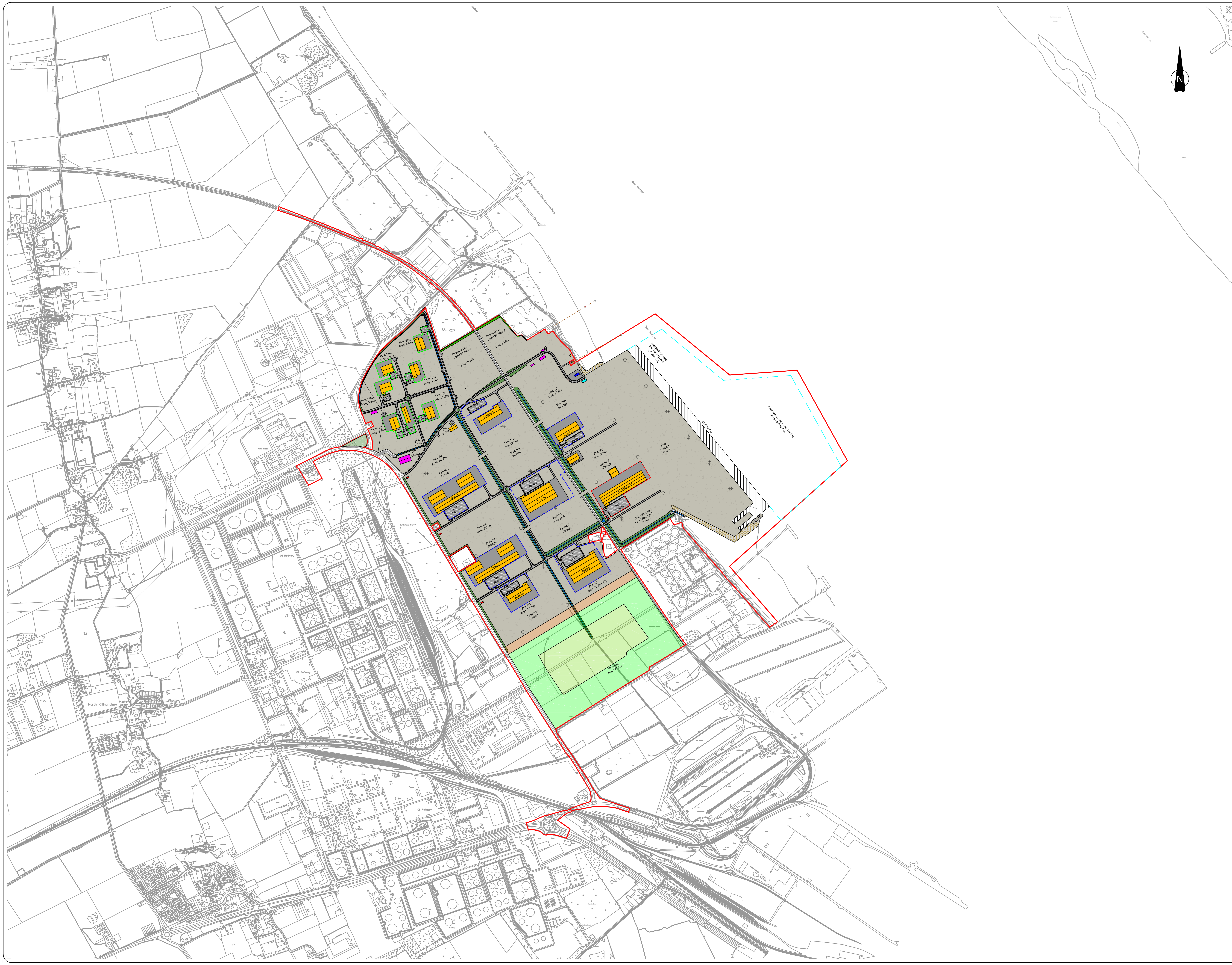
Title: Site Location Plan

PRELIMINARY

Scale:	Drawn By	Checked By	Approved By
1:50,000@A3	R Keirl	R Cram	R Cram
Date:	21/09/2010	21/09/2010	21/09/2010

Drawing No.: AME - 02001

Revision: E



KEY

- Limit of deviation for siting of building up to 50m high.
- Limit of deviation for siting of building up to 25m high.
- Limit of deviation for siting of building up to 15m high.
- 48 Space Car Park
- Stone Surfacing
- Concrete Surfacing
- Rock Revetment
- Existing Lighting Column (21-30m High)
- Proposed Lighting Column (55m High)
- Existing Cooling Water Intake
- Existing Cooling Water Outfall
- Existing Mooring Dolphin
- Existing Building
- Proposed Building
- Electric Substation
- HMRC Office
- Berthing Pocket
- Waste Recycling & Transfer Facility
- Able Approach Channel

Rev	Date	Comments	Drw	Chk	App
B	31/10/11	Mitigation area amended	RK	PMS	PMS
A	07/09/11	Issued with DCO Application	JH	RC	RC

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www.ableuk.com

Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Indicative Masterplan

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:10,000@A1	J Harris	R Cram	R Cram
Date	07/09/2011	07/09/2011	07/09/2011

Drawing No. AME - 1010

Revision: B

KEY

Rev	Date	Comments	Drw	Chk	App
F	03/11/11	Quay Amended	JH	RC	RC
E	07/02/11	Layout extended	SDB	RC	RC
D	01/02/11	Layout amended	SDB	RC	RC
C	15/11/10	Layout amended	SDB	RC	RC
B	20/10/10	Layout amended	SDB	RC	RC
A	15/10/10	Preliminary Issue	SDB	RC	RC

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Project: Able Marine Energy Park

Client: ABLE UK Ltd

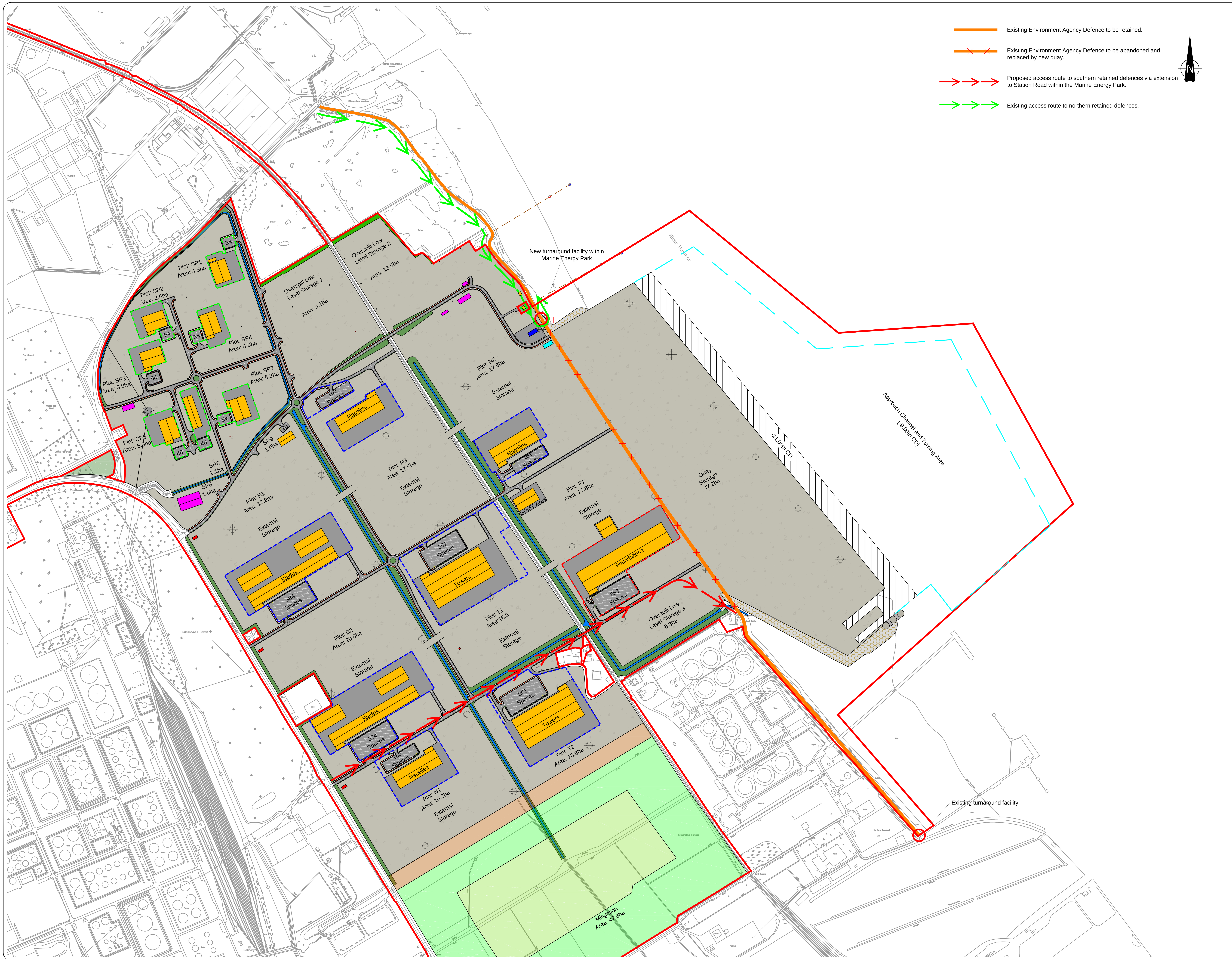
Title: Finished Ground Levels

FOR APPROVAL

Scale:	Drawn	Checked	Approved
1:5000@A1	SDB	RC	RC
Date	15/10/2010	15/10/2010	15/10/2010

Drawing No. AME - 04001

Revision: F



KEY

Rev	Date	Description	By	Chk	App
C	03/11/11	General Amendments	JH	RC	RC
B	06/09/11	General Amendments	JH	RC	RC
A	12/04/11	Preliminary Issue	SDB	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Proposed Access Arrangements to Retained Environment Agency Defences

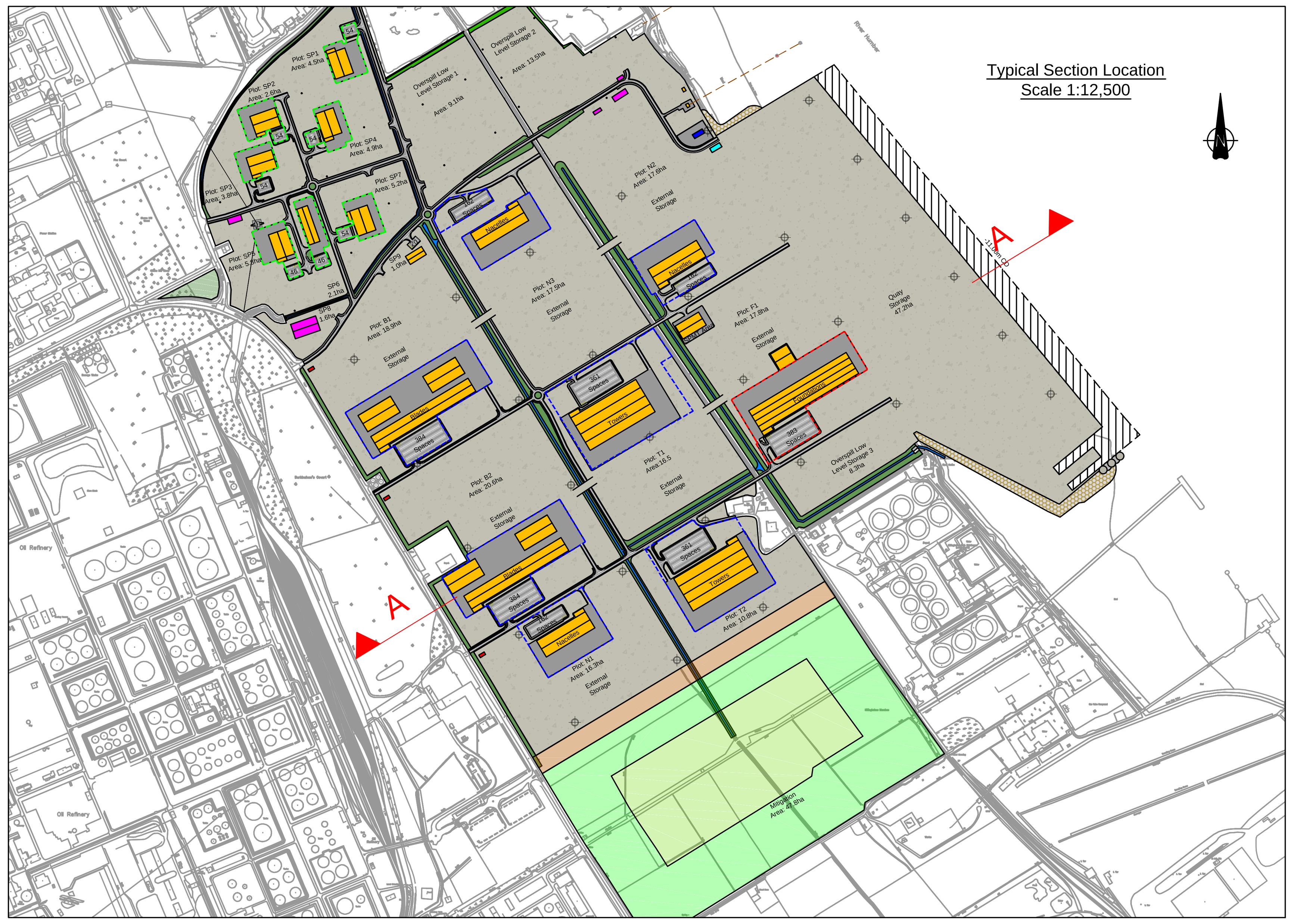
PRELIMINARY

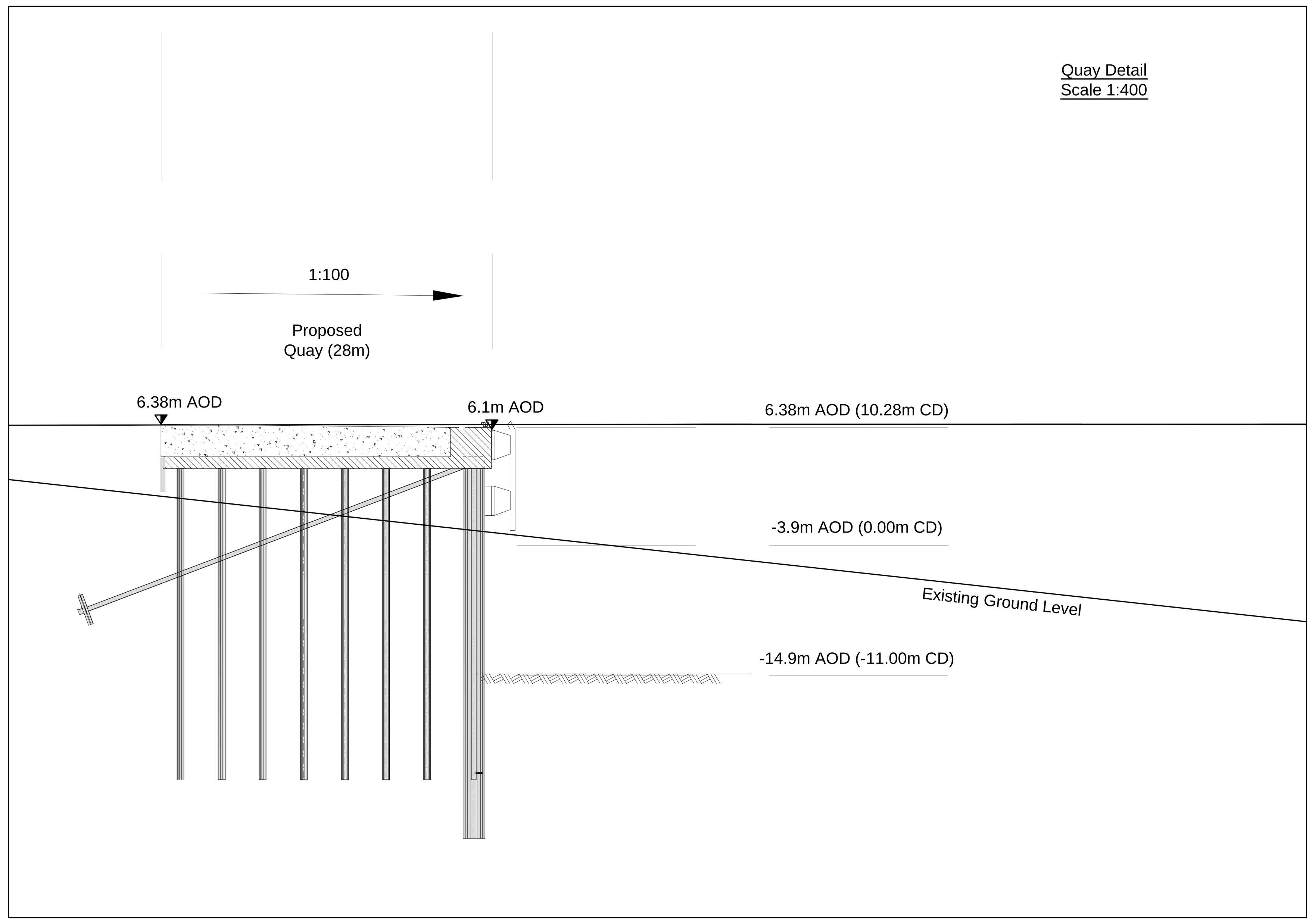
Scale:	Drawn By	Checked By	Approved By
1:5,000@A1	SDB	R Cram	R Cram
Date:	12/04/2011	12/04/2011	12/04/2011

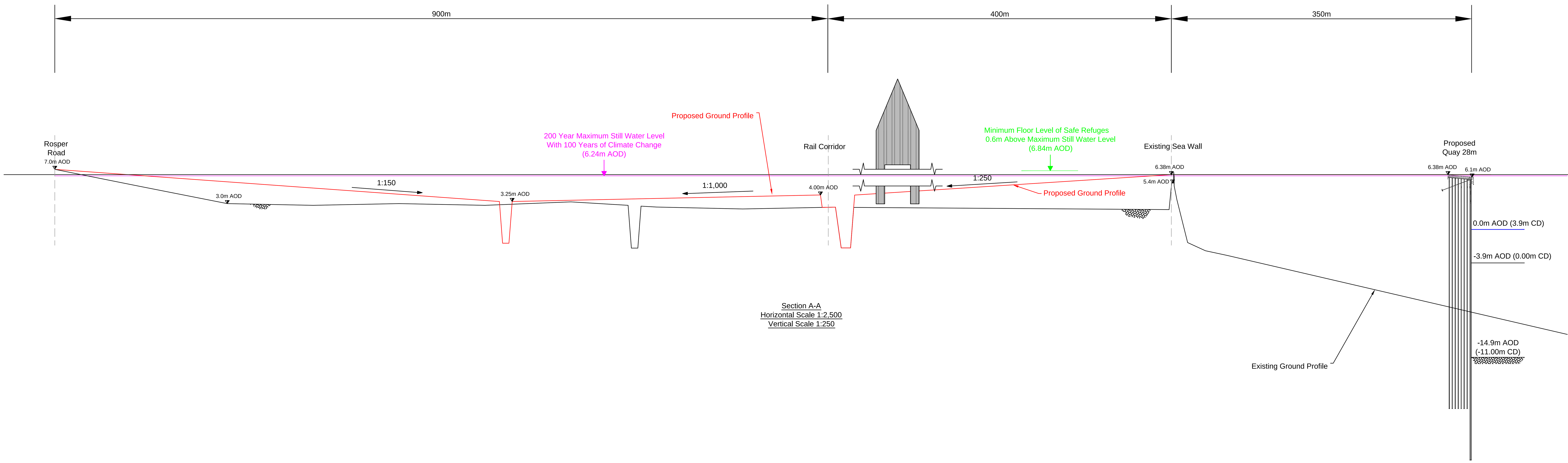
Drawing No. AME - 01151

Revision: C

Cross Section Location Plan







Section A-A
Horizontal Scale 1:2,500
Vertical Scale 1:250

KEY

Notes:

1. Building detail is Indicative

Rev	Date	Comments	Drw	Chk	App
G	03/11/11	General Amendments	JH	RC	RC
F	30/09/11	General Amendments	RK	RC	RC
E	28/09/11	General Amendments	JH	RC	RC
D	20/09/11	Vertical Scale Amended	JH	RC	RC
C	18/08/11	General Amendments	JH	RC	RC
B	03/08/11	General Amendments	JH	RC	RC
A	18/11/10	Preliminary Issue	PP	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

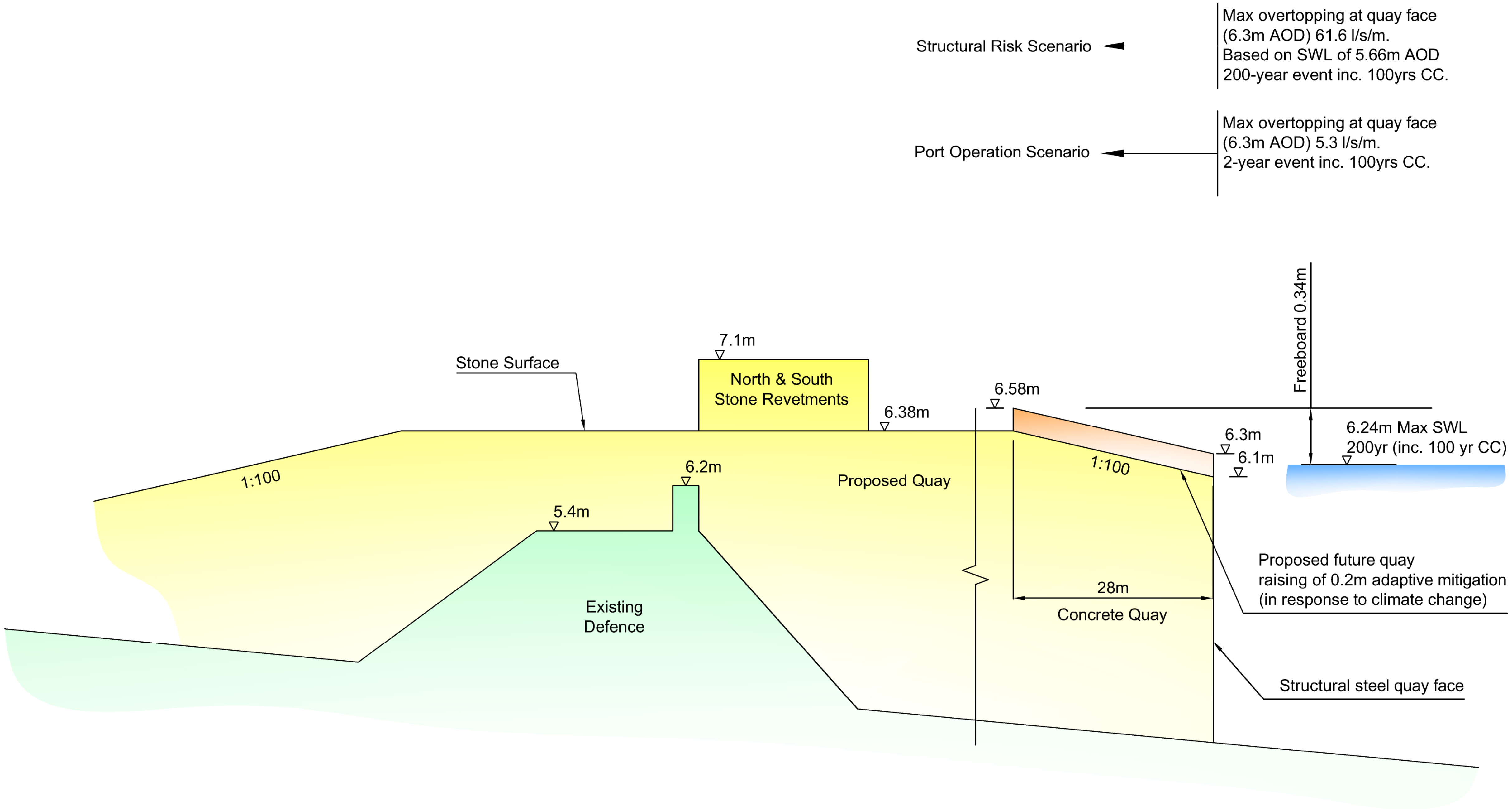
Title: Typical Section Through Site

PRELIMINARY

Scale:	Drawn	Checked	Approved
As Shown@A1	P Parsley	R Cram	R Cram
Date	26/04/2011	26/04/2011	26/04/2011

Drawing No. AME - 06038

Revision: G



KEY

Notes

1. All levels in m AOD.
2. SWL = Still Water Level
3. CC = Climate Change

Rev	Date	Comments	Drw	Chk	App
B	01/08/11	Overtopping rates revised for raised quay face level of 6.3m AOD	JH	RC	RC
A	21/04/11	Preliminary Issue	PP	PP	RC

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Project: Able Marine Energy Park

Client: Able Humber Ports Ltd

Title: Schematic Section Through Quay

PRELIMINARY

Scale:	Drawn	Checked	Approved
NTS@A3	P Parsley	P Parsley	R Cram
Date	21/04/2011	21/04/2011	21/04/2011

Drawing No. AME - 02045

Revision: B

Rev	Date	Description	By	Chk	App
G	02.11.11	Revision IPC Application	BKY	SVF	HTA
F	21.10.11	Revision IPC Application	BKY	SVF	HTA
E	16.09.11	Revision IPC Application	BKY	SVF	HTA
D	31.08.11	Revision IPC Application	BKY	SVF	HTA
C	30.08.11	Revision IPC Application	BKY	SVF	HTA
B	19.01.11	Revision of Northern Revetment/ Breakwater	BKY	SVF	HTA
A	07.01.11	EIA Masterplan Revision	BKY	SVF	HTA
0	17.09.10	Preliminary Issue	BKY	SVF	HTA

KEY

- Levels to Chart Datum
- Details based on preliminary design
- Levels given for the Approach Channel and the Harbour Bed are the maximum maintained levels.

Cross Sections (B) (D) (E) (H)
Drawing No.: D-003

Cross Sections (C) (F) (G)
Drawing No.: D-004

Front Wall Elevation (1)
Drawing No.: D-005

Northern Return Wall Elevation (2)
Drawing No.: D-006

Southern Return Wall Elevation (3)
Drawing No.: D-007

- Existing Cooling Water Intake
- Existing Cooling Water Outfall
- Proposed Lighting Column (50m High)

0 25 50 100 150 250
Scale 1:2500 (A1) METRES
Scale 1:5000 (A3)

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Quay General Arrangement

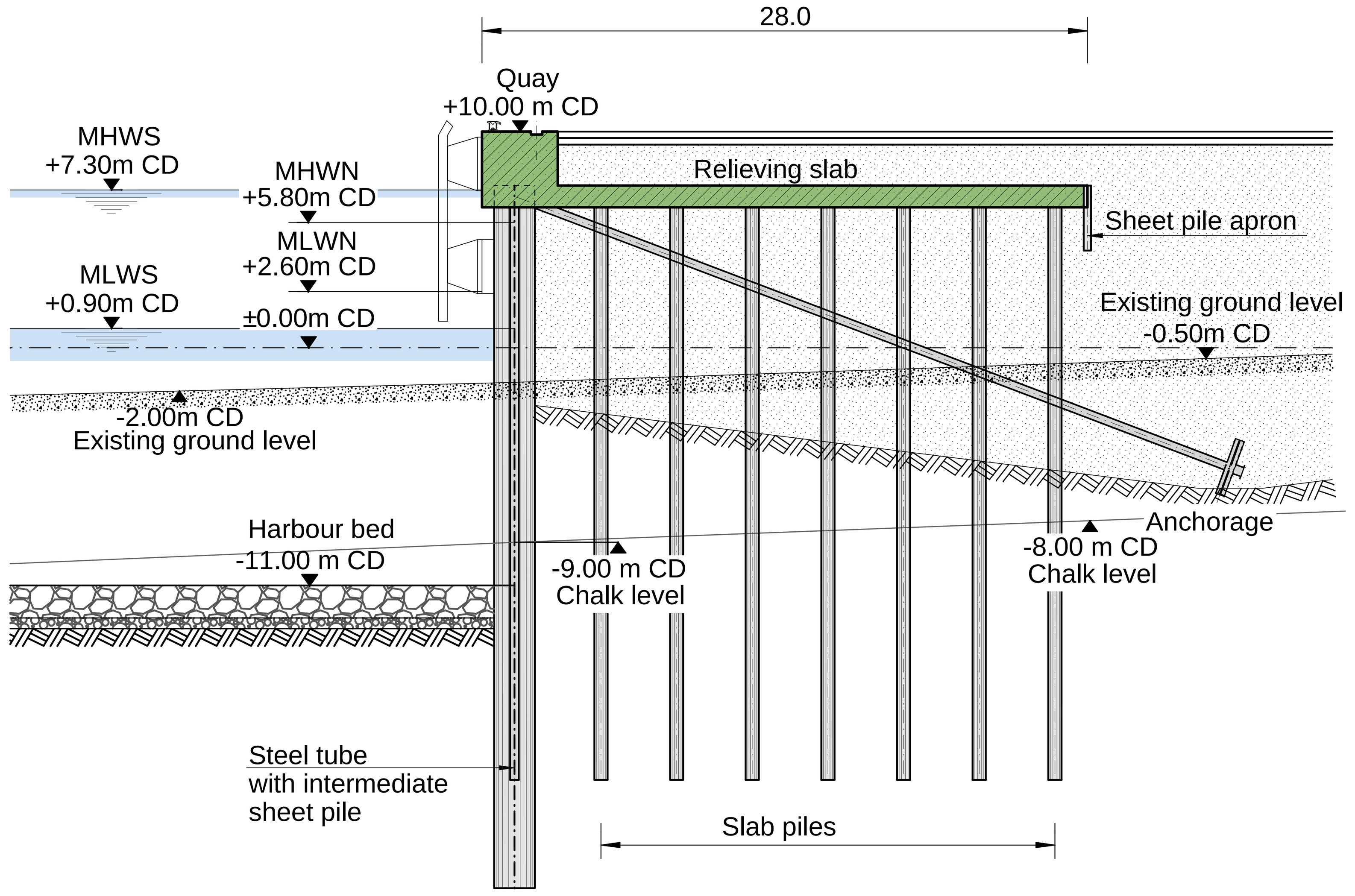
PRELIMINARY

HOCHTIEF
SOLUTIONS AG
Civil Engineering and Marine Works
Lübeckertordamm 1
20099 Hamburg / Germany
Tel. 0049-40/ 21986-0
Fax. 0049-40/ 21986-200

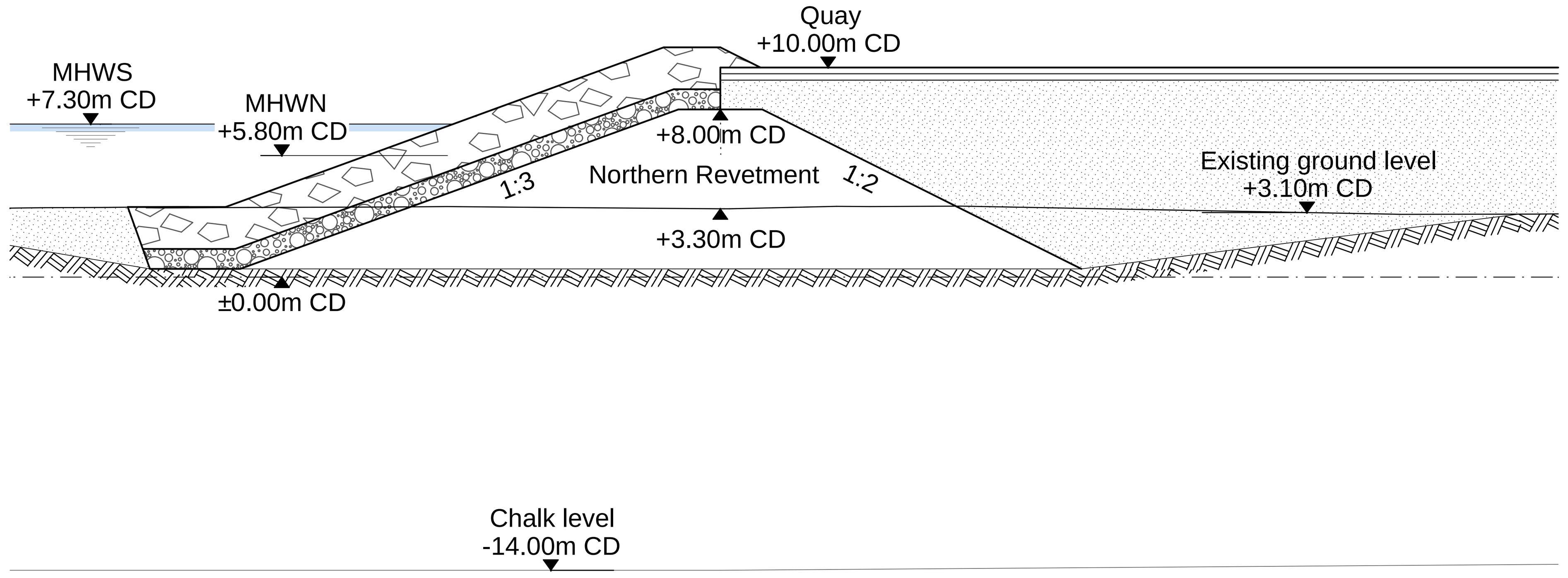
Scale:	Drawn By	Checked By	Approved By
1 : 2500 @A1	BKY	SVF	HTA
Date:	17.09.2010	17.09.2010	17.09.2010

Drawing No.: AMEP_P1D_D_001 Revision: G

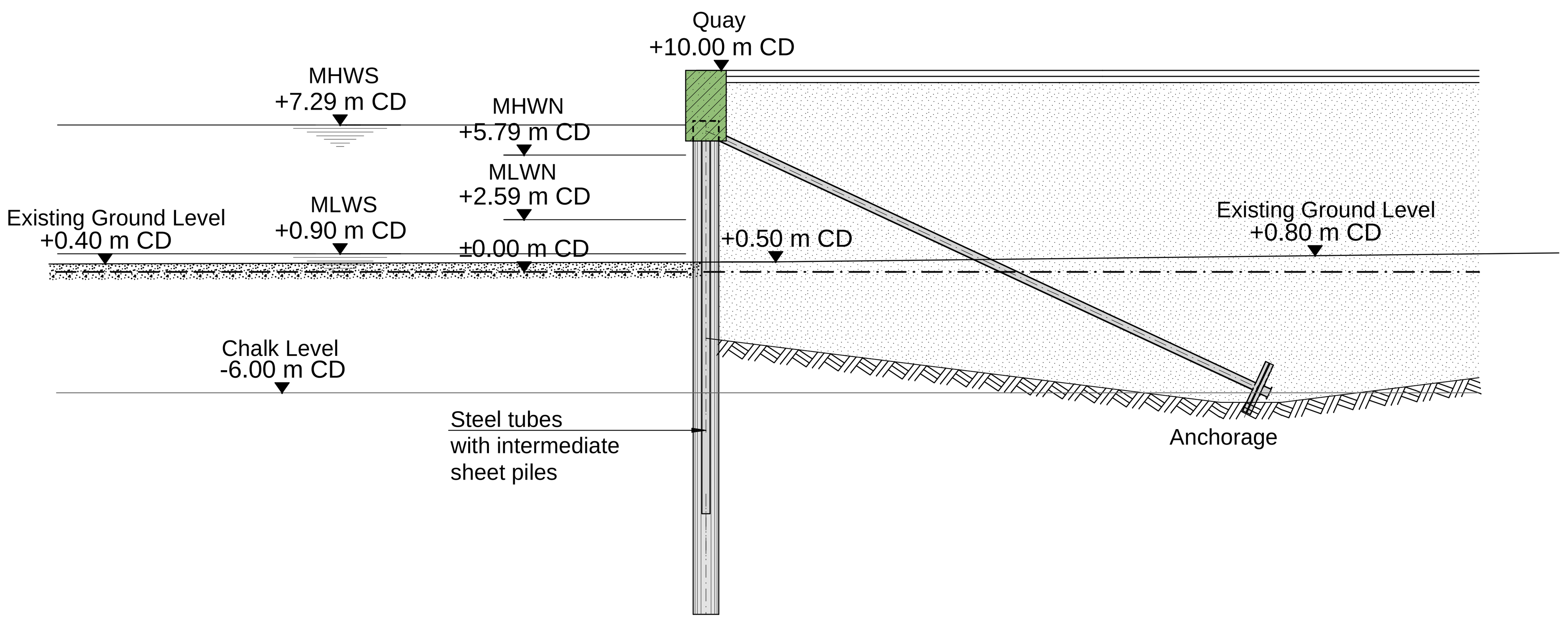
Cross Section B-B



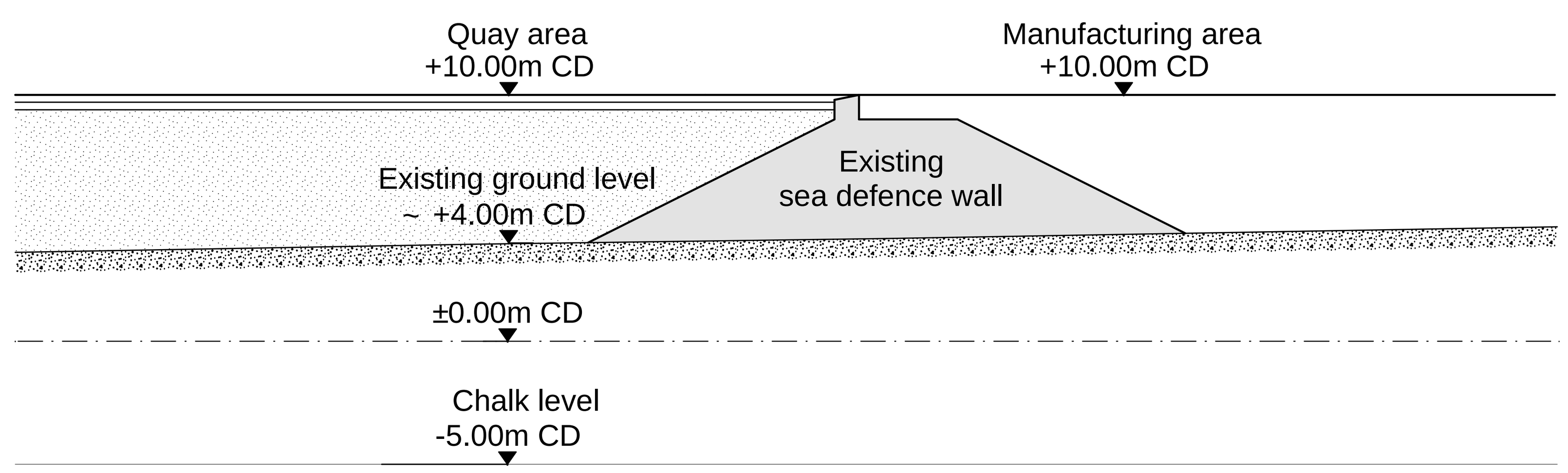
Cross Section E-E



Cross Section D-D



Cross Section H-H



0 2,5 5 10 15 25
Scale 1:250 (A1) METRES
Scale 1:500 (A3)

KEY

- -Levels to Chart Datum
- -Details based on preliminary design
- -Levels given for the Approach Channel and the Harbour Bed are the maximum maintained levels

Rev	Date	Description	By	Chk	App
F	21.10.11	Revision IPC Application	ASS	SVF	HTA
E	16.09.11	Revision IPC Application	ASS	SVF	HTA
D	31.08.11	Revision IPC Application	ASS	SVF	HTA
C	30.08.11	Revision IPC Application	ASS	SVF	HTA
B	19.01.11	Revision of Northern Revetment/ Breakwater	ASS	SVF	HTA
A	07.01.11	EIA Masterplan Revision	ASS	SVF	HTA
0	17.09.10	Preliminary Issue	BKY	SVF	HTA

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www.ableuk.com

Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Quay Sections 1 of 2

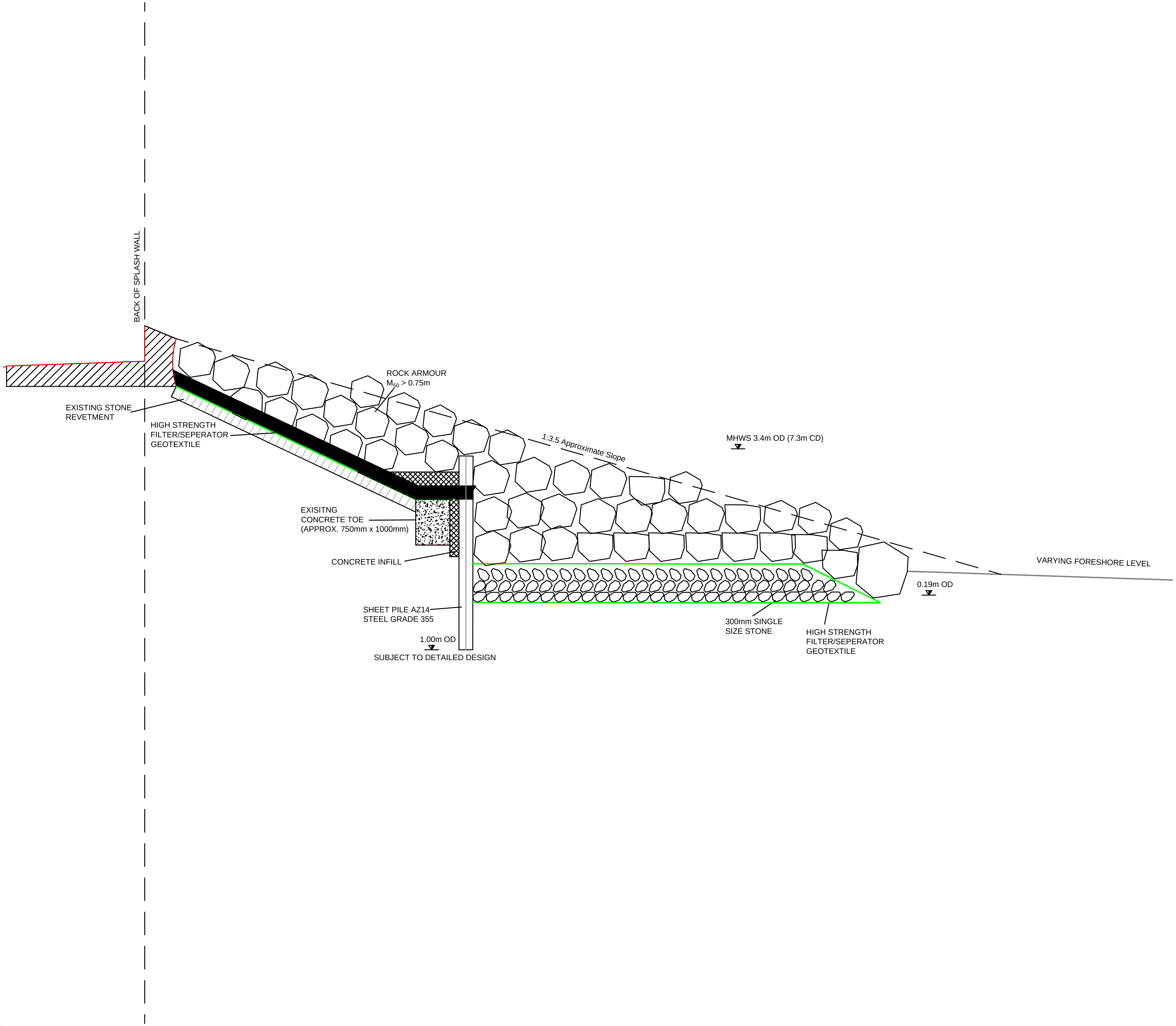
PRELIMINARY

HOCHTIEF
SOLUTIONS AG
Civil Engineering and Marine Works
Lübeckertordamm 1
20099 Hamburg / Germany
Tel. 0049-40/ 21986-0
Fax. 0049-40/ 21986-200

Scale:	Drawn By	Checked By	Approved By
1 : 250 @A1	BKY	SVF	HTA
Date:	17.09.2010	17.09.2010	17.09.2010

Drawing No.: AMEP_P1D_D_003

Revision: F



KEY

Rev	Date	Comments	Drw	Chk	App
B	07/12/11	Splash Wall Removed	JH	RC	RC
A	03/11/11	Preliminary Issue	JH	RC	RC

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email: info@ableuk.com
www.ableuk.com

Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Indicative Rock Armour Protection to Existing Northern Defences

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:80@A3	J Harris	R Cram	R Cram
Date	03/11/2011	03/11/2011	03/11/2011

Drawing No. AME - 06065

Revision: B

B. Topographical Survey

B.1 The Previously Developed Northern Part of the Site

Drg. No. AME-04002A: Consented Finished Site Levels

B.2 The Undeveloped Southern Part of the Site

Drg. No. 5160/11A: Topographical Survey

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KEY

- AREA COMPLETE
- AREA UNDER CONSTRUCTION

Rev	Date	Description	By	Chk	App
A	13/01/11	Preliminary Issue	SDB	RC	RC

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Project: Able Marine Energy Park

Client: ABLE UK Ltd

Title: Consented Finished Site Levels

PRELIMNARY

Scale:	Drawn By	Checked By	Approved By
1:5,000@A3	SDB	RC	RC
Date:	14/01/11	14/01/11	14/01/11

Drawing No.: AME - 04002

Revision: A

Topographical Survey Legend

Drainage/Services Legend

Levels related to Ordnance Survey Datum using GPS

Coordinates related to Ordnance Survey grid using GPS

This Topographical Survey has been produced without local scale correction i.e. on an orthographic coordinate grid system site centred around STN GPC

Please note, due to obstructions such as vegetation First Point Surveys Ltd. cannot guarantee all pertinent information has been surveyed.

Due to obstructions on the revetment wall several levels have not been obtainable.

FIRST POINT SURVEYS
Land, Engineering & Building Surveyors
2, Stoneacre ▪ Grimbald Crag Close ▪ Knaresborough ▪ HG5 8PJ
Tel 01423 869351 ▪ Fax 01423 883371
info@FirstPointSurveys.co.uk ▪ www.FirstPointSurveys.co.uk

TITLE
Additional Topographical Survey
Able Humber Port
Land off Rosper Road
Immingham

CLIENT
Able UK Ltd
Able House
Billingham
Teesside UK
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email: info@ableuk.com
www.ableuk.com

DATE	DRAWN BY	CHKD. BY
Sept. 2010	TS	MIH

DRG NO	PLOT SCALE
5160 / 11A	to fit border

REV	AMENDMENT	DATE	BY	CHKD.
A	Wave return wall heights added	21/10/2010	TS	MIH

C. Information from the Environment Agency

C.1 Product 4 Flood Risk Information

The Environment Agency supplied a comprehensive package of "Product 4" flood risk information comprising:

- A letter dated 29 October 2010.
- Map 1 - Flood Map.
- Map 2- Historic Flood Extent Map.
- Map 3 - Tidal Flood Levels.
- Map 4 - National Flood and Coastal Defence Database (NFCDD) Information.
- Maps 5a & 5b - Modelled Overtopping Flood Extents.
- Map 6 - Cross Section & Crest Level Information for Existing Tidal Defences.
- Standard Notice - Commercial.

C.2 Flood Hazard Mapping

The Environment Agency supplied Flood Hazard Mapping information comprising:

- A letter dated 27 October 2010.
- Hazard/Depth/Velocity Map for the year 2006 (1 in 200 year event).
- Hazard/Depth/Velocity Map for the year 2006 (1 in 1,000 year event).
- Hazard/Depth/Velocity Map for the year 2115 (1 in 200 year event).
- Hazard/Depth/Velocity Map for the year 2115 (1 in 1,000 year event).
- Special Licence - Commercial.
- Map of Locations of Modelled Breaches.

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Environment Agency

David Stark
<david.stark@jbaconsulting.co.uk>

Our ref: CCN/2010/25421
Your ref:

Date: 29 October 2010

Dear Mr Stark

Detailed Flood Risk Assessment Data Request for the Marine Energy Park, Killingholme.

Thank you for your request of 7 October 2010 to use Environment Agency data, Product 4 in the development of the Flood Risk Assessment for the above site. The information is attached.

If you have requested this information to help inform a development proposal, then you should note the detail in the attached advisory text on the use of Environment Agency Information for Flood Risk Assessments / Flood Consequence Assessments.

Map 1 – Flood Map
A copy of the current Flood Map for the area is enclosed. The Flood Map indicates the area at risk of flooding, assuming no flood defences exist, for a flood event with a 0.5% chance of occurring in any year for flooding from the sea, or a 1% chance of occurring for fluvial (river) flooding. It also shows the extent of the Extreme Flood Outline which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

The Flood Map only indicates the extent and likelihood of flooding from rivers or the sea. It should also be remembered that flooding may occur from other sources such as surface water sewers, road drainage, etc.

Map 2 – Historic Flood Extent Map
A copy of the Historic Flood Extent Map for your area is enclosed. This shows the extent of previous recorded flooding in your area, notably January 1953. Further information about this event is shown on the attached datasheet.

It is possible that other flooding may have occurred that we do not have records for, and other organisations, such as the Local Authority or Internal Drainage Boards, may have records.

Map 3 – Tidal Flood Levels
Please find attached available **tidal** flood levels as requested. These levels have an assessment date of 2006, which should be used in any consideration of future increases due to climate change. The levels are in metres above Ordnance Datum Newlyn (mODN) and are valid for 12 months from the date of issue.

Map 4 – National Flood and Coastal Defence Database (NFCDD) Information
Map 4 shows the location of the tidal defences protecting this site. This information is obtained from the National Flood and Coastal Defence Database (NFCDD). Further information about these defences is shown on the attached datasheet.

The **tidal** defences protecting this site consist of concrete floodwalls, are in a good to fair condition and provide protection against a flood event with a 0.67% chance of occurring in any year (1 in 150). We inspect these defences regularly to ensure that any potential defects are identified early.

Map 5a & 5b – Modelled Flood Extents
Please find attached a map showing the results of the Lincolnshire Coast and Humber Tidal Overtopping Model (October 2010) for your area. This shows modelled flood extents, taking into account flood defences.

Map 6 - Cross Section & Crest Level Information
Please find enclosed a typical cross section through the defence adjacent to your site. This information was produced for use in the Lincolnshire Coast and Humber Tidal Overtopping Modelling (October 2010). Map 6 shows the crest levels of the NFCDD defence line based on 1m resolution LiDAR information

Information for Informing a Flood Warning / Evacuation Plan
Also enclosed are a set of four maps showing the depth/timings for the first tidal cycle after a breach occurs for a range of present day and climate change scenarios. For your site the dominant breach is H18. This information is currently in Draft form, and more analysis work will be done on the data over the coming months to finalise it.

Land Drainage
The information provided is limited to flood risk from the sea and rivers with catchment areas greater than $3km^2$. The property is in an area of extensive land drainage which may pose an additional risk of flooding. Further information should be sought from the North East Lindsey Internal Drainage Board (tel: 01469 588991).

This information is provided subject to the enclosed notice, which you should read.

If you have any queries or would like to discuss the content of this letter further please contact Adam Treverton using the telephone/email details below. Please quote our CCN reference number in all correspondence where data is referenced, including the Flood Risk Assessment.

Yours sincerely

FOR John Ray
Team Leader, Flood Risk Mapping & Data Management

Direct dial 01522 785806
Direct fax 01522 785018
Direct e-mail adam.treverton@environment-agency.gov.uk

Enc.
Detailed FRA Maps, Datasheet, FRA/FCA Advisory Text, Standard Notice (Commercial)

Use of Environment Agency Information for Flood Risk Assessments / Flood Consequence Assessments

Important

If you have requested this information to help inform a development proposal, then you should note the following: In England, you should refer to the Environment Agency's Flood Risk Standing Advice and PPS25 and its associated Practice Guide for information about what flood risk assessment is needed for new development in the different flood zones. These documents can be accessed via:
http://www.environment-agency.gov.uk/research/planning/82587.aspx
http://www.communities.gov.uk/publications/planningandbuilding/pps25floodrisk
http://www.communities.gov.uk/publications/planningandbuilding/pps25practiceguide

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

In **Wales**, you should refer to TAN15 for information about what flood consequence assessment is needed for new development in the different flood zones
http://new.wales.gov.uk/topics/planning/policy/tans/tan15?lang=en

You should also refer to any Strategic Flood Consequence Assessment produced by your local planning authority.

In both **England and Wales** you should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a flood risk or flood consequence assessment (FRA/FCA) where one is required, but does not constitute such an assessment on its own.

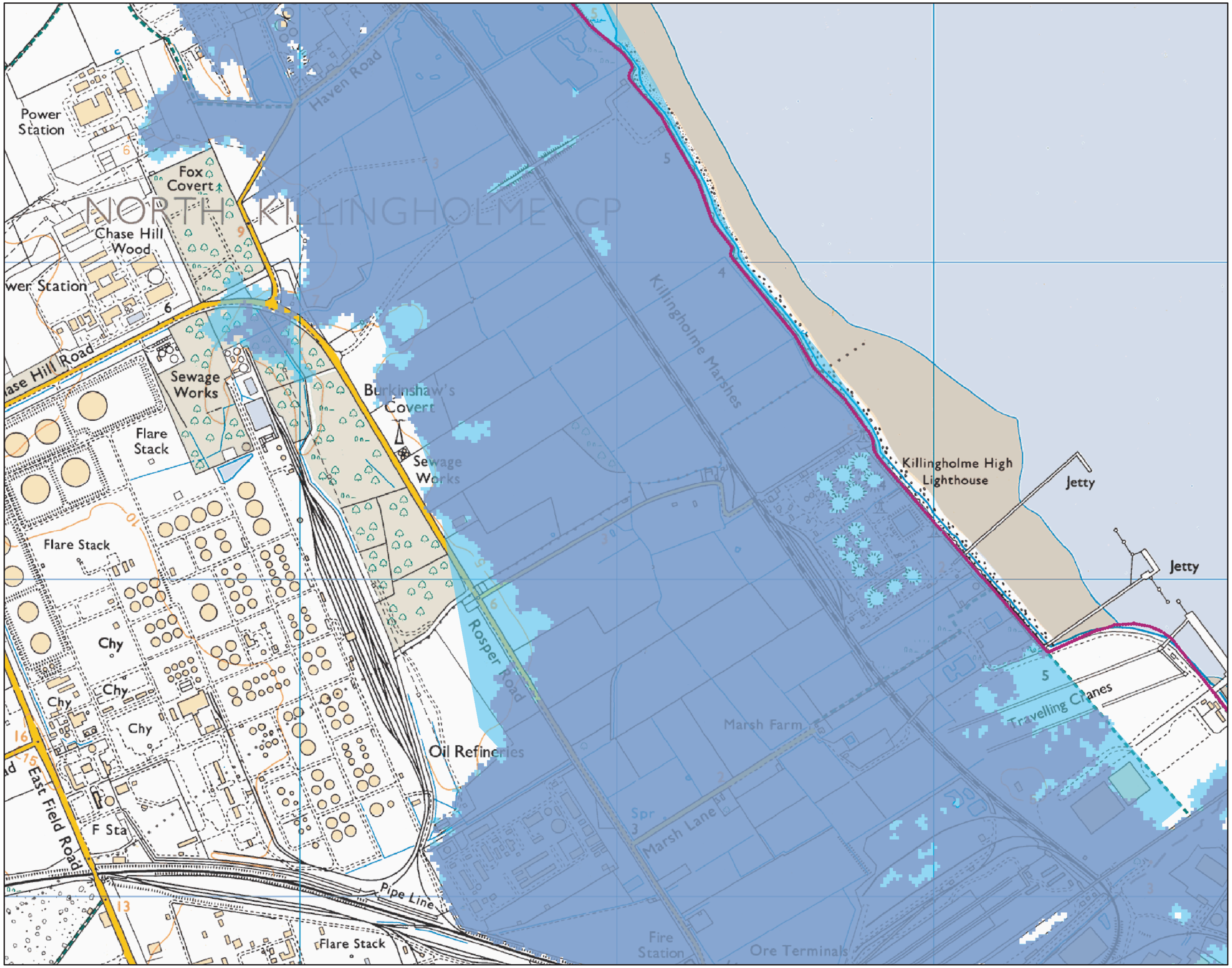
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. The information produced by the local planning authority referred to above may assist here.

3. Where a planning application requires a FRA/FCA and this is not submitted or deficient, the Environment Agency may well raise an objection.

4. For more significant proposals in higher flood risk areas, we would be pleased to discuss details with you ahead of making any planning application, and you should also discuss the matter with the local planning authority.

Map 1. Flood Map

Map centred on TA 1700 1830 - created October 2010 [Ref: CCN-2010-25421]



Environment Agency

Scale 1:12,500

- Main River
- Raised Defences
- Flood Storage Areas
- Area at Risk of Flooding from Rivers or The Sea
- Extreme Flood Outline

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.

- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

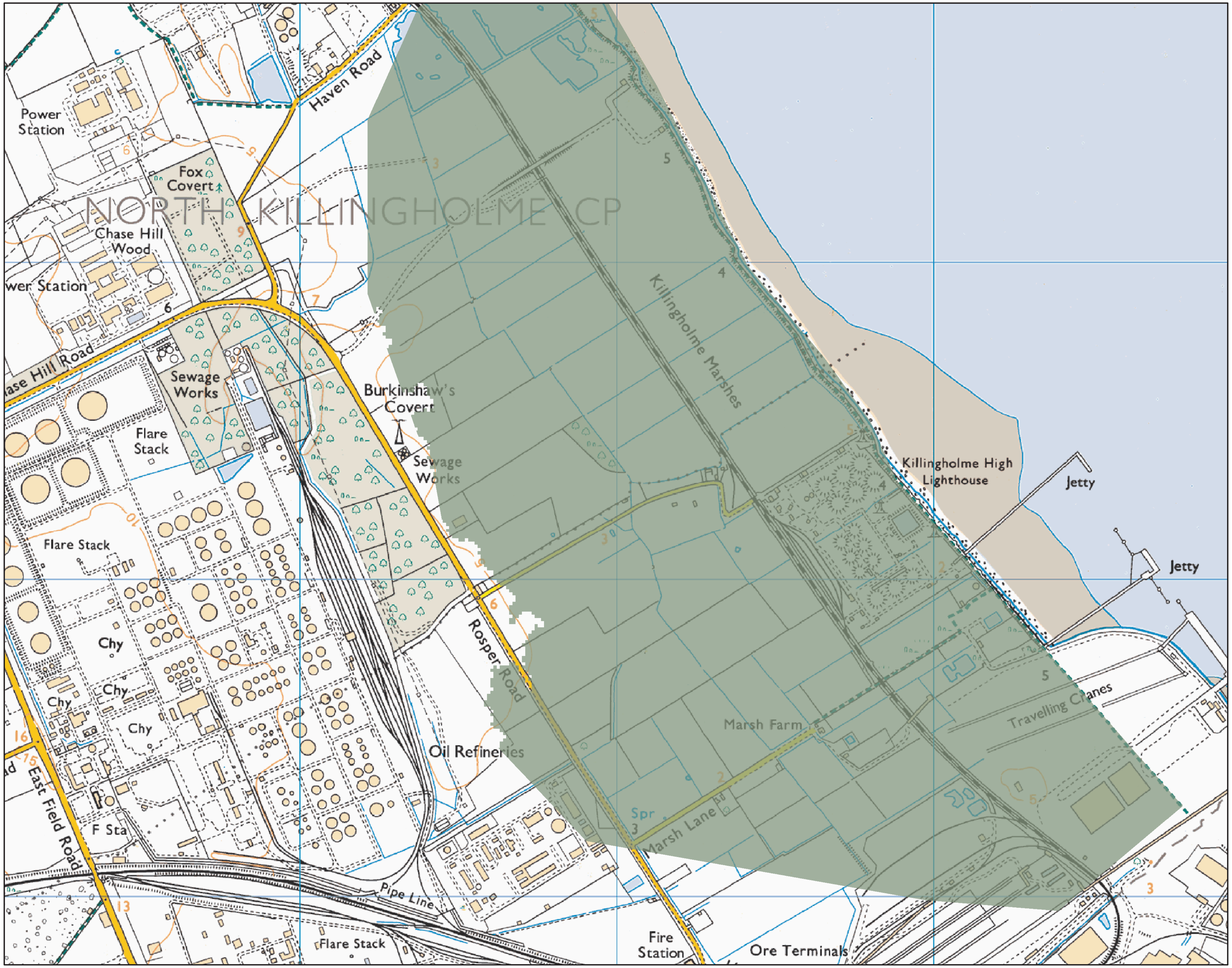
These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

Created by the Flood Risk Mapping & Data Management Team, Lincoln

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Map 2. Historic Flood Extent Map

Map centred on TA 1700 1830 - created October 2010 [Ref: CCN-2010-25421]



Environment Agency

Scale 1:12,500

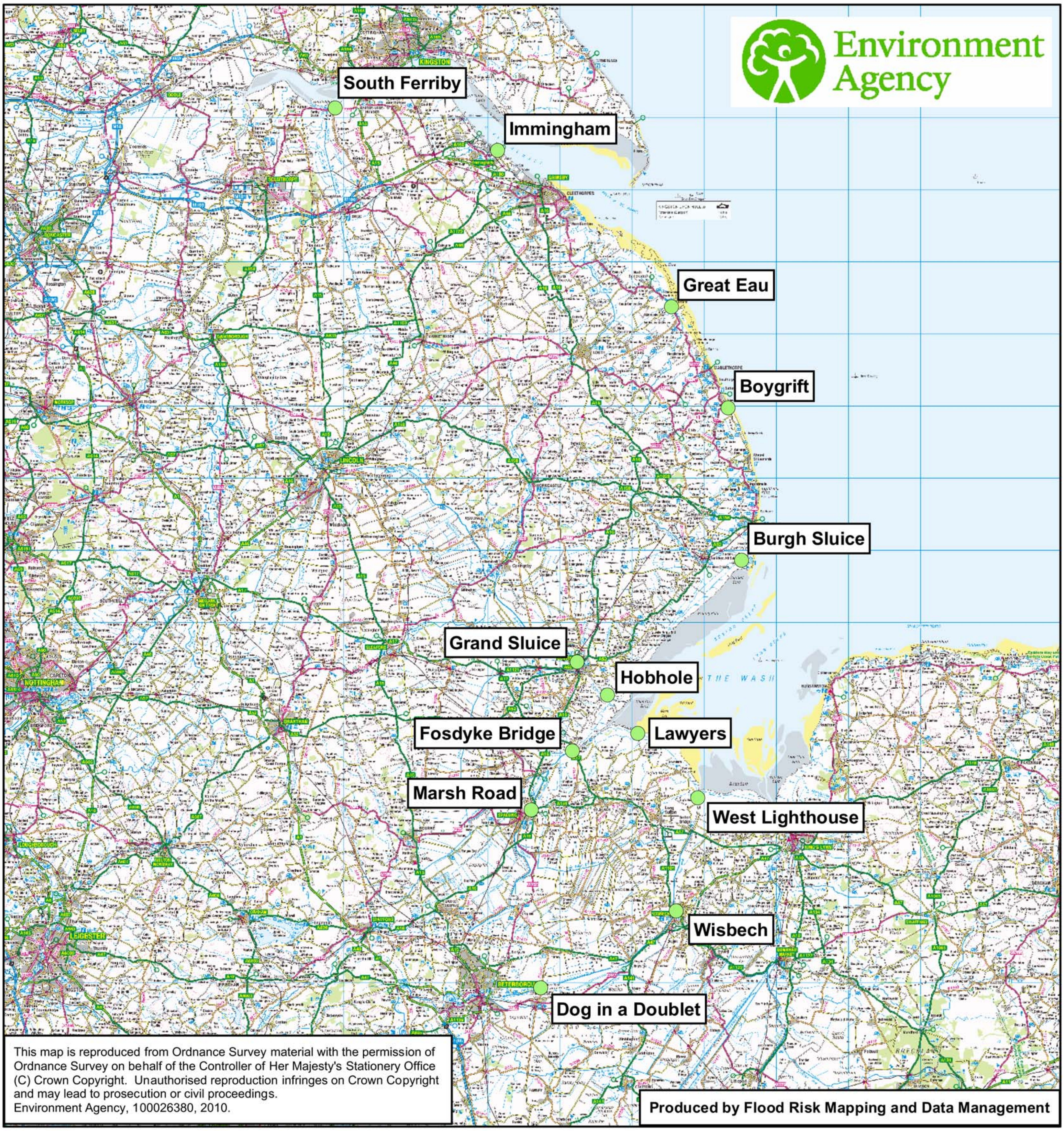
- Main River
- January 1953 Flood Extent

Please refer to the attached datasheet for more information

Created by the Flood Risk Mapping & Data Management Team, Lincoln

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Map 3 - Tidal Flood Levels



Tidal Levels mODN - based Northern Area Tidal Model Analysis 2006

Location	Easting	Northing	100% (1 in 1)	10% (1 in 10)	4% (1 in 25)	2% (1 in 50)	1% (1 in 100)	0.5% (1 in 200)	0.1% (1 in 1000)
South Ferriby	498772	421418	4.90	5.29	5.45	~	~	5.55	5.63
Immingham	521381	415464	4.08	4.49	4.65	4.76	4.88	5.05	5.34
Great Eau	545500	393800	3.80	4.19	4.34	4.46	4.57	4.69	4.96
Boygrift	553300	379800	3.84	4.24	4.41	4.53	4.65	4.77	5.05
Burgh Sluice	555190	358620	4.26	4.45	4.63	4.76	4.90	5.03	5.34
Hobhole	536610	339940	4.82	5.30	5.49	5.64	5.78	5.93	6.27
Lawyers	540750	334550	4.84	5.32	5.51	5.66	5.80	5.95	6.29
West Lighthouse	549150	325750	4.88	5.37	5.57	5.71	5.86	6.01	6.35
Grand Sluice	532400	344500	4.88	5.33	5.51	5.65	5.78	5.93	~
Fosdyke Bridge	531700	332200	4.91	5.38	5.56	5.71	5.85	5.99	~
Marsh Road	526000	324000	5.04	5.44	5.60	5.73	5.85	5.98	~
Wisbech	546100	310000	4.83	5.25	5.41	5.53	5.66	5.78	~
Dog in a Doublet	527300	299300	3.67	4.00	4.13	4.22	4.32	4.42	~

Environment Agency

Datasheet [Ref: CCN-2010-25421]

Historic Flooding Information

Flood Event Code	Name	Start Date	End Date	Source of Flooding	Cause of Flooding
EA053195301	January 1953 Flooding along the Lincolnshire coast	31/01/1953	01/02/1953	North Sea	Overtopping of defences

NFCDD Defence Information

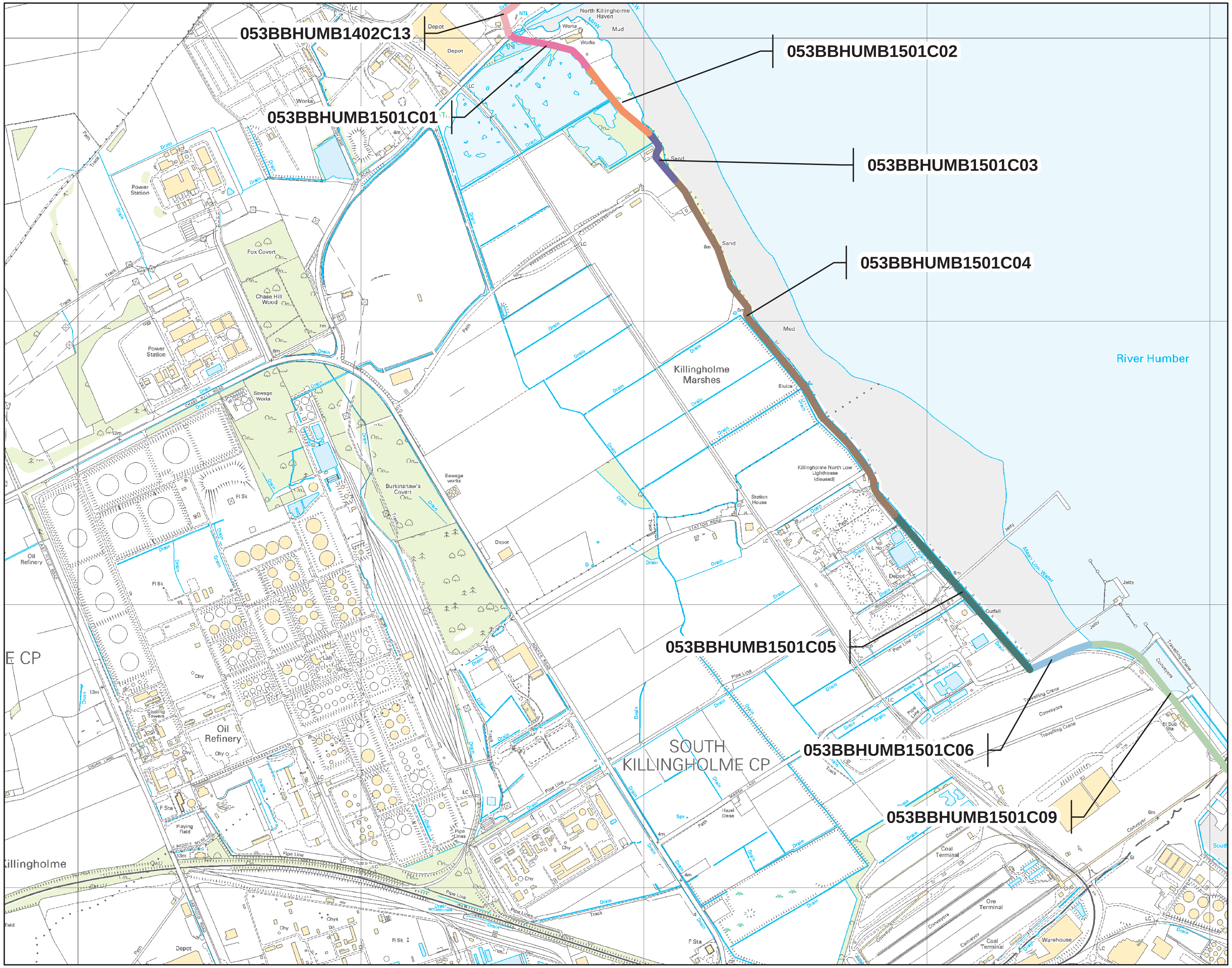
Asset Reference	Maintainer	Asset Type	Asset Description	Last Inspection	Overall Condition
053BBHUMB1402C12	private	sea defence (man-made)	Reclamation area. High spoil bank/heap from reclaimed land immediately infront of floodwall.	15 September 2010	3
053BBHUMB1402C13	Environment Agency	sea defence (natural)	Hard defence	15 September 2010	3
053BBHUMB1501C01	Environment Agency	sea defence (man-made)	Recurve wall defence	11 May 2010	3
053BBHUMB1501C02	Environment Agency	sea defence (man-made)	Recurve wall defence	11 May 2010	3
053BBHUMB1501C03	Environment Agency	sea defence (man-made)	Recurve wall defence	11 May 2010	2
053BBHUMB1501C04	Environment Agency	sea defence (man-made)	Recurve wall defence	11 May 2010	3
053BBHUMB1501C05	Environment Agency	sea defence (man-made)	Recurve wall defence	11 May 2010	2
053BBHUMB1501C06	private	sea defence (man-made)	Reclamation area	11 May 2010	2
053BBHUMB1501C09	private	sea defence (man-made)	New sea defence protecting reclaimed land ABP	11 May 2010	2

Key to Overall Condition Grades

Grade	Rating	Description
1	Very Good	Cosmetic Defects that will have no effect on performance
2	Good	Minor defects that will not reduce the overall performance of the asset
3	Fair	Defects that could reduce performance of the asset
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation needed.
5	Very Poor	Severe defects resulting in complete performance failure.

Map 4. National Flood and Coastal Defence Database (NFCDD) Information

Map centred on TA 1700 1830 - created October 2010 [Ref: CCN-2010-25421]



Environment Agency

Scale 1:14,000

NFCDD Defences

Asset Reference

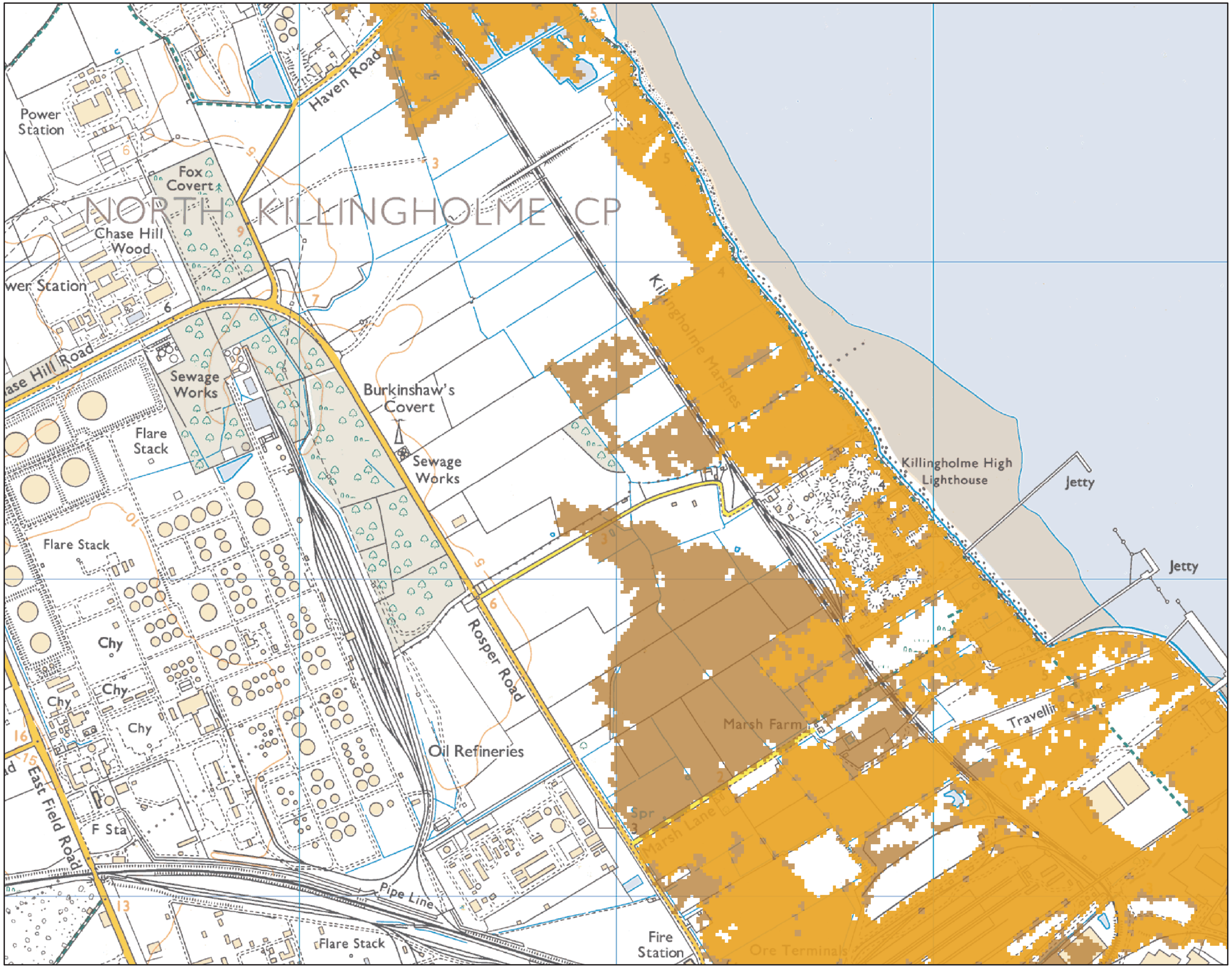
- 053BBHUMB1402C13
- 053BBHUMB1501C01
- 053BBHUMB1501C02
- 053BBHUMB1501C03
- 053BBHUMB1501C04
- 053BBHUMB1501C05
- 053BBHUMB1501C06
- 053BBHUMB1501C09

Please refer to the attached datasheet for more information

Created by the Flood Risk Mapping & Data Management Team, Lincoln

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Fig 5a. Modelled Flood Extents (Present day overtopping, with defences)
Map centred on TA 1700 1830 - created October 2010 [Ref: CCN-2010-25421]



Environment Agency

Scale 1:12,500

With-defences modelled flood extents

Present day 0.5% (1 in 200)

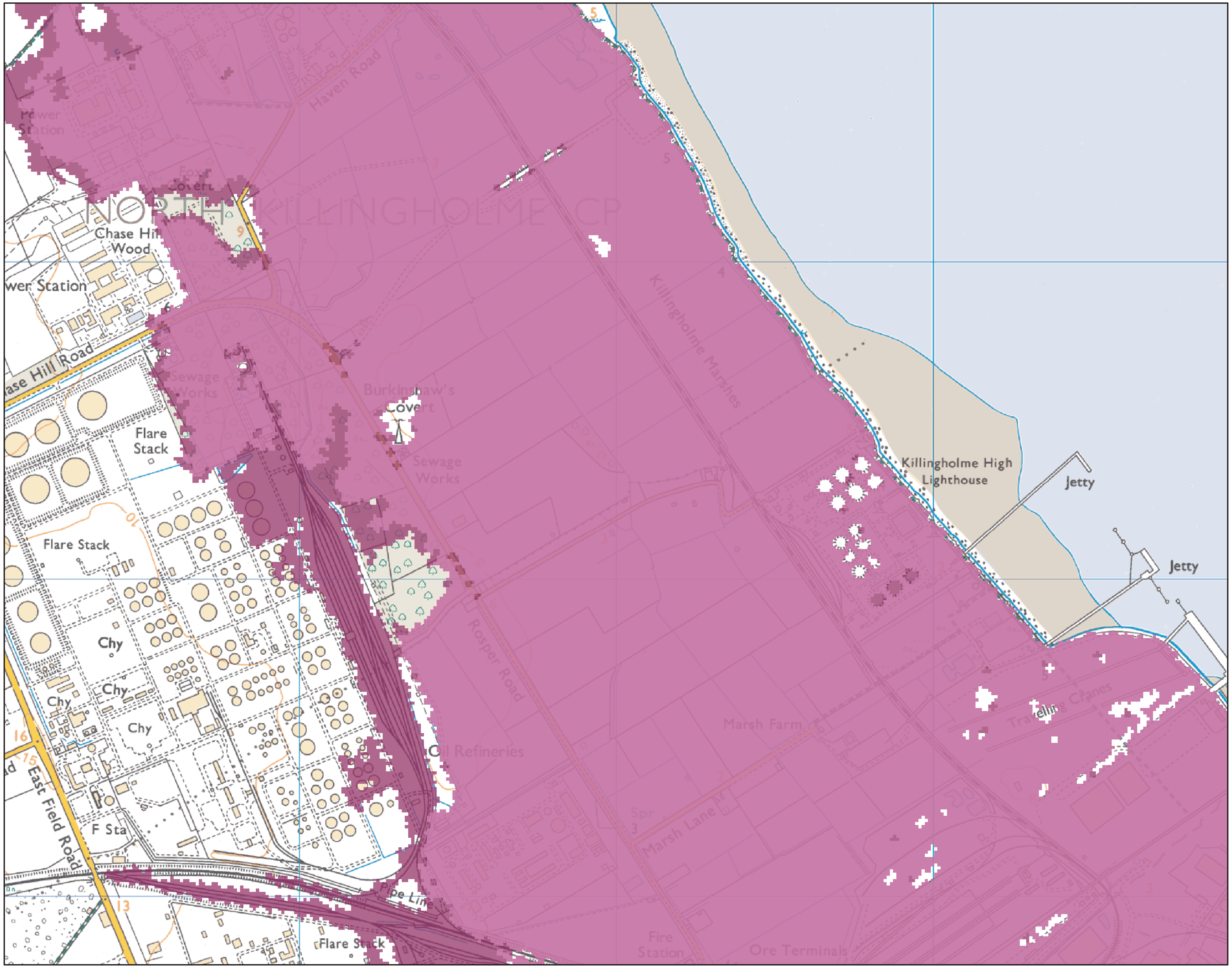
Present Day 0.1% (1 in 1000)

Created by the Flood Risk Mapping and Data Management Team, Lincoln

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Fig 5b. Modelled Flood Extents (Climate Change overtopping, with defences)

Map centred on TA 1700 1830 - created October 2010 [Ref: CCN-2010-25421]



Environment Agency

Scale 1:12,500

With-defences modelled flood extents

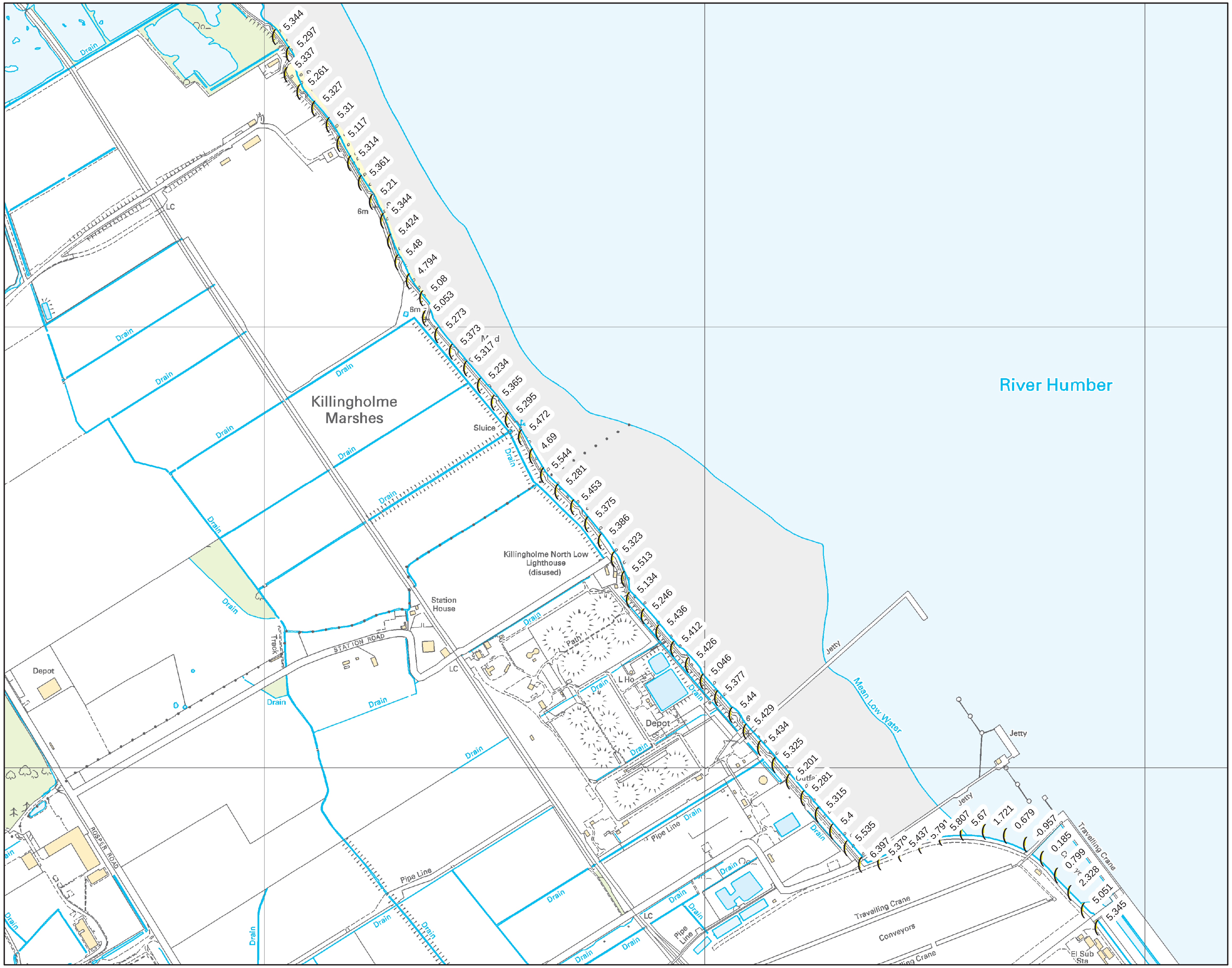
- Climate Change 0.5% (1 in 200)
- Climate Change 0.1% (1 in 1000)

Created by the Flood Risk Mapping and Data Management Team, Lincoln

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Map 6. Defence Crest Heights, derived from NFCDD Defence Line and 1m resolution LiDAR

Map centred on Killingholme Marshes - created October 2010 [Ref: CCN-2010-25421]



Environment Agency

Scale 1:9,000

(1m Lidar Derived Crest Levels

Please refer to the attached datasheet for more information

Created by the Flood Risk Mapping & Data Management Team, Lincoln

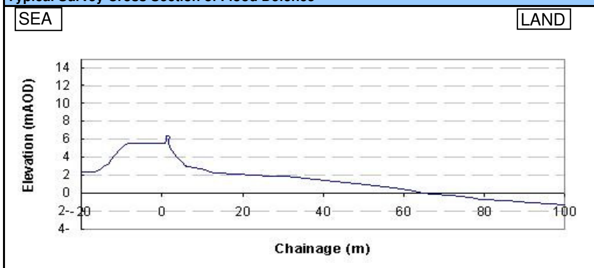
Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

NORTHERN AREA TIDAL MODELLING
OVERTOPPING
OVERTOPPING SECTION SUMMARY SHEET

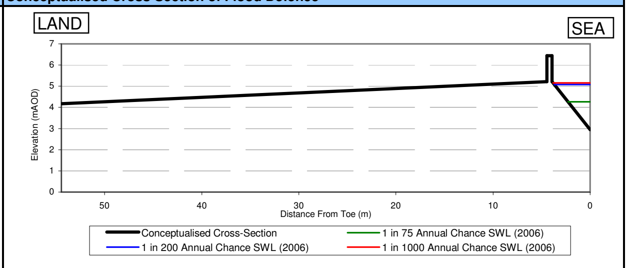
Overtopping Section	Section Location
	North Killingholme
OT-19	National Grid Reference
	517546, 418822

Defence Cross Section

Typical Survey Cross Section of Flood Defence



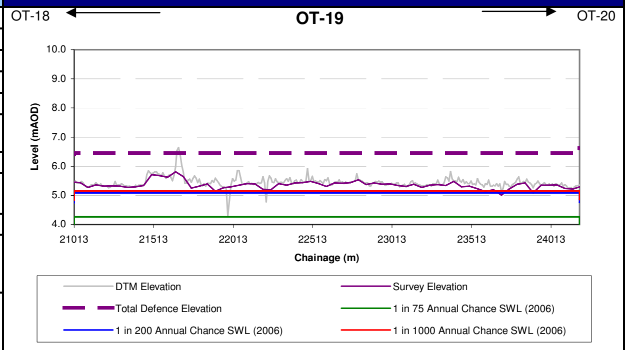
Conceptualised Cross Section of Flood Defence



Physical Parameters

Parameters	Value	Data Source
Crest Elevation (mAOD)	5.21	1987 Survey
Wall Height (m)	1.24	1987 Survey
Total Defence Elevation (mAOD)	6.45	1987 Survey
Toe Elevation (mAOD)	2.95	1987 Survey
[Crest - Toe] Height (m)	2.26	1987 Survey
Defence Width of Seaward Face (m)	4	1987 Survey
Crest Width (m)	0.55	1987 Survey
Gradient of Seaward Face (1 in x)	1.97	1987 Survey
Section Length (m)	3179	
Conceptualised Defence Type	Wave Return Wall	
Material of Seaward Face	One layer of rock armour on impermeable base	1987 Survey

Long Profile



Non-Physical Parameters

Annual Chance	Climate Conditions	Still Water Level (mAOD)	Significant Wave Height (m)	Calculation Range*	Maximum Overtopping Unit Discharge ($m^3/s/m$)
1 in 1	2006	4.26	1.48	1	0.0003
1 in 10	2006	4.67	1.48	1	0.0008
1 in 75	2006	5.03	1.48	2	0.0034
1 in 100	2006	5.08	1.48	2	0.0041
1 in 150	2006	5.16	1.48	2	0.0054
1 in 200	2006	5.21	1.48	2	0.0064
1 in 1000	2006	5.36	1.48	2	0.0114
1 in 200	2115	6.35	2.71	2	0.8102
1 in 1000	2115	6.50	2.71	3	1.1031

**Calculation Range Notes*

- *1 = Within valid range of EA Manual*
- *2 = Outside valid range of EA Manual and SWL is less than TDL +0.5m*
- *3 = Outside valid range of EA Manual and SWL is between TDL +1.0m and TDL +1.5m*
- *4 = Outside valid range of EA Manual and SWL is between TDL +1.0m and TDL +1.5m*
- *5 = Outside valid range of EA Manual and SWL is between TDL +1.5m and TDL +2.0m*

Additional Information/Comments

Revison Record

Revision	Date	Originator	Checker	Approver
B	30/07/2010	WJG	KS	SYE

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- detriment to the Agency's ability to achieve its objectives, or
- detriment to the environment, including the risk of reduced future enhancement, or
- being prejudicial to the effective management of information held by the Agency, or
- damage to the Agency's reputation

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We will under no circumstance be liable for indirect, special, or consequential damages including any loss of business, revenue, profits, goodwill, reputation, anticipated savings or data in relation to your use of the information supplied to you. Nothing within this Agreement will operate to exclude any liability for death or personal injury arising as result of the negligence of the Environment Agency, or any of their employees or agents. Any implied promise or warranty is excluded as far as the law allows. Our maximum aggregate liability in connection with this agreement shall not exceed the total sum of one thousand pounds

5. Intellectual Property Rights

No Intellectual Property Rights are transferred or licensed to you save those which are expressly provided in this agreement

6. Assignment

You may not transfer or in any other way make over to any third party the benefit of this agreement either in whole or in part

7. Waiver

Failure by either of us to exercise or enforce any rights available to it, or any forbearance, delay or grant of indulgence, will not be construed as a waiver of rights under this agreement or otherwise

8. Entire agreement

This agreement constitutes the entire agreement between us and supersedes all oral or written agreements, representations, understandings or arrangements (whether previous, contemporaneous or future) relating to its subject matter. You agree to waive any right to rescind this agreement by virtue of any misrepresentation and not to claim damages for any misrepresentation that is not fraudulent

9. Severance

If any part of the agreement is found by a court of competent jurisdiction or other competent authority to be unenforceable, then that part will be severed from the remainder of the agreement which will continue to be valid and enforceable to the fullest extent permitted by law

10. Variation and Termination

This agreement may not be amended, modified, varied or supplemented but it may if both of us agree be terminated or replaced by a new agreement

11. Relationship of Parties

We are not in a partnership or joint venture, nor is either of us the agent of the other or authorised to act on behalf of the other

12. Rights Of Third Parties

No third parties shall have rights to enforce any part of this agreement under the Contracts (Rights of Third Parties) Act 1999

13. Governing Law

This agreement shall be governed and construed in accordance with English law

Contact: enquiries@environment-agency.gov.uk 08708 506506

David Stark
<david.stark@jbaconsulting.co.uk>

Our ref: CCN/2010/25421

Date: 27 October 2010

Dear Mr Stark

Flood Hazard Mapping – Marine Energy Park, Killingholme.

Thank you for your request for copies of our flood hazard mapping for the above location.

Enclosed with this letter is a plan showing the location of the breaches we have modelled, together with four plans showing the maximum values of flood depth, velocity and hazard rating (danger to people) for the following scenarios:

- Year 2006 0.5% (1 in 200) chance event
- Year 2006 0.1% (1 in 1000) chance event
- Year 2115 0.5% (1 in 200) chance event
- Year 2115 0.1% (1 in 1000) chance event

It is important that you read the contextual notes on the maps and also the enclosed licence which details the restrictions on use of this data, particularly Section 7. You must not use the information unless you agree to all the terms. Any such use is deemed to be an acceptance of the terms.

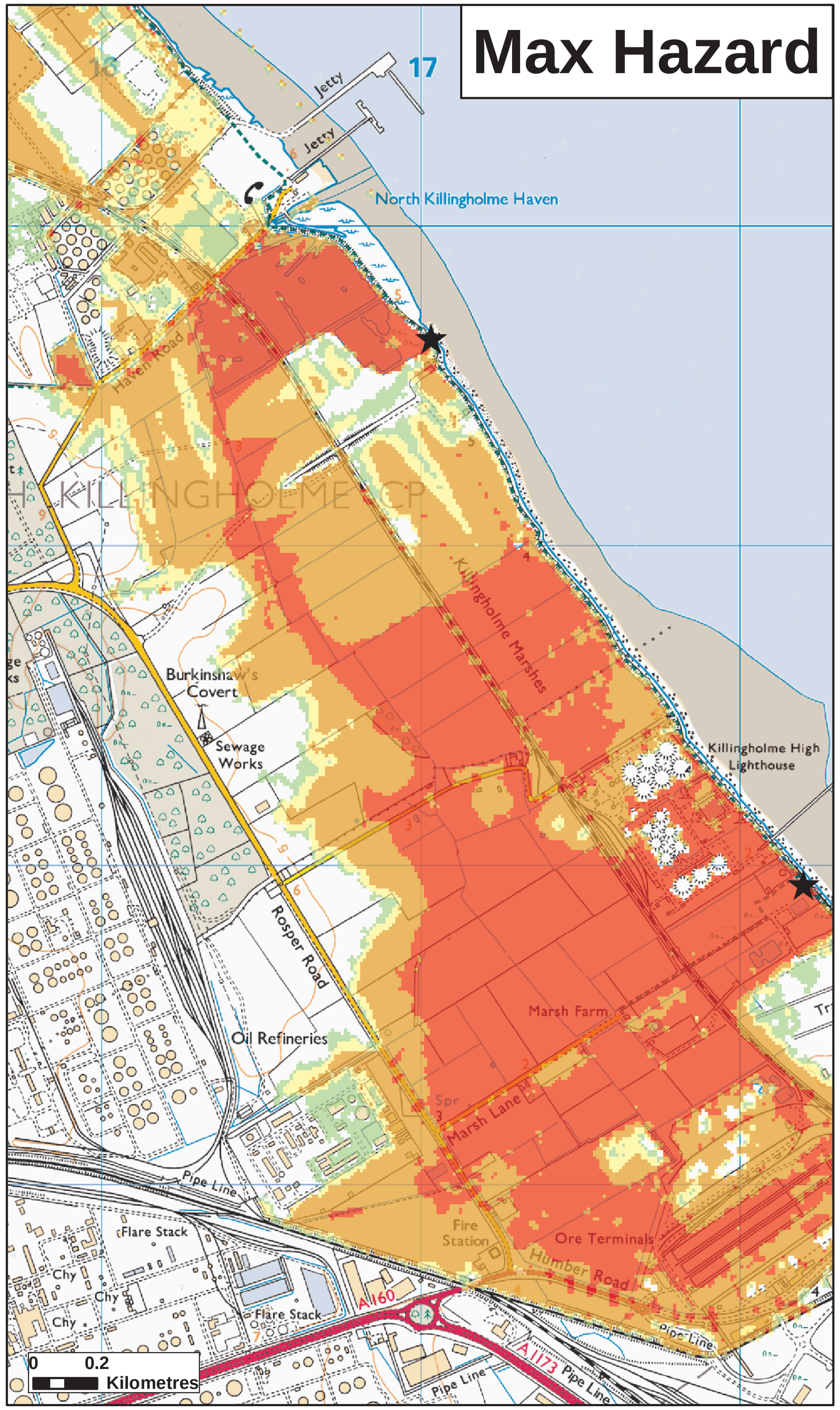
If you have any queries regarding the hazard mapping please contact us.

Yours sincerely,

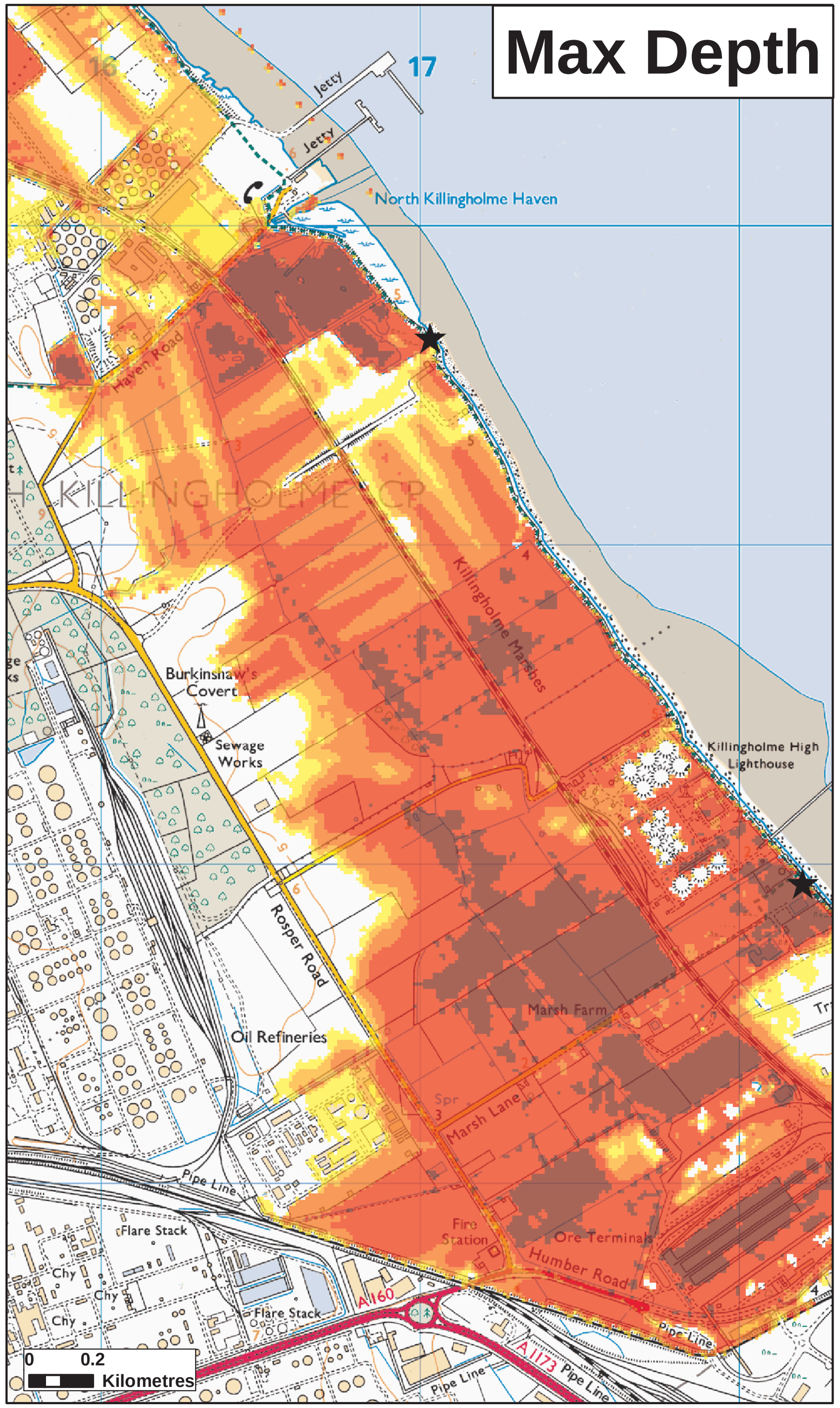
John Ray

John Ray
Flood Risk Mapping and Data Management Team Leader
Direct dial 01522 785805
Mobile 07920 501378
e-mail : john.ray@environment-agency.gov.uk

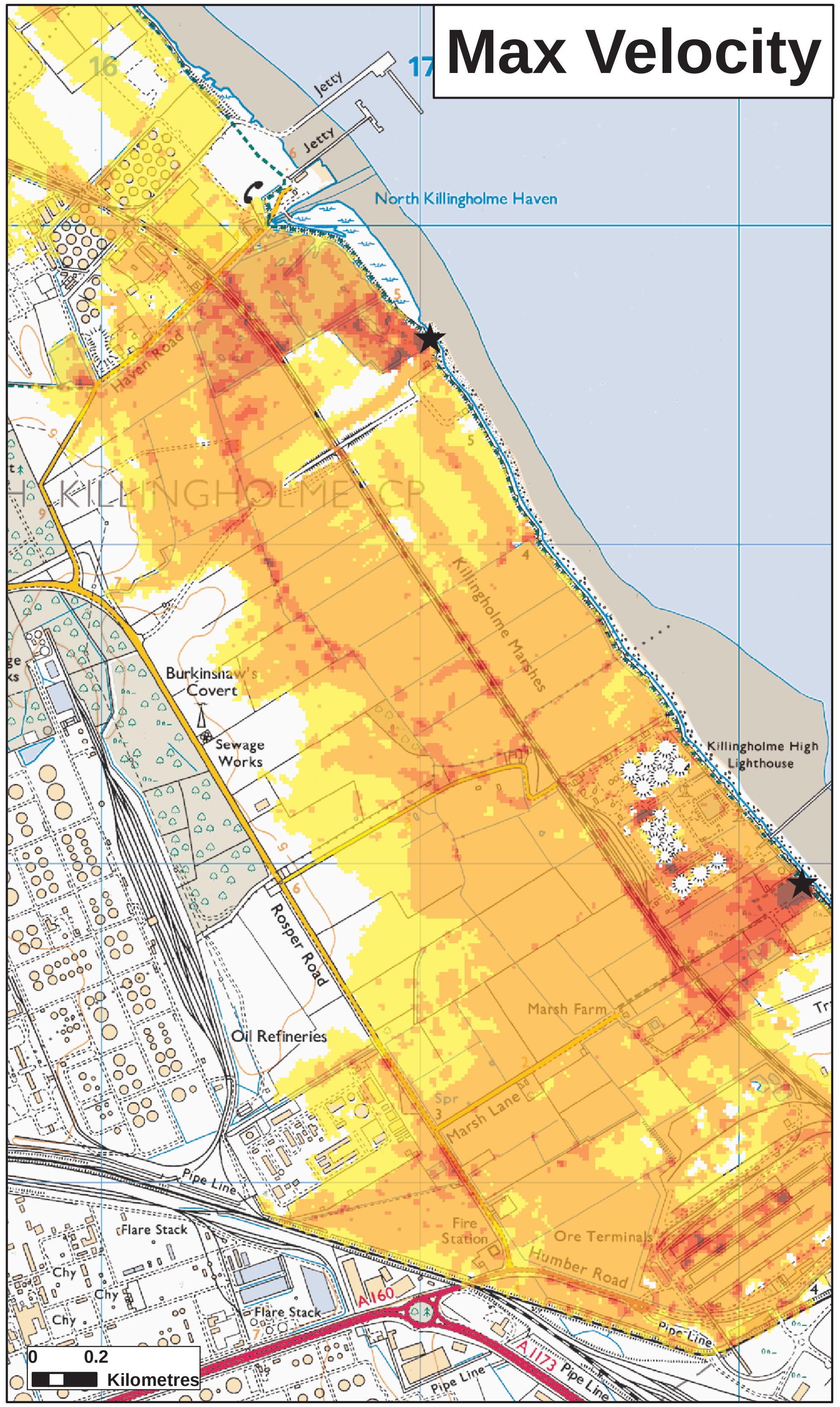
Max Hazard



Max Depth



Max Velocity



^ **Modelled Breach Locations** - see also the accompanying plan "Location of Modelled Breaches"

Max Hazard (Flood Risk to People : FD2320)	Max Depth (m)	Max Velocity (m/s)
Less than 0.75 (Low Hazard)	0 - 0.25	0 - 0.3
Between 0.75 and 1.25 (Danger for Some)	0.25 - 0.50	0.3 - 1.0
Between 1.25 and 2.0 (Danger for Most)	0.50 - 1.0	1.0 - 1.5
Greater than 2.0 (Danger for All)	1.0 - 2.0	1.5 - 2.5
	2.0 +	2.5 +

Date Printed	October 2010	Scenario year	2006	Scenario	0.5% (1 in 200)

This map shows the level of flood hazard to people (called a hazard rating) if our flood defences are breached at certain locations, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater across the floodplain.

The map is based on computer modelling of simulated breaches at intervals along the coastline and at certain points on Main Rivers. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. Our defences generally provide a good standard of flood defence but a risk of breaching remains.

The map does not show the possible consequences of overtopping of the tidal defences, though overtopping of fluvial defences is included. Separate maps of the flood extent from just overtopping are available.

These hazard maps do not replace the flood zone maps used in Planning Policy Statement 25 (PPS25).

Please contact the Environment Agency for information on how these maps are used in the management of flood risk.

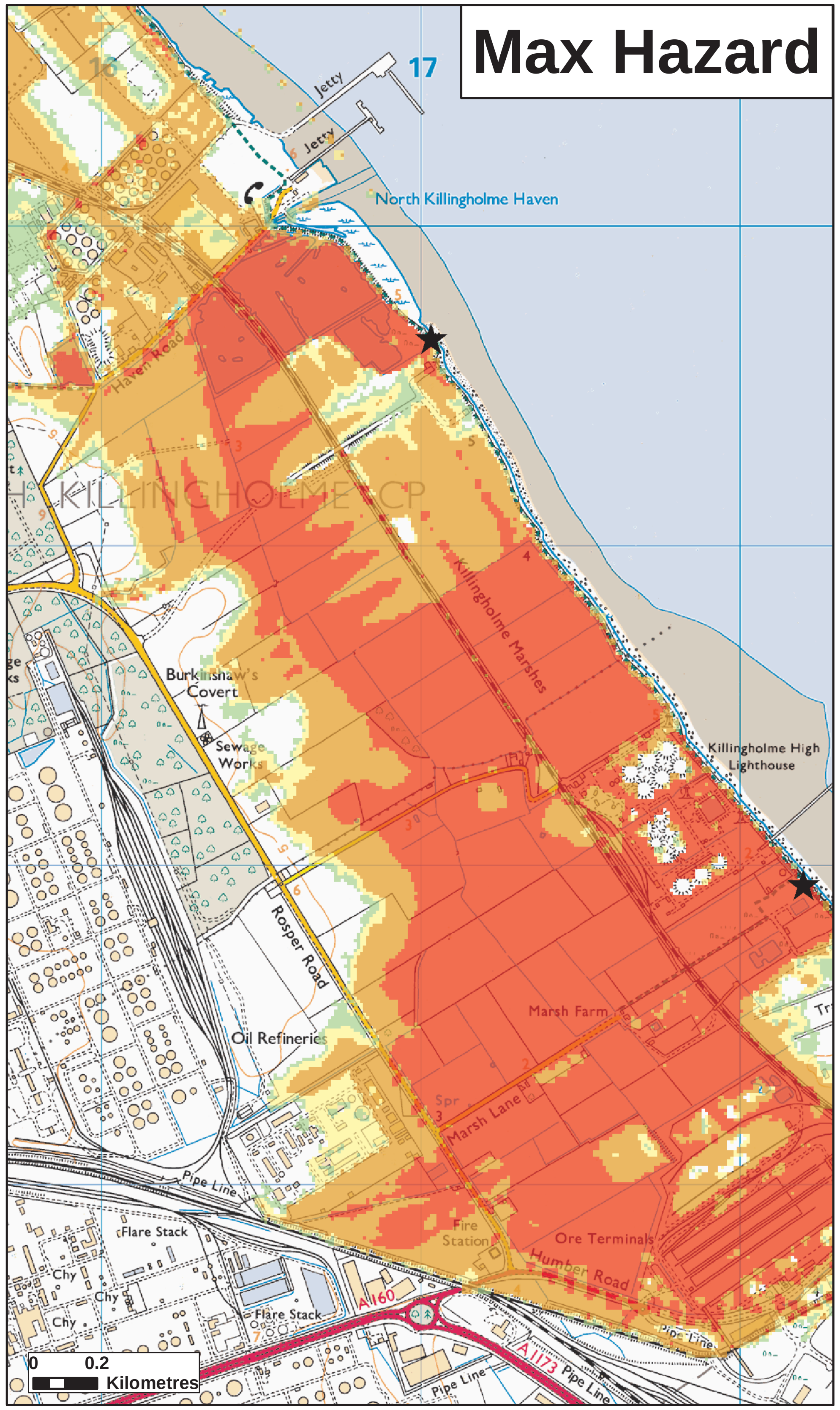
General Enquiries No: 08708 506 506. Weekday daytime calls cost 8p plus up to 6pm from BT Weekend Unlimited. Mobile and other providers charges may vary

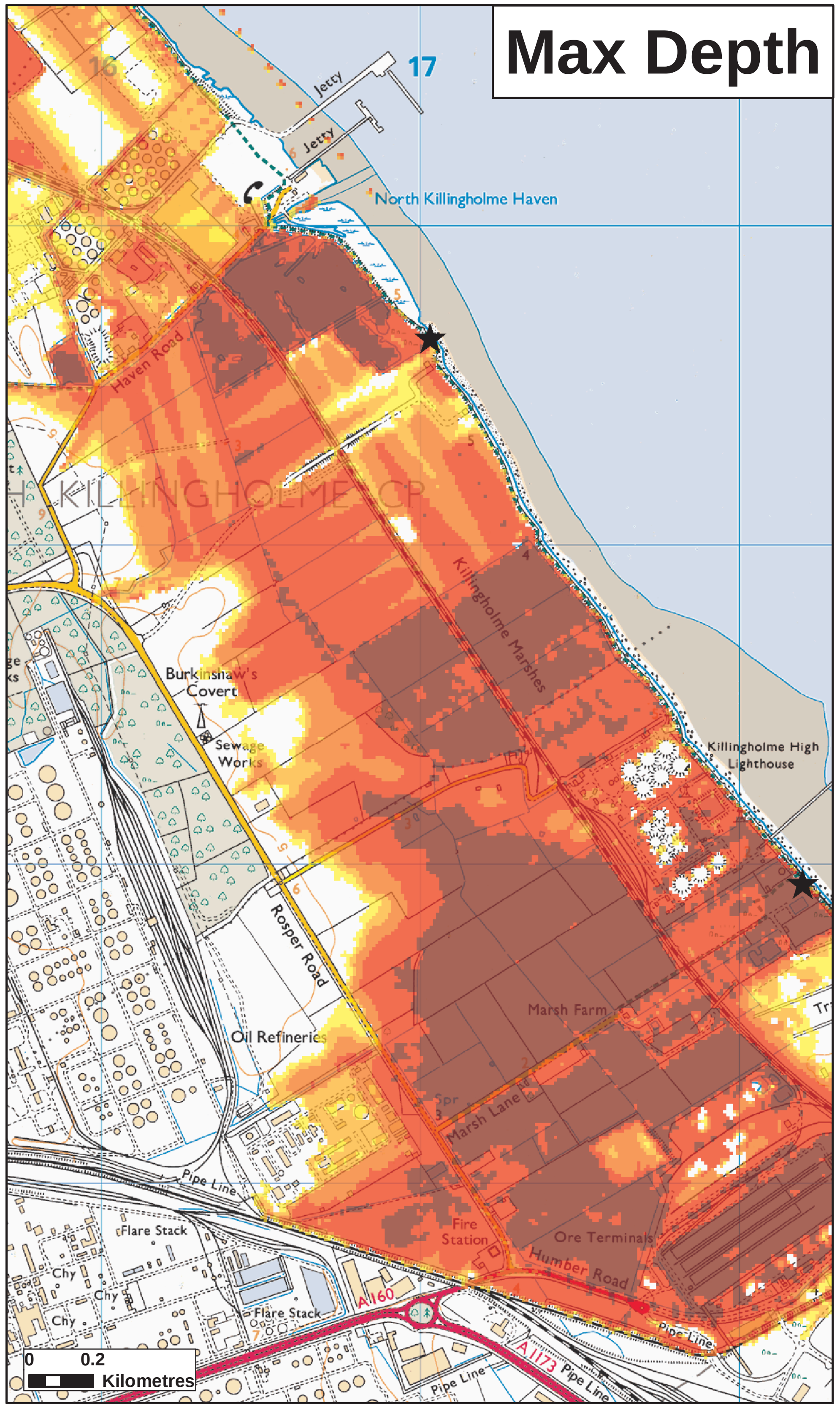
Environment Agency

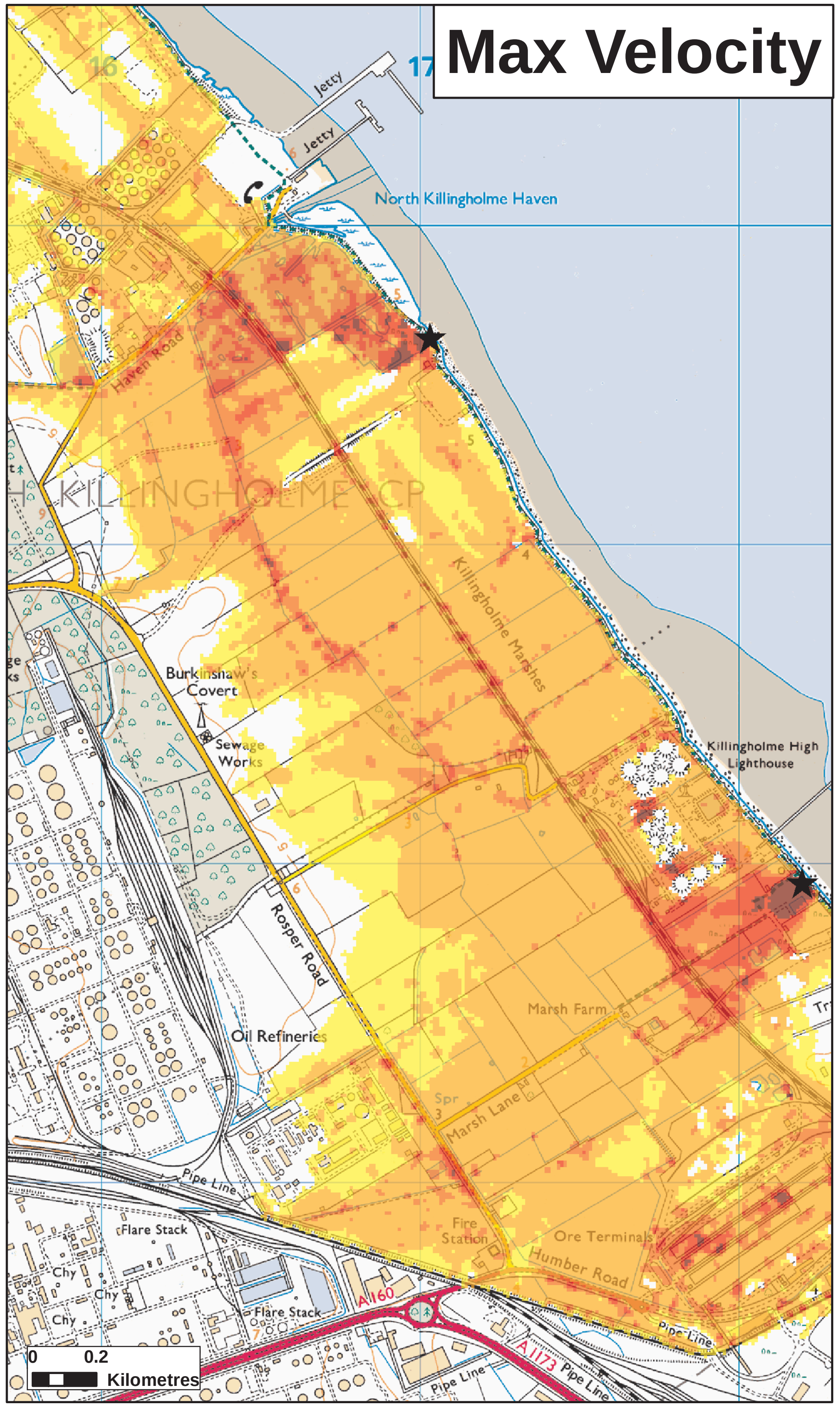
Produced by the Flood Risk Mapping & Data Management Team, Lincoln

Northern Area Tidal Hazard Mapping

Map Centered on TA 1700 1830







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Max Hazard (Flood Risk to People : FD2320)	Max Depth (m)	Max Velocity (m/s)
Less than 0.75 (Low Hazard)	0 - 0.25	0 - 0.3
Between 0.75 and 1.25 (Danger for Some)	0.25 - 0.50	0.3 - 1.0
Between 1.25 and 2.0 (Danger for Most)	0.50 - 1.0	1.0 - 1.5
Greater than 2.0 (Danger for All)	1.0 - 2.0	1.5 - 2.5
	2.0 +	2.5 +

Date Printed	October 2010	Scenario year	2006	Scenario	0.1% (1 in 1000)

This map shows the level of flood hazard to people (called a hazard rating) if our flood defences are breached at certain locations, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater across the floodplain.

The map is based on computer modelling of simulated breaches at intervals along the coastline and at certain points on Main Rivers. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

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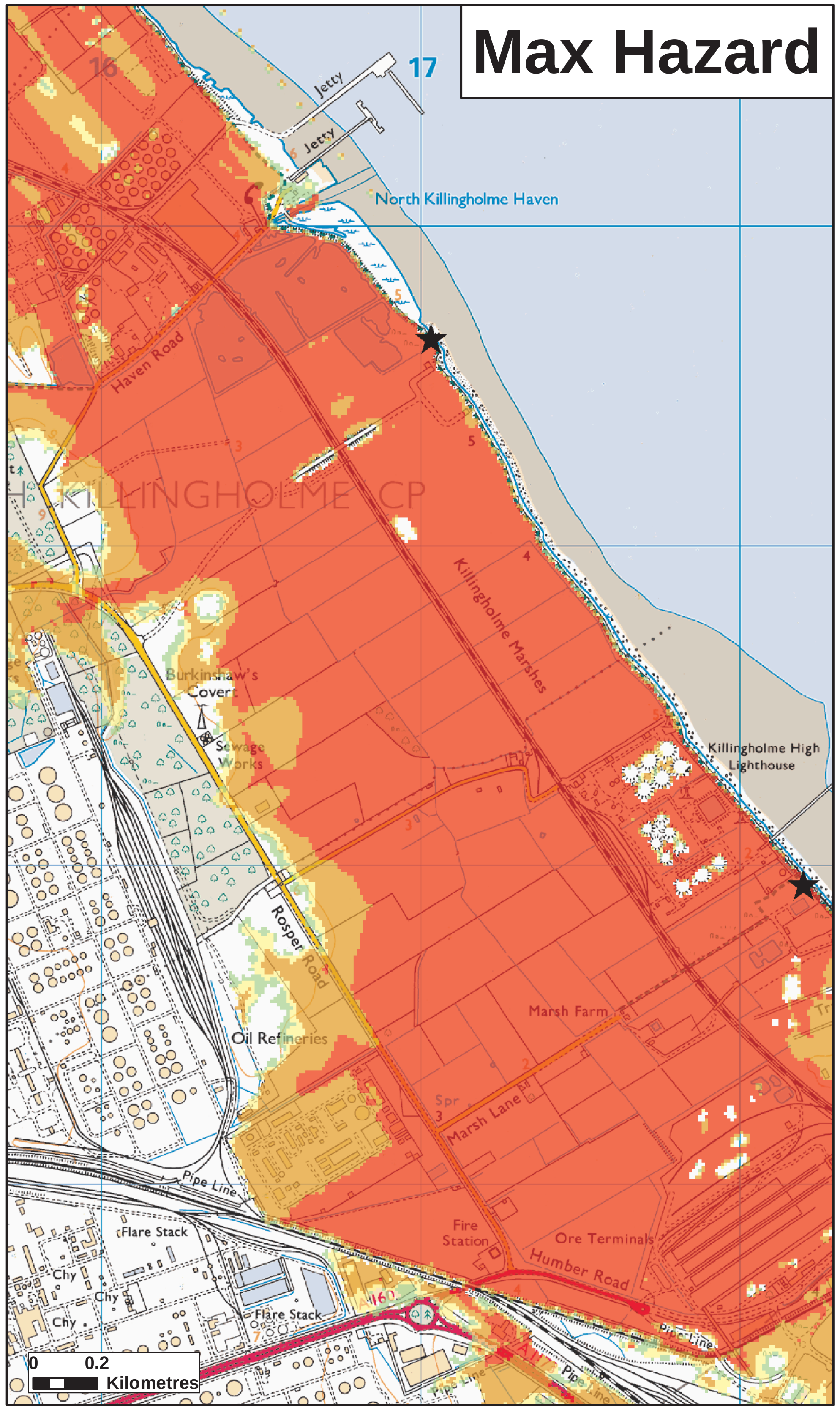
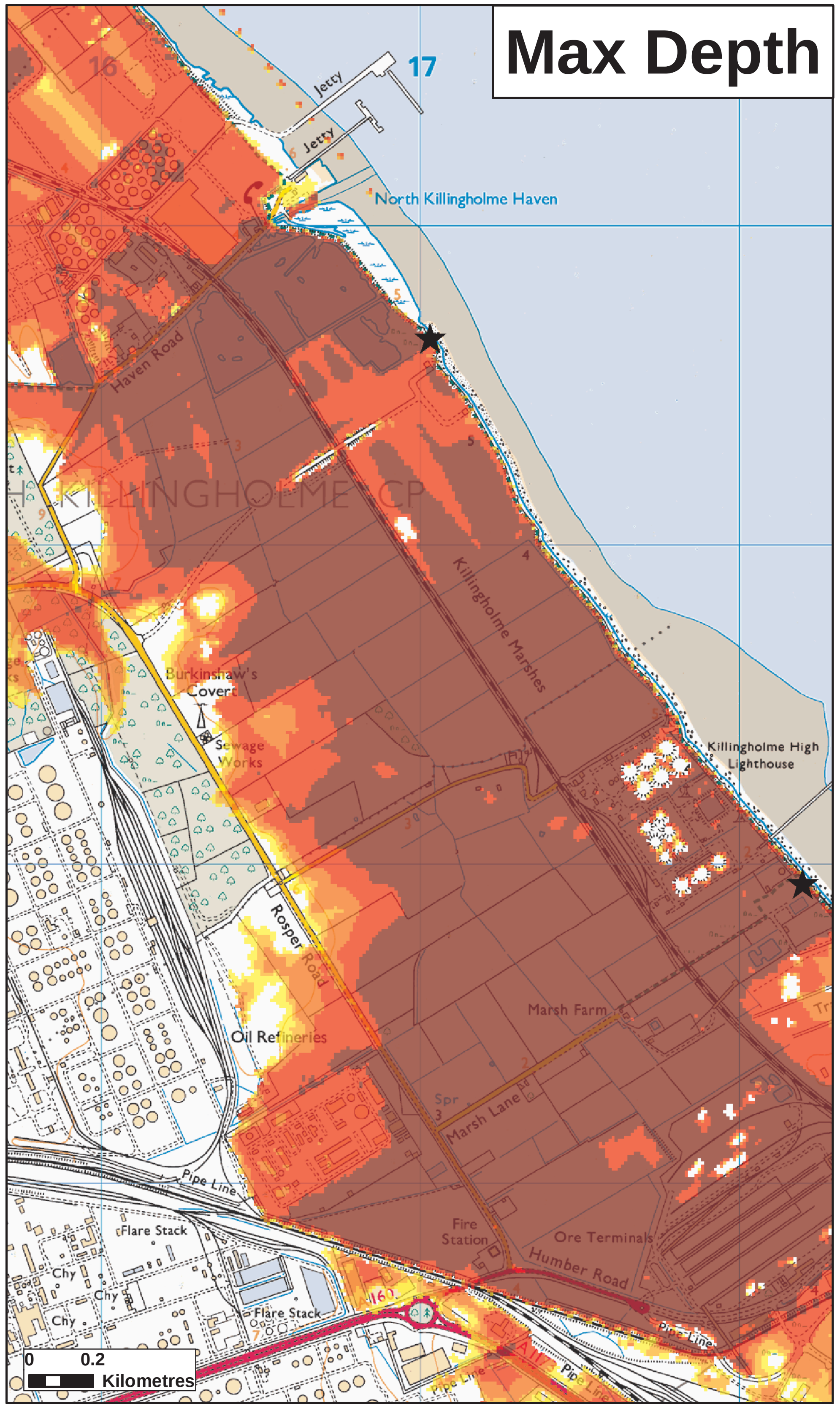
Environment Agency

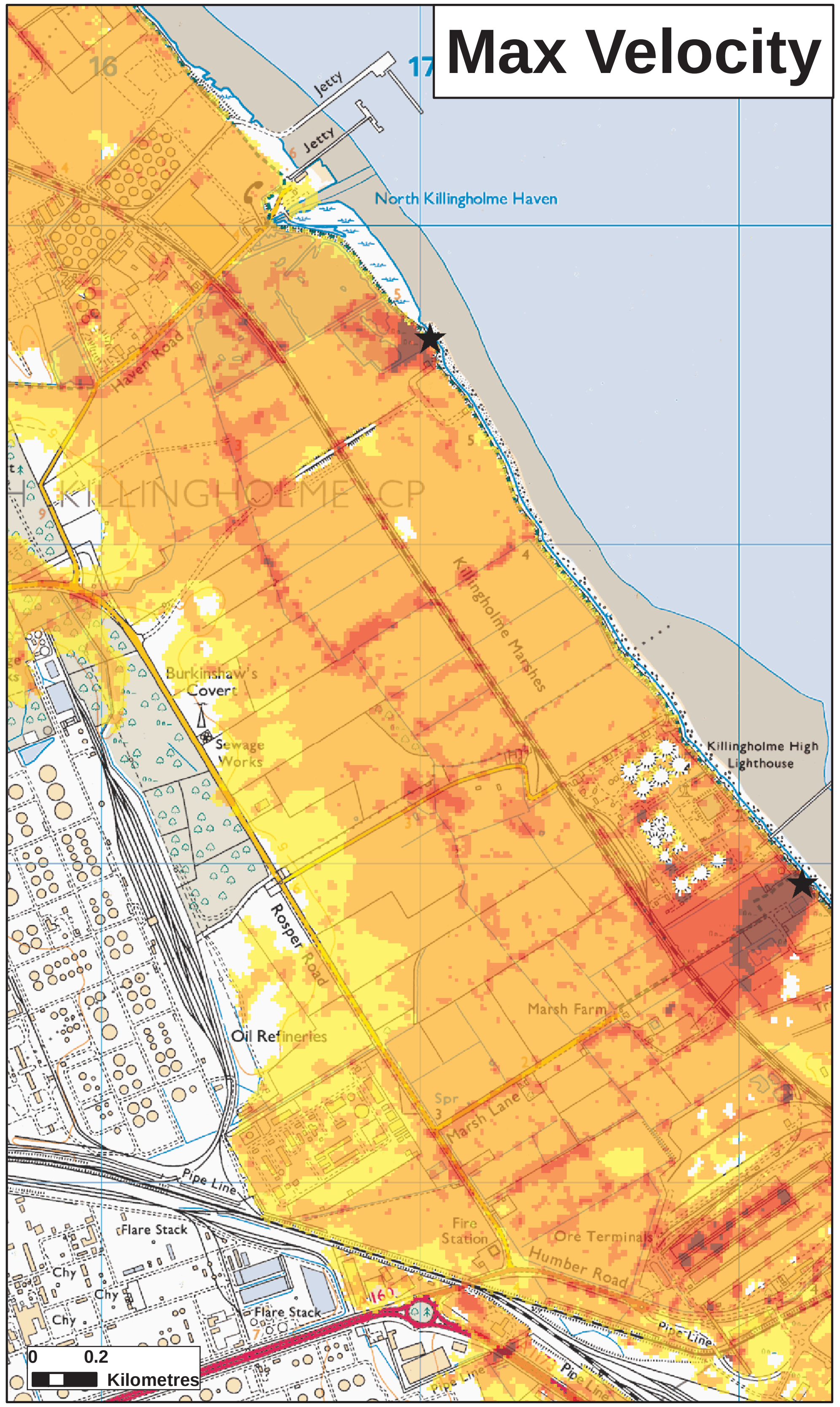
Produced by the Flood Risk Mapping & Data Management Team, Lincoln

Northern Area Tidal Hazard Mapping

Map Centered on TA 1700 1830







^ Modelled Breach Locations - see also the accompanying plan "Location of Modelled Breaches"

Max Hazard (Flood Risk to People : FD2320)	Max Depth (m)	Max Velocity (m/s)
Less than 0.75 (Low Hazard)	0 - 0.25	0 - 0.3
Between 0.75 and 1.25 (Danger for Some)	0.25 - 0.50	0.3 - 1.0
Between 1.25 and 2.0 (Danger for Most)	0.50 - 1.0	1.0 - 1.5
Greater than 2.0 (Danger for All)	1.0 - 2.0	1.5 - 2.5
	2.0 +	2.5 +

Date Printed	October 2010	Scenario year	2115	Scenario	0.5% (1 in 200)

This map shows the level of flood hazard to people (called a hazard rating) if our flood defences are breached at certain locations, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater across the floodplain.

The map is based on computer modelling of simulated breaches at intervals along the coastline and at certain points on Main Rivers. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. Our defences generally provide a good standard of flood defence but a risk of breaching remains.

The map does not show the possible consequences of overtopping of the tidal defences, though overtopping of fluvial defences is included. Separate maps of the flood extent from just overtopping are available.

These hazard maps do not replace the flood zone maps used in Planning Policy Statement 25 (PPS25).

Please contact the Environment Agency for information on how these maps are used in the management of flood risk.

General Enquiries No: 08708 506 506. Weekday daytime calls cost 8p plus up to 6pm from BT Weekend Unlimited. Mobile and other providers charges may vary

Environment Agency

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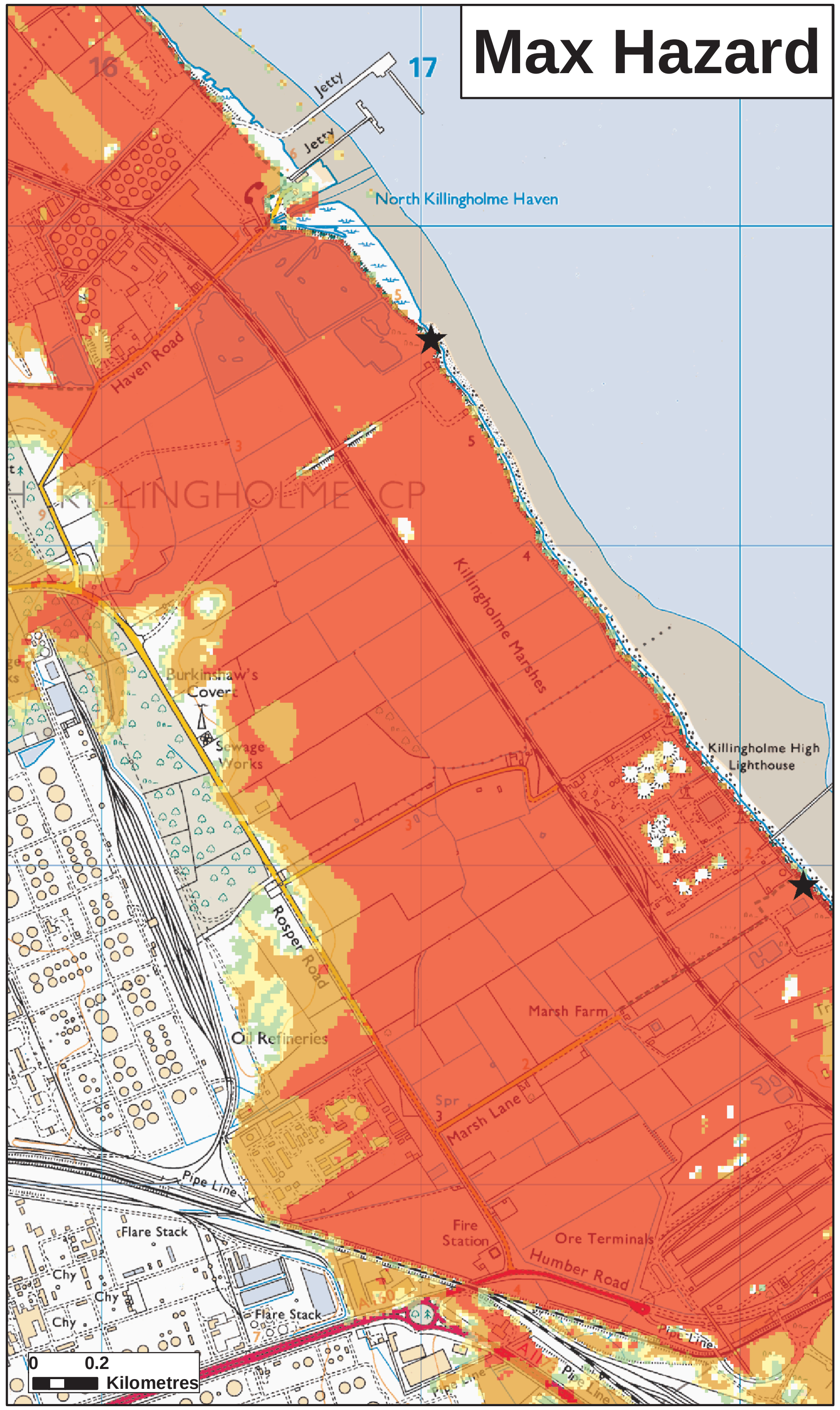
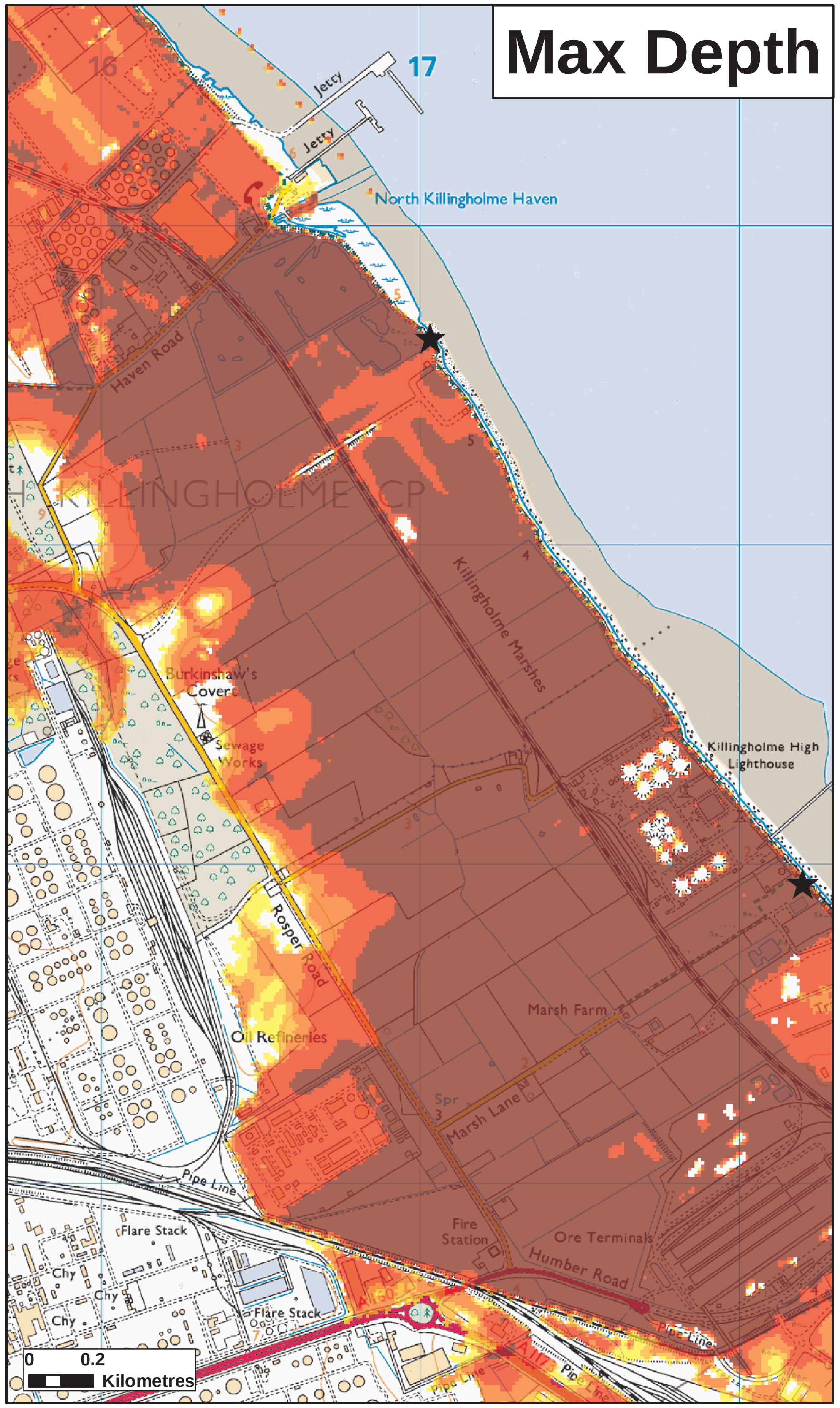
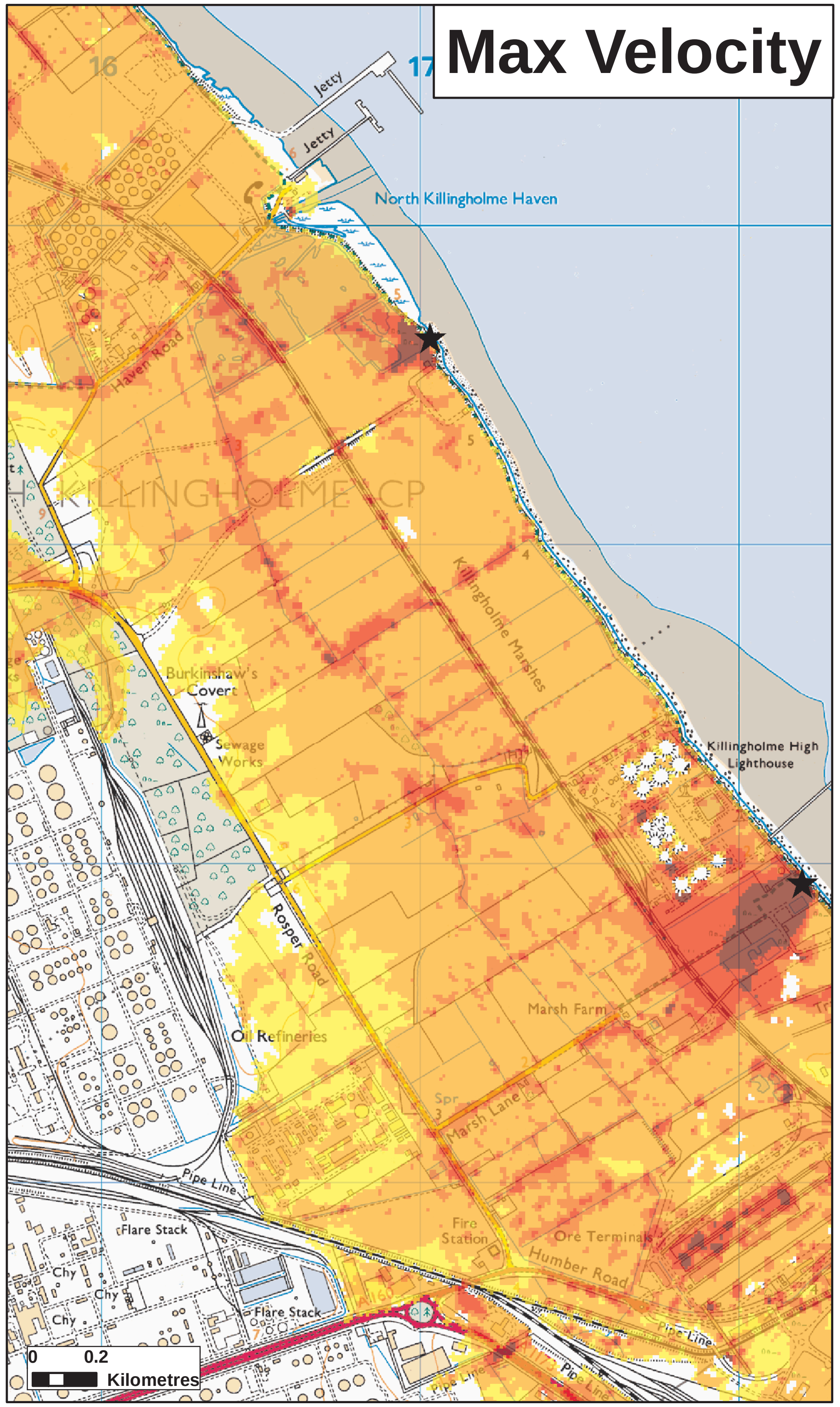
Northern Area Tidal Hazard Mapping

Map Centered on TA 1700 1830







^ **Modelled Breach Locations** - see also the accompanying plan "Location of Modelled Breaches"

Max Hazard
(Flood Risk to People : FD2320)

- Less than 0.75 (Low Hazard)
- Between 0.75 and 1.25 (Danger for Some)
- Between 1.25 and 2.0 (Danger for Most)
- Greater than 2.0 (Danger for All)

Max Depth (m)

- 0 - 0.25
- 0.25 - 0.50
- 0.50 - 1.0
- 1.0 - 2.0
- 2.0 +

Max Velocity (m/s)

- 0 - 0.3
- 0.3 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5 +

Date Printed	October 2010	Scenario year	2115	Scenario	0.1% (1 in 1000)

This map shows the level of flood hazard to people (called a hazard rating) if our flood defences are breached at certain locations, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater across the floodplain.

The map is based on computer modelling of simulated breaches at intervals along the coastline and at certain points on Main Rivers. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. Our defences generally provide a good standard of flood defence but a risk of breaching remains.

The map does not show the possible consequences of overtopping of the tidal defences, though overtopping of fluvial defences is included. Separate maps of the flood extent from just overtopping are available.

These hazard maps do not replace the flood zone maps used in Planning Policy Statement 25 (PPS25).

Please contact the Environment Agency for information on how these maps are used in the management of flood risk.

General Enquiries No: 08708 506 506. Weekday daytime calls cost 8p plus up to 6ppm from BT Weekend Unlimited. Mobile and other providers charges may vary

Environment Agency

Produced by the Flood Risk Mapping & Data Management Team, Lincoln

Northern Area Tidal Hazard Mapping

Map Centered on TA 1700 1830

Special Licence – Commercial (FRA/FCA-C)

Ref: CCN/2010/25421

PARTIES

ENVIRONMENT AGENCY whose principal office is at Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4UD ("The Agency") (1) **and**

JBA CONSULTING, whose registered office is at South Barn, Broughton Hall, Skipton, North Yorkshire, BD23 3AE, ("the Licensee") (2)

BACKGROUND

This licence applies if you are seeking permission for commercial re-use of Agency information that comprises special data and

a) you have asked for data, information or documents from us that you seek to use in the preparation of a flood risk / consequence assessment and
b) what you propose would not be covered by the terms of the Environment Agency's Standard Notice

LICENCE

We, the Environment Agency ("**We**"), and you, the recipient of the Information ("**You**") agree that:

1. This agreement ("the agreement") which is dated on the date of signing below includes these paragraphs, the Schedules below, the Standard Terms and Conditions for Commercial Internal Use of Environment Agency Information in Appendix 1
2. We will provide you (if you do not already have a copy) with the Information specified in Schedule 3
3. You will pay us the Licence Fees due under this agreement
4. If it is not possible to interpret consistently the Special Conditions in Schedule 6 below and the Standard Terms and Conditions in Appendix 1 the Special Conditions will prevail
5. "Information" can include information, data, records, documents and other Content of any kind.

SCHEDULE 1 – Charges

LICENCE FEES

Licence Fees are cost recovery charges that aim to recover the Agency's costs of reproducing and disseminating information that it licences and are all reviewed annually on 1st April.

1. **FoI/EIR Charges**

   These are the actual internal costs incurred in supplying the Information and any Updates or customising the Information to a different format or delivery mechanism specifically requested by the Licensee.

   £25 (not VAT rated)

2. **Standard Internal Use Charges**

   These are annual costs recovery charges based on the number and types of licences issued and the actual costs incurred in licensing information externally in the preceding year. Different types of Information have different cost recovery based charges and the annual review will, inter alia, re-assess which charging band to apply. Accordingly the charge may go up or down. Charges for the first year are the annual charge pro rata to the following April 1st.

   £10 + VAT

3. **External Charges**

   These are the actual charges that the Agency has to pay to third parties that directly relate to the licensed use of Information contained in this agreement (such as the payment of Third Party Royalty Fees). If the rate at which these are payable by the Agency changes (whether up or down) this will not be reflected in the charges payable by the Licensee until the following April 1st review.

i. Third Party Royalty Fees applicable to Internal Use by the Licensee:

None

ii. Third Party Royalty Fees in relation to External Use (if any)

None

iii. Other External Charges:

None

SCHEDULE 2 – Additional Approved Uses

1. You may use the Information in any way connected to the preparation of a flood risk/consequence assessment in relation to a specific piece of land or geographic area ("the Site") including taking extracts of our data to include within the assessment and using the data to input into a model to produce outputs needed for the flood risk/consequence assessment.
2. You may supply the assessment or related outputs to any third party if the only Environment Agency Information included is non-Copy Derived Information and such supply is directly connected with the preparation of a flood risk/consequence assessment in relation to the Site.
3. Environment Agency Information or Copy Derived Information can only be used in the assessment or related outputs as Fixed Format copies.

SCHEDULE 3 – The Information

1. NAME

Northern Area Hazard Mapping

i. Description:

Maps showing maximum values of hazard rating (danger to people), depth and velocity for specific modelled breach scenarios.

ii. Format:	Fixed PDF
iii. Is it a set of documents such as technical reports:	No
iv. Version number (if applicable):	Version 1 – release date February 2010
v. Updates included:	No
vi. Licensee Update Frequency:	Not applicable
vii. Dataset Update Frequency:	Not applicable
viii. Licensee Update Date:	Not applicable
ix. Licensee Update Supply Date:	Not applicable
x. Licensee Update Go Live Date:	Not applicable
xi. Are there any known third party rights:	No
xii. **Full details/attributes:**	No attributes – fixed format only.

SCHEDULE 4 – Contact Details

ENVIRONMENT AGENCY

John Ray - Flood Risk Mapping and Data Management Team Leader
Tel: 01522-785805 john.ray@environment-agency.gov.uk

LICENSEE

Mr David Stark
Tel: 01756 799919 David.stark@jbaconsulting.co.uk

SCHEDULE 5 – Commencement Date

This agreement commences on 27/10/2010 for a period of one year expiring at the end of 27/10/2011.

The next major licensing review will be in 2013 for implementation in 2014.

SCHEDULE 6 – Special Conditions

1. You will supply to the Environment Agency copies of any assessments and related outputs created pursuant to the supply of the Information (including any model and all input, processing and output data) and any records of historic flooding on the Site regardless of the flood source all of which are hereinafter referred to as “the Data”.
2. If any Information (including model input/outputs) is altered or modified in any way by you, you will, when supplying the Data, enclose documentation detailing the changes “the Changes”.
3. You will offer us an opportunity to review and comment on the Data and the Changes and agree not to publish or supply the Data or any part thereof to any third party if we choose to review and comment. If we do choose to review and comment we will do so within 10 Working Days of receipt of the Data.
4. You hereby grant the Environment Agency an unrestricted and perpetual licence to use the Data or any part thereof for all purposes including, but without limitation, supply to others as required by law and incorporation into the Environment Agency's flood mapping and risk assessment data.
5. The Information supersedes all equivalent Information previously supplied.
6. For technical reasons the data you have been supplied maybe greater than strictly necessary for the site or project you are working on and so contain more data than specified in Schedule 3. You must not use such additional data.
7. YOU MUST NOT USE THE INFORMATION IN PURSUANCE OF THIS LICENCE UNLESS YOU AGREE TO ALL THE TERMS. Any such use is deemed to be an acceptance of the terms thereby immediately creating a binding contract between us.

SCHEDULE 7 – Information Warning

1. The sensitive nature of the hazard maps and their ability to create public concern, particularly if misinterpreted, should be recognised and the maps used accordingly. Where hazard mapping is provided in PDF format it may only be reproduced ‘as is’, ie in the specific format it is provided, including contextual notes below

2. The following Contextual Notes are to be included in any reproduction of hazard maps.

This map shows the level of flood hazard to people (called a hazard rating) if our flood defences are breached at certain locations, for a range of scenarios. The hazard rating depends on the depth and velocity of floodwater across the floodplain.

The map is based on computer modelling of simulated breaches at intervals along the coastline and at certain points on Main Rivers. Each breach has been modelled individually and the results combined to create this map. Multiple breaches, other combinations of breaches, different sized tidal surges or flood flows may all give different results.

The map only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. Our defences generally provide a good standard of flood defence but a risk of breaching remains.

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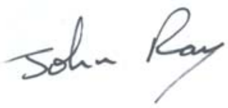
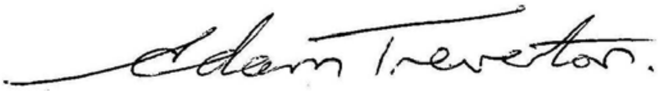
These hazard maps do not replace the flood zone maps used in Planning Policy Statement 25 (PPS25).

Please contact the Environment Agency for information on how these maps are used in the management of flood risk.

General Enquiries No: 08708 506 506. Weekday daytime calls cost 8p plus up to 6ppm from BT Weekend Unlimited. Mobile and other providers charges may vary.

Signed on behalf of the Environment Agency

Name	John Ray
Job Title	Flood Risk Mapping and Data Management Team Leader
Signature	
Witnessed by (Name)	Adam Treverton
Witness job title (or address if not Agency)	Team Member 1, Flood Risk Mapping and Data Management Team
Witness Signature	
Date	27 October 2010

Appendix 1 – Standard terms and conditions for Commercial Internal Use of Environment Agency Information

1. Definitions and Interpretation

1.1. In this agreement the following words shall have the following meanings unless the context otherwise requires:

"Agency Dataset" means the relevant primary Dataset or Content source created and (where applicable) maintained for the statutory functions of the Agency which is national (if such exists) or local (if not national)

"Confidential Information" means any information relating to this agreement disclosed by one party to the other under this agreement or coming to the Licensee's or the Agency's attention directly or indirectly as a result of this agreement whether orally or in writing and whether or not such information is expressly stated to be confidential or marked as such provided that such information is confidential in nature

"Content" has the same meaning as in the Re-Use of Public Sector Information Regulations 2005

Consultant Licensee means a person who is licensed to use the Information, who is not using the information for their own purposes, not making a new product from the Information and not selling the Information, who is acting under a contract to a client or customer for whom they have acquired the Information

"Contractor Use" means passing of Information or Derived Information to a person (Contractor) who is contracted to provide services, when:

- use is limited to the purposes of that contract, and
- all terms of the original licence are applied, and
- the Contractor is paid for the work done under that contract, and
- the Contractor does not pass the Information to any person other than the person contracting with them or a subcontractor who complies with these conditions

"Copy Derived Information" means that the Derived Information includes a copy of the Information as a whole or a substantial part of it or that the Derived Information can be reverse engineered to create a copy of the Information or a substantial part thereof

"Dataset" means a collection of thematically linked data, information, records, documents or other Content in the same format whether or not the collection is all in one place or in a single database or other single system

"Dataset Update Frequency" means the frequency with which an Agency Dataset is updated for all the Agency's purposes

"Derived Information" has the meaning indicated in the definition of External Derived Use below

"External Use" means External As-Is Use and/or External Derived Use

"External As-is Use" means use that, is not Internal Use, that involves supply or display of all, or a part of, the Information as it is or with minor display changes (font, colour, size, etc) only and does not include incorporation of information into a report, or merging of information with explanatory text or advice or changing format other than between Fixed Format types

"External Derived Use" means a supply of Information by the Licensee or the giving of rights of access to the Information that does not comprise Internal Use and is the result of processing Information by incorporating, merging, modelling, calculating or transforming it to produce new information ("Derived Information") that is either:

- Copy Derived Information, or
- Information that requires the physical input of the original Information into a rules-based process whether or not that process is automated

"Fixed Format" means Information that is formatted in such a way as to be static and unalterable (or not easily alterable without the loading of special software). It will typically include hard copy, pdf format, image format (such as jpeg, gif, tiff and bmp) and video format (such as mpeg, avi and wmv)

"Go Live Date" means the date identified as such in Schedule 3, upon which the Information shall be utilised, or any later date in respect of which the Agency has given 5 Working Days Notice to the Licensee

"Information" means the Datasets (including sets of documents) or other Content identified in Schedule 3 (which can include methodologies) and where applicable this term shall include Corrected Information

"Information Warning" means information required by Schedule 7 to be taken into account when using the Information

"Intellectual Property Rights" means any patent, copyright, database right, registered design, trademark or other industrial or intellectual property together with any applications for any of the foregoing

"Intermediary Use" means supply of the Information by an End Licensee who is not licensed for External Use to a person who is acting as an agent, distributor or other form of intermediary ("Intermediary") supplying the End Licensee's products to customers provided that:

- the Information is used only to aid in the production of a product on behalf of that End Licensee and
- no charge is made by that End Licensee for the supply of the Information to the Intermediary, and
- there is no and will not be any Information or Derived Information in that product, and
- all terms of the original licence are applied

"Internal Use" means use of Information or Derived Information that is not supplied externally other than for Contractor Use, Professional Use, Intermediary Use and Regulatory Use

"Licence Fees" means charges that aim to recover the Agency's costs of reproducing and disseminating information that it licences which comprise:

- any charges payable under the Agency's Charging for Access to Information Work Instruction which defines charges made under the Freedom of Information Act or the Environmental Information Regulations in respect of the marginal costs of making the Information available and/or supplying in an alternative format (FOI/EIR Charges), and/or
- standard Internal Use charges as published each year by the Agency with any appropriate discounts or cap applied, and/or
- external costs incurred by the Agency that directly relate to the licensed use of Information contained in this agreement

as identified in Schedule 1

"No Detriment Principle" means that any intended use of Information must not represent a risk of:

- being misleading to the End Licensee, or
- detriment to the Agency's ability to achieve its objectives, or
- detriment to the environment, including the risk of reduced future enhancement, or
- being prejudicial to the effective management of information held by the Agency, or
- damage to the Agency's reputation

"Notice" means a notice given in accordance with condition 20

"Professional Use" means supply by a Consultant Licensee who is a professional adviser of full and un-amended copies of Information to a client and any other person who reasonably needs the Information in relation to that client matter in respect of which the Information was obtained provided that a copy of the Agency's Standard Notice (Commercial) is sent with the Information so supplied which the recipient is informed they must comply with.

"Regulatory Use" means inclusion of a Fixed Format unaltered extract of Information in any documentation that is required to be supplied to a court, tribunal or regulatory body (but not including a trade association) where the inclusion of such extract is reasonably necessary in connection with a hearing, application or other judicial or regulatory process

"Re-use" shall have the same meaning as in Regulation 4 of the Re-use of Public Sector Information Regulations 2005

"Terminal Use Restriction" means the limit on the number of terminals permitted, specified in Schedule 1, to gain direct access to (this includes viewing) the Information or any Copy Derived Information and for the purposes of this condition "terminals" means servers, desktop or portable computers, personal digital assistants, mobile phones or any other electronic means of viewing or using information

"Working Day" means Monday to Friday inclusive from 9:00am to 5:30pm excluding UK public holidays

"written" includes fax and email and any other electronic text

"Year" means each period of twelve months commencing on the Commencement Date and each anniversary thereof

1.2. Unless the context otherwise requires:

1.2.1 a reference to any statute, statutory provision or statutory instrument includes a reference to that statute, statutory provision or statutory instrument together with all rules and regulations made under it or them as from time to time amended, consolidated or re-enacted

1.2.2 words importing a gender shall include all genders

1.2.3 reference to any person includes any legal entity, including without limitation a natural person or incorporated entity

1.2.4 words importing a singular include the plural and vice versa

1. Background

2.1 The Agency is to the best of its knowledge and belief the owner of the Intellectual Property Rights in the Information, or is licensed to supply that part of the Information in respect of which a third party owns Intellectual Property Rights

2.2 The Licensee has requested a licence for internal Use of the Information and the Agency has agreed to license the Information in accordance with this agreement

2. Term

This agreement shall commence with effect from the Commencement Date and shall continue for a period of one year ("the Term") when it will expire automatically without notice, subject to earlier termination as set out in condition 12

3. Supply of Information to the Licensee by the Agency

3.1 The Agency shall use all reasonable endeavours to supply to the Licensee one copy of the Information from the current Agency Dataset held by the Agency (to the extent that the Licensee does not already hold such Information) on the Commencement Date or as soon as practicable thereafter, provided that no obligation to supply shall arise until after the Agency has received cleared payment of the Licence Fees

3.2 Where the Information exists in electronic form the Agency shall supply it in that form but shall at its discretion choose the means of supply (which may include supply on disks)

4. Licence and use of Information by the Licensee

5.1 In consideration for the mutual promises and obligations in this agreement and the payment by the Licensee of the Licence Fees the Agency hereby grants to the Licensee a non-transferable, non-exclusive revocable licence subject to the terms of this agreement to make Internal Use of the Information and also any use identified in Schedule 2

5.2 This licence is given to the Licensee personally and not to any affiliated company or organisation

6. Obligations of the Parties

6.1 The Licensee shall:

6.1.1 not use the Information other than as licensed by Condition 5

6.1.2 Not supply or communicate outside the Licensee or any Intermediary any information, product or service that has used the Information in its creation before the Go Live Date

6.1.3 On the Go Live Date or as soon as possible thereafter comply with the requirements of condition 13.1 in respect of previous versions of the Information as if this agreement has terminated for those previous versions

6.1.4 comply with any Terminal Use Restriction and any restriction on use of the Information that derive from third party rights in respect of the Information that are identified in Schedule 3

6.1.5 take full note of any Information Warning

6.1.6 take all reasonable technical, contractual and other security measures to protect the integrity and security of Information and to prevent any use of the Information contrary to this agreement and any breach of this sub-condition which has a demonstrable effect shall be capable of being treated as a material breach of this agreement

6.1.7 not refer to the Agency or use Information in any marketing or publicity material without prior approval of the Agency in writing

6.1.9 do nothing which might contravene the No Detriment Principle and any breach of this sub-condition which has a demonstrable effect shall be capable of being treated as a material breach of this agreement provided that provision of truthful responses to enquiries put to the Licensee which are purely factual in nature shall not be capable of constituting a breach of this agreement unless they are a breach of condition 11

6.1.10 give Notice to the Agency as soon as reasonably practicable if:

a. it becomes aware that it is in breach of this agreement,
b. it suspects or discovers any possible infringement of the Agency's Intellectual Property Rights in the Information by a third party, or
c. that use of the Information under this agreement might be an infringement of any third party's Intellectual Property Right or of any third party's contractual rights derived therefrom or be any other breach of confidentiality or statute,

and shall, subject to any legally binding confidentiality, supply copies of any relevant documentation to the Agency

6.2 The Agency shall:

6.2.1 where it provides Information directly to the Licensee use all reasonable skill and care in providing the Information and in particular ensuring that the Information (taking into account, where relevant, the need to assemble and quality check) is an accurate and up to date copy of the Information held within the relevant Agency Dataset and will contain all the data fields or other attributes set out in Schedule 3

6.2.1 supply to the Licensee such information and assistance as the Licensee may reasonably request for the purposes of this agreement in connection with the processes and procedures used to create and supply the Information to the Licensee (to the extent that these are not confidential to the Agency and the Agency is not in breach of any Intellectual Property Rights, contractual restrictions or other confidentiality in disclosing them)

6.2.2 if the Agency updates its standard conditions or enters into any agreement with another licensee for similar use of the Information on different terms and conditions to those in this agreement and the differences are not attributable to different circumstances, publish such new conditions or supply a copy thereof to the Licensee and allow (but not oblige) the Licensee to terminate under condition 12 and to enter into new agreement on such new terms and conditions if there is no other change

6.3 Each Party shall deal justly and fairly with the other, carry out its obligations under this agreement using reasonable care and skill and shall in connection with this agreement comply with all relevant legislation and regulatory requirements

7. Payment

7.1 The Licensee shall pay the Licence Fees on or prior to the Commencement Date

7.2 VAT is due on all Licence Fees except FoI/EIR Charges

7.3 If any payment due under Condition 9 is not paid or is overdue, interest shall be due at the rate of three per cent (3%) above the base rate from time to time of the Barclays Bank plc from the due date until the date of payment on the amount outstanding. Interest will accrue from day to day on the basis of a year of 365 days and will be compounded quarterly in arrears from the date when payment should have been made until the date of actual payment

8. Limitation of Liability

8.1 The Agency does not warrant that the Information will always be accurate, complete or up to date or that the Information will provide any particular facilities or functions or be suitable for any particular purpose. The Licensee must ensure that the Information meet its needs and is entirely responsible for the consequences of any use of the Information.

8.2 If an electronic format has been used, the Agency does not promise that the media on which the Information are provided will always be free from defects, computer viruses, worms, trojan horses, software locks or other similar code of a destructive or unwelcome nature. The Licensee should carry out all necessary checks prior to loading the Information on to its computer system

8.3 Neither party shall other than in respect of conditions 6.1.8, 10.2 and 11.1 be liable to the other or any other person (whether in contract or in negligence or in other tort or otherwise) for:

a. any economic losses (including without limitation loss of revenues, profits, contracts, business or anticipated savings) other than Licence Fees, or

b. any loss of goodwill or reputation or

c. any special, indirect or consequential losses in any case whether or not such losses were within the contemplation of the parties at the date of this Licence (including loss of business, profit, reputation or goodwill) arising out of or in connection with this agreement or its subject matter

8.4 The Agency's and the Licensee's maximum aggregate liability to the other (including legal costs) in connection with this agreement shall not exceed the total sum of Licence Fees due hereunder

8.5 Neither party shall be liable for any claim arising under this agreement unless Notice of the claim is given to the other within six months of becoming aware of the circumstances giving rise to such claim, or of such time as the relevant party ought reasonably to have become aware of such circumstances

8.6 The Agency shall not be liable under this agreement for any defect in its Intellectual Property Rights to the Information if:

8.6.1 it has used best endeavours to ensure that Information where the defect occurs (being one of those separately identified and numbered sections in Schedule 3 or any addition thereto) is in the generality the property of the Agency or property of a third party who has licensed the Agency to supply its information and

8.6.2 such defect in Intellectual Property Rights in that part of the Information after the application of condition 10.3 would not require the withdrawal of that part in full or a significant part thereof, it being accepted that less than five percent (5%) (measured either as to value, geographically, or by quantity) would not be significant

8.7 Nothing in this condition 8 shall limit or exclude either party's liability for death or personal injury arising from its negligence

8.8 Except as expressly provided in this agreement, all representations, conditions and warranties whether express or implied (by statute or otherwise) are hereby excluded to the fullest extent permitted by law provided that this shall not exclude statutory or common law rights in respect of negligence

9. Audits

9.1 Not more than once in any Year the Licensee shall permit the Agency or its agents to have access to its records of dealings in respect of the Information on not less than 5 Working Days' Notice in order to verify that the Information is being used only for Internal Use, compliance with the No Detriment Principle and whether any other provision of the agreement has been breached and to take and retain copies of such records for its own use

9.2 If the results of the verification under condition 9.1 reveal that External Use has been made of the Information or any other significant breach of the agreement is identified, the cost of the verification shall be paid by the Licensee, but otherwise such cost shall be borne by the Agency

9.3 The Agency shall be entitled to invoice the Licensee for any costs due to it under condition 9.2 and the Licensee shall pay such sums within 20 Working Days of the date of the Agency's invoice together with VAT at the then prevailing rate

10. Intellectual Property Rights

9.1 No Intellectual Property Rights are transferred or licensed to the Licensee save those which are expressly provided in this agreement

9.2 The Agency warrants that subject to condition 8.6 it has all other powers and rights necessary to grant to the Licensee the licences set out in condition 5

10.3 If any use of any part of the Information in accordance with this agreement infringes any Intellectual Property Rights the Agency shall use all reasonable endeavours to obtain the right (without charge) for the Licensee to continue to use the infringing Information. If however the Agency is unable to do this, without prejudice to condition 10.2 and any other remedy the Licensee may have, the Agency shall use all reasonable endeavours to modify (or replace) the infringing Information so as to be as close to the usefulness of the original Information as reasonably possible or (if this is not possible) remove the infringing Information from Schedule 3

10.4 Neither party shall be entitled to bring an action for specific performance of the other party's obligations under this agreement where the performance of such obligation would be in breach of the Intellectual Property Rights of a third party

11. Confidentiality

10.1 The Licensee and the Agency agree:

11.1.1 to keep Confidential Information in strict confidence and secrecy

10.1.1 not to use any Confidential Information other than for the purposes of this agreement

10.1.2 to restrict the disclosure of any part of Confidential Information to such of their respective employees, agents and contractors who need access to it to enable them to perform their obligations under or in connection with this agreement and to bring to the attention of such persons the duty of confidentiality under this condition before allowing them access to Confidential Information unless they are already bound by alternative equivalent obligations and

10.1.3 not to disclose any Confidential Information to any other third parties without the prior written consent of the other

11.2 This condition shall not apply to Confidential Information:

10.3.1 which when it was disclosed was in the public domain otherwise than because of a breach of an obligation of confidentiality, or

10.3.2 that a party could be required to disclose by law, or

10.3.3 that has been disclosed in accordance with the Public Interest Disclosure Act 1998, the Freedom of Information Act 2000, the Environmental Information Regulations 2004 or the Re-use of Public Sector Information Regulations 2005 or

10.3.4 received by a party from a third party at liberty to disclose it

10.4 Neither party shall be entitled to bring an action for specific performance of the other party's obligations under this agreement where the performance of such obligation would breach a legally binding confidentiality requirement of a third party

12. Termination

11.1 The Agency shall be entitled to terminate this agreement by 20 Working Days’ Notice if the Licensee is in material breach of any of the terms of this agreement and, in the case of a breach capable of remedy, has failed to remedy that breach within 20 Working Days of receipt of such Notice specifying the breach and requiring its remedy

12.2 The Licensee shall be entitled to terminate this agreement by 20 Working Days' Notice for any reason

12.3 The rights to terminate this agreement given by this condition shall be without prejudice to any other right or remedy of either party in respect of the breach concerned (if any) or any other breach

13. Consequences of Termination

13.1 On expiry of this agreement or its termination for whatever reason the Licensee’s entitlement to use the Information under this agreement shall cease and all copies of the Information or any Copy Derived Information in the Licensee's possession or the possession of any person making Contractor Use or Intermediary Use shall be destroyed and no refund of Licence Fees shall be payable

13.2 Conditions 9 and 11 shall survive the expiry or termination of this agreement for a period of five years

14. Force Majeure, National Security and Agency’s Operating Requirements

14.1 Neither party shall be liable to the other for any delay in or failure of performance of its obligations under this agreement (other than an obligation to pay money) arising from any cause beyond its reasonable control including, without limitation, any of the following: Act of God; governmental act (including acts of regulatory authorities); statutory obligation; industrial action; any change in the law or the interpretation of the law by the courts; war; fire; flood; explosion or civil commotion (“Force Majeure”)

14.2 If a party is affected by Force Majeure it shall forthwith give Notice to the other party of the nature and extent of such Force Majeure

14.3 If Force Majeure prevails for a continuous period in excess of 20 Working Days the parties shall enter into bona fide discussions with a view to alleviating its effects or to agreeing upon such alternative arrangements as may be fair and reasonable

15. Assignment

The Licensee may not transfer or in any other way make over to any third party the benefit of this agreement either in whole or in part without the express prior written consent of the Agency such consent not to be unreasonably withheld or delayed

16. Waiver

Failure by either party to exercise or enforce any rights available to it, or any forbearance, delay or grant of indulgence, will not be construed as a waiver of its rights under this agreement or otherwise

17. Entire agreement

This agreement constitutes the entire agreement between the parties and supersedes all oral or written agreements, representations, understandings or arrangements relating to its subject matter other than subsequent written alterations to this agreement mutually agreed by the parties. The parties irrevocably and unconditionally waive any right to rescind this agreement by virtue of any misrepresentation and to claim damages for any misrepresentation save in each case where such misrepresentation was made fraudulently

18. Severance

If any part of the agreement is found by a court of competent jurisdiction or other competent authority to be unenforceable, then that part will be severed from the remainder of the agreement which will continue to be valid and enforceable to the fullest extent permitted by law

19. Variation

This agreement may not be amended, modified, varied or supplemented except in writing signed by or on behalf of the Agency and the Licensee

20. Notices and Consents

20.1 Notices under this agreement shall be in writing, in English, and shall be sent to the address of the party as set out in this agreement (or such other address in the United Kingdom as either party may notify to the other in accordance with this condition)

20.2 Notices shall be marked, in the case of a notice to the Licensee, for the attention of the Managing Director, and in the case of the Agency for the attention of the Head of the Enterprise Centre

20.3 Notices may be sent by first class mail, by email or by facsimile transmission

20.4 Correctly addressed notices sent by first class mail shall be deemed to be delivered 2 Working Days after posting

20.5 Correctly addressed facsimile transmissions or emails shall be deemed to be delivered when sent provided that a confirmation copy is sent by first class mail within 24 (twenty four) hours

20.6 Nothing in these standard conditions shall prevent the sender of any Notice from choosing a longer period than the minimum required

20.7 Any consent, approval or agreement given pursuant to this agreement shall be in writing and in the case of the Licensee shall be signed on its behalf by its Managing Director and in the case of the Agency shall be signed on its behalf by the Head of the Information Enterprise Centre

21. Relationship of Parties

Nothing in this agreement shall create a partnership or joint venture between the parties, nor shall this agreement constitute one party the agent of the other or give either party authority to act or hold itself out as having authority to act on behalf of the other, or confer or purport to confer on any third party any benefit or rights in respect of the terms of this agreement

22. Dispute Resolution

22.1 All disputes under or in connection with this agreement shall be referred first to the parties’ respective managers with responsibility for the day to day management of this agreement

22.2 If the parties’ respective managers are unable to resolve the dispute within a period of 10 Working Days from its being referred to them, the dispute shall be referred at the instance of either party to the parties’ respective Chief Executive Officers

22.3 If the parties’ respective Chief Executive Officers are unable to resolve the dispute within 10 Working Days from it being referred to them, the dispute shall be referred to the Centre for Dispute Resolution who shall appoint a mediator and the parties shall then submit to the mediator’s supervision of the resolution of the dispute

22.4 Recourse to this dispute resolution procedure shall be binding on the parties as to submission to the mediation but not as to its outcome. Accordingly all negotiations connected with the dispute shall be conducted in strict confidence and without prejudice to the rights of the parties in any future legal proceedings. Except for any party’s right to seek interlocutory relief in the courts, no party may commence other legal proceedings under the jurisdiction of the courts or any other form of arbitration until 20 Working Days after the appointment of the mediator

22.5 If, with the assistance of the mediator, the parties reach a settlement, such settlement shall be put in writing and, once signed by a duly authorised representative of each of the parties, shall remain binding on the parties

22.6 The parties shall bear their own legal costs of this dispute resolution procedure, but the costs and expenses of mediation shall be borne by the parties equally

22.7 Nothing in this condition shall restrict the Parties' rights to seek interim relief

23. Rights Of Third Parties

No third parties shall have rights to enforce any part of this agreement under the Contracts (Rights of Third Parties) Act 1999

24. Governing Law

This agreement shall be governed and construed in accordance with English law

^ **Modelled Breach Locations**

0 3.5 7 14 Kilometres

This map indicates the location of where we have modelled the consequence of breaches in the defences along the coastline and tidal rivers. We have mapped the the maximum values of Hazard Rating (Danger to People), Depth and Velocity.

We have not assumed that all breaches occur at the same time, but have modelled each breach individually and overlaid the results to find the maximum values.

Our modelling only considers the consequences of a breach, it does not make any assumption about the likelihood of a breach occurring. Our defences generally provide a good standard of flood defence but a risk of breaching remains.

Please contact the Environment Agency for information on how these maps are used in the management of flood risk.

General Enquiries No: 08708 506 506.
Weekday daytime calls cost 8p plus up to 6pm from BT Weekend Unlimited. Mobile and other providers charges may vary

Environment Agency

Produced by the Flood Risk Mapping & Data Management Team, Lincoln
General Enquiries No: 08708 506 506

Northern Area Tidal Hazard Mapping

Location of Modelled Breaches

D. Information from the North East Lindsey Drainage Board

Hannah Reed supplied a large package of flood risk information for the existing Killingholme Marshes Drainage System and their associated improvement scheme. The following relevant key items of information are included in this report:

D.1 Table of Estimated Flood Levels

Hannah Reed document 1-C204032 Estimated Flood Levels.pdf

D.2 Plan of the Killingholme Marshes Drainage System

Hannah Reed document 1-C204032 Killingholme Marshes Drain Names.pdf

D.3 Killingholme Marshes River Station Plan

Hannah Reed document 1-C204032 Killingholme RiverSta Plan.pdf

D.4 Standard Criteria for Drainage of Development Land

Hannah Reed document 2-C204032 Standard Criteria for Drainage of Development Land.pdf

D.5 Catchment Development Plan

Hannah Reed document 2-C204032 -SK13 Catchment Development Plan.pdf

D.6 Killingholme Marshes Improvement Scheme

Hannah Reed Drawing No. 12-C204032/201 RevP6: Scheme General Arrangement Plan.

D.7 Control Philosophy of Pumping Station

Hannah Reed document 13-C204032 Control Philosophy of Pumping Station.pdf.

D.8 Overview of Design Philosophy

Hannah Reed document 14-C204032 Overview of Design Philosophy.pdf.

D.9 Email from Simon Darch 01-12-2010: Surface Water Drainage

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Estimated Flood Levels - 1% Probability Event

AS EXISTING			***PROPOSED STRATEGY***		
Includes drain 11A discharging to North Haven Catchment			Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr	Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)	Label	Max Flow (cumecs)	Max Stage (mOD)
			11AN-1042	4.633	2.749
			11AN-1040	4.633	2.748
			10S-AC9U	1.204	2.748
			10S-AC9D	1.204	2.744
			10S-AC8U	1.204	2.748
			10S-AC8D	1.204	2.744
			10S-AC7U	1.204	2.748
			10S-AC7D	1.204	2.744
			10S-AC6U	1.204	2.748
			10S-AC6D	1.204	2.744
			10S-AC5U	1.204	2.748
			10S-AC5D	1.204	2.744
			10S-AC5WU	0.144	2.748
			HYD35_024	1.465	2.748
			10S-AC5WD	0.144	2.744
			HYD18_004	0.36	2.744
10A-1595	0.316	2.922	10A-1595	6.12	2.744
10A-1589	0.312	2.922	10A-1589	6.117	2.742
10A-1588	0.312	2.922	10A-1588	6.435	2.742
			HYD42_004	0.337	2.742
10A-INF	0.614	-9999.99	10A-INF	0.01	-9999.99
10A-1512	0.379	2.922	10A-1512	6.405	2.706
10A-1506	0.376	2.922	10A-1506	6.402	2.703
10A-1500	0.376	2.922	10A-1500	6.399	2.699
10A-1496	0.369	2.922	10A-1496	6.397	2.701
10A-1490	0.357	2.922	10A-1490	6.395	2.696
10A-1484	0.34	2.922	10A-1484	6.392	2.692
10A-1476	0.34	2.921	10A-1476	6.388	2.688
10A-1380	0.267	2.921	10A-1380	6.379	2.648
10A-1373	0.262	2.921	10A-1373	6.379	2.645
10A-1367	0.262	2.684	10A-1367	6.744	2.645
			GREEN	0.137	2.645
			HYD43_004	0.426	2.645
10A-1364	0.261	2.683	10A-1364	6.744	2.635
10A-1358	0.261	2.5	10A-1358	6.744	2.631
10A-1352	0.26	2.5	10A-1352	6.744	2.629
10A-1350	0.26	2.487	10A-1350	6.745	2.627
10A-1341	0.258	2.487	10A-1341	6.745	2.624
			10A-1234	6.746	2.59
10A-1233	0.398	2.485	10A-1233	8.166	2.59
			HYD49_003	0.314	2.59
			HYD48_004	0.36	2.59
			HYD46_003	0.322	2.59
			HYD45_002	0.275	2.59
			HYD44_004	0.419	2.59
10A-1148	0.513	2.483	10A-1148	8.107	2.565
10A-1036	0.475	2.482	10A-1036	7.938	2.525
10A-1031	0.472	2.483	10A-1031	7.895	2.525
10A-1025	0.472	2.471	10A-1025	7.888	2.526
10A-1021	0.47	2.471	10A-1021	7.884	2.521
10A-1016	0.495	2.41	10A-1016	8.864	2.384

Estimated Flood Levels - 1% Probability Event

AS EXISTING		
Includes drain 11A discharging to North Haven Catchment		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10A-1009	0.492	2.41
10A-871	0.488	2.414
10A-870	0.542	2.414
10A-734	0.531	2.409
10-693	1.131	2.409
10-687	1.132	2.409
10-678	1.132	2.409
10-671	1.135	2.409
10-541	1.189	2.409
10-421	1.194	2.409
10-415	1.194	2.409
10-405	1.195	2.409
10-400	1.195	2.409
10-380	1.196	2.409
10-374	1.197	2.409
10-365	1.197	2.41
10-359	1.197	2.41
10-214	1.308	2.41
33878	1.405	2.41
12693	1.406	2.41
46296	1.407	2.41
45200	1.407	2.41
10-23C	2.549	2.41
10-0C	2.549	2.41
10-0	2.549	4.3
10--1	2.551	4.3
10--10	2.605	4.3
10--100	3.132	4.3

PROPOSED STRATEGY		
Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10A-1009	8.858	2.381
10A-871	8.739	2.37
10A-870	8.82	2.37
10A-734	8.644	2.349
10-693	12.273	2.372
10-687	11.295	2.389
10-678	12.102	2.331
10-671	12.947	2.307
10-541	13.743	2.291
10-421	13.486	2.303
10-415	12.607	2.299
10-405	13.311	2.298
10-400	15.206	2.276
10-380	15.482	2.249
10-374	15.418	2.278
10-365	15.117	2.344
10-359	16.016	2.268
10-214	17.421	2.285
Oct-92	19.711	2.219
Oct-34	22.798	2.183
Oct-26	18.282	2.198
Oct-23	17.907	2.246
OUT	52.672	2.246
OUT--1	26.787	3.088
OUTA--1	9.414	3.088
OUTA--2	2.973	3.099
OUTA--50	1.86	4.343
OUTA--51	1.853	4.343
OUTA--98	2.398	4.3
OUTC--1	10.066	3.088
OUTC--2	2.973	3.099
OUTC--99	3.65	4.3
OUTC--50	1.86	5.504
OUTC--51	2.345	5.457
OUTC--98	3.942	4.3
OUTB--1	13.969	3.088
OUTB--2	3.636	3.099
OUTB--50	1.86	4.343
OUTB--51	1.853	4.343
OUTB--98	2.423	4.3
OUTB--99	2.599	4.3
OUTA--99	2.258	4.3
OUT--99	5.551	4.3
OUTD	5.53	4.3
10X-sweet	0.1	2.994
OUT2	54.35	2.246
HYD53_003	1.489	2.246
OUT2--1	18.892	2.919
OUT2A--1	6.923	2.919
OUT2A--2	2.151	2.941

Estimated Flood Levels - 1% Probability Event

AS EXISTING		
Includes drain 11A discharging to North Haven Catchment		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10-F1-693	0	2.121
10-F1-678	0	2.121
10-F1-671	0	2.121
10-F1-541	0	2.121
10-F1-421	0	2.121
10-F2-405	0	2.401
10-F2-400	0	2.401
10-F2-380	0	2.401
10-F2-365	0	2.401
10-F2-359	0	2.401
10-F2-34	0	2.401
10-F2-26	0	2.401
10-F3-678	0.121	2.357
10-F3-671	0.063	2.357
10A-F1-1148	0	2.491
10A-F1-1036	0	2.491
10A-F2-1148	0.128	2.413
10A-F2-1036	0.064	2.413
10A-F3-1595	0	2.771
10A-F3-1589	0	2.771
10A-F3-1512	0	2.771
10A-F3-1496	0	2.771
10A-F3-1500	0	2.771
10A-F3-1490	0	2.771
10A-F4-1595	0.042	2.688
10A-F4-1588	0	2.688
10A-F4-1512	0	2.688
10A-F4-1500	0	2.688
10A-F4-1496	0	2.688
10A-F4-1490	0.002	2.688

PROPOSED STRATEGY		
Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
OUT2A--50	1.86	4.35
OUT2A--51	1.853	4.343
OUT2A--98	1.853	4.3
OUT2B--1	6.297	2.919
OUT2B--2	2.511	2.941
OUT2B--50	1.86	4.343
OUT2B--51	1.853	4.343
OUT2B--98	1.853	4.3
OUT2C--1	6.297	2.919
OUT2C--2	2.252	2.941
OUT2C--50	1.86	5.504
OUT2C--51	5.383	5.457
OUT2C--98	6.614	4.3
OUT2C--99	7.006	4.3
OUT2B--99	2.003	4.3
OUT2A--99	1.85	4.3
OUT2--99	5.551	4.3
OUT2D	5.531	4.3
OUT--101	11.06	4.3
OUT--200	26.672	4.3
10-F1-693	0	2.121
10-F1-678	0	2.121
10-F1-671	0	2.121
10-F1-541	0	2.121
10-F1-421	0	2.121
10-F2-405	0	2.401
10-F2-400	0	2.401
10-F2-380	0	2.401
10-F2-365	0	2.401
10-F2-359	0	2.401
10-F2-34	0	2.401
10-F2-26	0	2.401
10-F3-678	0.004	2.11
10-F3-671	0	2.11
10A-F1-1148	0	2.493
10A-F1-1036	0.003	2.493
10A-F2-1148	0.402	2.352
10A-F2-1036	0.155	2.352
10A-F3-1595	0	2.771
10A-F3-1589	0	2.771
10A-F3-1512	0	2.771
10A-F3-1496	0	2.771
10A-F3-1500	0	2.771
10A-F3-1490	0	2.771
10A-F4-1595	0	2.651
10A-F4-1588	0	2.651
10A-F4-1512	0	2.651
10A-F4-1500	0	2.651
10A-F4-1496	0	2.651
10A-F4-1490	0	2.651

Estimated Flood Levels - 1% Probability Event

AS EXISTING		
Includes drain 11A discharging to North Haven Catchment		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10A-F4-1476	0.001	2.688
10A-F4-1471	0	2.688
10A-F5-1976	1.255	2.9
10A-F5-1847	0.896	2.9
10A-F5-1833	0.008	2.9
10A-F5-1756	0	2.9
10A-F5-1625	0	2.9
9B-913	0.916	2.407
9B-907	0.916	2.407
9B-889	0.917	2.405
9B-883	0.917	2.406
9B-788	1.025	2.404
9B-783	1.025	2.404
9B-776	1.04	2.409
9B-770	1.041	2.409
10-INF	0.305	-9999.99
10A-693	0.531	2.409
10A-1471LF	0.155	2.921
10A-1341LF	0.184	2.487
10A-1233LF	0.144	2.485
10-671LF	0.1	2.409
10-214LF	0.094	2.41
9B-907WU	0	2.407
9B-907C	0.916	2.407
9B-889C	0.917	2.405
9B-889WD	0	2.405
9B-783WU	0.103	2.404
9B-776WD	0.103	2.409
9B-783C	1.025	2.404
9B-776C	1.025	2.409
10A-1021WU	0	2.471
10A-1021IN	0.47	2.471
10A-1016WD	0	2.41
10A-1021C	0.47	2.454
10A-1016C	0.47	2.444
10A-1016OT	0.47	2.41
10-687WU	0	2.409
10-687IN	1.132	2.409
10-678WD	0	2.409
10-687C	1.132	2.409

PROPOSED STRATEGY		
Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10A-F4-1476	0	2.651
10A-F4-1471	0	2.651
10A-F5-1976	0	2.522
10A-F5-1847	0.242	2.522
10A-F5-1833	0	2.522
10A-F5-1756	0	2.522
10A-F5-1625	0	2.522
9B-913	1.443	2.312
9B-907	1.391	2.325
9B-889	1.337	2.402
9B-883	1.368	2.396
9B-788	1.507	2.399
9B-783	1.391	2.401
9B-776	1.634	2.352
9B-770	2.029	2.372
HYD1_011	4.609	2.372
HYD14_001	0.717	2.372
10-INF	0.01	-9999.99
10A-693	8.588	2.372
10A-1471LF	0.003	2.685
10A-1341LF	0.003	2.624
10A-1233LF	0.002	2.59
10-671LF	0.003	2.307
10-214LF	0.003	2.285
9B-907WU	0	2.325
9B-907C	1.391	2.325
9B-889C	1.337	2.402
9B-889WD	0	2.402
9B-783WU	0.094	2.401
9B-776WD	0.094	2.352
9B-783C	1.391	2.401
9B-776C	1.391	2.352
10A-1595C	0.371	2.76
10A-1595OT	0.371	2.744
10A-1595WD	0	2.744
10A-1471	6.385	2.685
10A-1021WU	0	2.521
10A-1021IN	8.345	2.521
HYD50_003	0.376	2.521
HYD51_003	0.187	2.521
10A-1016WD	0	2.384
10A-1021C	8.345	2.471
10A-1016C	8.345	2.466
10A-1016OT	8.345	2.384
10-687WU	0	2.389
10-687IN	5.647	2.389
10-687IN2	5.647	2.389
10-687C2	5.647	2.383
10-678C2	6.051	2.343
10-678WD	0	2.331

Estimated Flood Levels - 1% Probability Event

AS EXISTING		
Includes drain 11A discharging to North Haven Catchment		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10-678C	1.132	2.409
10-678OT	1.132	2.409
10-415WU	0	2.409
10-415IN	1.194	2.409
10-405WD	0	2.409
10-415C	1.194	2.409
10-405C	1.195	2.409
10-405OT	1.195	2.409
10-374WU	0.605	2.409
10-365WD	0.605	2.41
10-374C	1.197	2.409
10-365C	1.197	2.41
10-365OT	1.197	2.41
10-693SR	0	-9999
10-678SR	0	-9999
10-671SR	0	-9999
10-541SR	0	-9999
10-421SR	0	-9999
10-405SR	0	-9999
10-400SR	0	-9999
10-380SR	0	-9999
10-365SR	0	-9999
10-359SR	0	-9999
10-34SR	0	-9999
10-26SR	0	-9999
10-678SL	0.121	-9999
10-671SL	0.063	-9999
10A-1148SR	0	-9999
10A-1036SR	0	-9999
10A-1148SL	0.128	-9999
10A-1036SL	0.064	-9999
10A-1595SR	0	-9999
10A-1588SR	0	-9999
10A-1512SR	0	-9999
10A-1500SR	0	-9999
10A-1496SR	0	-9999
10A-1490SR	0	-9999
10A-1595SL	0.042	-9999
10A-1588SL	0	-9999

PROPOSED STRATEGY		
Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10-678OT2	6.051	2.331
10-687C	5.647	2.383
10-678C	6.051	2.343
10-678OT	6.051	2.331
10-415WU	0	2.299
10-415IN	6.304	2.299
10-415IN2	6.304	2.299
10-415C2	6.304	2.294
10-405C2	6.655	2.307
10-405WD	0	2.298
10-405OT2	6.655	2.298
10-415C	6.304	2.294
10-405C	6.655	2.307
10-405OT	6.655	2.298
10-374WU	0.353	2.278
10-374IN2	8.395	2.278
10-374C2	8.395	2.271
10-365C2	8.204	2.366
10-365OT2	8.204	2.344
10-365WD	0.353	2.344
10-374IN	7.106	2.278
10-374C	7.106	2.277
10-365C	7.002	2.356
10-365OT	7.002	2.344
10-693SR	0	-9999
10-678SR	0	-9999
10-671SR	0	-9999
10-541SR	0	-9999
10-421SR	0	-9999
10-405SR	0	-9999
10-400SR	0	-9999
10-380SR	0	-9999
10-365SR	0	-9999
10-359SR	0	-9999
10-34SR	0	-9999
10-26SR	0	-9999
10-678SL	0.004	-9999
10-671SL	0	-9999
10A-1148SR	0	-9999
10A-1036SR	0.003	-9999
10A-1148SL	0.402	-9999
10A-1036SL	0.155	-9999
10A-1595SR	0	-9999
10A-1588SR	0	-9999
10A-1512SR	0	-9999
10A-1500SR	0	-9999
10A-1496SR	0	-9999
10A-1490SR	0	-9999
10A-1595SL	0	-9999
10A-1588SL	0	-9999

Estimated Flood Levels - 1% Probability Event

AS EXISTING		
Includes drain 11A discharging to North Haven Catchment		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10A-1512SL	0	-9999
10A-1500SL	0	-9999
10A-1496SL	0	-9999
10A-1490SL	0.002	-9999
10A-1476SL	0.001	-9999
10A-1471SL	0	-9999
10-359LF	0.111	2.41
10A-1588LF	0.131	2.922
10S-1876	2.085	3.099
10S-1618	2.077	2.922
10X-991	0.028	2.41
10X-979	0.024	2.41
10X-979WU	0.023	2.41
10X-979CU	0.001	2.41
10X-972CD	0.001	2.41
10X-972WD	0.023	2.41
10X-972	0.024	2.41
10X-800	0.03	2.415
10X-685	0.015	2.452
10X-685WU	0	2.452
10X-685CU	0.115	2.452
10X-678CD	0.115	2.452
10X-678WD	0	2.452
10X-199	0.648	2.41
10X-000	1.047	2.41
10Y-660	0.172	2.414
10Y-600	0.173	2.417
10Y-400	0.178	2.417
10Y-367	0.179	2.421
10Y-sweet	0.1	2.421
10X-991WU	0.028	2.41
10Y-660WU	0.172	2.414
10Y-367CU	0.279	2.421
10Y-367WU	0	2.421
10Y-358CD	0.279	2.42
10Y-358WD	0	2.42
10Y-358	0.279	2.42
10Y-200	0.285	2.411
10Y-000	0.316	2.41
10Z-861	0.041	2.409
10Z-861WU	0.041	2.409
10Z-800	0.033	2.423
10Z-600	0.029	2.42
10Z-539	0.03	2.415
10Z-sweet	0.1	2.415
10Z-539BU	0.13	2.415
10Z-530BD	0.13	2.415

PROPOSED STRATEGY		
Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10A-1512SL	0	-9999
10A-1500SL	0	-9999
10A-1496SL	0	-9999
10A-1490SL	0	-9999
10A-1476SL	0	-9999
10A-1471SL	0	-9999
10X-991	1.92	2.439
10X-979	0.516	2.465
10X-979WU	0.533	2.465
10X-979CU	0.049	2.465
10X-972CD	0.049	2.502
10X-972WD	0.533	2.502
10X-972	0.516	2.502
10X-800	1.318	2.84
10X-685	0.673	2.994
10X-685WU	0	2.994
10X-685CU	0.723	2.994
10X-678CD	0.723	2.995
10X-678WD	0	2.995
10X-678	0.723	2.995
10X-600	1.57	2.894
10X-400	2.411	2.82
10X-200	2.676	2.608
10X-199	3.612	2.608
10X-000	3.221	2.246
10Y-660	2.071	2.365
10Y-600	1.561	2.515
10Y-400	2.107	2.634
10Y-367	0.472	2.789
10Y-sweet	0.1	2.789
10X-991WU	1.92	2.384
HYD16_001	0.27	2.384
HYD15_001	0.338	2.384
10Y-660WU	2.071	2.37
HYD52_001	0.195	2.37
10Y-367CU	0.522	2.789
10Y-367WU	0	2.789
10Y-358CD	0.522	2.791
10Y-358WD	0	2.791
10Y-358	0.522	2.791
10Y-200	1.412	2.686
10Y-000	0.936	2.608
10Z-861	0.429	2.368
10Z-861WU	0.429	2.352
10Z-800	0.456	2.467
10Z-600	0.313	2.501
10Z-539	0.52	2.599
10Z-sweet	0.1	2.599
10Z-539BU	0.62	2.599
10Z-530BD	0.62	2.599

Estimated Flood Levels - 1% Probability Event

AS EXISTING		
Includes drain 11A discharging to North Haven Catchment		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10Z-539WU	0	2.415
10Z-530	0.13	2.415
10Z-467	0.13	2.416
10Z-461	0.13	2.415
10Z-400	0.131	2.413
10Z-200	0.142	2.411
10Z-000	0.338	2.41
10Z-530WD	0	2.415

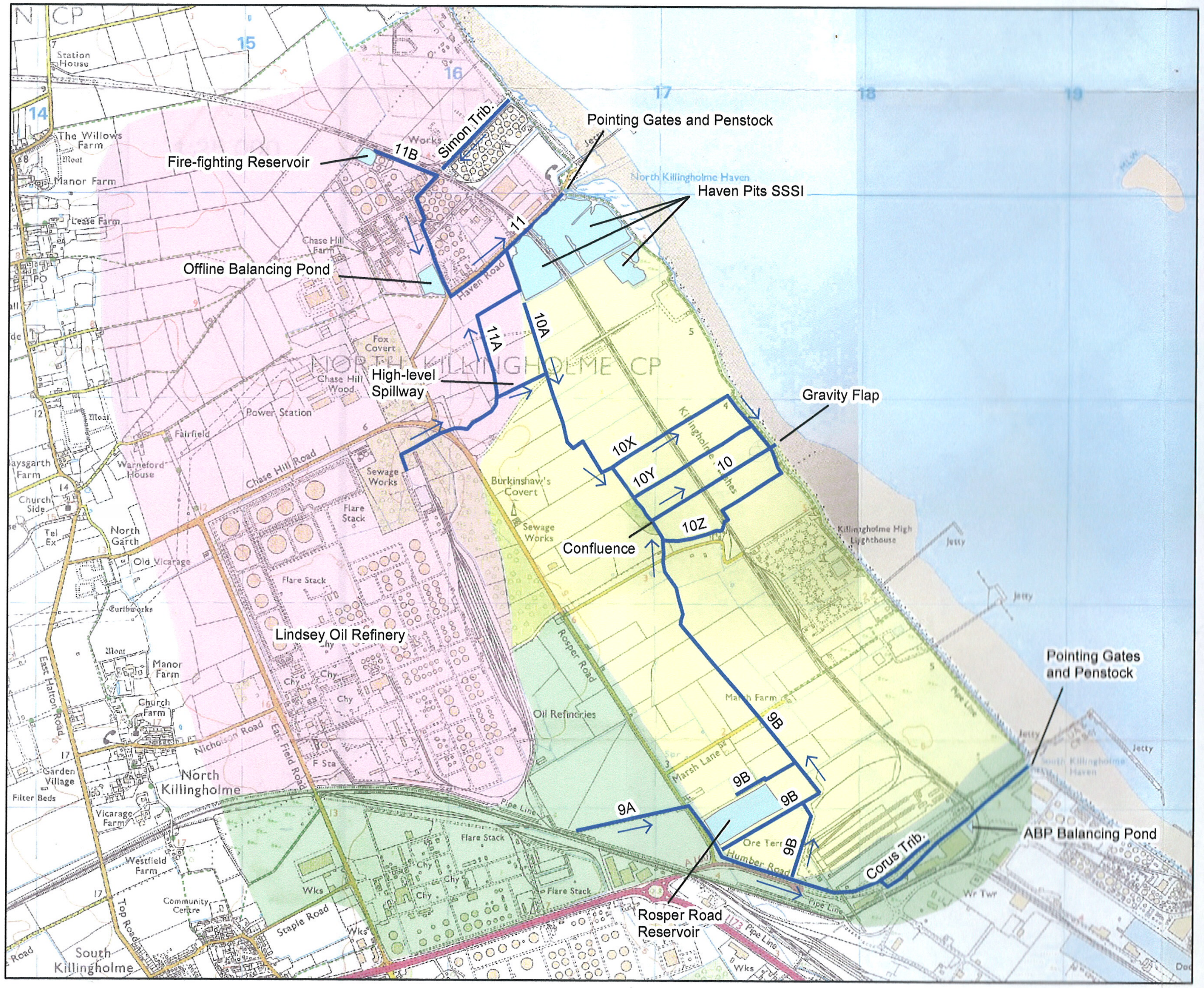
PROPOSED STRATEGY		
Includes developed catchment flows (phase2 entered as point inflow at confluence with drain 10), but excludes widening in Drain 9		
Duration		4.5 hr
Label	Max Flow (cumecs)	Max Stage (mOD)
10Z-539WU	0	2.599
10Z-530	0.62	2.599
10Z-467	0.514	2.554
10Z-461	0.356	2.603
10Z-400	0.677	2.498
10Z-200	0.433	2.34
10Z-000	1.198	2.246
10Z-530WD	0	2.599
fpondbank	0.3	0
fpondbank2	0.3	3.098
ORU	0.3	3.098
ORD	0.3	0
11AN-1122	4.458	2.749
11AN-1497	3.928	2.858
OUTC--2C	1.86	3.099
ABS-OUTC--2	1.6	3.099
OUTC--50C	1.86	3.099
ABS-OUTC--51	1.6	5.457
OUTB--2C	2.036	3.099
ABS-OUTB--2	1.6	3.099
OUT2B--2C	1.86	2.941
ABS-OUTB--51	1.6	4.343
ABS-OUT2B--2	1.6	2.941
OUTB--50C	1.86	3.099
ABS-OUT2B-51	1.6	4.343
OUTA--2C	1.86	3.099
ABS-OUTA--2	1.6	3.099
OUTA--50C	1.86	3.099
ABS-OUTA--51	1.6	4.343
OUT2C--2C	1.86	2.941
ABS-OUT2C--2	1.6	2.941
OUT2C--50C	1.86	2.941
ABS-OUT2C-51	1.6	5.457
OUT2B--50C	1.86	2.941
OUT2A--2C	1.86	2.941
ABS-OUT2A--2	1.6	2.941
OUT2A--50C	1.86	2.941
ABS-OUT2A-51	1.6	4.343
OUTC--51C	3.942	5.457
OUTC--98C	3.942	5.473
OUTB--51C	2.423	4.343
OUTB--98C	2.423	4.342
OUTA--51C	2.398	4.343
OUTA--98C	2.398	4.342
OUT2C--51C	6.614	5.457
OUT2C--98C	6.614	5.474
OUT2B--51C	1.853	4.343
OUT2B--98C	1.853	4.342
OUT2A--51C	1.853	4.343
OUT2A--98C	1.853	4.342

North East Lindsey Drainage Board

Killingholme Marshes Strategic Review

Location Plan and Indicative Catchment Boundaries

Hannah · Reed
Consulting Engineers
www.hannahreed.co.uk



Boundaries are based on available topographic information, Drainage Board records, and interpretation of Flood Estimation Handbook defined catchments.

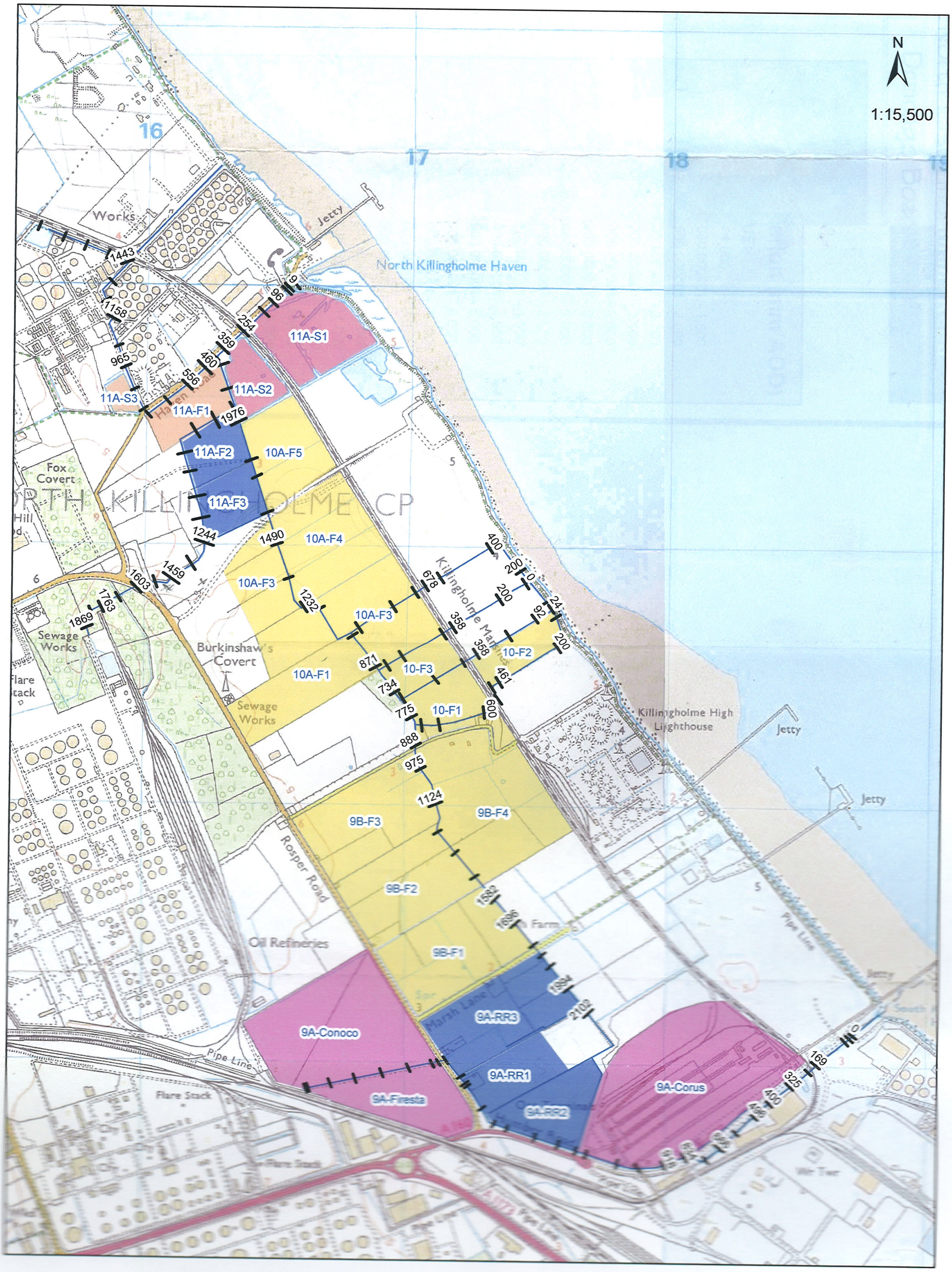
Hannah-Reed reference 204032/GIS/101

North East Lindsey Drainage Board

Killingholme Marshes Strategic Review

Floodplain Schematic & Chainage Locations

Hannah · Reed
Consulting Engineers
www.hannahreed.co.uk



Hannah-Reed reference 204032/GIS/103

Legend
<all other values>
Catchment
Marshes
North
SSSI
South
Transfer

North East Lindsey Drainage Improvement Scheme

Standard Criteria for Drainage of Development Land

Able Marine Energy Park

The Board's strategy seeks to provide a catchment solution that allows development the benefit of unattenuated discharge and an improved standard of fluvial flood protection through improved conveyance, storage and discharge of fluvial flood waters to the Humber Estuary. The strategy is reliant on both the co-operation and financial contribution of landowners in the catchment, who are stakeholders in the benefits.

The existing catchment is currently constrained both by the restriction in size of the gravity outlet from the marshes and the topographic level of the land that results in gravity drainage being tide locked during the high tide period. The existing catchment relies heavily on the storage both in the channel and on the natural flood plains of the marshes.

The proposed strategy will increase the opportunity for gravity flow during low tide periods through a series of gravity outlet doors at the back of each pump bay. They are designed to operate within a tight hydraulic head range to mitigate flood risk in the main channel, and are therefore shallow and wide in dimension. During high tide periods flow will be evacuated via a series of high-capacity low-lift land drainage pumps. Again these are designed to operate within a tight upstream head range, and will operate on an automated staggered start-stop regime. With the flat topography of the catchment the system will rely on the draw-down of the hydraulic head to convey flows through the channels.

All development in the catchment should adhere to the following strategy objectives and criteria:

- Development shall not impede the flow (and proposed flows) in the Board's system or impact on the riparian rights of other landowners.
- Direct discharge of surface water will be permitted to the Board Drains for allowable development areas included in the strategy (reference HRA C-204032/Sk13).
- Points of discharge should follow the natural drainage paths.
- Additional cross-catchment flow, or development not included in the strategy, will not be permitted without additional compensatory measures.
- Corridors for flood mitigation infrastructure (reference HRA C-204032/Sk13) should be protected, and appropriately master-planned into developments.
- Open channels and tributaries should be retained throughout the catchment to retain their contribution to conveyance and storage. Where channels are removed additional compensatory storage (in addition to that proposed in the strategy) shall be provided at an appropriate like-for-like volume at an appropriate location and level.
- Where necessary, internal channels should be widened to improve conveyance into the main drains, and maximise storage in the drainage system.

- Ground raising is permitted to developable areas to establish a safe level of protection commensurate with the vulnerability classification.

- A minimum standard of fluvial protection of 1% probability is expected for all office buildings unless otherwise agreed.

- Lower standards of protection may be considered for port related storage facilities were surface ponding and flooding can be tolerated.

- Permeable surfacing should be adopted for storage areas and non-essential hardstanding areas to reduce the burden on the drainage system wherever practicable unless otherwise agreed with the Board.

- Where large impermeable surfaces are implemented the level and drainage strategy should be designed to avoid rapid and concentrated sheet run-off with shallow gradients and extended longitudinal runs used. The risk of surcharging at the outfalls will dictate the need for shallow surface drainage methods.

- Unless otherwise agreed the on-site surface water infrastructure should generally be designed to contain no more than the 1 in 30 annual storm frequency in accordance with current practice. The design should include provision for exceedence to avoid overland flood paths impacting on building or adjacent properties.

- Drain crossings should be limited to essential access only. On the main channels existing farm crossings shall be removed and structures replaced with clear span bridges so as to avoid additional hydraulic losses or increasing the risks of blockage.

- Development layouts must not impede the Board’s access or ability to maintain the channel system, and drainage infrastructure.

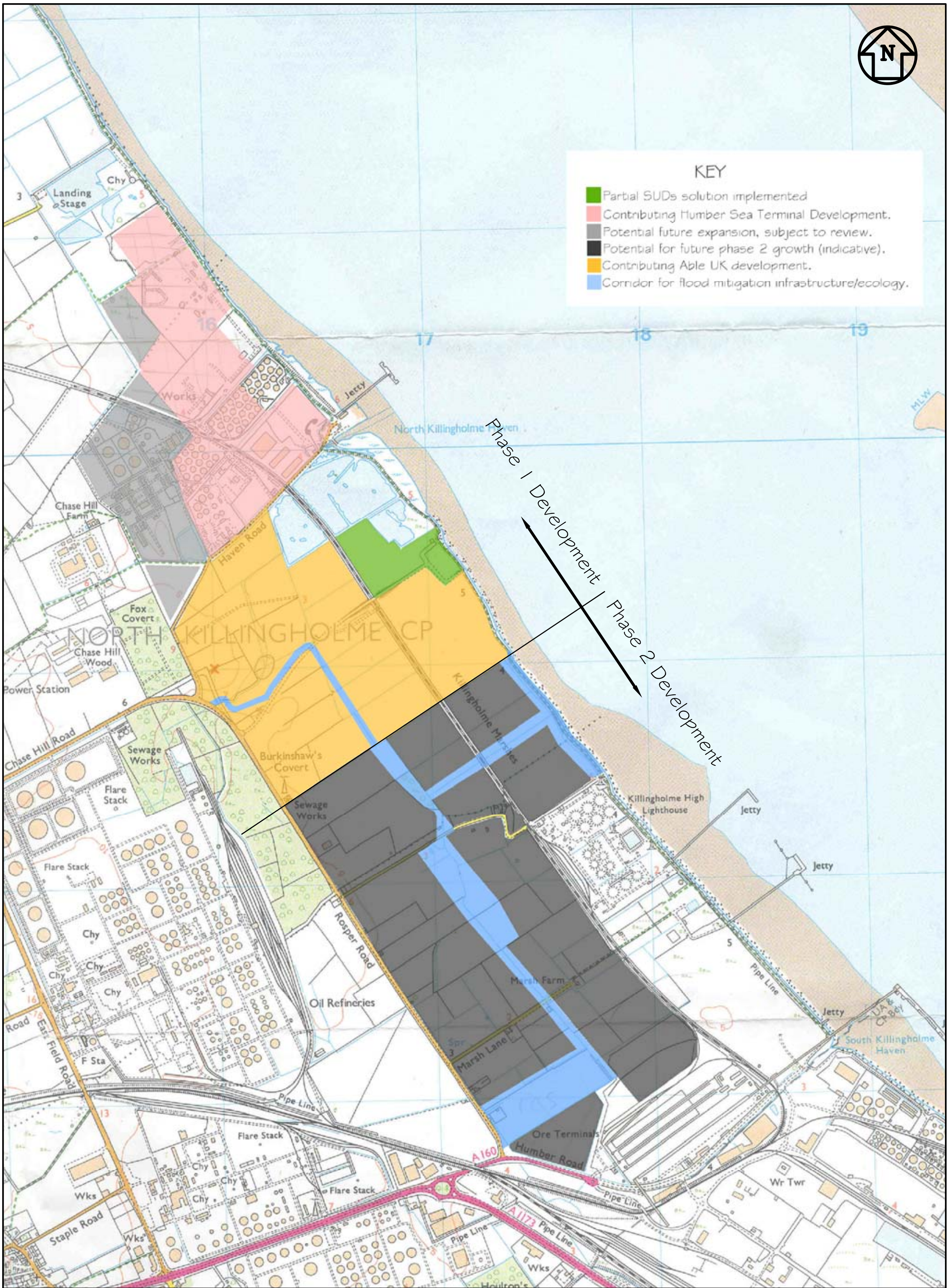
- An adaptive approach to climate change is promoted in the strategy. The identified corridors for flood mitigation have included zones where additional flood storage might be provided in the future.

- The development shall not adversely impact the tidal defences for the catchment.

- Proportional financial contributions based upon total site area are to be made by developers/landowners to implement the strategy.

Although the strategy will improve standards of protection and release areas of flood risk land for development, it retains the need for large quantities of catchment flood storage and infrastructure. The delivery and land take necessary for this infrastructure therefore remains a constraint on the potential of the area, and this needs to be appropriately considered in the master plan for development.

Prepared by Hannah-Reed, November 2010



P1	Initial issue	JA	DS		02/04/09
Rev	Description	Dr	Ch	Appr.	Date

Drawing Number: C-204032/SK13

Rev: P1

Client: North East Lindsey Drainage Board

Scale: NTS

Sheet: A4

Project: Killingholme Marshes Improvement Works

Title: Catchment Development Plan

Hannah Reed
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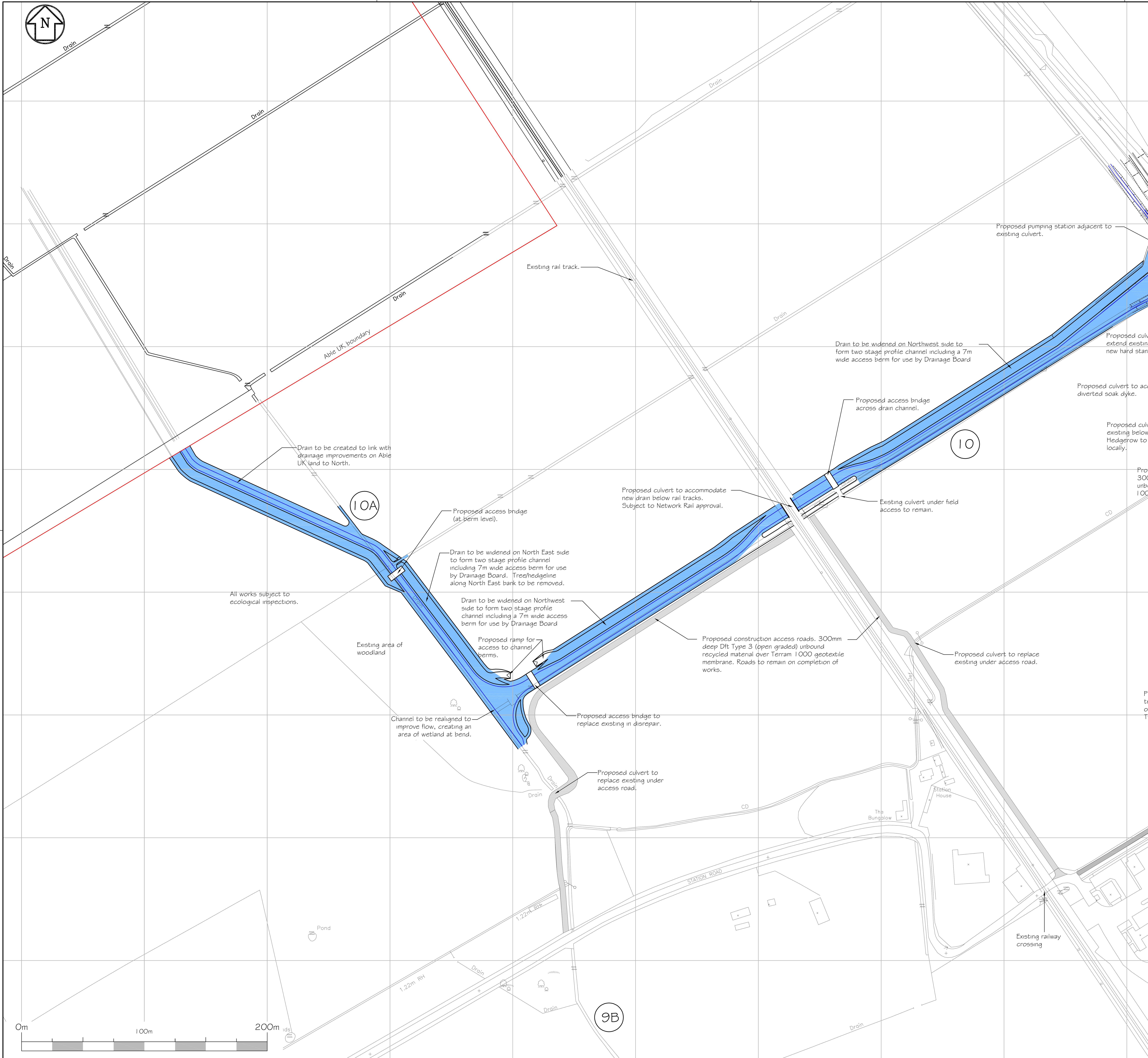
CAD FILENAME: C-204032/SK13



NOTES

1. DO NOT SCALE - Use figured dimensions only.
2. All dimensions shown are in millimetres unless otherwise stated.
3. The Contractor is to verify all dimensions on site before commencing work or preparing shop drawings.
4. This drawing is to be read in conjunction with all Engineers drawings and specifications.
5. All levels shown are to OS datum + 100m

PRELIMINARY

Rev	Description	Dr	Ch	Date
P6	Drain crossing removed.	JA	DS	16/04/09
P5	channel & berm adjusted, ramps added	JA	DS	25/03/09
P4	Notes. Drain widening toward Able UK site. Grid added	HA	DS	19/03/09
P3	Dwg Scale. Drain alignment around railway	JA	DS	25/02/09
P2	Drain alignment link to Able UK drain	JA	DS	10/02/09
P1	Initial issue	JA	DS	07/01/09

Client
North East Lindsey Drainage Board

Project
Killingholme Marshes
Improvement Works

Title
Scheme General Arrangement
Plan

Hannah • Reed
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Sheet Size	A1	Scale	1:1500
Drawn	JA	Drawing Number	Rev
Checked	DS	C-204032/201	P6
Approved	-		

A1 BS1192 : Part 1 1984

North East Lindsey Drainage Improvement Scheme

Control Philosophy of Pumping Station

The Board's strategy includes the provision of a pumping station that will allow surface water discharge to continue during the storm event throughout the 4.5 hour potential tide lock cycle, whilst also maximising the potential for gravity flow during low tide periods.

With all six bays implemented the station will have an approximate design pumped capacity of 9.6 cumecs. The pumps will automatically operate on a rotational duty-assist basis. The capacity has been designed to supplement the available storage within the catchment, and control levels within a notably small head range of around 2m between standing and design water levels. In a severe storm the station has the potential to evacuate over 70,000m^3 of water during a tide lock cycle, the equivalent of about 20mm of rainfall across the marshes catchment. Supplementary storage within the drainage catchment therefore remains fundamental in mitigating risk during the design event.

The precise pumping control has yet to be fully finalised and may necessitate some operational experience to avoid excessive hunting of the pumps, particularly in the interim prior to the full development of the catchment. For the purposes of modelling and catchment assessment, reference should be made to the pump schematic C-204032/Sk21 for indicative start and stop levels used to simulate the design event. In practice a greater separation is likely to be necessary in the start levels.

A series of gravity doors will be provided to increase discharge capacity when gravity conditions prevail. To maximise the use of the gravity discharge during the falling tide in the storm, the pumps will also have a level differential control. Pumping would therefore cease at times when gravity discharge becomes feasible on the falling tide and fluvial levels remain high.

With the flat topography of the catchment, rapid evacuation at the station is essential in developing sufficient draw-down to drive the high flows through the catchment's open channels. The strategy relies on channel and structure improvements to minimise losses in the hydraulic gradients wherever practicable through the lowlands. Two staged channels and clear span crossings are therefore proposed for all key watercourses.

Two lines of tidal defences are allowed for at the pump station. The initial line of defence is at the foreshore with the continuity of the sea wall and flapped valves to the outlet chambers providing defence. The raised surge chamber and flapped outlets provide a secondary line of defence at the station.

For environmental and planning reasons the height of the station has been kept at a low level, below the flood embankment where possible, whilst still retaining a high level of fluvial flood protection to all control and electrical components.

Prepared by Hannah-Reed, November 2010

North East Lindsey Drainage Improvement Scheme

Overview of Design Philosophy

A strategic catchment review for the Killingholme Marshes catchment was undertaken by Hannah-Reed on behalf of the Board in 2004, that drew upon conclusions from similar studies for the North Haven and South Haven Catchments. The overriding objective of the Board's strategy is to mitigate the potential flood risk to the two pits near the North Haven. With the freshwater pit afforded SSSI status and the saline pit RAMSAR designation, the Board considered that additional measures were necessary to improve the standard of protection of these assets from fluvial inundation.

With development pressures mounting in all three catchments, the Marshes study concluded that a strategy could be developed and promoted that could address the immediate concerns of the three catchments. The key elements of the strategy are:

- To divert water from the upper extents of the North Haven catchment (Lindsey oil Refinery) into the Marshes catchment, where both flow and pollution risk could be better managed.
- Improve flow conveyance and storage through the Marshes catchment so as to allow direct discharge from proposed development.
- Provide improved gravity and pumped discharge to maximise the evacuation of water throughout the tide cycle.
- Reduce the flood risk in the catchment to facilitate ground raising in the Marshes and enable development.

The flow diversion was implemented as part of Able UK's earlier development to the north of the Marshes catchment, linking the discharge from Lindsey Oil Refinery to the channel passing through Area D. The initial phase of implementing two-stage carrier channels has also commenced through the Able site. This will connect to the proposed channel alignment of the Pump Station scheme beyond the existing site boundary. These main channels provide the bulk of the flood risk storage.

The Board's strategy includes the provision of a pumping station that will allow surface water discharge to continue during the storm event throughout the 4.5 hour potential tide lock cycle, whilst also maximising the potential for gravity flow during low tide periods. Initially a nominal capacity of 4.5 cumecs (3 pumps rated at around 1.5 cumecs per pump nominal capacity) was identified to cater for the first phase of development; the current Able UK holdings and the diversion work undertaken. The strategy identified for this capacity to be doubled with supplementary storage as the southern area of the marshes catchment was developed, including the site identified for the marine park and the Drax renewable energy plant. The designed scheme has provision for six pumped bays therefore, and an approximate design pumped capacity of 9.6 cumecs (with each pump delivering 1.6 cumecs at design heads) and a series of high capacity gravity doors to dramatically increase discharge capacity when gravity conditions prevail.

To avoid extending the tide lock period and placing increased reliance on the pumped discharge, the proposals do not include a significant lowering of the gravity outfall. The significant topographical limitations on the channel gradients therefore remain. Improved standards of protection are therefore targeted by improving the flow characteristics through the catchment, and by ground raising in low lying areas to facilitate appropriate freeboard.

With the flat topography of the catchment, rapid evacuation at the outfall is essential in developing sufficient draw-down to drive the high flows through the catchment's open channels. The strategy relies on channel and structure improvements to minimise losses in the hydraulic gradients wherever practicable through the lowlands so that areas on the fringes of the marsh can also benefit. Two staged channels and clear span crossings are therefore proposed for all key watercourses, and these have been designed for the northern extents of the marshes catchment.

It is noted that although contributing flows have been assessed and provision made within the main channel (Drain 10) for the southern development, the drains and structures have yet to be designed through the southern drain (9B). Improvement measures are likely, however, to be similar in nature to those identified through drain 10A. With a significant reduction in level at the point of bifurcation a similar level of betterment of flood protection would also be anticipated/targeted, so that areas can be removed from the natural flood plains in a similar manner.

Any alternative location will need to deliver the following:

- Same pumped capacity at design head without loss of efficiency.
- No lesser gravity discharge capacity within the operational level range.
- No lesser standard of protection to drains 10, 10A and 9B* against existing strategy.
- No loss of in-channel storage.
- Smooth passage of flow from all existing drains, maintaining nominal gradients.
- Minimal need for crossing structures to avoid headloss.
- Acceptable culvert invert and soffit levels at the under rail track crossing.
- Stable channel batters and erosion protection measures.
- Protect easing aquatic habitat where possible by widening single bank only.
- Ease of access to the station for the Board's operatives, 24/7.
- Access to the channels for maintenance.
- Station site serviceable for electric power supply.
- Suitable construction access.
- No notable environmental constraints.
- The scheme is being assessed under the CEEQUAL scheme and any alternative design should offer either an environmental or sustainability benefit(s).

*to date drain 9B has been modelled in the pre-development scenario, or modelled in the strategy without the developed flow and channel improvements (contributing development discharge to drain 10 was entered as a point discharge at the confluence). Therefore there is no direct data for comparison other than the flood water levels at the existing confluence. This could either be used as a target level, or additional modelling will be necessary to present a robust case that the alternative is not detrimental to the southern extents of the Marshes catchment.

It is imperative that the alternative proposals do not impact on the riparian rights of others or detriment the benefits of the Board's strategy.

Prepared by Hannah-Reed, November 2010

David Stark

From: Simon Darch [S.Darch@hannahreed.co.uk]
Sent: 01 December 2010 16:53
To: David Stark
Cc: Daniel Sharp; David Noble (david.noble123@btinternet.com); trevorvessey@yahoo.com; Richard Annable; Paul Jones; rcram@ableuk.com
Subject: RE: 2010s4400 ABLE Marine Energy Park. Killingholme - Surface Water Drainage Queries

See notes below in red, I trust they are self-explanatory

Simon Darch
Projects Director
Hannah - Reed

Hannah, Reed and Associates Limited, Telford House, Fulbourn, Cambridge, CB21 5HB
Tel 01223 882000 Fax 01223 881888 (Registered office at above address. Registration no 1860196)

From: David Stark [mailto:david.stark@jbaconsulting.co.uk]
Sent: 01 December 2010 16:19
To: Simon Darch
Cc: Richard Annable; rcram@ableuk.com; Paul Jones; trevorvessey@yahoo.com; david.noble123@btinternet.com
Subject: 2010s4400 ABLE Marine Energy Park. Killingholme - Surface Water Drainage Queries

Simon,

I have reviewed the very comprehensive package of flood risk information which you kindly supplied recently on a CD. I would be grateful if you could clarify some surface water drainage queries:

Assumed Impermeability Factor for Modelling Development Runoff
Drg. No. 10-C204032/sk22/P1 (WinDes Network Area Diagram for Phase 2 Development) includes the note "Development areas assumed 100% impermeable". At our meeting with Trevor Vessey and David Noble on 11 October 2010, David Noble explained that, in the design of the NELDB Improvement Scheme, discharges from future developments were assumed to be "unrestricted" based on an 80% impermeability factor. Please could you clarify which impermeability factor should be used when modelling the improvement scheme for the IDB system?
The strategy will promote permeable surfaces wherever practicable for storage areas, but has made allowances for up to a maximum of 80% contributing impermeable area. The 100% used in Sk22 included a safety factor to ensure that the main channel and associated structures were appropriately sized, and could potentially cater for future climate change.

Drainage Strategy for Climate Change
As I understand it, you have designed the proposed NELDB Improvement Scheme for the 1% (100-year) AEP event. Correct Document 2-C204032 outlines NELDB Standard Criteria for Drainage of Development Land (Able Marine Energy Park). This document includes the statement "An adaptive approach to climate change is promoted in the strategy. This is partly to allow for flexibility in the development timings, and the take-up of contributing area as discussed above; if greater contribution of permeable surfacing can be used there may not be a need for additional measures The identified corridors for flood mitigation have included zones where additional flood storage might be provided in the future". This note presumably refers to areas coloured blue on Drg. No. 2-C204032-SK13 (corridors for flood mitigation infrastructure/ecology)? Correct Are you expecting the ABLE Masterplan to show that these (or similar) areas are reserved for possible additional flood storage infrastructure to combat the impact of climate change? Yes, provision should be made or mitigation offered for all loss of storage Could provision of additional pumping capacity be another option for mitigating the impact of climate change? This might be feasible, but not preferred on cost grounds.

Avoidance of Rapid Concentrated Sheet Runoff
Document 2-C204032 outlines NELDB Standard Criteria for Drainage of Development Land (Able Marine Energy Park). This document includes the statement "Where large impermeable surfaces are implemented the level and drainage strategy should be designed to avoid rapid and concentrated sheet runoff with shallow gradients and

extended longitudinal runs used”. It is recognised that these areas are not public car parks and the minimum code-of-practice gradients for draining flows from the surface to the drainage system need not apply, as some standing water or sheet flow across the surface can be tolerated. Large areas should therefore be drained via relatively shallow lateral and longitudinal gradients to slow the time of entry, and allow ponding on the hard-standing surfaces in intense rainfall events. Low design standards could also be adopted for the drainage system. We do not fully understand this requirement and would appreciate some further clarification. i.e we do not anticipate steep gradients and high-capacity channels to rapidly drain hard-surfaced storage areas, some detention at source is expected in notable events, preferably through the use of permeable surfacing but where hard surfaces are essential they should be designed to reduce rapid run-off.

Many thanks.

Kind regards

David Stark

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E. Surface Water Drainage Strategy

E.1 Drg. No. AME-04004E: Indicative Surface Water Drainage System for a Factory Plot

E.2 Drg. No AME-01155A: Typical Long Section Through Valley Line and Yard Drain

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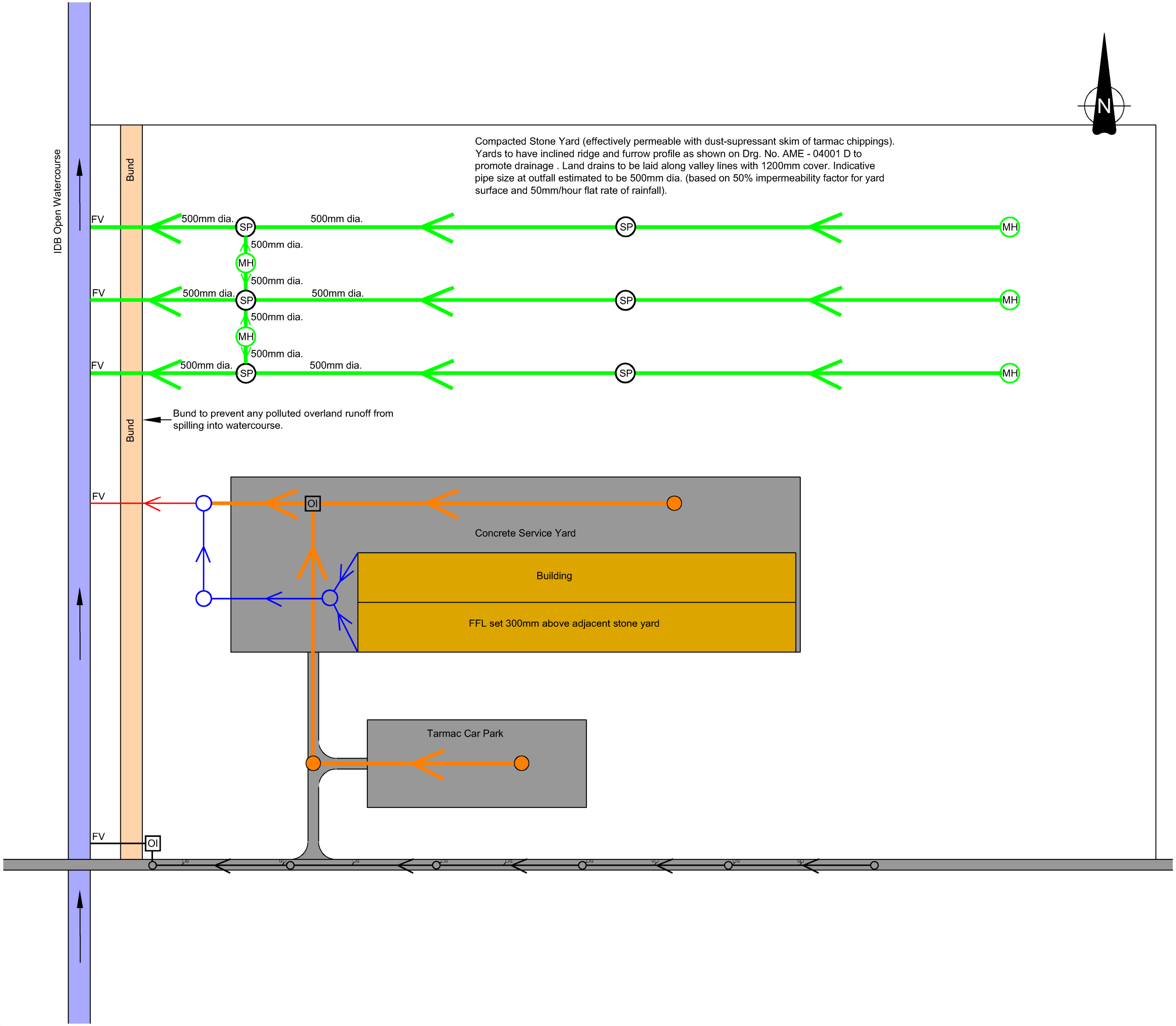

KEY

- MH Manhole
- OI Oil Interceptor
- Highway Drain (maintained by Able)
- G Road Gully
- Roof Drainage
- Paved Area Drainage
- Combined Drain (Roofs & Paved Areas)
- SP Silt Pit
- Land Drain (Perforated or Porous)
- FV Outfall with Flap Valve

NOTES

1. The Marine Energy Park will be a secure private facility with private roads and sewers.
2. Hollow kerbing (e.g. beany blocks) may be appropriate on flat roads.
3. High capacity slot drains may be appropriate in service yards.
4. Tenant responsible for plot drainage.
5. Periodic raking of the surface of the compacted stone yards may be required to maintain permeability.
6. Where a risk of a major pollution event is assessed to be significant, penstocks will be provided upstream of the outfall.

Rev	Date	Comments	Drw	Chk	App
E	12/04/2011	General Amendments	SDB	RC	DS
D	22/03/2011	General Amendments	SDB	RC	DS
C	09/03/2011	General Amendments	SDB	RC	DS
B	17/01/2011	General Amendments	JH	RC	DS
A	12/01/2011	Preliminary Issue	SDB	RC	DS

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

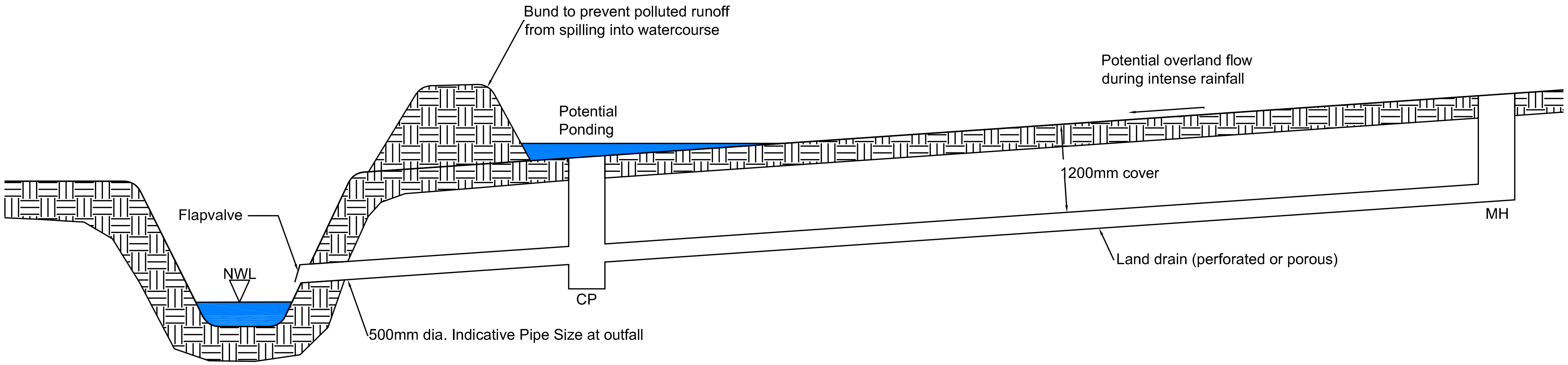
Title: Indicative Surface Water Drainage System for a Factory Plot

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:10,000@A3	SDB	RC	DS
Date	12/01/2011	12/01/2011	12/01/2011

Drawing No. AME - 04004

Revision: E



KEY

MH Manhole

CP Catch Pit

NWL Normal Water Level

Notes

1. See Drg. No. AME-04004 for a plan of a yard drainage system.

Rev	Date	Comments	Drw	Chk	App
A	15/04/2011	Preliminary Issue	SDB	DS	DS

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Typical Long Section Through Valley Line & Yard Drain

PRELIMINARY

Scale:	Drawn	Checked	Approved
NTS@A3	SDB	DS	DS
Date	15/04/2011	15/04/2011	15/04/2011

Drawing No. AME - 01155

Revision: A

F. Foul Water Drainage Strategy

Drg. No. AME-04003A: Preliminary Layout of Foul Water Drainage System

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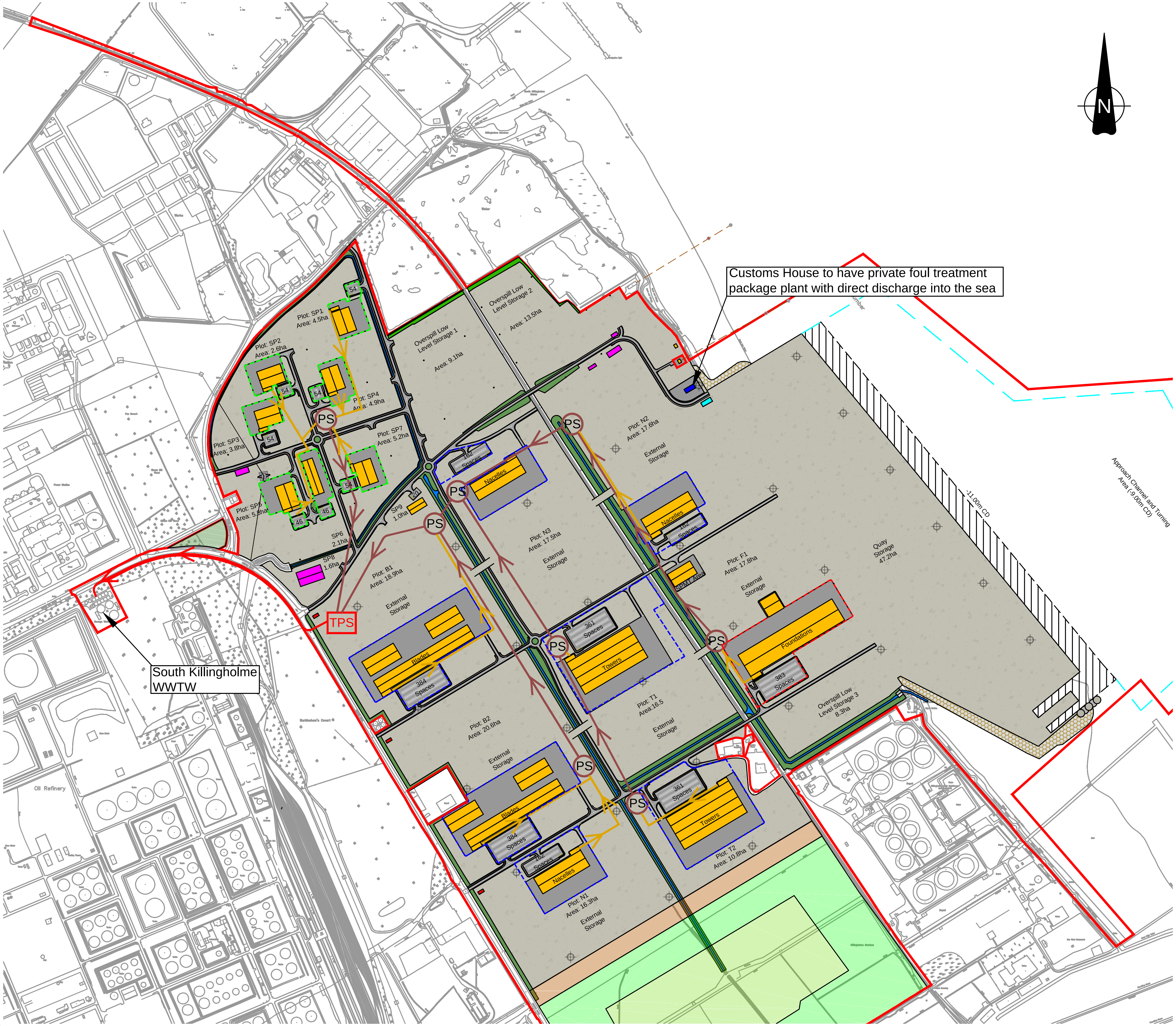

KEY

Red arrow	Offsite Rising Main to be Constructed/Adopted by Anglian Water
TPS	Terminal Foul Pumping Station to be Constructed/Adopted by Anglian Water
Brown arrow	Private Foul Rising Main
Orange arrow	Private Gravity Drain
PS	Private Foul Pumping Station

Rev	Date	Comments	Drw	Chk	App
C	03/11/11	Masterplan Updated	JH	RC	RC
B	26/04/2011	Customs House Drain amended	SDB	RC	DS
A	12/01/2011	Preliminary Issue	SDB	RC	DS

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Preliminary Layout of Foul Water Drainage System

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:10,000@A3	SDB	RC	DS
Date	12/01/2011	12/01/2011	12/01/2011

Drawing No.: AME - 04003

Revision: C

KEY

- Offsite Rising Main to be Constructed/Adopted by Anglian Water
- TPS — Terminal Foul Pumping Station to be Constructed/Adopted by Anglian Water
- Private Foul Rising Main
- Private Gravity Drain
- PS — Private Foul Pumping Station

Rev	Date	Comments	Drw	Chk	App
B	26/04/2011	Customs House Drain amended	SDB	RC	DS
A	12/01/2011	Preliminary Issue	SDB	RC	DS

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Preliminary Layout of Foul Water Drainage System

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:10,000@A3	SDB	RC	DS
Date	12/01/2011	12/01/2011	12/01/2011

Drawing No.: AME - 04003

Revision: B

G. Relocation of the NELDB Pumping Station

JBA Draft Report v5.0 dated 15 June 2011.

Report Title: Able Humber Ports Facility - Pumping Station Feasibility, Killingholme Marshes.

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Able Humber Ports Facility Pumping Station Feasibility, Killingholme Marshes

Final Report

June 2011

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft v1.0 / 28.03.2011		Richard Cram
Draft v2.0 / 20.04.2011	Additional Options	Richard Cram
Draft v3.0 / 13.05.2011		Richard Cram
Draft v4.0 / 23.05.2011	Client Review	Richard Cram
Final v5.0 / 15.06.2011		Richard Cram

Contract

This report describes work commissioned by John Loftus (Group Purchasing Manager), on behalf of Able UK Ltd., by purchase order no. 74844 dated 18 November 2010. Able UK Ltd's representative for the contract was Richard Cram. Paul Jones and Balaji Angamuthu of JBA Consulting carried out this work.

Prepared by ....Paul Jones ONC HNC BSc

Engineer

Prepared by ....Balaji Angamuthu BEng MTech MSc

Engineer

Reviewed by ....Christopher Wright BSc CEng MICE

Principal Engineer

Purpose

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Executive Summary

Introduction

Killingholme Marshes is located 4.5 km north-west of Immingham, North East Lincolnshire. The Marshes lie within the North East Lindsey Drainage Board (NELDB) and currently discharges land drainage runoff from the catchment through a gravity structure into the River Humber.

Able UK Ltd. are proposing a Marine Energy Park (AMEP) within the Marshes and proposes a quay out into the River Humber which poses an obstruction to the current gravity outfall.

To improve the standard of protection within the catchment and incorporate the increase in runoff from the proposed developed area the NELDB proposes to construct a pumping station.

A review has therefore been carried out on the site constraints in order to assess alternative locations for the proposed pumping station.

Review of Constraints

Constraints affecting the location of the pumping station and maintaining the open channels that feed the pumping station include the proposed quay, proposed development topography, an E-ON cooling pipe system, a railway line, a sludge or brine main, underground electricity cables and telecommunication lines.

Options

Route A refers to locating the IDB pumping station north of the proposed quay with a 1 in 4000 bed gradient for an open channel from Station Road to the River Humber defences and crosses the E-ON cooling pipes adjacent the railway where these pipes are inverted.

Route B is based upon a similar philosophy as Route A but with the inclusion of a booster pumping station to allow the level of the bed downstream of the booster station to be raised to reduce the depth of channel in terms of maintenance and avoid the E-ON cooling pipes inverted adjacent to the railway.

Route C is based upon a similar philosophy as Route A but follows a more direct route to the River Humber defences. The route crosses the E-ON cooling pipes and would expose the pipes. It is understood that diverting the pipes would be prohibitive and therefore not taken forward for hydrodynamic modelling.

Route D refers to locating the IDB pumping station south of the proposed quay with a 1 in 4000 gradient for an open channel from Station Road to the River Humber defences which does not cross the E-ON cooling pipe system and avoids all known services.

Hydrodynamic Modelling

An unsteady state hydraulic model was built using modelling software ISIS v3.4.0.110. Hannah Reed provided the base model which included inflows for the 1 in 100 year design flow, a WIN-DES flow input representing the increase in runoff form the proposed developed area and the proposed pumping station rules.

The Hannah Reed model was modified to suite Route A, B and D with additional storage channels to suit the proposed development.

Route A resulted in a 1 in 100 year water level of 3.4m AOD which was contained within channel through the proposed development site.

Route B resulted in a 1 in 100 year water level upstream of the proposed booster pumping station of 3.2m AOD and downstream of 4.1m AOD. The effect of increasing pumping station was briefly explored by increasing the pumping capacity to $2m^3/s$ per pump resulting in a downstream water level of 3.8mAOD.

Route D resulted in a 1 in 100 year water level of 3.45m AOD which was contained within channel through the proposed development site.

Dependant on the upstream channel design requirements of the NELDB all routes may require additional storage within the developed area or an increase in capacity of the pumping station.

Conclusions

Route A may present additional siltation problems due to the proposed bed level, north of the proposed quay, being 127mm lower that the invert of the existing gravity outfall and represents the largest amount of earthworks.

Route B results in a bed level at the River Humber defences of 1.325m some 900mm above the existing gravity outfall invert. This route represents the highest level of capital and operating expenditure.

Route C would expose the E-ON cooling pipes within an open channel. This is based upon an existing concrete cover slab in the bed of the channel protecting the pipes. This proposed route would require additional deepening at this location and therefore require a diversion of the pipes.

Route D would provide the shortest route, reduced earthworks and provide a similar bed level at the River Humber defences to the existing gravity outfall invert. The layout of the proposed quay may require amendment at the site of the proposed pumping station and land ownership issues would require resolving between the two developers and the NELDB. This route represents the lowest level of capital and operating expenditure.

Recommendation

It is recommended that Route D is taken further for consideration between Able UK Ltd. and the NELDB locating the intended pumping station south of the proposed quay.

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Abbreviations

IDB	Internal Drainage Board
NELDB	North East Lindsey Drainage Board

1. Introduction

1.1 Background

Killingholme Marshes is located 4.5 km north-west of Immingham, North East Lincolnshire and currently discharges land drainage runoff from the catchment through a gravity structure into the River Humber at National Grid reference TA 176, 186 (coordinates E517612, N418652) as identified in Figure 1-1.

The Marshes lie within the North East Lindsey Drainage Board (NELDB) District, who maintain the ordinary watercourses and the gravity outfall.

Figure 1-1 Existing Site Plan (Street View, OS Open Data, 2011)

Able UK Ltd. are proposing a Marine Energy Park (AMEP) as indicated in Figure 1-2 and Appendix A. The proposal includes raising land within the Marshes and a new quay.

Figure 1-2 Indicative Site Plan (Able UK Ltd. rev.c, Jan 2011)

1.2 Problem

The North East Lindsey Drainage Board has identified the need to '*mitigate the potential flood risk to the two pits near the North Haven* [because] *the freshwater pit afforded SSSI status and the saline pit RAMSAR designation*' (Hannah-Reed, 2010).

To improve the standard of protection the NELDB has proposed a pumping station at the existing gravity outfall location.

The station is to include gravity and pumped discharge into the River Humber. A nominal pumping capacity of 4.5 cumecs (provided by three pumps) was proposed for the first phase of development to the north of the Killingholme Marshes site. The current proposal, incorporating the whole of the AMEP development within the Marshes and the proposed Drax renewable energy plant, *'has provision for six pumped bays* [and] *an approximate design pumped capacity of 9.6 cumecs'* (Hannah-Reed, 2010).

The further development by Able within the Marshes includes the quay which poses an obstruction on the current gravity outfall and proposed pumping station position.

1.3 Purpose

In order for Able UK Ltd. to progress with their intended development and for NELDB to improve the standard of protection, this feasibility report has reviewed the site constraints in order to assess alternative locations for the proposed pumping station.

2. Review of Constraints

2.1 Overview

A review of options for the location of a proposed land drainage pumping station required for the proposed AMEP development within Killingholme Marshes site has been carried out. This review includes existing and proposed topography, existing falls and bed levels of ordinary watercourses and services.

2.2 Reference Drawings

The following drawings were used for this review;

Appendix A	AME - 01066 B EIA MASTERPLAN
Appendix B	AME - 03000 B Existing Service Constraints
Appendix C	GBR 522-T217-11-1011 B Make-up and purge water pipes railway crossing
Appendix D	AME - 04001 Finished Ground Levels

2.3 Existing Topography

The area is typically low lying flat agricultural land to the south of the Marshes and developed tarmac surfaces to the north. Site levels currently lie between 3 to 4 m AOD where the higher land is found within the developed area to the north.

Additional topographic channel survey was undertaken in December 2010 to inform the review. Existing bed levels and banks were taken across the site and are included within Appendix E.

The lowest point on the ordinary watercourse system (at the existing gravity outfall) has been recorded as 0.394 m AOD.

South of the confluence between the north and south catchments the bed level has been recorded as 0.742 m AOD and north of the confluence the bed level has been recorded as 0.653 m AOD.

2.4 Proposed Topography

The development includes proposals to raise ground levels from the railway line at approximately 4 m AOD eastwards up to approximately 6 metres AOD as determined from the electronic version of Appendix D.

2.5 Services

Services present within the area have been identified on drawing AME - 03000 B (in Appendix B) and include E-ON cooling pipes, underground electricity cables, telecoms and a water main.

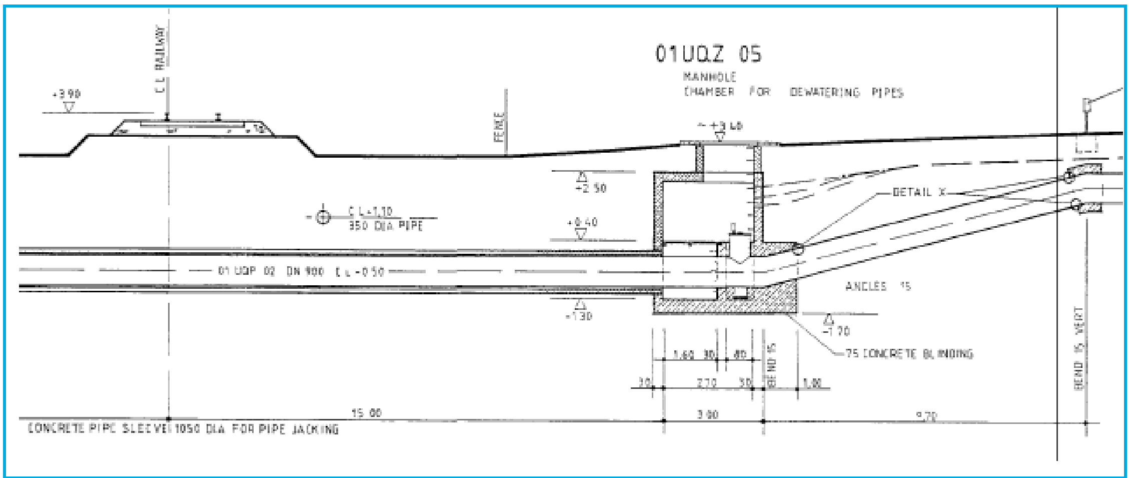
2.5.1 Electricity and Telecoms

The underground electricity and telecommunication lines are parallel to the railway line. Alterations to these service positions may be required dependant on location and depth which were not determined within this study.

2.5.2 E-ON Cooling Pipes

The E-ON cooling pipes run across the site north-east to north-west and are inverted underneath the existing railway line running south to north as shown in Figure 2-1. Further details of the cooling water pipework are included within Appendix C.

Figure 2-1 E-ON Cooling Pipe Cross Section (E-ON, 1991)



2.5.3 Anglian Water Sludge or Brine Main

The main runs south-west to north-east from the sewage works into the River Humber. Any proposed works to watercourses in the area of the main may require lowering of the main as the pipework is currently exposed as shown in Figure 2-2.

Figure 2-2 Existing Sludge or Brine Main

2.6 Proposed Quay

The proposed quay has the greatest influence on pumping station location. The current proposals infer that the preferred location for a pumping station would be north of the quay. A position south of the quay may be feasible but alteration to the current quay proposals would be required and the land is not wholly owned by Able UK Ltd. which may affect access south of the quay.

In order to assess the viability of all options the following pages address both the northern and southern locations for the proposed pumping station.

Figure 2-3 Area North of Proposed Quay (Able UK Ltd., 2011)

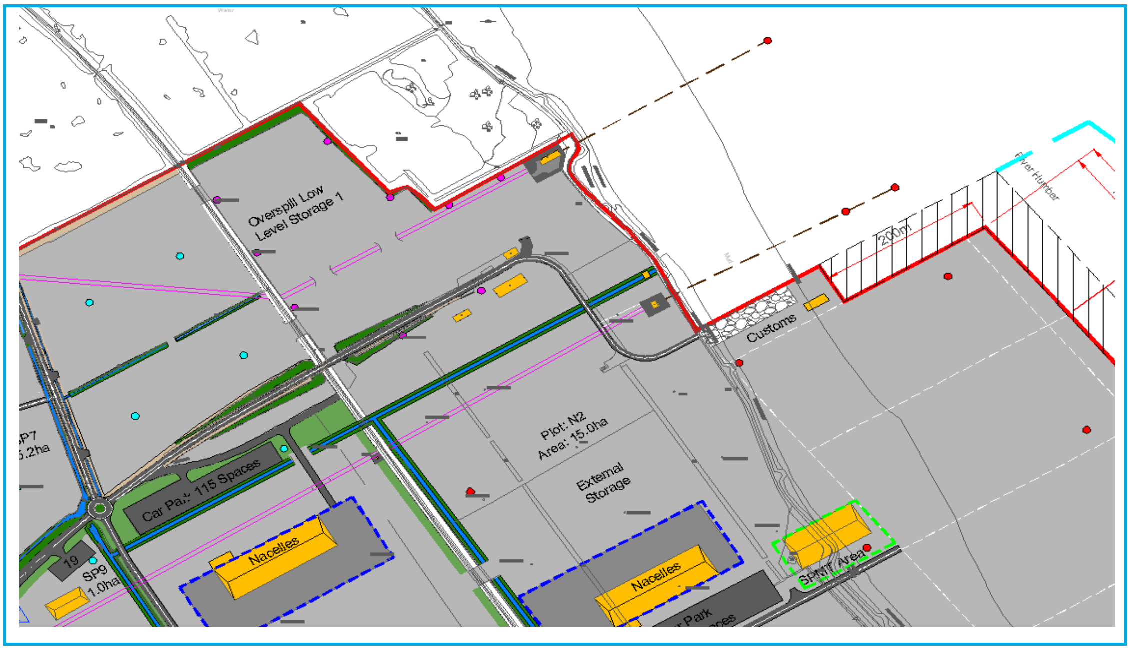
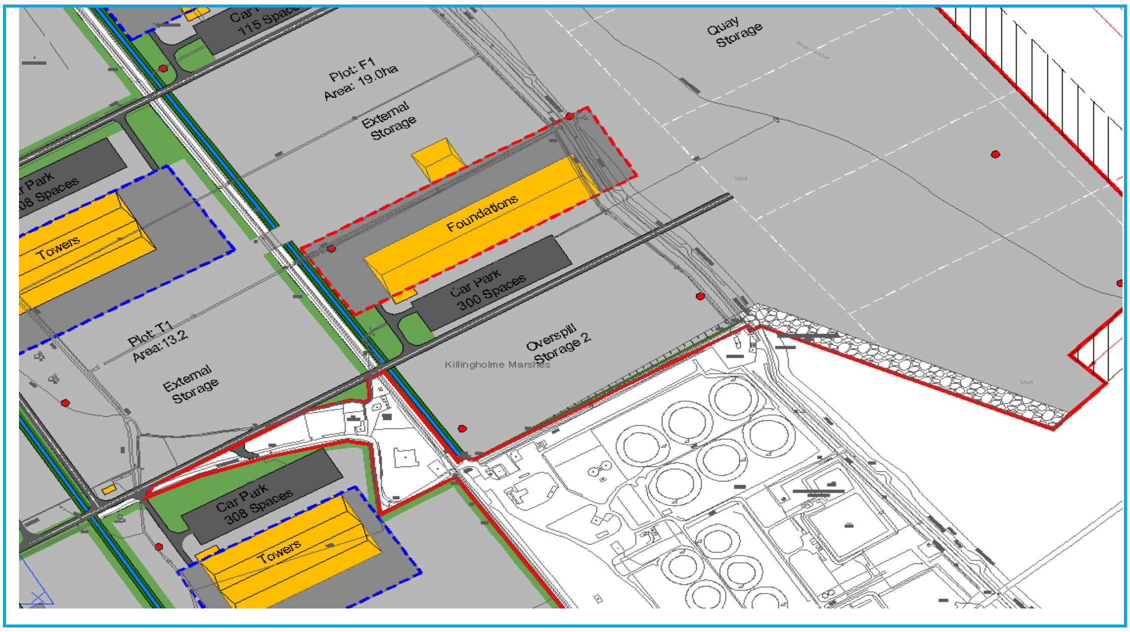


Figure 2-4 Area South of Proposed Quay (Able UK Ltd., 2011)



3. Options

3.1 Objective

The main objective of this study is to determine a feasible location for the pumping station along with associated watercourse routes after consideration of the all constraints and proposed development.

Four alternative routes have been identified and assessed as follows.

3.2 Route A

Route A refers to locating the proposed IDB pumping station north of the quay as identified within Appendix E.

Figure 3-1 Indication of Route A (Street View, OS Open Data, 2011)

3.2.1 Gradient

The lowest point on the existing system is the concrete invert level at the existing gravity outfall inlet recorded by GPS as 0.394m AOD. To locate a new pumping station north of the proposed quay, adjacent to the E-ON cooling pipe control house, a gradient of 1 in 4000 has been applied over a distance of approximately 1650 metres as 'Initial Route A' in Figure 3-1. This equates to a bed level at the pumping station of -0.018m AOD if a proposed route were to be taken from the existing outfall position. Considering existing and proposed ground levels, the depth of the watercourse at the inlet to the pumping station would be in the region of 4.8 metres *(4.747m – -0.018m).*

In contrast, if the station were to be located at the existing outfall with consideration of the proposed ground levels of around 5.7m AOD, the depth of watercourse at the existing outfall position would be in the region of 5.3 metres *(5.7m – 0.394m).*

Alternatively, the lowest point on the incoming southern drainage system near Station Road is 0.742m AOD. If a new route could be formed from Station Road *('Route A' in Figure 3-1)* with consideration of the northern drainage system the resultant drain depth at the pumping station would be 4.485m *(4.747m existing ground level – 0.262m proposed bed level).*

3.3 Route B

Route B refers to locating the proposed IDB pumping station north of the proposed quay as identified within Appendix E but with a booster pumping station to allow bed levels downstream to be raised and create a more manageable watercourse.

Figure 3-2 Route B with Booster Station (Street View, OS Open Data, 2011)

3.3.1 Gradient

A booster station is included at the location shown in Figure 3-2 at approximate chainage 1,056m *(also indicated on the longitudinal section within Appendix G drawing no.* 2010s4614-003*).*

This is based upon a 1 in 4000 gradient taken from Station Road bed level of 0.742m AOD, allowing the northern drainage system *(with an existing bed level of 0.866m AOD)* to fall into the proposed watercourse at chainage 536m *(to a proposed bed level of 0.608m AOD)* and ending at the booster station at chainage 1,056m.

The booster station would then allow the downstream proposed bed level to be raised to 1.589m AOD *(approximately 2 metres drain depth when compared to proposed ground levels).* A 1 in 4000 gradient is then applied along the length of 1,076m to the proposed IDB pumping station where the bed would be 1.325m AOD and the depth of the drain would be approximately 3 metres.

The proposed IDB pumping station has a design capacity of approximately 4.5 m^3/s based upon 3no. pumps. We understand that the proposed station will also have 3no. additional sumps to provide a total station capacity of approximately 9.6 m^3/s.

Table 3-3 provides an indication of costs for a booster station for the capacities described above. It is based upon past experience on similar projects;

Table 3-1: Global Estimate for Booster Pumping Station

Item	4.5 m³/s Booster Station with 3no. additional sumps Cost (£)	9.6 m³/s Booster Station Cost (£)
Structural and Earthworks Contract	1,800,000	1,800,000
M & E Pump Contract	300,000	650,000
M &E Weedscreen Cleaner Contract	120,000	120,000
Telemetry Contract	25,000	25,000
New Electricity Supply (incl. Meters)	50,000	50,000
Total Construction Cost	***2,295,000***	***2,645,000***
Engineers Fees (design, tender & site supervision)	229,500	264,500
Environmental Fees (EIA, surveys, mitigation)	20,000	20,000
TOTAL Scheme Cost	**2,544,500**	**2,929,500**

It would be recommended that the estimates (or returned tenders) for the Internal Drainage Board scheme are used for comparison.

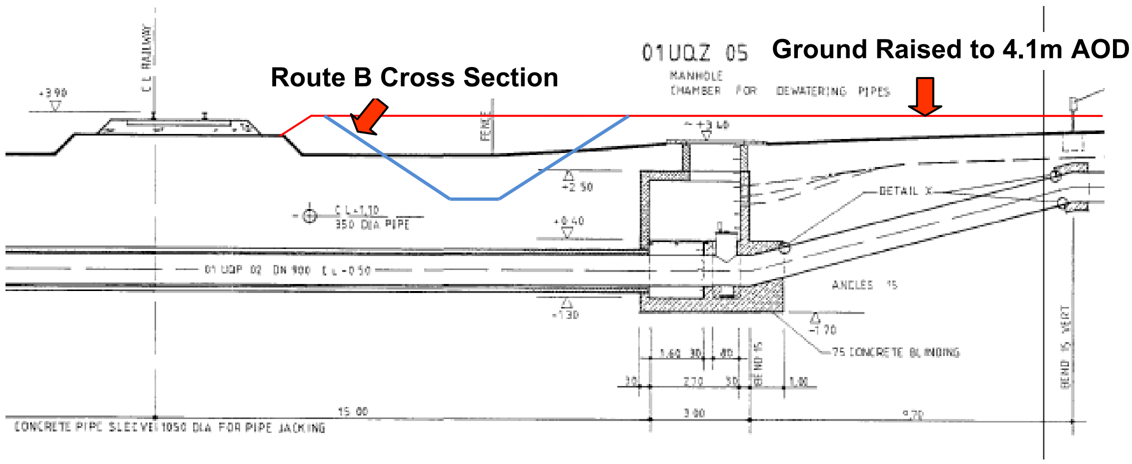
3.3.2 E-ON Cooling Water Pipes

The distance between the railway line and E-ON cooling pipe manhole is approximately 10 metres as indicated in Figure 3-3. The proposed cross section at this point on Route B is a 1.5 metre wide bed, 1 in 1.5 side slopes and a watercourse depth of approximately 2.6 metres as indicated on the longitudinal section within Appendix G.

With reference to Appendix C, the pipework consists of 1no. 700mm diameter pipe and 1no. 900mm diameter pipe both at an invert of -0.95m AOD. The soffit of the 900mm diameter pipe is recorded as -0.05m AOD and provides approximately 1.5 metres of cover from the soffit of the largest pipe to the proposed bed of Route B after considering the proposed ground levels of approximately 4.1m AOD.

The proposed cross section would be a total of 9.3 metres in width and is shown graphically within Figure 3-3 below.

Figure 3-2 Route B Cross Section on E-ON Cooling Pipe Section (E-ON, 1991)



Approval from E-ON would be required for any excavation above the existing pipelines

3.4 Route C

Route C refers to locating the pumping station north of the proposed quay as identified within Appendix E.

Figure 3-4 Indication of Route C (Street View, OS Open Data, 2011)

3.4.1 Gradient

Taking the lowest point on the incoming southern drainage system near Station Road as 0.742m AOD and providing a 1in 4000 gradient along 1,900 metres to a position north of the proposed quay, the average depth of drain would be approximately 4.485m similar to that of Route A.

3.4.2 E-ON Cooling Water Pipes

The 1no. 700mm diameter pipe and 1no. 900mm diameter pipe both have an invert of -0.2m AOD along Route C. The respective soffit levels are 0.5m AOD and 0.7m AOD which conflict with the proposed bed levels of 0.377m AOD. The E-ON pipes would therefore be exposed above design bed levels by approximately 320mm and would form an obstruction to flow.

It is understood that the cost of diverting the E-ON pipelines would be prohibitive and therefore this route has not been taken forward for hydrodynamic modelling or further consideration.

3.5 Route D

Route D refers to locating the proposed IDB pumping station south of the proposed quay as identified within Appendix E.

Figure 3-5 Indication of Route D (Street View, OS Open Data, 2011)

3.5.1 Gradient

Taking the lowest point on the incoming southern drainage system near Station Road as 0.742m AOD and providing a 1in 4000 gradient along 1,410 metres to a position south of the proposed quay, the average depth of drain would approximately 2.9m which compares to existing drain depths of around 2.7m. The depth of the proposed watercourse at the approach to the pumping station would be approximately 3.3 metres deep with a bed level of 0.39m AOD which is approximately the level of the existing gravity outfall.

4. Hydrodynamic Modelling

4.1 Introduction

An unsteady state hydraulic model has been carried out to study the proposed drainage systems. Hydraulic modelling software ISISv3.4.0.110 was chosen for this purpose and is the same software used by Hannah Reed in their work.

4.2 Model build

4.2.1 Assumptions and Limitations

The representation of any complex system by a model requires a number of assumptions to be made. In the case of a one-dimensional hydraulic model of a river system, it must be assumed that:

- The cross sections accurately represent the river.
- The design flows are an accurate representation of flows of a given return period.
- Channel and floodplain roughness are an accurate representation of flood conditions.

For in-bank flows, the selection of all the coefficients has been carefully considered to limit any unrealistic results from the model.

4.2.2 Model extent

The extents of the proposed drainage routes have been modelled from upstream of the development site to the Humber Estuary. Figure 4-1 to Figure 4-3 shows the extent of the model for different proposed drainage routes.

Figure 4-1 Route A Model Indication (Street View, OS Open Data, 2011)

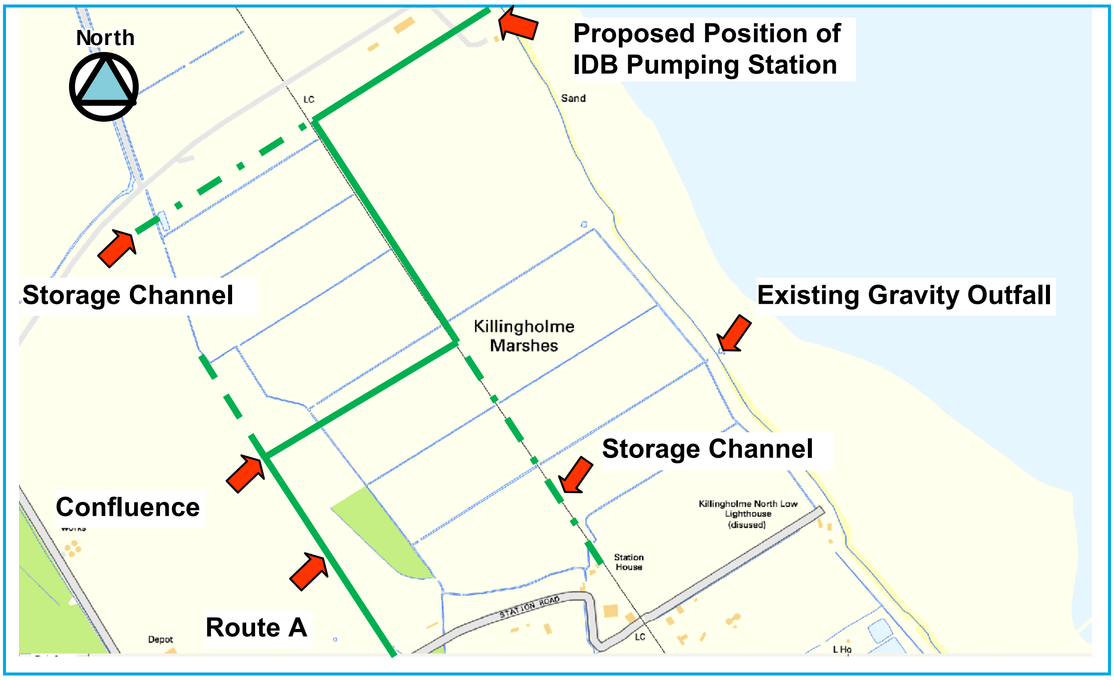
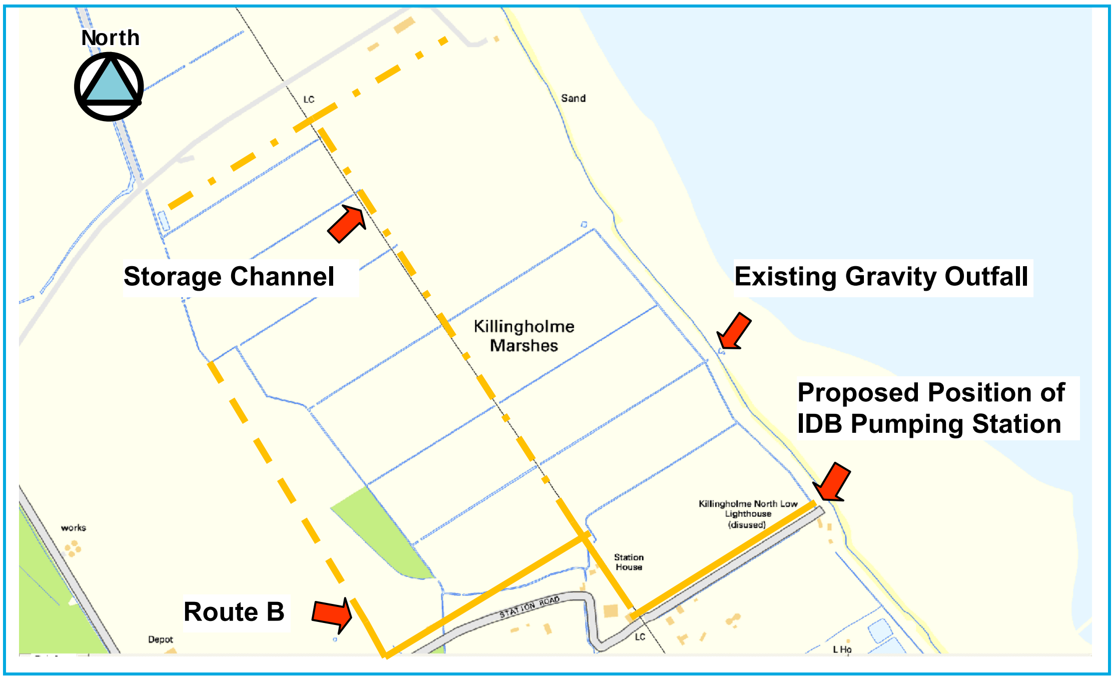


Figure 4-2 Route B Model Indication (Street View, OS Open Data, 2011)

Figure 4-3 Route D Model Indication (Street View, OS Open Data, 2011)



4.2.3 Source data

Topographic survey information was provided by JBA in December 2010 relative to GPS OS datum and compared with survey information from Hannah-Reed documentation.

4.2.4 Building the model

Unsteady state hydraulic modelling has been chosen to model the proposed drainage routes, storage channels, pumps and other hydraulic structures. Only unsteady state hydraulic modelling can demonstrate the effectiveness of the storage within the drainage system.

Flow within the river channel is represented by cross sections. The cross sections are modelled in ISIS using river section units as far as possible in accordance with the Environment Agency Best Practice Guidance[1]. Labels consist of a 4-letter code to identify the river, a digit to identify the reach, and a number to identify the chainage.

Only Routes A, B and D have been modelled due to the initial conclusion for Route C within Section 3.4.

Hannah Reed's model was modified to build the model for this study.

The following modifications have been applied to the Hannah Reed model to simulate proposed drainage routes:

1. All drainages and structures upstream of the IDB pumping station approach channel were removed.

Then,

2. the proposed drainage route was added to the edited model;
3. The inflow from the development site was retained as it is in the Hannah Reed model;
4. All other inflow points from the northern, western and southern catchments were represented along the line of the proposed drainage route;
5. From the downstream end of the approach channel the model of the IDB pumping station from Hannah Reed's work was retained.

All cross sections within the model relate to chainages on each route longitudinal section.

4.2.5 Structure

The models include all hydraulic structures likely to have an influence on water levels. These include pumping capacity, culverts and flap valve structures. It is assumed that there are no blockages at any structures in the model.

4.2.6 Channel roughness

Manning's roughness coefficient of 0.027 was used to represent the channel roughness. The same values of roughness co-efficient have been used by Hannah-Reed hydraulic roughness in their model.

4.2.7 Boundary conditions

Inflows to the model are specified using flow-time relationships. The inflow values were derived from the Hannah Reed model and provided maximum water level-flow for the 1 in 100 year event. Inflows were input into the model with the duration of 4.5 hours, peaking at approximately 2.25 hours. The peak flows used as inflows are given in the Table 4-1.

Table 4-1: Peak of inflows

Catchment	Inflows (cumecs)
Northern	9.04
Western 1	5.07
Western 2	0.19
Southern	1.44
Development site	1.49

The downstream boundary condition was replicated from the Hannah Reed model representing a River Humber tidal time series.

[1] Environment Agency. Using computer river modelling as part of a flood risk assessment. Best practice guidance.

4.3 Model runs and results

The models of Route A, B and D were simulated for 1 in 100 year inflow event in the ISIS software. Each simulation was run for 8 hours of the tide period which included the peak of the tide.

4.3.1 Route A

The Route A model was first built and simulated for the 1 in 100 year event. The first iteration of the model included proposed drain cross sections with a 5m wide bed, 7m wide berm at 1m above the bed and 1 in 1.5 side slopes based on Hannah Reed drawing C-204032/401. For these sections, the simulated results showed the maximum 1 in 100 year water level was around 0.5m higher than the drain bank levels.

In the second iteration two storage channels were added as shown in plan in Figure 4-1 in order to avoid flooding of the development. Figure 4-4 shows the longitudinal plot of the maximum 1 in 100 year water level in the main channel of Route A and in the two storage channels. The maximum water level is within the bank at the development site with varying freeboards.

Dependant on the upstream channel design requirements of the IDB this system may require additional storage within the developed area or an increase in the capacity of the pumping station.

Figure 4-4 Route A Model Longitudinal Section

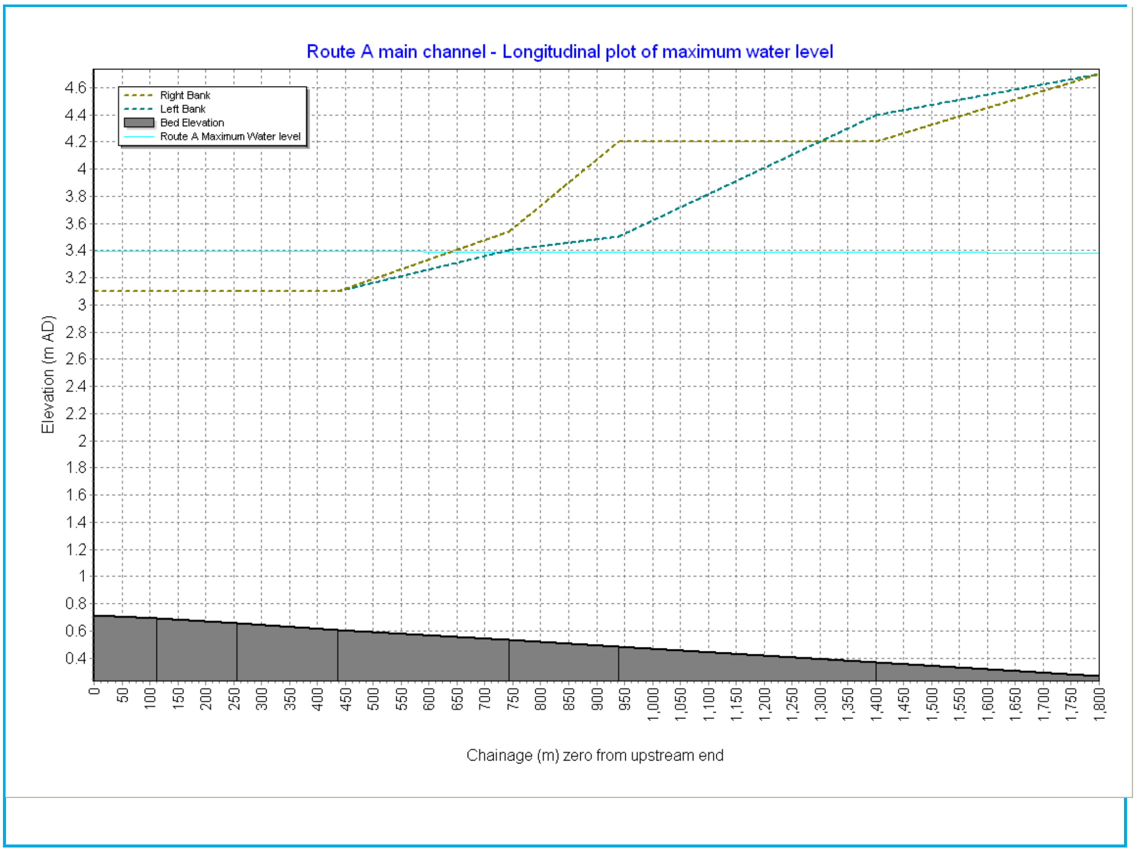
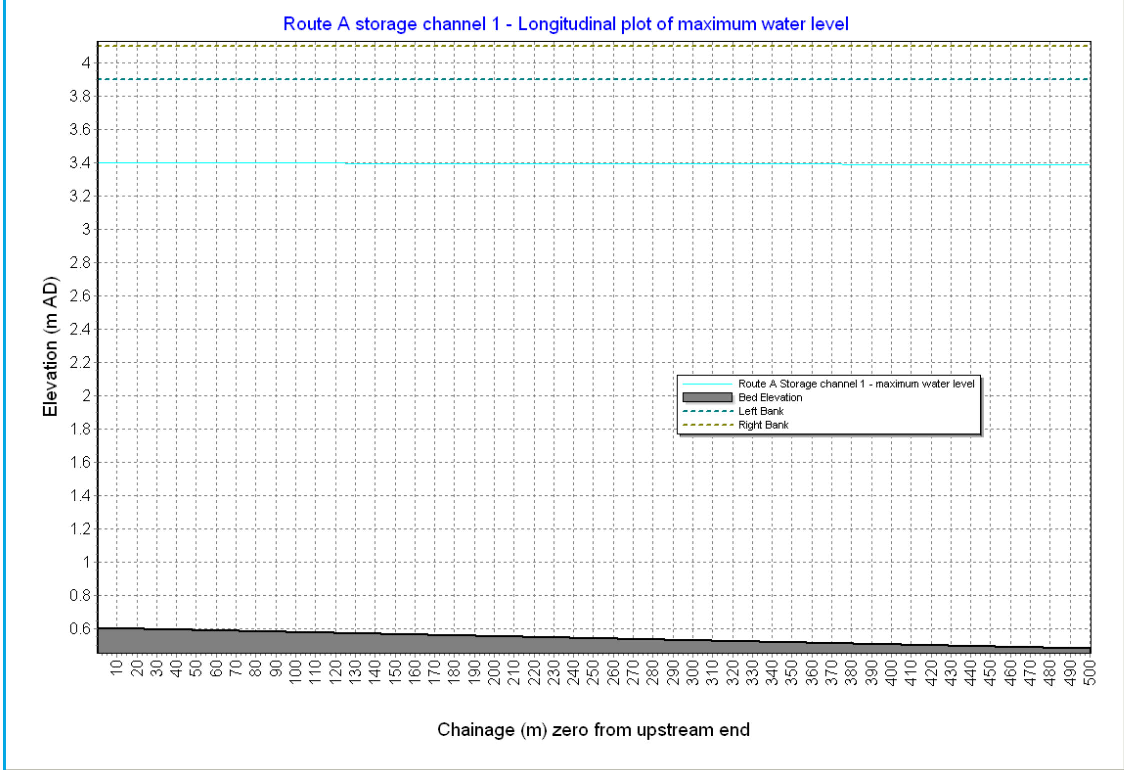
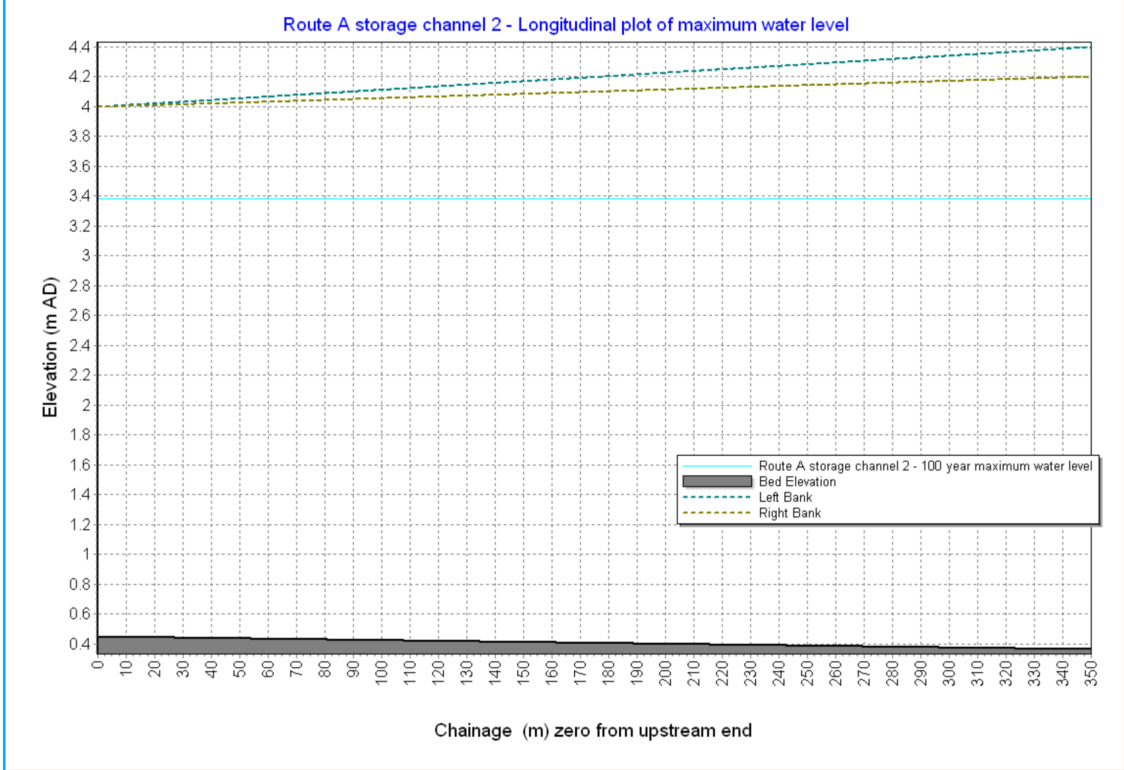


Figure 4-4 Route A Model Longitudinal Section





4.3.2 Route B

As identified in the assessment of Route A, the cross sections need to be 5m wide at the bed with a 7m wide berm at 1 m above the bed and 1 in 1.5 side slopes. Two storage channels were also added in this option to avoid flooding at the development site as shown in Figure 4-2.

Figure 4-5 shows the longitudinal plot of the maximum water for the 1 in 100 year event in the main channel of Route B and two storage channels. The maximum water level is within the bank at the development site with varying freeboards.

Figure 4-5 longitudinal section also demonstrates the effect of increasing the pumping capacity from approximately 1.6m³/s per pump to 2.0m³/s per pump in order to increase the freeboard from the proposed development ground levels.

Dependant on the upstream channel design requirements of the IDB this system may require additional storage within the developed area or an increase in the capacity of the pumping station.

Figure 4-5 Route B Model Longitudinal Section (1.6 m³/s per pump & 2.0m³/s per pump)

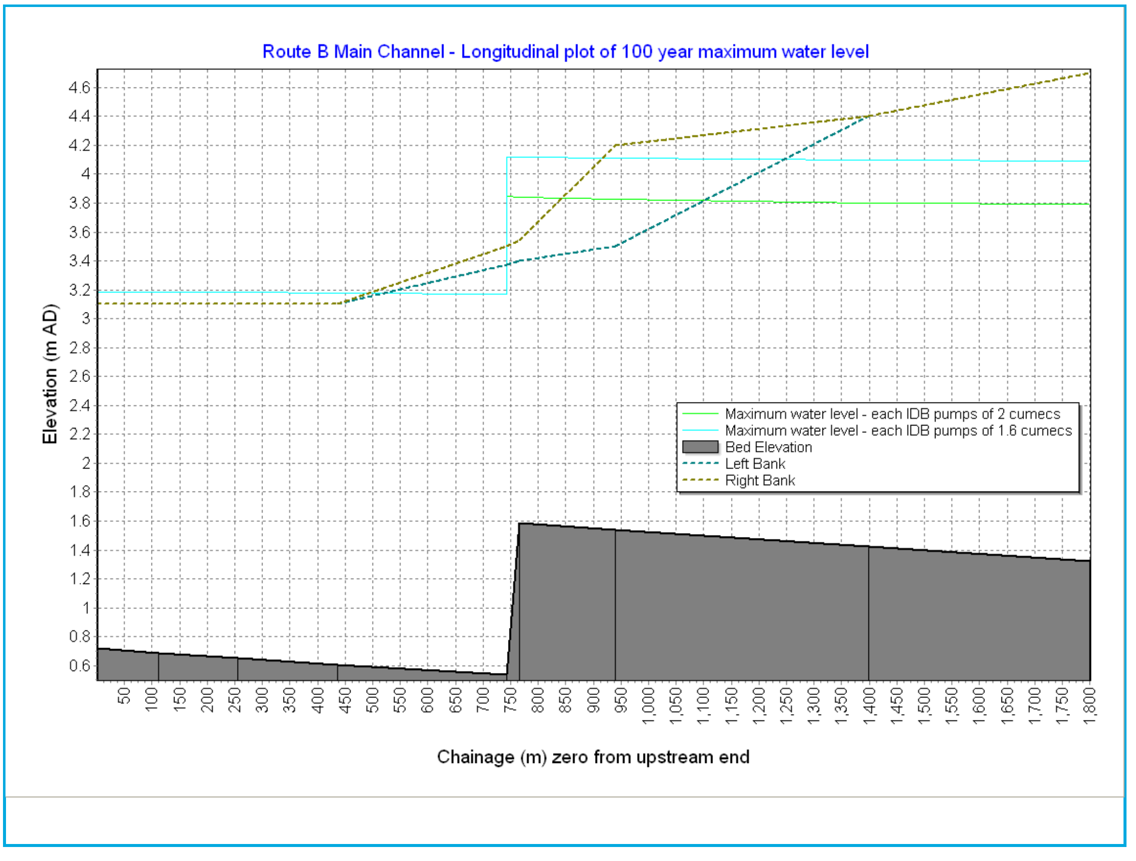
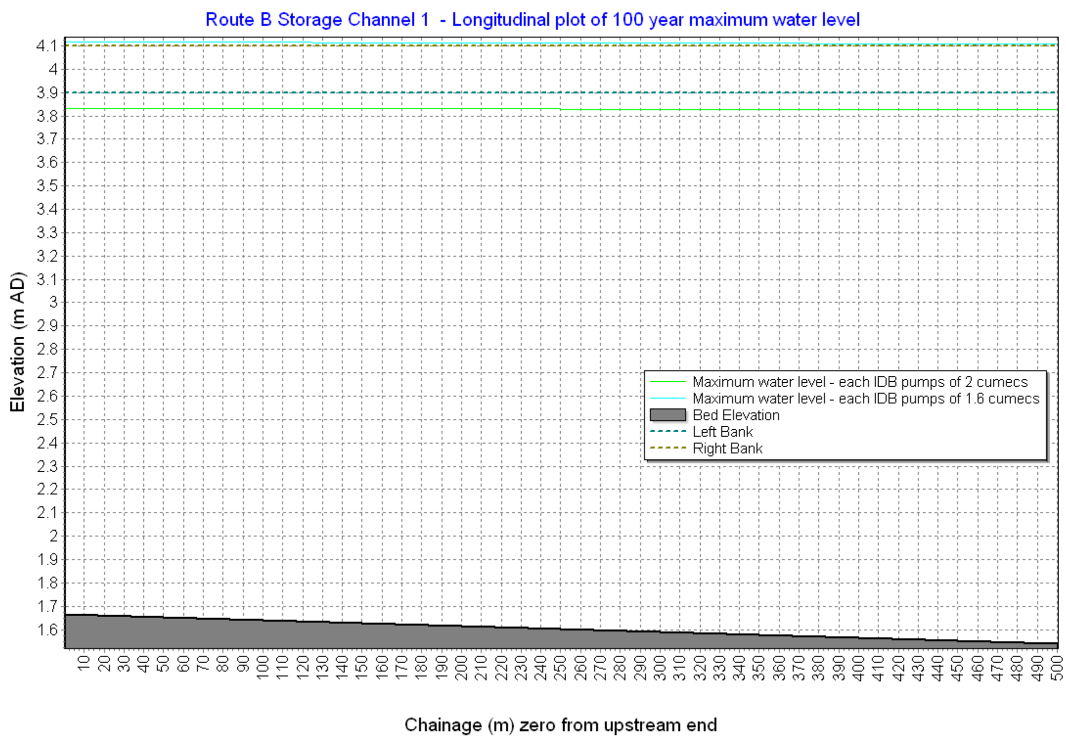
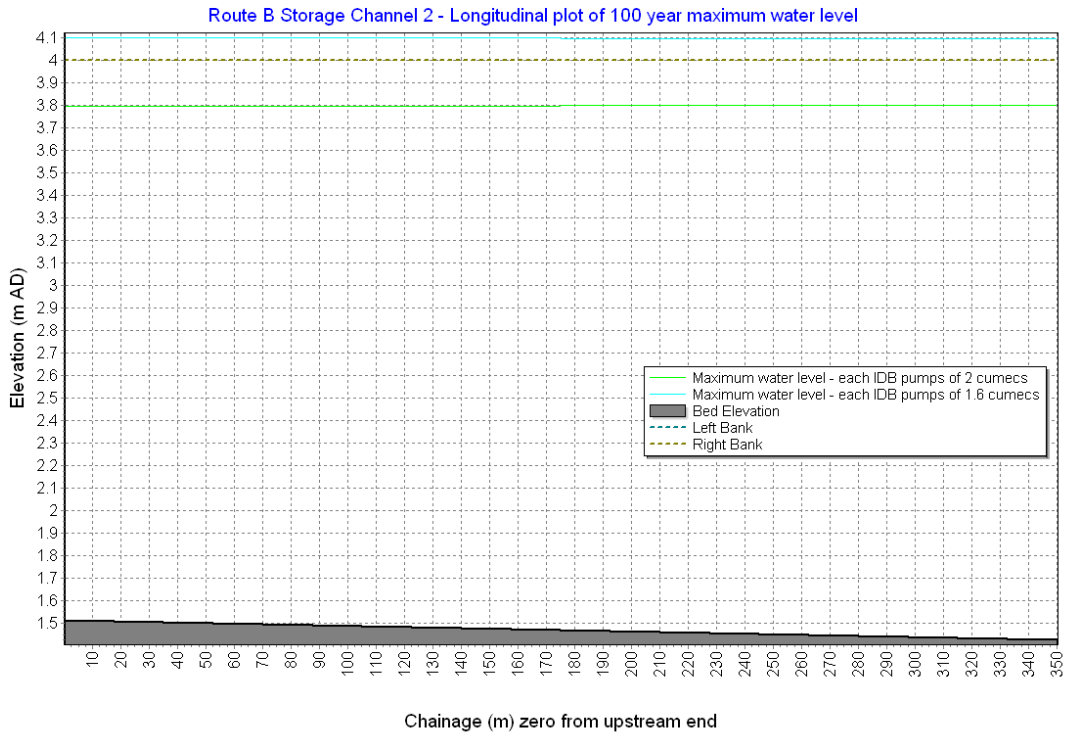


Figure 4-5 Route B Model Longitudinal Section (1.6 m^3/s per pump & 2.0m^3/s per pump)





4.3.3 Route D

As identified in the assessment of Route A, the cross sections need to be 5m wide at the bed with 7m wide berm at 1 m above the bed and 1 in 1.5 side slopes. Three storage channels were also added in this option to avoid flooding at the development site as shown in Figure 4-3.

Figure 4-6 shows the longitudinal plot of the maximum 1 in 100 year water level within the main channel of Route D and three storage channels. The maximum water level is within the bank at the development site with varying freeboards.

Dependant on the upstream channel design requirements of the IDB this system may require additional storage within the developed area or an increase in the capacity of the pumping station.

Figure 4-6 Route D Model Longitudinal Section

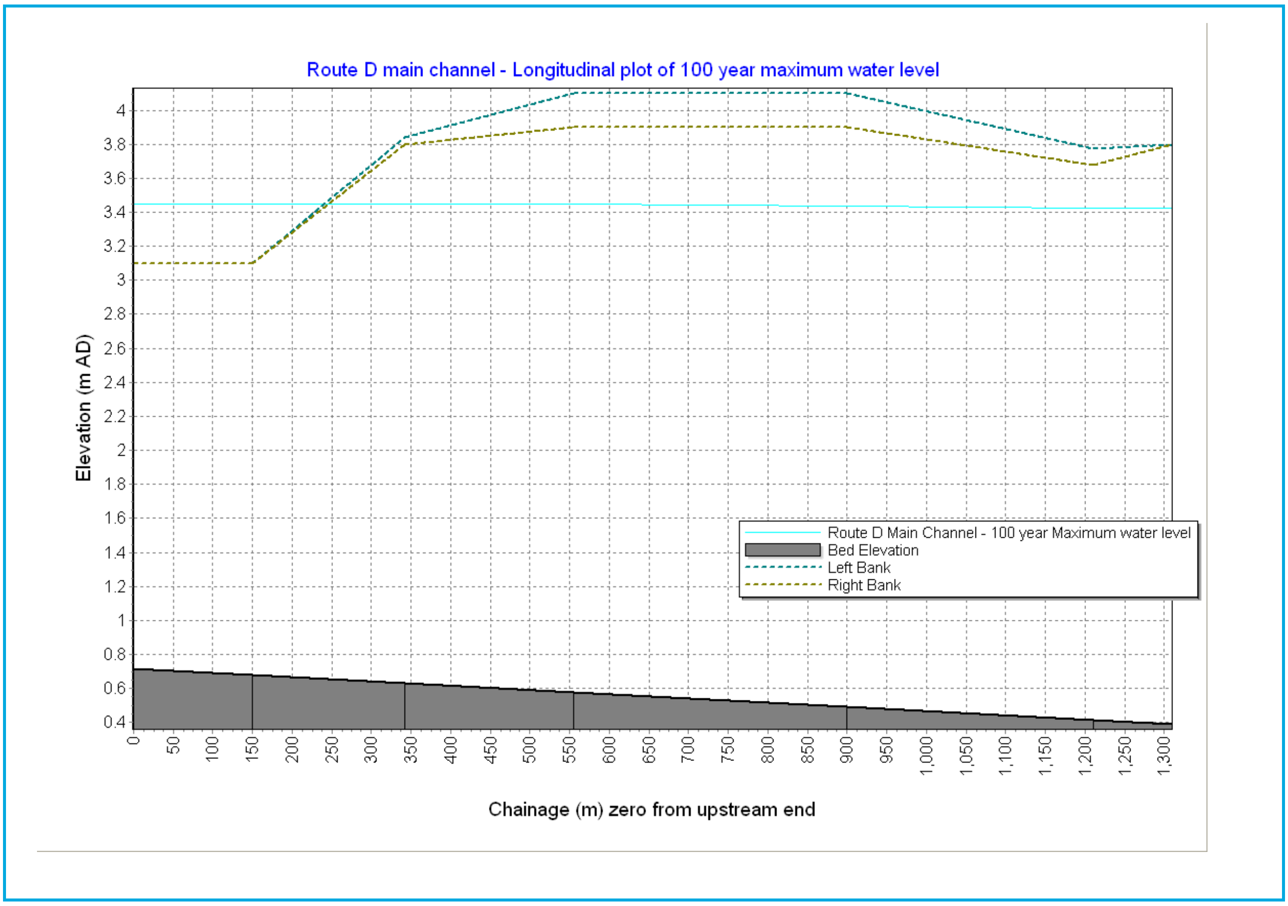
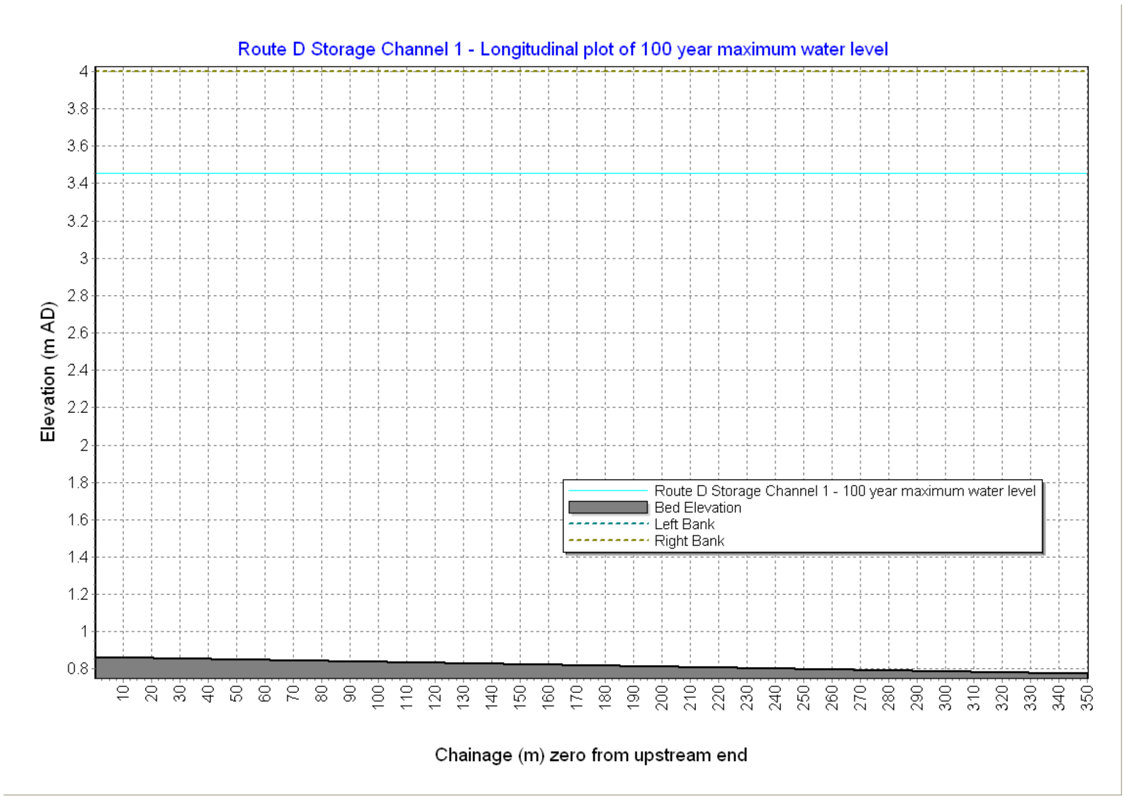


Figure 4-6 Route D Model Longitudinal Section



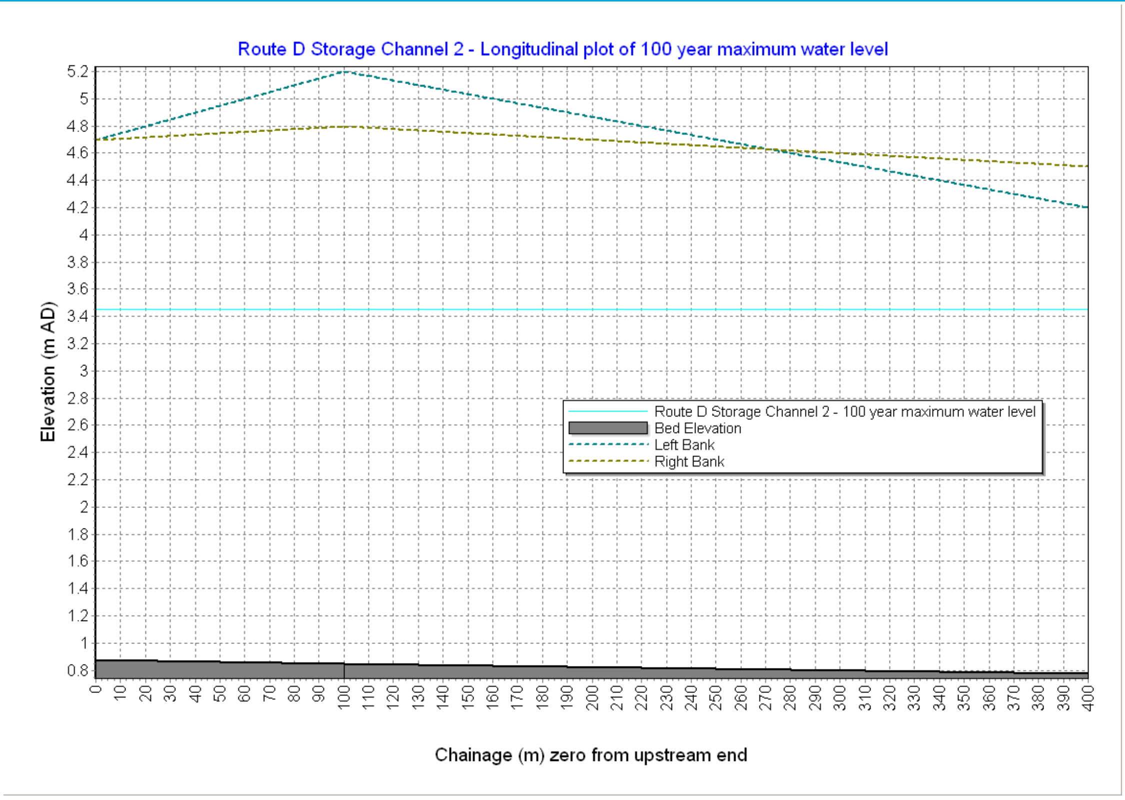
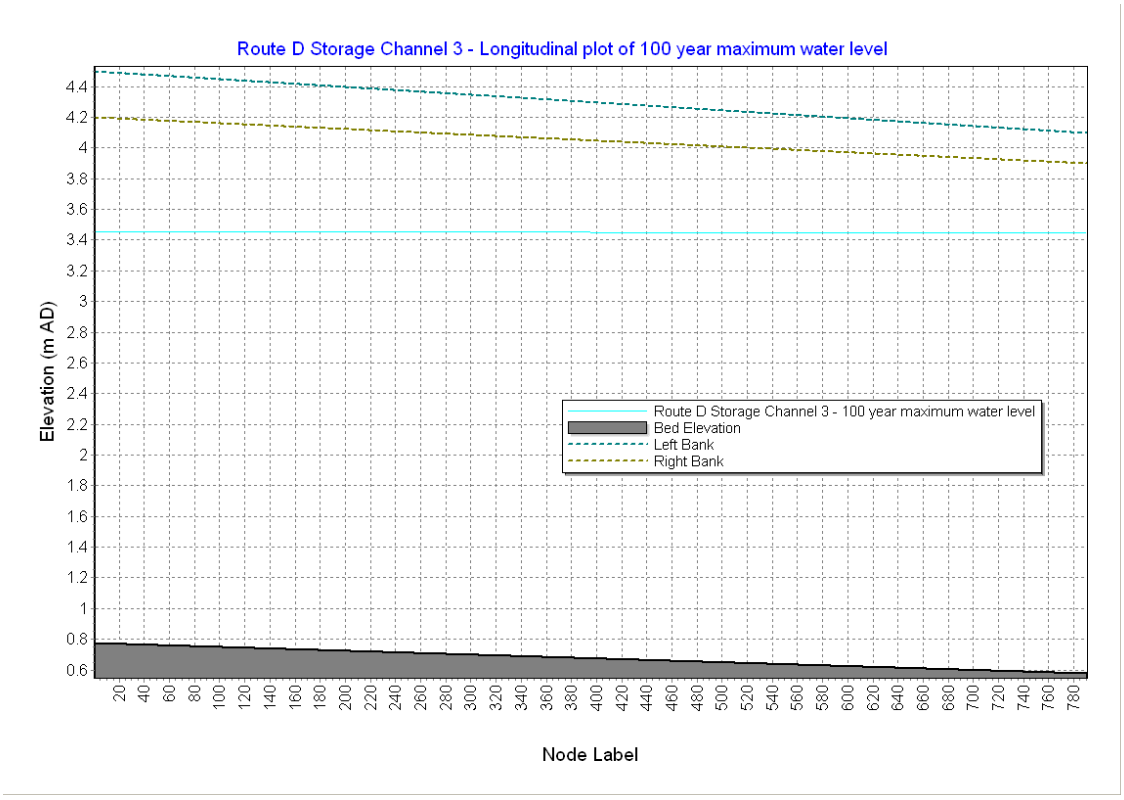


Figure 4-6 Route D Model Longitudinal Section



5. Conclusions and Recommendations

5.1 Conclusions

5.1.1 Route A

Providing a 1 in 4000 gradient from Station Road to a position north of the proposed quay provides a feasible solution in terms of drainage and the associated 1 in 100 year water levels which are typically 3.4m AOD some 500mm below the existing railway line at 3.9m AOD. However, the drain depth proposed on this route varies from 2.5m to 4.485m. The resultant width of the cross section at the pumping station would be approximately 32 metres which incorporates a 17 metre wide bed, 1 in 1.5 side slopes and a 7 metre wide access berm on either bank, similar to proposals from Hannah-Reed which indicated a cross section width of approximately 40 metres. The depth of drain would present maintenance problems and may require stabilisation dependant on the ground conditions. The bed level at the IDB pumping station would be 0.267m AOD which is approximately 127mm below the existing gravity outfall invert and may present further siltation problems at the gravity discharge to the River Humber.

5.1.2 Route B

Based upon a similar philosophy as Route A, a 1 in 4000 gradient has been applied from Station Road down to chainage 1,056m where a 9.6m³/s booster station would lift inflow into a raised bed profile downstream creating a more manageable watercourse depth varying between 2m and 3m. The bed level at the proposed IDB pumping station north of the indicative quay would be 1.325m AOD some 900mm above the existing gravity outfall invert and the width of the cross section would be approximately 29 metres. The associated 1 in 100 year flood level throughout the developed site would be 4.1m AOD downstream of the booster pumping station and 3.2m AOD upstream of the booster pumping station.

5.1.3 Route C

The route includes a 1in 4000 gradient over a similar length to Route A and B from Station Road to a position north of the proposed quay. The E-ON cooling pipes would become exposed within the open channel of this proposed route providing an obstruction to flow. This route is not considered a feasible option to progress as the pipes would require diversion.

5.1.4 Route D

This route includes a 1 in 4000 gradient from Station Road to a position south of the proposed quay. It provides reduced earthworks compared with Routes A and B, has no requirement for a booster station and provides the shortest route from Station Road. The bed level at the proposed position of the IDB pumping station would be 0.390m AOD which forms a similar level to the existing gravity outfall invert and provides a cross section width of approximately 29 metres. The resultant 1 in 100 year flood levels are typically 3.45m AOD.

However, the current proposed quay layout may require amendment to accommodate the pumping station location. A further consideration may be ownership of the land at the site of the proposed pumping station, as it is understood that two developers share the ownership of the field adjacent to Station Road behind the River Humber bank.

5.2 Recommendation

It is recommended, based upon constructability, drainage management, capital cost and operating cost that Route D is taken further for consideration between the relevant parties for the location of the proposed IDB pumping station to the south of the quay.

Appendices

A. Able UK Ltd. Indicative Site Plan

AME - 01066 B EIA MASTERPLAN

KEY

Limit of Deviation for Siting of Building upto 50m high.

Limit of Deviation for Siting of Building upto 25m high.

Limit of Deviation for Siting of Building upto 15m high.

48 Space Car Park

Rev	Date	Description	By	Chk	App
B	30/11/10	Dredge/Approach Added	PP	RC	RC
A	25/11/10	Preliminary Issue	PP	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: EIA Masterplan

DRAFT

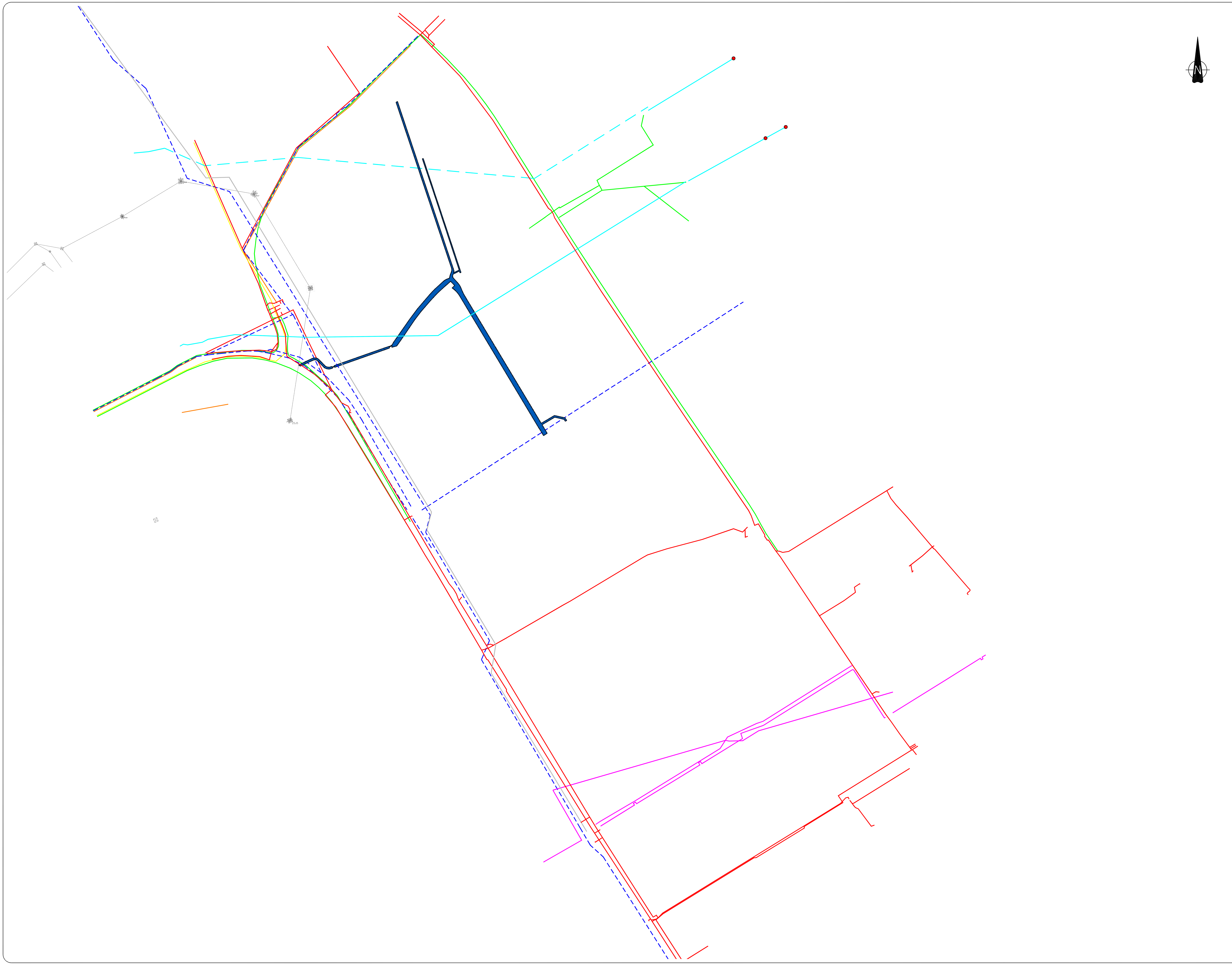
Scale:	Drawn By	Checked By	Approved By
1:5,000@A1	P Parsley	R Cram	R Cram
Date:	25/11/2010	25/11/2010	25/11/2010

Drawing No. AME - 01066

Revision: B

B. Existing Service Constraints Plan

AME - 03000 B Existing Service Constraints



KEY

- Water
- Gas
- Electric
- Sewage
- Telecoms
- Cooling Water Pipes (e.On)
- Cooling Water Pipes (Centrica)
- Oil Pipeline
- Humber Bundle Route

Rev	Date	Description	By	Chk	App
B	13/10/10	Electrical Service Amended	JH	JM	RC
A	17/08/10	Preliminary Issue	RK	JM	RC

Z:\ABLE UK - Standards\Drawing Templates\ABLE LOGO.tif

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Project: ABLE MARINE ENERGY PARK

Client: ABLE UK Ltd

Title: Existing Service Constraints

PRELIMINARY

Scale:	Drawn By	Checked By	Approved By
1:5,000@A1	R Keirl	J Monk	R Cram
Date:	17/08/2010	17/08/2010	17/08/2010

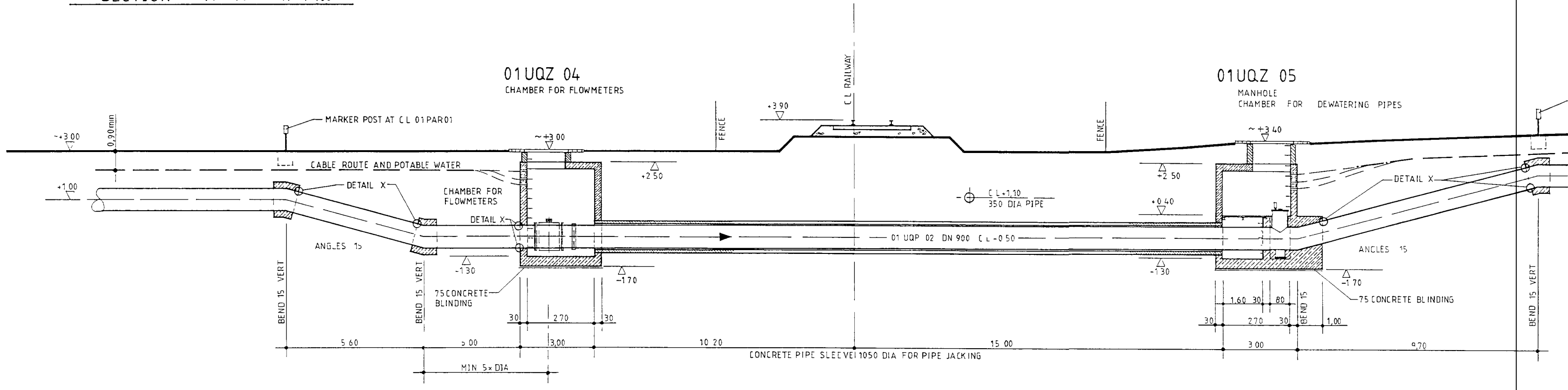
Drawing No. AME - 03000

Revision: B

C. E-ON Cooling Pipe System (crossing railway)

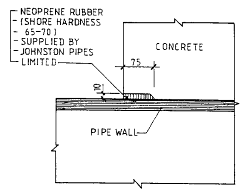
GBR 522-T217-11-1011 B Make-up and purge water pipes railway crossing (E-ON)

SECTION A-A M 1 100

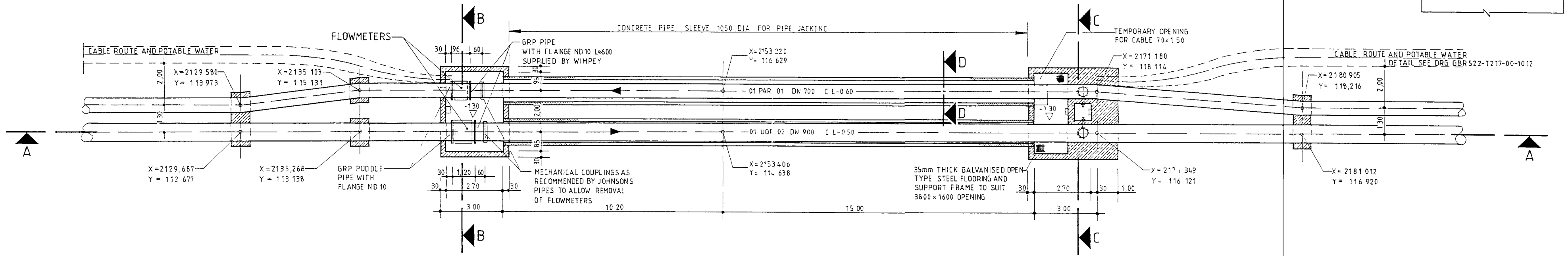


DETAIL X scale 1 10

FOR ALL WALLS AND BENDS



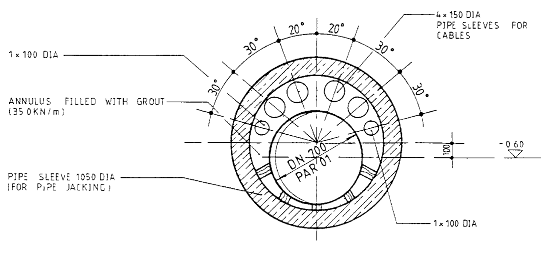
GROUND FLOOR M 1 100



REFERENCE DRAWINGS
GBR 522-T217-00-1012

ALL LEVELS ARE IN METRES RELATIVE TO ORDNANCE DATUM (NEWLYN)

SECTION D-D M 1 20



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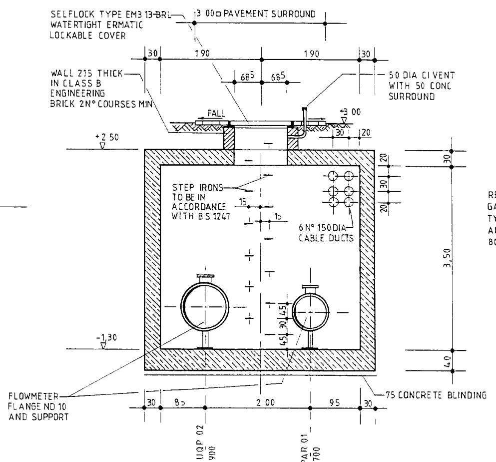
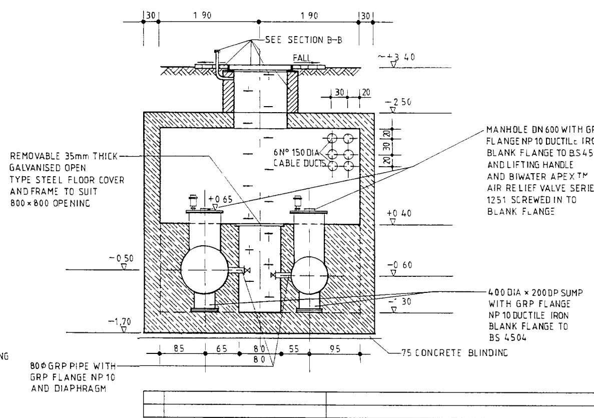


SECTION C-C M 1 50



JOB	KILLINGHOLME POWERGEN POWER STATION
SYSTEM	C W SYSTEM
SUB-SYSTEM	MAKE-UP AND PURGE WATER SYSTEM
DRG IDENT	KLA / BF / 30 111 B
SPEC NO	KLA / EY / 01

POWERGEN KILLINGHOLME CCGT PROJECT — GBR 522

Scale 1 50 1 100 — UE

	Datum	Name
gezeich.	19 03 91	SIERPINSKI
bearb.	19 03 91	KUMMER
geprüft	19 03 91	HOFER

MAKE-UP AND PURGE WATER PIPES RAILWAY CROSSING

01 PAR 01
01 UQP 02
01 UQZ 04/05

T 217

Siemens AG
Unternehmensbereich KWU

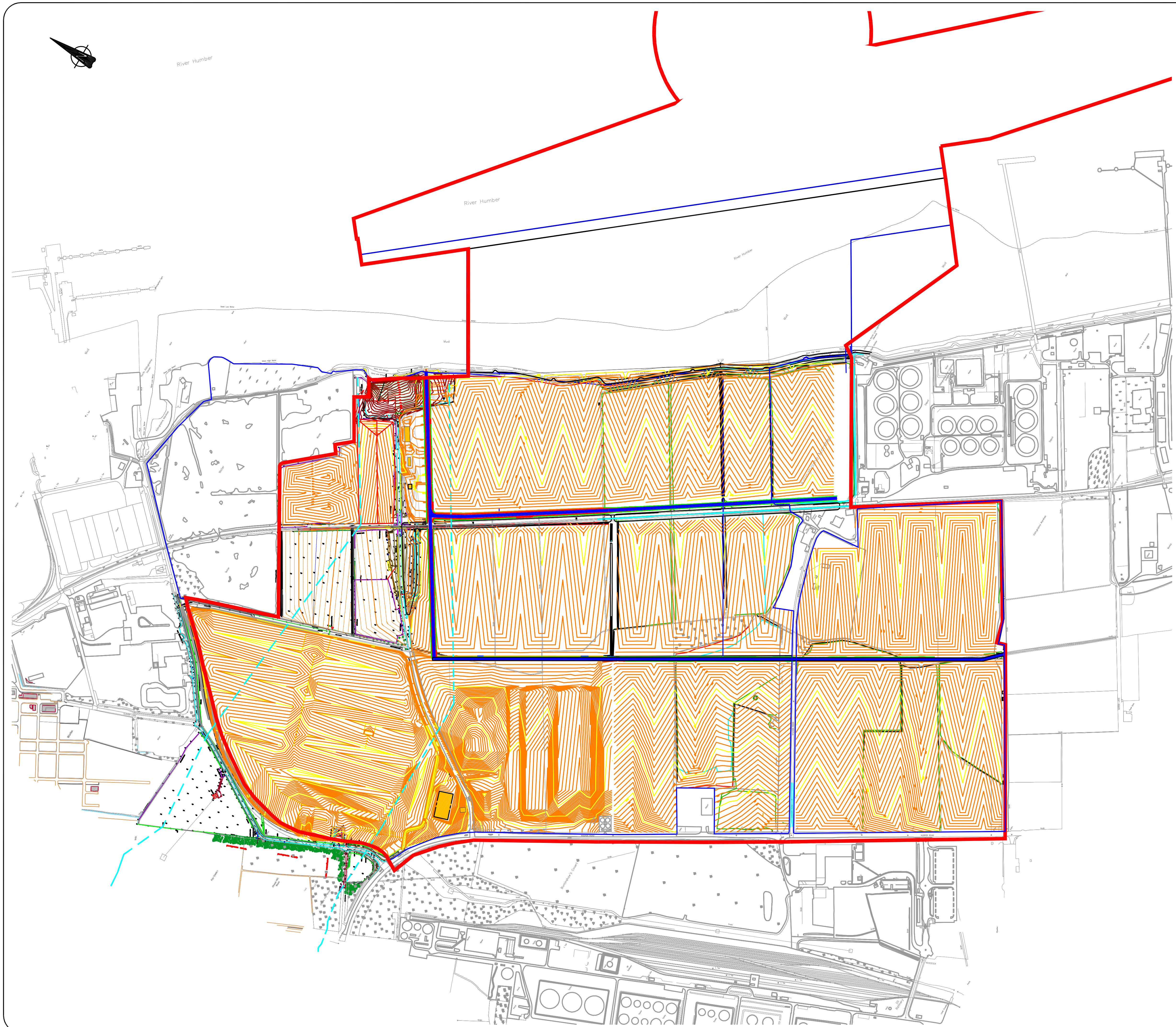
GBR 522 - T 217 - 11 - 1011 B

Rev	Datum				
B	9 12 92	SIER	KUM	HOFER	AS SHOWN / AS BUILT
A	1 08 91	SIER	KUM	HOFER	COMPLETE REVISED

1095088 — 2 185 897

D. Finished Ground Levels

AME - 04001 Finished Ground Levels



KEY

Rev	Date	Description	By	Chk	App
A	14/09/10	Preliminary Issue	SDB	RC	RC

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Project: Able Marine Energy Park

Client: ABLE UK Ltd

Title: Finished Site Levels

PRELIMNARY

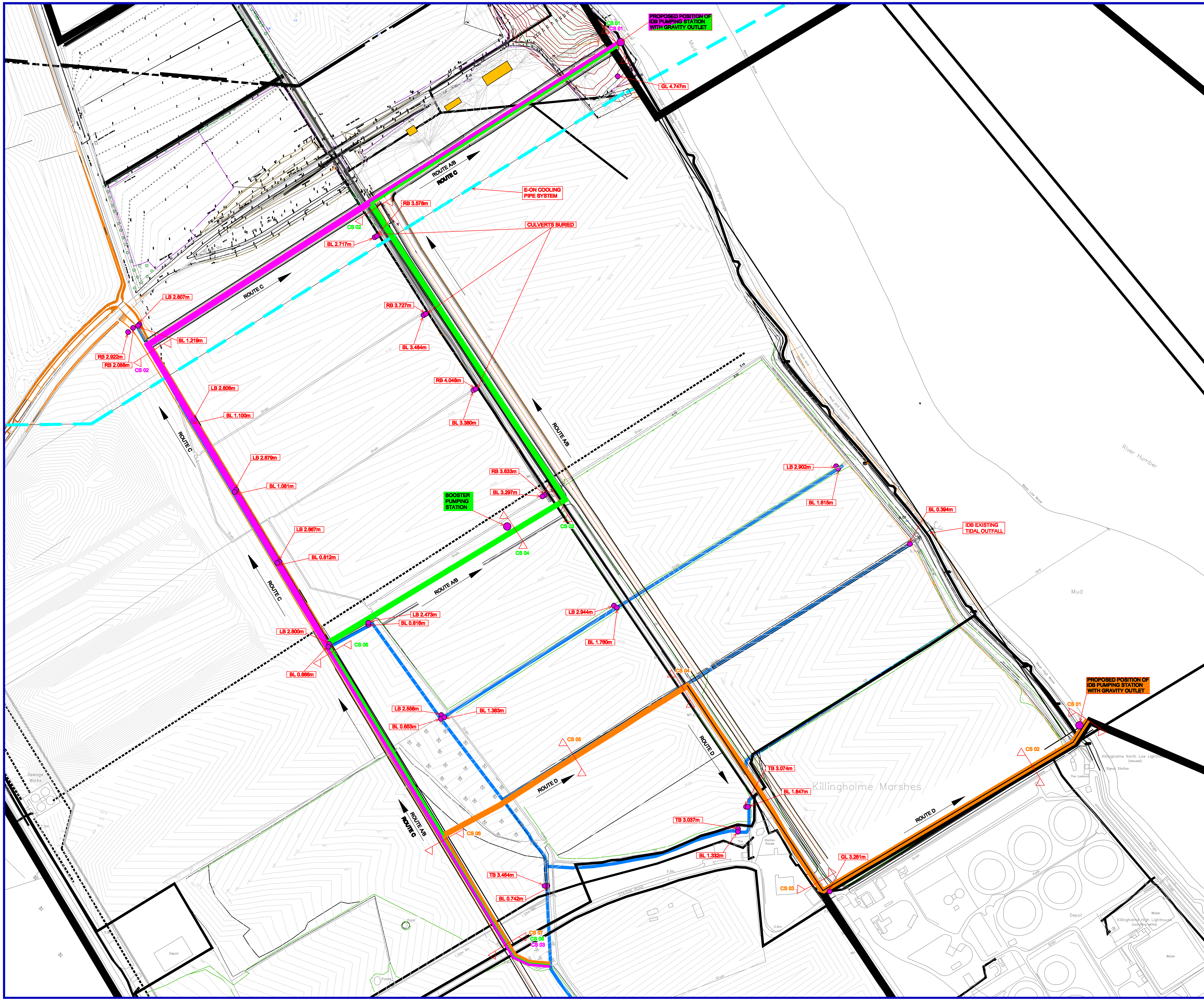
Scale:	Drawn By	Checked By	Approved By
1:10,000@A3	SDB	RC	RC
Date:	14/09/10	14/09/10	14/09/10

Drawing No. AME - 04001

Revision: A

E. General Arrangement

2010s4614-001 General Arrangement



General Notes

1. All dimensions shown are in millimetres unless otherwise stated and levels in metres to Ordnance Datum.

Key

Route A & Route B

Route C

Route D

E-On cooling pipes

Anglian Water pipeline

Existing watercourses

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved

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for

Able UK Ltd

Able Humber Ports Facility Pumping Station Feasability

Site Plan

Scale: 1:2500 @ A1

Drawn:	S Newall	21.04.11
Designed:	P Jones	11.04.11
Checked:		
Approved:		

Digital File Name: 2010s4614-001.dwg

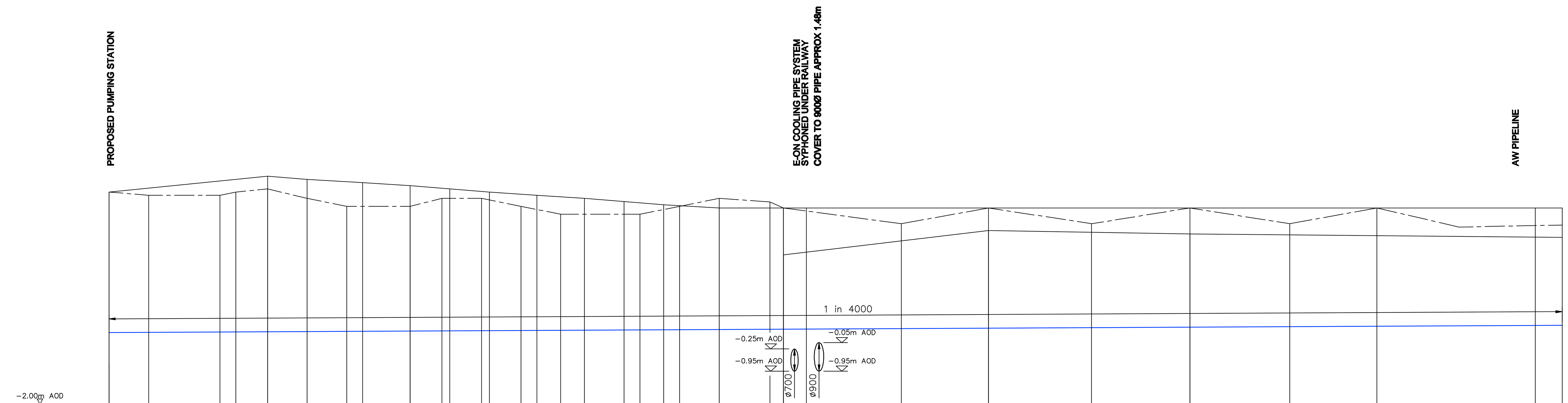
Drawing Number:	Rev.:	Sheet No.:	Status:
2010s4614 - 001		1 of 1	Draft

F. Longitudinal Section Route A

2010s4614-002 Longitudinal Section Route A

General Notes

1. All dimensions shown are in millimetres unless otherwise stated and levels in metres to Ordnance Datum.



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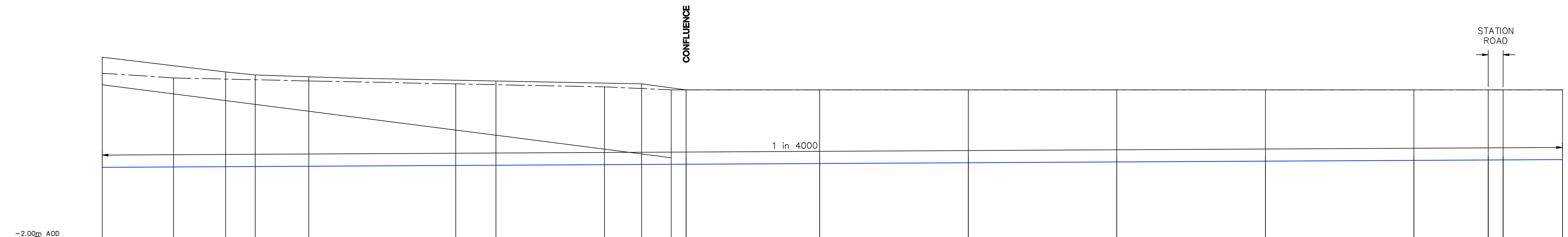
25.000	4.600				
70.000	4.600				
80.00	4.700				
100.000	4.800	5.200			
125.000	4.500	5.100			
150.000	4.250				
160.000		5.000			
190.000	4.250	4.900			
200.000					
210.000	4.500				
215.000		4.800			
235.000	4.500				
240.000		4.700			
260.000	4.250				
270.000		4.600			
285.000	4.000				
300.000		4.500			
310.000					
325.000		4.400			
335.000	4.000				
350.000		4.300			
360.000	4.250				
385.000	4.500	4.200			
417.000	4.400	4.200			0.371
425.500	4.200	4.200	2.717		
440.000	4.100	4.200	2.800		0.377
500.000	3.700				
555.000	4.200		3.484		
600.000					
620.000	3.700				
682.000	4.200		3.380		
700.000					
745.000	3.700				
800.000	4.200				
900.000					
917.000	3.500	4.200	3.297		0.496

CS 01 (0.000) — 90° SOUTHERN TURN, CS 02 (417.000) — 90° WESTERN TURN, CS 03 (917.000)

LONGITUDINAL SECTION – ROUTE A
Scale 1:2000 Horiz – 1:100 Vert



CHAINAGE	PROPOSED LEFT BANK	PROPOSED RIGHT BANK	EXISTING BED LEVEL	INVERT LEVEL	DESIGN LEVEL
917.000	3.500	4.200	3.297		0.496
965.000	3.500				
1000.000		3.700			
1020.000		3.600			
1056.000	3.400	3.540			0.533
1100.000					
1155.000	3.300				
1182.000		3.400			
1200.000					
1255.000	3.200				
1280.000		3.300			
1300.000	3.100		0.816		
1310.000	3.100	3.100	0.866		0.600
1350.000		3.200			
1400.000	3.100	3.100			
1500.000	3.100	3.100			
1600.000	3.100	3.100			
1700.000	3.100	3.100			
1800.000	3.100	3.100			0.730
1850.000					
1860.000					
1900.000	3.100	3.100	0.742		0.742

90° WESTERN TURN — CS 03 (917.000); CS 04 (1056.000); 90° SOUTHERN TURN — CS 05 (1310.000); CS 06 (1800.000)

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for

Able UK Ltd

Able Humber Ports Facility Pumping Station Feasability
Route A
Longitudinal Section

Scale: 1:2500 @ A1

Drawn: S Newall 20.04.11
Designed: P Jones 11.04.11
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Digital File Name: 2010s4614-002.dwg

Drawing Number:	Rev.:	Sheet No.:	Status:
2010s4614-002		1 of 1	Draft

G. Longitudinal Section Route B

2010s4614-003 Longitudinal Section Route B

General Notes

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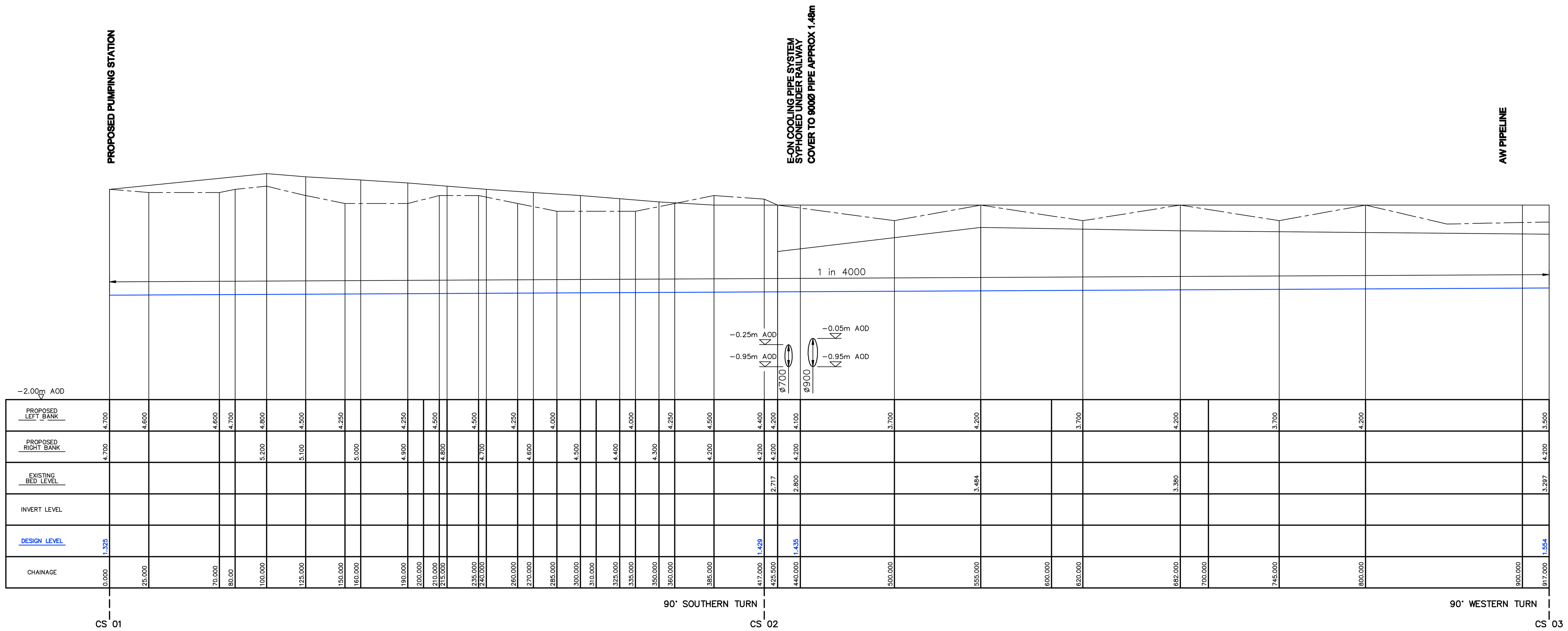

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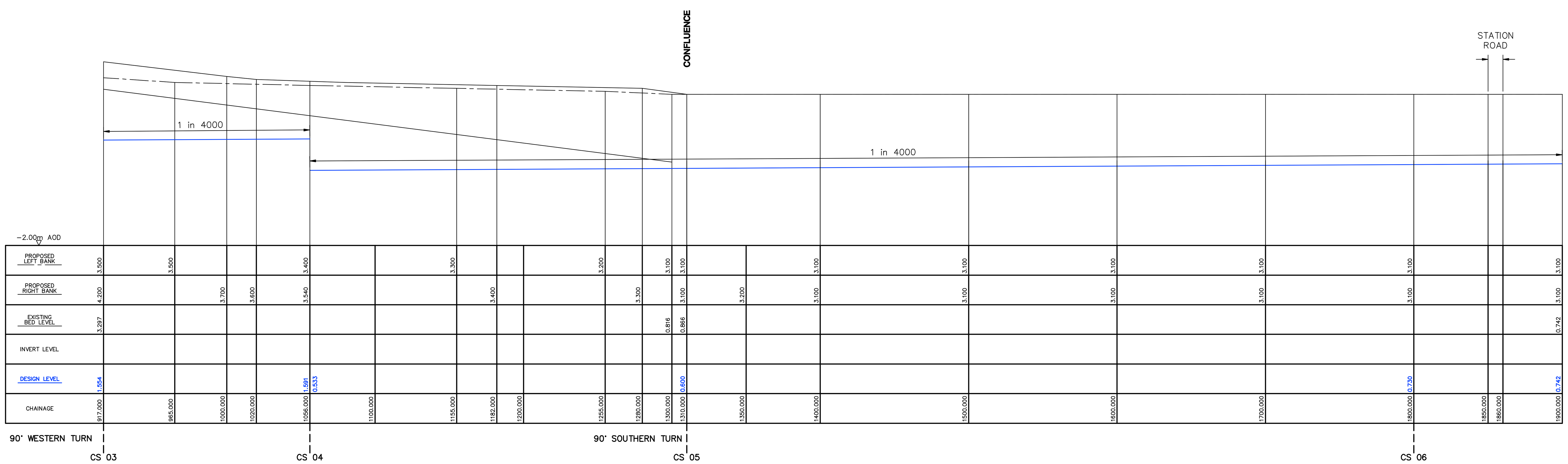
Scale 1:2000 Horiz – 1:100 Vert



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Able Humber Ports Facility Pumping Station Feasability
Route B
Longitudinal Section

Scale:	1:2500 @ A1	Drawn:	S Newall	20.04.11
		Designed:	P Jones	11.04.11
		Checked:		
		Approved:		

Digital File Name: 2010s4614-003.dwg

Drawing Number:	Rev.:	Sheet No.:	Status:
2010s4614-003		1 of 1	Draft

H. Longitudinal Section Route C

2010s4614-004 Longitudinal Section Route C

General Notes

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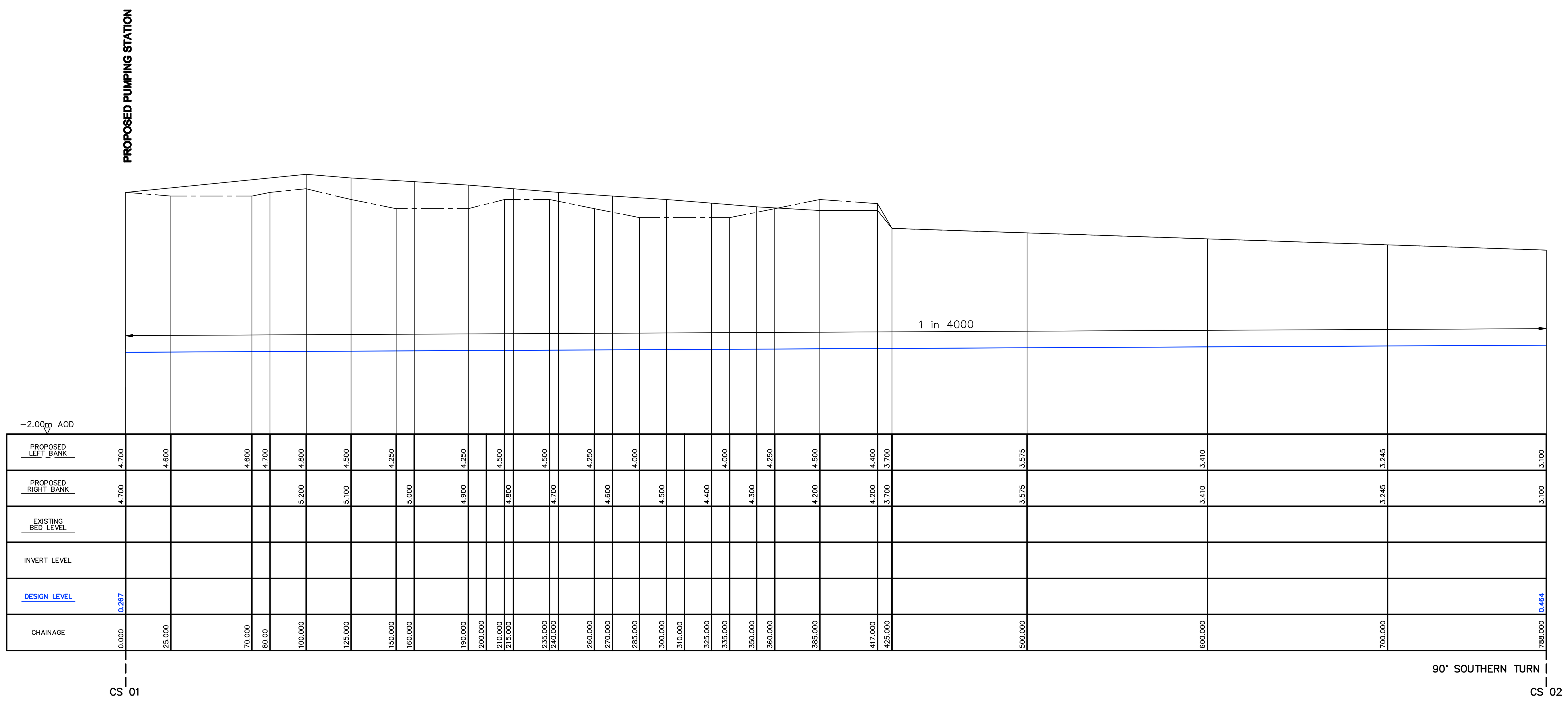

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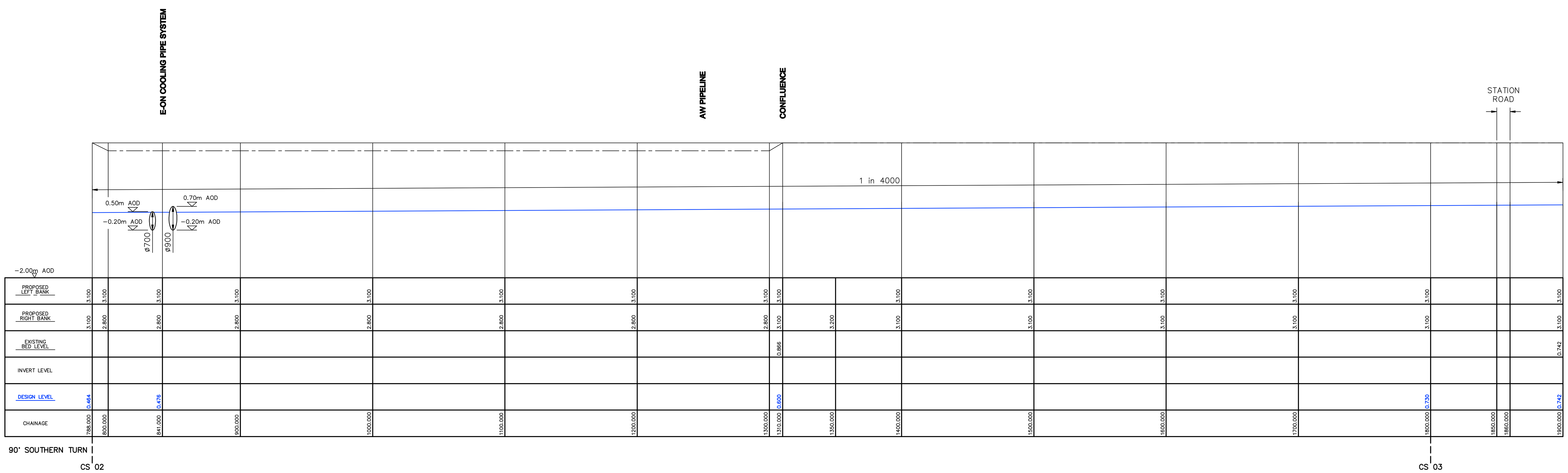
Scale 1:2000 Horiz – 1:100 Vert



Rev.	Modifications	Date	Drawn	Designed	Checked	Approved

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for

Able UK Ltd

Able Humber Ports Facility Pumping Station Feasability
Route C
Longitudinal Section

Scale:	Drawn:	S Newall	20.04.11
1:2500 @ A1	Designed:	P Jones	11.04.11
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	Approved:		

Digital File Name: 2010s4614-004.dwg

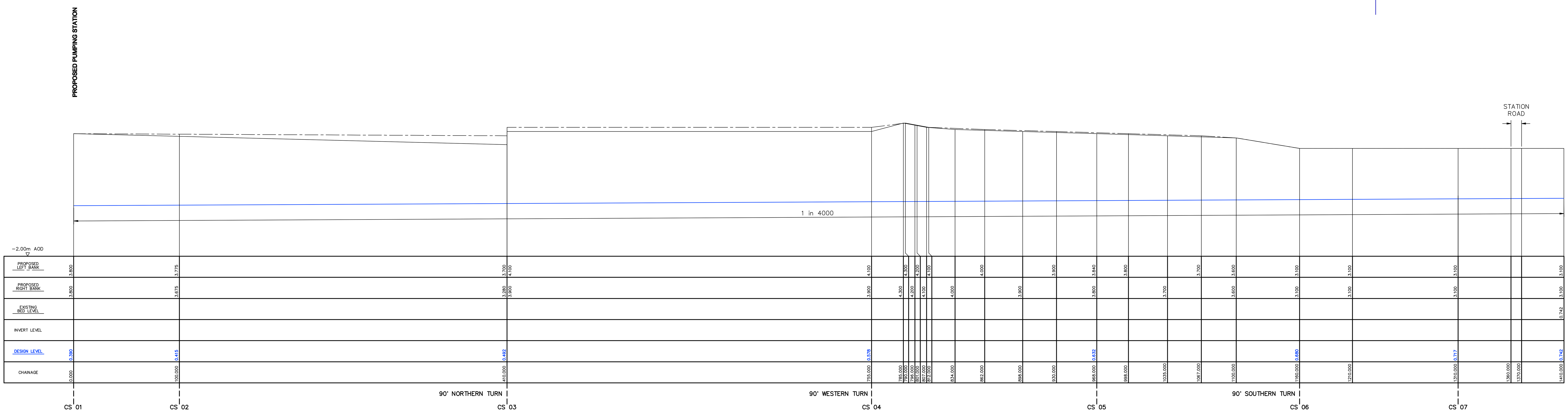
Drawing Number:	Rev.:	Sheet No.:	Status:
2010s4614-004		1 of 1	Draft

I. Longitudinal Section Route D

2010s4614-005 Longitudinal Section Route D

General Notes

1. All dimensions shown are in millimetres unless otherwise stated and levels in metres to Ordnance Datum.



LONGITUDINAL SECTION – ROUTE D
Scale 1:2000 Horiz – 1:100 Vert

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for

Able UK Ltd

Able Humber Ports Facility Pumping Station Feasability
Route D
Longitudinal Section

Scale: 1:2500 @ A1

Drawn: S Newall 20.04.11
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Checked:
Approved:

Digital File Name: 2010s4614-005.dwg

Drawing Number:	Rev.:	Sheet No.:	Status:
2010s4614-005		1 of 1	Draft

References

Hannah-Reed (2010) North East Lindsey Drainage Improvement Scheme, Overview of Design Philosophy, UK.

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H. Quay Design Modelling

JBA Note to File No. 13 dated 31 August 2011.

Subject: Calculation Record (v7): Wave Overtopping at AMEP Quay Assessment.

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NOTE TO FILE

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Contract	Humber Estuary Quay Design Modelling
Client	Able UK Ltd.
Day, Date and Time	31st August 2011
Author	C Batstone
Checked By	J Hornsby (numerical check)
Reviewed By	K Keating
Distribution	R Cram (Able), D Stark (JBA Consulting)
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1 SYNOPSIS

This note describes an assessment carried out to estimate wave overtopping rates at the proposed MEP quay. The impacts of wave reflection on the local flood risk are also examined.

2 CONTEXT

2.1 Overtopping thresholds

The Marine Energy Park (MEP) quay extends into the Humber Estuary and as a consequence will be exposed to wave action and wave overtopping. This represents a potential flood hazard to people and property.

Planning Policy Statement (PPS) 25 is used when considering flood risk and new development. This provides advice on what type of development is appropriate in each Flood Zone (delineating range of risk). Port infrastructure (i.e. docks in this case) is regarded as “water compatible” and appropriate for the estuary environment at the proposed development location, subject to the completion of an acceptable Flood Risk Assessment. Of relevance to the content of the FRA, PPS25 has a policy aim to “reduce the overall level of flood risk in the area through the layout and form of the development”. The Environment Agency has recommended that Able include an assessment of the potential wave overtopping rates. The Agency has three requirements:

1. Demonstration that wave overtopping waters can be managed without enhancing flood risk in the hinterland. This issue will be dealt with within the Flood Risk Assessment completed for the development.
2. Demonstration that the new port facility will be designed so as to be reasonably safe for current and future potential users.
3. Check whether wave reflections from new development could cause additional wave overtopping hazard at existing adjacent structures.

This calculation record summarises the work completed. Guidance on specific overtopping rates and their likely consequences is provided by the EurOtop manual[1]. Relevant suggested limits are reproduced in Table 1 to Table 3.

Table 1: Limits for overtopping for pedestrians

Hazard type and reason	Mean discharge, q (l/s/m)
Appropriately trained and prepared staff, who are expecting adverse conditions (the main concern for the development)	1-10
Aware pedestrian, who will tolerate getting wet and with a clear sight of the sea	0.1

[1] EurOtop, 2007: Wave Overtopping of Sea Defences and Related Structures: Assessment Manual. www.overtopping-manual.com

Table 2: Limits for overtopping for vehicles

Hazard type and reason	Mean discharge, q (l/s/m)
Driving at low speed, overtopping by pulsating flows at low flow depths, no falling jets, vehicle not immersed	10-50
Driving at moderate or high speed, impulsive overtopping giving falling or high velocity jets (not likely to be relevant to Able MEP)	0.01-0.05

Table 3: Limits for overtopping for damage to "promenade or revetment seawalls"

Hazard type and reason	Mean discharge, q (l/s/m)
Damage to paved or armoured promenade behind seawall (the more likely structural form)	200
Damage to grassed or lightly protected promenade or reclamation cover (unlikely to be relevant to the development)	50

Furthermore the manual states that, as a rule of thumb, the hazard effect of an overtopping discharge at a point *x* metres back from the sea wall crest will be to reduce the overtopping discharge by a factor of *x* (over a range of 5-25m).

With this guidance in mind Able UK suggested that the quay be designed to accommodate the following criteria:

- For functional safety (and prevent too frequent cessation of operation), a limit of 10 l/s/m for a 1:10-year overtopping event should ideally be imposed given that access to the frontage can be controlled;
- For structural integrity, a limit of 200 l/s/m for a 1:200-year overtopping event should be imposed along the front and side of the quay where a concrete pavement is proposed.

The Environment Agency suggests that the lifetime of the quay be set at 100 years. Therefore the above criteria must be fulfilled for overtopping events that incorporate PPS25 guidance on sea level rise for this length of time.

2.2 Proposed quay design

Figure 1 shows the proposed quay design. The quay elevation proposed is 6.38mOD, reducing uniformly over 28m to 6.1mOD along the main frontage. This frontage, which will be the most exposed, will consist of a vertical wall, the toe of which will be at -14.9mOD (-11mCD). The approach area adjacent to the quay-side berths is to be maintained at a depth of -12.9mOD (-9mCD). The north-facing quay side will be protected by a sloping revetment that extends out from the coastline by 179m to a point where the bed level is -2.8mOD. The level of the toe of the sea defence at the existing coastal defences is 2.5mOD. Extending farther out the design includes a breakwater, consisting of an extension of the revetment finished by an area of bunding. This breakwater encloses a berthing area on the north face and effectively removes wave overtopping flood risk on the quay surface. At the south face the southern revetment extends in an east-south-east direction from the coastline to approximately 190m from the existing defences where the bed level is 0.5mOD. The south face extends towards the north shore for 90m, at which point the bed level is -1.5mOD. As for the north side of the quay a breakwater extends out from here, enclosing the southern berthing area.

The revetments that adjoin the north and south quay faces are characterised by a 1:2 slope, rising to an elevation of 7.1mOD (11mCD) (this represents a 0.72m increase in elevation at the ends of the quay). The

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surface of the revetments is to consist of rock armour with rocks of approximately 600mm size. JBA Consulting has not been commissioned to provide specific advice on the revetment design (e.g. rock sizing).

Figure 1: MEP quay detail (©OS OpenData™)

Able have indicated that the quay elevation may be increased by 200mm in time to mitigate the increased overtopping risk brought about by predicted sea level rise.

3 WAVE OVERTOPPING ASSESSMENT METHODOLOGY

The worst case scenario of wave overtopping at the quay is to be assessed and compared with the design criteria. In order to determine the worst case scenario consideration must be given to the profiles of the sides of the quay as well as the local wave climate. Wave overtopping at the frontage is assessed using the Neural Network Tool described in the EurOtop manual. This method estimates wave overtopping using multiple parameters to specify the form of the defence to be analyzed.

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A still water level/wave height joint probability analysis study provides details of the prevailing wave climate at South Killingholme[2]. Wave overtopping calculations were performed using values for water level, wave height and wave period specified in this report. Calculations were carried out for combinations of the 1:10-year and 1:200-year joint probability events, with 100 years of projected climate change (CC) added (meaning 100 years of sea level rise) from the time of the quay construction. The water levels provided in the ABPmer report are to a mean sea level in 1991. The lifetime of the quay is to be from its construction in 2014 until 2114. The CC guidance gives 1.19m of sea-level rise from 1991 to 2114 and a 10% increase in wave heights in 100 years time. These are considered to be conservative estimates, given recent findings in UKCP09 that predict reduced rates of sea level rise and no increased storminess[3].

The assessment does not provide an allowance for freeboard: this may be relevant to the Flood Risk Assessment. The 200mm potential rise in the quay frontage provides some contingency but this is to be considered further within the FRA.

3.1 Overtopping of the main quay frontage

The quay frontage is directly exposed to waves propagating toward it from the north shore. However waves from upstream and downstream that will impact at an angle are likely to be much larger due to the far greater fetch (fetch lengths are approximately: 4km to the north shore, 12km to Hull, 23km to Spurn Head). A worst case scenario is for downstream waves to impact at an angle of 52˚ to a line perpendicular to the frontage (Figure 2). The quay front consists of a vertical wall, which is described using the Neural Network Tool. Descriptions of the 15 parameters that are specified as inputs to this tool are given in Table 4, along with the values used to describe the vertical wall of the quay frontage. The conservative roughness coefficient choice of 1 assumes a smooth surface.

The table refers to SWL: still water level expressed in mOD (-ve being below OD). The spectral mean wave period is given as $T_{m-1,0}$[4].

[2] ABPmer, 2007: The Humber Tidal Database and Joint Probability Analysis of Large Waves and High Water Levels, Annex II: Addendum to Data Report. R.810. Report for the Environment Agency.

[3] Lowe, J. A., Howard, T., Pardaens, A., Tinker, J., Holt, J., Wakelin, S., Milne, G., Leake, J., Wolf, J., Horsburgh, K., Reeder, T., Jenkins, G., Ridley, J., Dye, S., Bradley, S. (2009), UK Climate Projections science report: Marine and coastal projections. Met Office Hadley Centre, Exeter, UK.

[4] No information is given in the ABPmer report on the type of wave period provided. Therefore the spectral wave mean period is assumed. Test overtopping calculations showed that for a 10% change in wave period, the change in overtopping rate was of the order of 10%.

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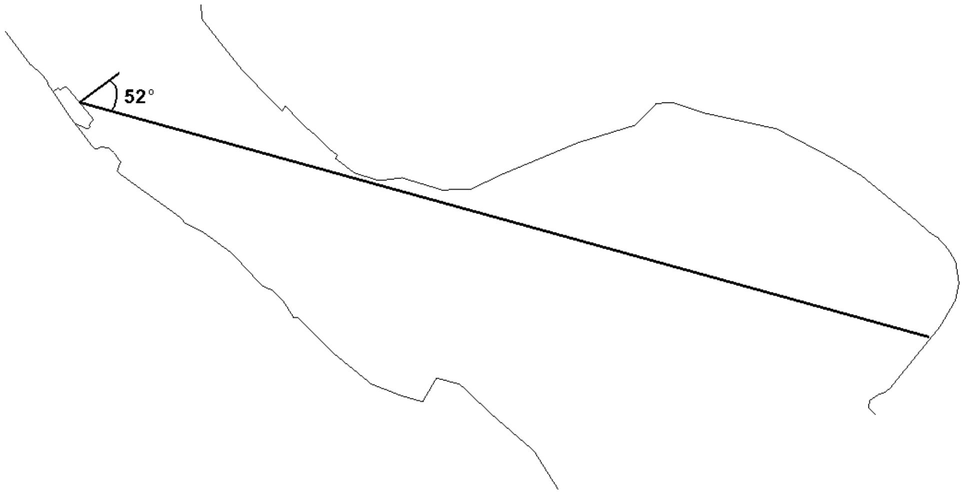
Table 4: Neural Network overtopping calculation tool parameters for the quay frontage vertical wall

Neural Network parameter	Vertical wall assessment
1. Angle of Wave attack (˚)	52
2. Water depth in front of structure (m)	SWL + 14.9
3. Significant Wave Height at the toe of structure (m)	Hs
4. Wave period (s)	$T_{m-1,0}$
5. Water depth at the toe of structure (m)	(same as 2.)
6. Width of toe (m)	0
7. Roughness coefficient	1
8. Angle of down slope (cotangent)	0
9. Angle of upper slope (cotangent)	0
10. Crest freeboard in relation to SWL (m)	6.1 - SWL
11. Berm width (m)	0
12. Water depth at the berm of the structure (m)	0
13. Berm slope (m)	0
14. Armour freeboard in relation to SWL (m)	(same as 10.)
15. Armour width (m)	0

Figure 2: Incident angle of worst case wave attack along the quay frontage



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3.2 Overtopping of the south or north quay faces

The largest waves are likely to originate from the south-east: the direction of greatest fetch length. However the quay will be somewhat protected along the south face by the area of reclaimed land at the Immingham Bulk Terminal. The rake piled structures of the South Killingholme Oil Jetty and adjacent Immingham Gas Jetty to the south will also reduce wave energy propagating towards the MEP site due to frictional effects. During extreme wave activity there is a 90m long stretch of the south side of the quay that is 'exposed'. Towards the south bank coastline the quay side diverts to the north and is therefore sheltered. Towards the north bank coastline the quay side is protected by the breakwater and 60m of water. Therefore any wave overtopping at the breakwater is highly unlikely to pose a risk on the surface of the quay.

Wave overtopping calculations are performed using the Neural Network Tool parameters specified in Table 5 to describe the revetment defence. A worst case scenario of waves hitting the defence directly is specified. The rock face is denoted by a roughness coefficient of 0.55, deduced from guidance provided in the EurOtop manual (2007)[1].

Table 5: Neural Network overtopping calculation tool parameters for the quay side revetment

Neural Network parameter	Vertical wall assessment
1. Angle of Wave attack (˚)	0
2. Water depth in front of structure (m)	SWL + 1.5
3. Significant Wave Height at the toe of structure (m)	Hs
4. Wave period (s)	$T_{m-1.0}$
5. Water depth at the toe of structure (m)	(same as 2.)
6. Width of toe (m)	0
7. Roughness coefficient	0.55
8. Angle of down slope (cotangent)	2
9. Angle of upper slope (cotangent)	2
10. Crest freeboard in relation to SWL (m)	7.1 - SWL
11. Berm width (m)	0
12. Water depth at the berm of the structure (m)	0
13. Berm slope	0
14. Armour freeboard in relation to SWL (m)	(same as 10.)
15. Armour width (m)	0

The proposed revetment on the north side of the quay is of identical structure. Therefore the wave overtopping calculations for the south side apply to the north side too.

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4 OVERTOPPING CALCULATIONS

4.1 Main quay frontage

Table 6 shows the results of wave overtopping calculations performed using the Neural Network Tool for the quay frontage for 1:10-year water level/wave height combinations (plus CC projections), assuming a 52° angle of wave attack. Wave overtopping rates are quoted for the deterministic prediction. This is defined as the mean of the predicted distribution of wave overtopping plus one standard deviation (approximately equal to the 68th percentile). The largest overtopping rate occurs for a water level of 4.92mOD and a wave height of 1.65m. The table reveals that, for the worst case 1:10-year scenario predicted wave overtopping at the edge of the quay is 24 l/s/m. The 28m-long sloped edge of the quay would lead to the vast majority of this overtopped water flowing back into the estuary. The EurOtop manual states that, as a rule of thumb, the hazard effect of an overtopping discharge at a point *x* metres back from the sea wall crest will be to reduce the overtopping discharge by a factor of *x* (over a range of 5-25m).

It should be noted that the overtopping estimate now exceeds the upper 1 in 10 year threshold (10 l/s/m – see section 2.1) based on a 6.1mOD quay elevation. Able has indicated that the design will include an allowance to “top up” the front 28m of quay by 200mm if needed as a response to climate change. The calculation was therefore repeated for this quay elevation; however the result shown in Table 6 (16.2 l/s/m) reveals that this does not bring the overtopping down below 10 l/s/m for the 1:10-year event.

Table 7 shows the wave overtopping calculations for the worst case water level/wave height permutations for more frequent return periods. It can be seen that after 100 years of projected climate change, the 10 l/s/m limit is passed for the 1:2-year event for the original quay height of +6.1mOD. The addition of 200mm to the quay height gives a prediction of the limit being exceeded slightly more frequently than once every 5 years.

Table 6: Wave overtopping calculations for 1:10-year water level/wave height combinations

SWL (mOD) (1991)	Hs (m) (1991)	SWL (mOD) (2114)	Hs (m) (2114)	Wave period (s)	Q deterministic (~Q68%) (l/s/m)
3.00	1.72	4.19	1.89	4.9	11.8
3.73	1.50	4.92	1.65	4.5	23.9
3.73**	1.50	4.92	1.65	4.5	16.2
4.14	1.00	5.33	1.10	3.9	10.3

Note: ** repeated assessment with 6.3mOD quay height.

Table 7: Worst case wave overtopping calculations for various return periods

Return period (year)	SWL (mOD) (2114)	Hs (m) (2114)	Q deterministic (~Q68%) (l/s/m) (quay height = +6.1mOD)	Q deterministic (~Q68%) (l/s/m) (quay height = +6.3mOD)
5	4.92	1.52	17.1	10.8
2	4.92	1.33	8.8	5.3

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Table 8 shows the results for the 1:200-year water level/wave height combinations (plus CC projections), assuming a 52˚ angle of attack. The greatest wave overtopping rate (91.8 l/s/m) occurs for a water level of 5.66mOD and a wave height of 1.62m. This is below the 1:200-year threshold for structural damage (200l/s/m – see section 2.1). The overtopping rates for a quay height of +6.3mOD (i.e. with the 200mm proposed mitigation toppage) are also included in the table, which are lower as expected.

However it should be noted that ABPmer's univariate analysis of still water levels gives a 1:200-year level of 5.05mOD, and that in 2114 using DEFRA guidance this is projected to be 6.24mOD. Therefore much of the 28m wide front of the quay could be submerged during such an event. This is not a concern with regard to meeting the overtopping "structural damage" criterion but may be a consideration for the wider Flood Risk Assessment for the development.

Table 8: Wave overtopping calculations for 1:200-year water level/wave height combinations

SWL (mOD) (1991)	Hs (m) (1991)	SWL (mOD) (2114)	Hs (m) (2114)	Wave period (s)	Q deterministic (~Q68%) (l/s/m) (quay height = +6.1mOD)	Q deterministic (~Q68%) (l/s/m) (quay height = +6.3mOD)
3.73	1.98	4.92	2.18	5.1	73.8	55.4
4.47	1.47	5.66	1.62	4.4	91.8	61.6
4.79	1.00	5.98	1.10	3.9	52.0	32.3

The ABPmer report on wave and water levels within the estuary states that for a 14-year period of derived wave heights, only 0.02% of waves from the north bank reached a height of 0.6m (i.e. a 0˚ angle of attack). For completeness, wave overtopping calculations were performed for a 0˚ angle of attack, for water level/wave height combinations of the 1:10-year event that consisted of wave heights less than 0.7m. The predicted overtopping rates were lower than those reported above for all combinations.

4.2 South and north quay faces

Table 9 and Table 10 show the predicted wave overtopping rates at the revetments on the north and south sides of the quay for 1:10-year and 1:200-year combinations of water level/wave height respectively. The calculations assume a worst case angle of wave attack of 0˚. The predicted overtopping rates are significantly below the proposed thresholds for both return periods. Variations in these rates due to longer wave periods (to account for swell waves from the North Sea) are negligible compared to the magnitudes of the proposed thresholds.

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Table 9: Wave overtopping calculations for 1:10-year water level/wave height combinations

SWL (mOD) (2114)	Hs (m) (2114)	Wave period (s)	Q deterministic (~Q68%) (l/s/m)
4.19	1.89	4.9	0.3
4.92	1.65	4.5	0.7
5.33	1.10	3.9	0.1

Table 10: Wave overtopping calculations for 1:200-year water level/wave height combinations

SWL (mOD) (2114)	Hs (m) (2114)	Wave period (s)	Q deterministic (~Q68%) (l/s/m)
4.92	2.18	5.1	5.1
5.66	1.62	4.4	7.4
5.98	1.10	3.9	3.3

5 WAVE REFLECTION

When waves meet the edges of the proposed quay there will be a degree of reflected wave energy. This raises the issue of the possibility of increased flood risk at EA maintained defences adjacent to the quay due to greater wave heights (the standard of protection of the defences ranges from 1:50-years to 1:150-years[5]).

5.1 Wave reflection modelling

An assessment is carried out to examine whether wave reflection due to the MEP quay will lead to increased wave heights and flood risk assuming no increase in bed elevation for the 100 year climate change scenario. An assessment of wave propagation and reflection around the area of the quay was performed using the nearshore wave transformation model CMS-Wave[6]. CMS-Wave is developed and maintained by the US Army Corps of Engineers' Coastal Inlets Research Program. It is a phase-averaged, 2D wave spectral transformation model. The model calculates the shallow water wave transformation processes of depth-induced wave refraction and shoaling, current induced refraction and shoaling, depth and steepness-induced wave breaking, wind-wave growth, wave-wave interaction, and white-capping. Diffraction and wave reflection processes are parameterised within the model. The model grid resolution is approximately 15m by 15m around Killingholme, extending out to 150m by 150m farther away from the proposed quay location[7]. The model bathymetry is comprised of high resolution survey data from 2010 for sub-tidal areas stitched to 2m resolution EA LiDAR data from 2007 for inter-tidal areas.

The coastal defences at South Killingholme take the form of a small vertical wall fronted by a 1:3 gradient smooth slope. The crest of the wall is 6.2mOD, the top of the slope area is 5.0mOD and the toe is at 2.5mOD. The defence is fronted by a foreshore of gradient 1:40[8]. This foreshore will lead to depth limitation

[5] Environment Agency (2008) Humber Flood Risk Management Strategy: Planning for rising tides. Environment Agency, Leeds

[6] Coastal and Hydraulics Laboratory (2008) CMS-Wave: A Nearshore Spectral Wave Processes Model for Coastal Inlets and Navigation Projects. ERDC/CHL TR-08-13. US Army Corps of Engineers, Engineer Research and Development Center

[7] The model grid used in the flow and wave modelling studies of the Humber Estuary is detailed more comprehensively in the modelling studies report: JBA Consulting (2011) Able Marine Energy Park Modelling Studies. Able UK. JBA Consulting.

[8] Due to accumulation to the north of the reclamation area associated with the Humber International Terminal the foreshore slope varies considerably from 1:40 to 1:100. To be conservative the steepest foreshore is assumed.

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of certain wave conditions. This depth limitation dominates for joint probability water level/wave height combinations (for 1:200-year events in 2114) for waves higher than 1.6m (accompanying water levels are lower than 5.63mOD). Therefore, only joint probability permutations with waves lower than this (and therefore higher water levels) will be relevant to the reflection issue.

The percentage of incident wave energy that is reflected by a surface is dependent on the nature of that surface. For a perfect reflector a coefficient of reflection of 1.0 is specified. The sides of the quay will take the form of a slope with a gradient of 1:2, with a surface made from rocks with a mean diameter of 600mm. An estimation of a reflection coefficient for such a structure involves some uncertainty. Energy will be dissipated by friction against the rough surface, accentuated by the slope exposing a greater area of roughness. A value of 0.7 is estimated which is conservative for rubble mound breakwaters[9].

The wave model was run with the quay in place and also the existing conditions. Changes in wave heights due to reflection were deduced by comparing the two model outputs. Two scenarios of wave direction were simulated: waves of 1.6m from the east and from the north (the model still water level was set as the appropriate 1:200-year plus CC event combination of 5.66mOD). Figure 3 and Figure 4 show the estimated increases in wave height along the coastal defence for extreme waves from the east and north respectively. To the south of the quay an increase in wave height of 10cm is predicted; to the north a very localised increase of up to 40cm is estimated where the quay meets the sea defence. It should be remembered that, in the long term, both of the locations where wave height is shown to increase are likely to be subject to increased sedimentation, which will reduce wave overtopping flood risk by increased depth-limitation effects.

[9] Muttray, M., H. Oumeraci, and E. Oever, 2006: Wave reflection and wave run-up at rubble mound breakwaters. Coastal Engineering, pp 4314-4324

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Figure 3: Increase in wave heights for a 1:200-year water level/wave height event (in 2114) due to MEP quay for waves from the east

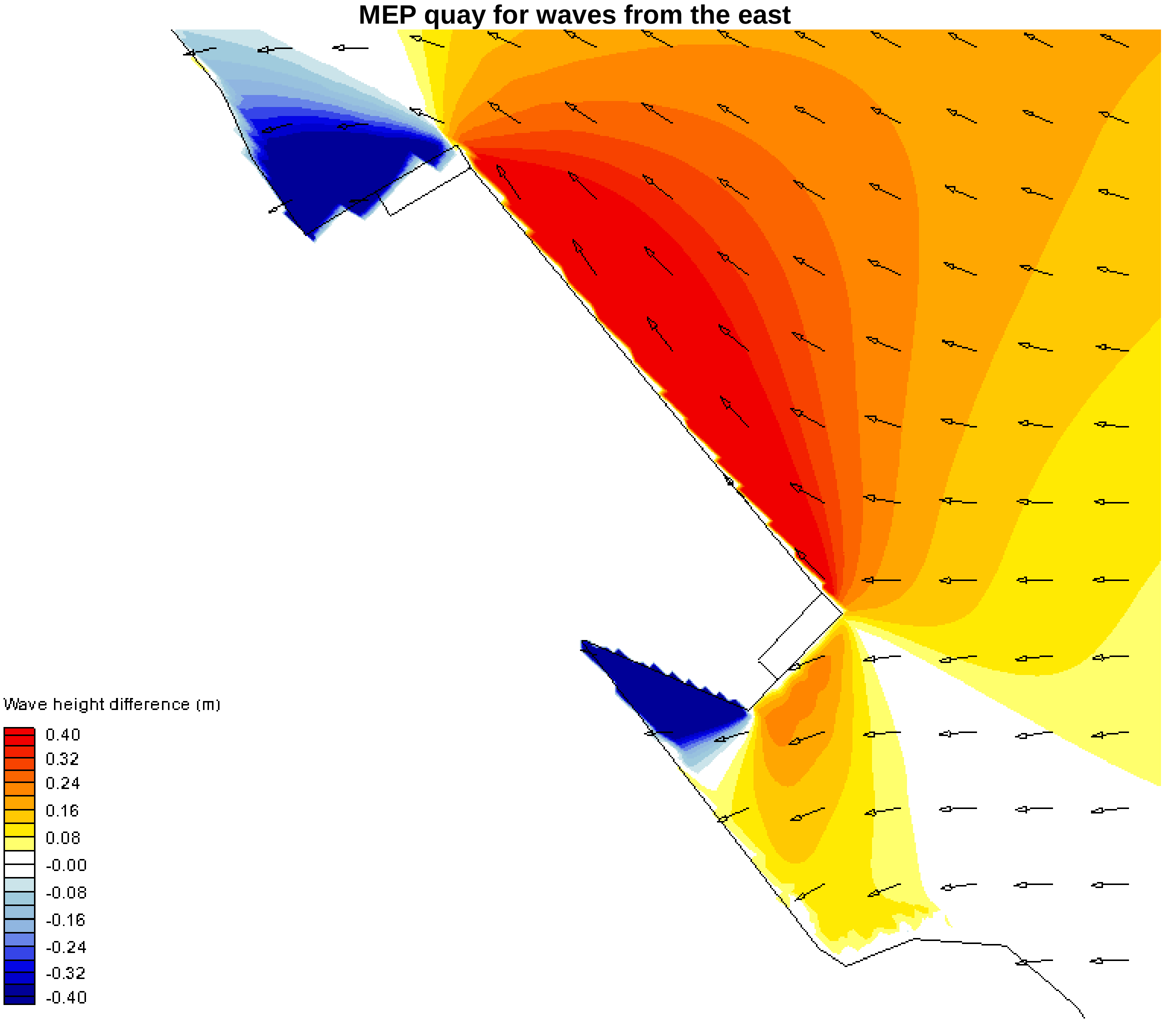

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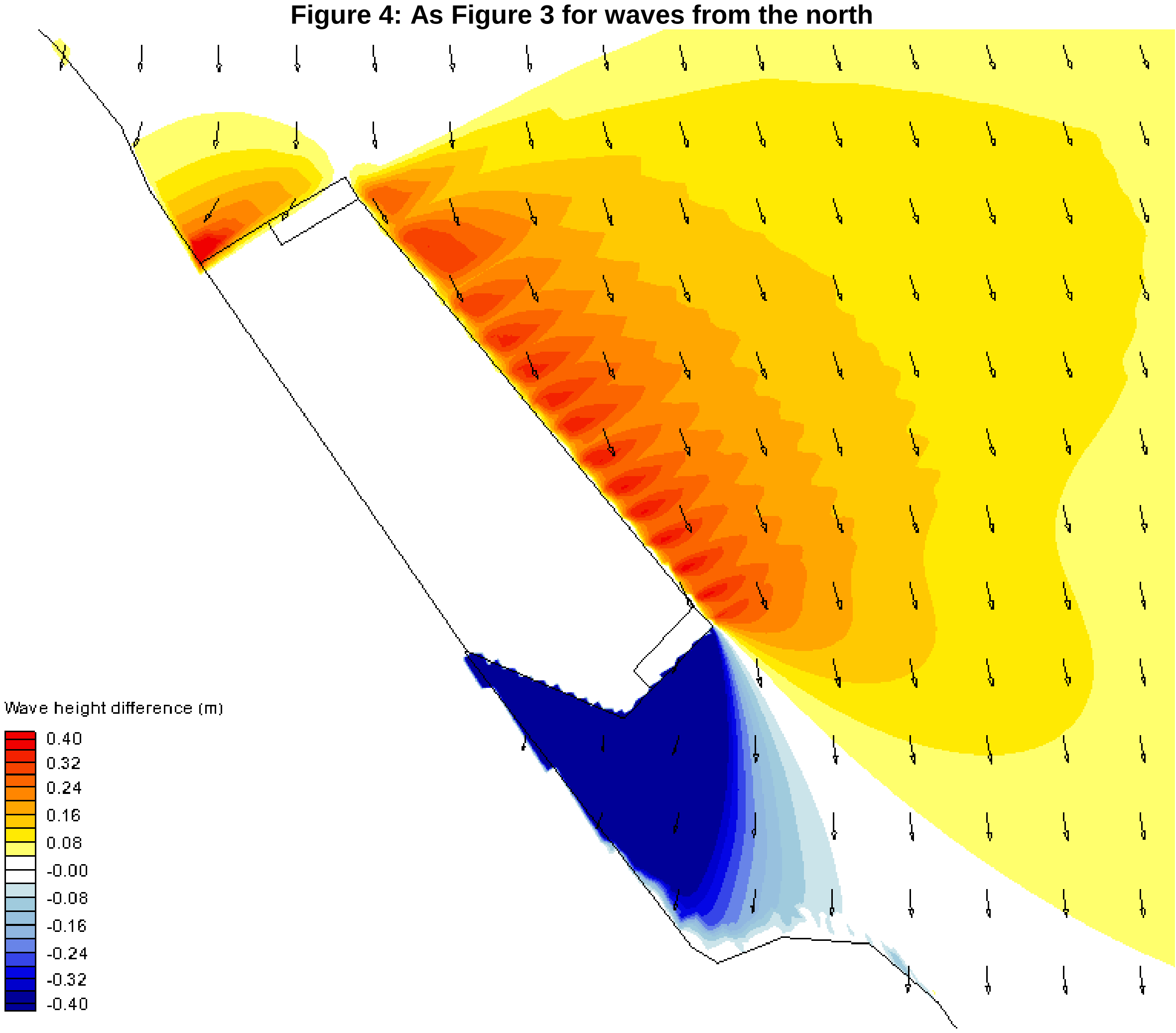
Figure 4: As Figure 3 for waves from the north



5.2 Effects on wave overtopping at sea defences (based on wave reflection modelling)

In order to gauge if there is a possible increase in flood risk at the adjacent sea defences due to the quay, the flood risk at the defences must first be assessed. The Neural Network Tool detailed in the EurOtop manual is used to parameterise the structure of the defence profile detailed above. Parameters used in the tool to achieve this are specified in Table 11. A joint probability 1:200-year water level of 5.66mOD (in 2114) and wave height of 1.62m is used. Calculations of wave overtopping rates for the worst case of direct wave attack (i.e. using an angle of 0˚) were calculated (though by their nature the waves reflected will be travelling to the coastline at an angle, we assume refraction effects leads to this direct attack in order to be conservative).

The 1:200-year joint probability event in 2114 has been simulated in order to show possible increases in wave overtopping due to wave reflection. We understand that the SOP of the defence is lower than this but that the EA have plans to raise the SOP to such a level in the future.

Table 11: Neural Network Tool set-up for South Killingholme defences

Neural Network Parameter	Value
1. Direction of wave attack (˚)	0
2. Water depth in front of structure (m)	5.66 - 2.5 = 3.16
3. Wave height at toe (m)	1.62
4. Wave period Tm (s)	4.5
5. Water depth at toe (m)	(same as 2.)
6. Toe width (m)	0
7. Roughness	1
8. Downward slope	3
9. Upward slope	0
10. Crest freeboard (m)	6.2 – 5.66 = 0.54
11. Berm width (m)	0
12. Water depth on berm (m)	0
13. Slope of berm	0
14. Armour crest freeboard (m)	(same as 10.)
15. Crest width (m)	0

Table 12 shows the wave overtopping rates calculated at the sea defence for the 1:200 year event in 2114. The calculations show that without the development the estimated overtopping at the sea defence will be severe. Overtopping rates for 10cm and 20cm increases in wave heights are included. The calculations show that for a 10cm increase the overtopping rate increases by 9%, 19% for a 20cm increase, and 37% for a 40cm increase. It should be noted that this is very much a worst case scenario and due to several factors[10] is unlikely to be the case. Moreover the areas at which this increase will occur will be very localised, constrained to the few locations where reflected waves from the quay may superimpose upon waves propagating directly from offshore.

Table 12: Wave overtopping rates at South Killingholme sea defence for 1:200-year event in 2114

Wave height (m)	Increase in wave height from 1:200-year joint probability wave (m)	Deterministic overtopping rate (Q68%) (l/s/m)
1.62		580.6
1.72	0.1	630.7
1.82	0.2	690.1
2.02	0.4	793.5

[10] Increased accumulation at the foreshore; overestimation of reflection coefficient; assumption of direct attack of reflected waves; assumption that reflected waves will be in phase with propagating waves.

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Contract	Humber Estuary Quay Design Modelling
Client	Able UK Ltd.
Day, Date and Time	31st August 2011
Author	C Batstone
Checked By	J Hornsby (numerical check)
Reviewed By	K Keating
Distribution	R Cram (Able), D Stark (JBA Consulting)
Subject	Calculation Record (v7): Wave overtopping at AMEP quay assessment

The wave reflection modelling analysis was repeated for predicted sea levels 15 years from the construction of the quay in 2014. This horizon is an approximation of the lifetime of the present sea defences[11]. In this scenario, due to the lower water levels than those predicted for 2114, depth-limitation of waves dominates to the south of the quay. This prevents any increase in wave heights due to reflection at the sea defence and there is consequently no increase in overtopping risk. Due to the steeper gradient of the foreshore to the north of the quay depth-limitation effects are not as great. Reflection can still add up to 40cm on wave heights (irrespective of the water level in 2029 being lower than in 2114) where the quay side meets the sea defence. These increases decay along the defence to the north of the quay, becoming negligible after approximately 200m. Table 13 shows the calculated wave overtopping rate in 2029 for a 1:200-year joint probability water level/wave height event. Also shown are the rates for increases in the wave height which may occur due to added wave energy from reflection off the quay. As can be seen, flood risk due to wave overtopping can increase due to larger waves. The increase of 0.4m is predicted to occur within 30m of the edge of the quay. The increase of 0.2m is predicted to occur within 90m of the quay, and the increase of 10cm is predicted to occur within 200m of the northern quay edge.

Table 13: As for Table 12 in 2029

Wave height (m)	Increase in wave height from 1:200-year joint probability wave (m)	Deterministic overtopping rate (Q68%) (l/s/m)
1.47		27.7
1.57	0.1	38.4
1.67	0.2	51.6
1.87	0.4	80.4

The Humber Strategy document[11] details a programme of works for each flood cell within the Estuary, for the subsequent 25 years. The effects of the quay on wave overtopping has therefore been examined for 2033, which represents the end of the current Humber Estuary Strategy period. Water levels are predicted to be 4cm higher in 2033 than 2029, leading to larger wave overtopping rates. Table 14 shows the wave overtopping rates at the defences for the most severe 1:200-year water level/wave height joint probability combination. The table includes the increases due to larger wave heights to the north of the quay due to wave reflection. Without the quay the overtopping rate is 30.8l/s/m; with the quay the overtopping rate immediately adjacent to the quay to the north is 88.9l/s/m, reducing farther to the north where wave reflection effects are less.

Table 14: As for Table 12 in 2033

Wave height (m)	Increase in wave height from 1:200-year joint probability wave (m)	Deterministic overtopping rate (Q68%) (l/s/m)
1.47		30.8
1.57	0.1	42.3
1.67	0.2	56.3
1.87	0.4	88.9

[11] Environment Agency (2008) Humber Flood Risk Management Strategy: Planning for rising tides. Environment Agency, Leeds

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A mitigation strategy for reducing the increased overtopping rate due to the quay is to place rock armour in front of the wall on the slope of the defence. This rock armour layer will cause significant dissipation of wave energy and reduce the overtopping rates during extreme events. The effect of a layer of rock armour was incorporated into the calculations of wave overtopping by adjusting the Neural Network tool roughness parameter suitably, informed by EurOtop manual[1] guidance for roughness values for rock armour. Table 15 shows the overtopping rates in 2033 for the defences with rock armour. As can be seen, the rock armour leads to significant wave dissipation. The wave overtopping rate for the most severe wave height due to wave reflection (19.7l/s/m) is lower than that experienced by the unmodified defences without the quay present (30.8l/s/m). The rock armour therefore appears to provide adequate mitigation for the effects of the quay on wave overtopping of the defences.

Table 15: As for Table 12 in 2033 for defences with rock armour

Wave height (m)	**Increase in wave height from 1:200-year joint probability wave (m)**	**Deterministic overtopping rate (Q68%) (l/s/m)**
1.47		6.8
1.57	0.1	9.3
1.67	0.2	12.5
1.87	0.4	19.7

Able UK have suggested upgrading the defences impacted by the quay in 2033 to limit *mean* (i.e. a value less than the Q68% shown in the tables) overtopping to 2l/s/m for a 1:200-year event. In order to do this the crest level of the wall could be raised in addition to putting rock armour in front of the sea wall. Table 16 reports the mean overtopping rates calculated for a 1:200-year event in 2033 at the defences with rock armour in place. With no quay the defence crest level needs to be raised by 25cm to bring the overtopping rate down below 2l/s/m. Where wave reflection due to the quay leads to a 10cm increase in wave height the crest level needs to be raised by 35cm. For a 20cm increase in wave height, a 50cm increase in crest level is required. Immediately next to the quay where an increase of 40cm in wave height is predicted the crest level needs to be raised by 70cm in order to reduce overtopping to below 2l/s/m.

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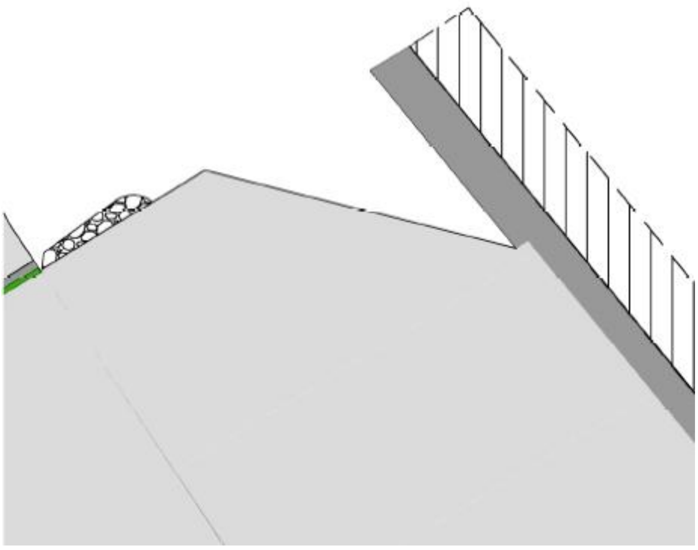
Table 16: Mean overtopping rates for 1:200-year event in 2033 for defences with rock armour

Wave height (m)	Increase in wave height from 1:200-year joint probability wave (m)	Crest level of sea defences (mOD)	Increase in crest level (m)	Mean overtopping rate (l/s/m)
1.47	0	6.20	0	3.8
1.47	0	6.45	0.25	1.7
1.57	0.1	6.20	0	5.2
1.57	0.1	6.55	0.35	1.8
1.67	0.2	6.20	0	6.7
1.67	0.2	6.70	0.50	1.7
1.87	0.4	6.20	0	10.5
1.87	0.4	6.90	0.70	1.8

5.3 Mitigation of reflected waves

Able have proposed changes to the northern end of the quay for mitigation of the predicted impacts on hydrodynamic and sedimentary processes. These include the design of a chamfer at the northernmost corner with a suspended deck attached (Figure 5). The rubble mound slope along the quay wall extending to the defence line is proposed to be assigned a gradient of 1:3.

Figure 5: North end of quay mitigation design



This redesign of the northern end of the quay will affect the wave reflection impacts highlighted above. Wave reflection modelling is performed again for a 1:200-year event in 2033 for waves travelling directly south (i.e. the direction leading to the most significant reflection impacts). The reflection coefficient for a 1:3 gradient rubble mound slope is 0.3[12]. Figure 6 shows the predicted increase in wave height for a 1:200-year event in 2033 due to the quay with the mitigation design. The chamfer leads to a significant decrease in reflected wave energy directed towards the coastal defences. This energy is reflected back into the estuary and dissipates within 200m. The suspended deck is not included in the simulation; the piles of the deck will act to dissipate wave energy in this area further. The wave energy reflected towards the defences is reduced further by the reduced gradient of the rubble mound on the side of the quay. The increase in wave height at the coastal defences adjacent to the quay is 25cm, which decreases to zero within a distance of 60m along the defences. Following on from the results presented in Table 16, calculations estimate that rock armour placed on the slope of the defences accompanied by an increase in the crest level by 50cm will limit the mean overtopping rate to 1.9l/s/m where the increase in wave height is 25cm. At the limit of the quay's impact 60m away, the defences require rock armour and an increase in the crest level of 25cm in order to limit the mean overtopping rate to 1.7l/s/m (with no modification the mean overtopping rate is 3.8l/s/m here).

Another method for reducing the wave overtopping at the sea defences is to reduce incident wave energy by placing more rock armour in front of the defences. Extending the rock armour out farther from the defence line will have this effect. In order to calculate the mean overtopping experienced at the defence for varying configurations of rock armour, the EurOtop method of PC Overtopping was used. This method allows for a more accurate specification of the exact dimensions of a defence. The mean overtopping rate specifying a defence with a 1 in 3 slope with a complete rock armour surface (i.e. up to the defence crest level of 6.2mOD), which extends out from the defence line by 11.1m is 3.6l/s/m. For a 1 in 3⅓ slope that extends 12.3m out, the mean overtopping rate is 1.9l/s/m. Therefore this latter scenario reduces overtopping to the north of the quay in 2033 for a 1 in 200-year wave height/water level event with the quay in place to less than the 2l/s/m specification.

12 Thompson, E. F., Chen, H. S., and Hadley, L. L. (1996). "Validation of numerical model for wind waves and swell in harbors," Journal of Waterway, Port, Coastal, and Ocean Engineering 122(5), 245-257

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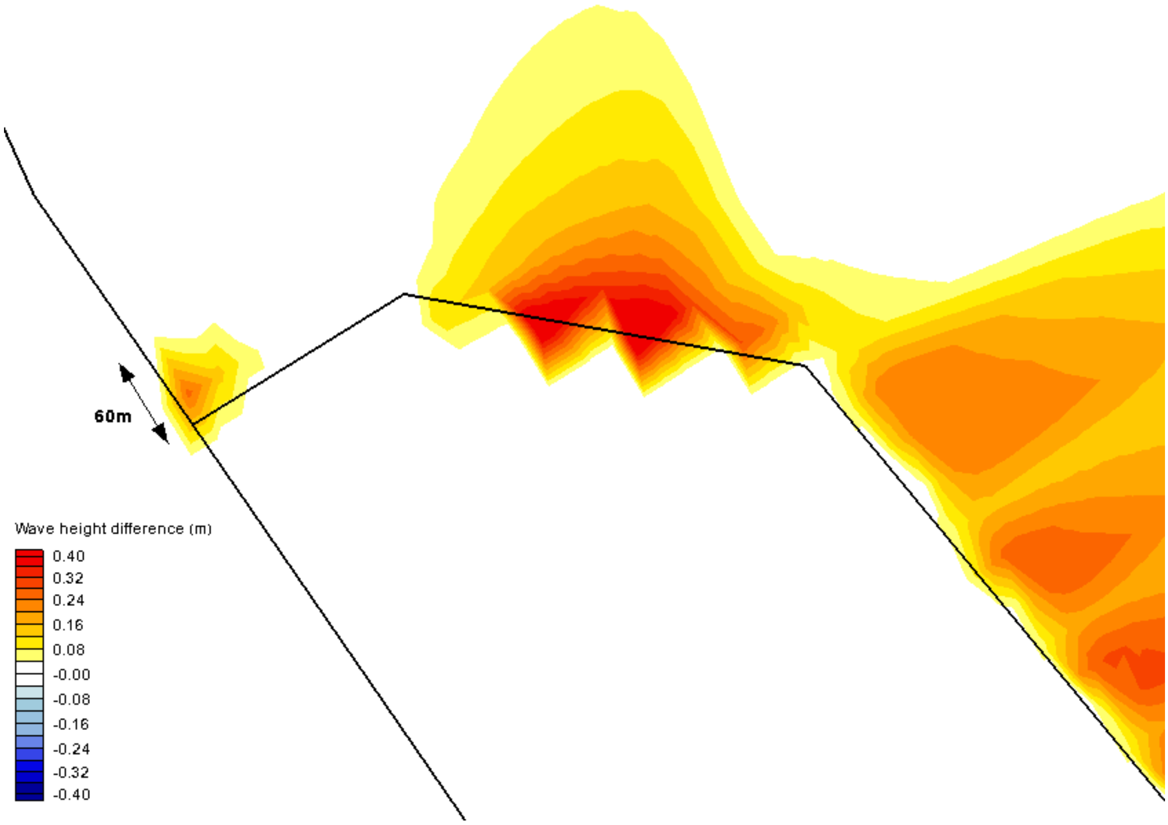
Figure 6: Increased wave heights for a 1:200-year event in 2033 due to the quay with mitigation design



6 SUMMARY OF IMPACTS

The predictions of wave overtopping at the quay show that the current design elevation along the frontage (+10 mCD) will limit overtopping to below 10 l/s/m in 2114 (the 100-year life time of the quay) for the worst case 1:2-year water level/wave height event. This overtopping rate is the EurOtop manual (Pullen et al., 2007) suggested upper limit that can be tolerated by 'appropriately trained and prepared staff, who are expecting adverse conditions' (Table 6). The design of the quay frontage includes a ramp with a 1:100 gradient for 28m away from the frontage. This ramp is likely to lead to the vast majority of overtopped water draining back into the estuary, therefore acting to mitigate flood risk towards the shoreline.

The quay elevation is sufficient to limit wave overtopping to below the 200 l/s/m 'structural damage' limit (Table 8) for a 1:200-year water level/wave height event in 2114. A univariate analysis of water levels indicates that during a 1:200-year event in 2114 part of the frontage is likely to be submerged. This is not a concern with regard to meeting the overtopping “structural damage” criterion but may be a consideration for the wider Flood Risk Assessment for the development.

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The breakwaters to the north and south of the quay appear to provide far greater protection on the quay against wave overtopping risk than at the frontage.

In the short term (15 years after quay construction) it is estimated that wave reflection from the quay walls will increase the overtopping risk along the sea defences to the north of the quay for approximately 200m (the 30m closest to the quay edge being most susceptible). There will be no increase along the sea defences to the south of the quay due to greater depth-limitation effects determined by the shallower gradient foreshore. A mitigation strategy for reducing the increased overtopping rate to the north due to the quay is to place rock armour in front of the wall on the slope of the defence. The rock armour leads to significant wave dissipation. The wave overtopping rate for the most severe wave height due to wave reflection is lower than that experienced by the unmodified defences without the quay present in 2033 (at the end of the 25-year Humber Strategy). The rock armour therefore appears to provide adequate mitigation for the effects of the quay on wave overtopping of the defences. In order to limit mean overtopping to below 2l/s/m the crest height of the defences nearest to the quay to the north could be raised by 70cm (in addition to rock armour being placed on the defence slope). This level reduces farther to the north where wave reflection impacts are less.

The mitigation design (chamfer and 1:3 rubble slope) reduces the impact of the quay in terms of wave reflection. For a 1:200-year event in 2033 the increase in wave height at the coastal defences adjacent to the quay is 25cm, which decreases to zero within a distance of 60m along the defences. Calculations estimate that rock armour placed on the slope of the defences accompanied by an increase in the crest level by 50cm will limit the mean overtopping rate to 1.9l/s/m where the increase in wave height is 25cm. At the limit of the quay's impact 60m away, the defences require rock armour and an increase in the crest level of 25cm in order to limit the mean overtopping rate to 1.7l/s/m (with no modification the mean overtopping rate is 3.8l/s/m here). Another method for reducing the wave overtopping at the sea defences is to reduce incident wave energy by placing more rock armour in front of the defences. For a 1 in 3⅓ slope, with rock armour placed from the defence crest level and extending 12.3m from the defence line, the mean overtopping rate is 1.9l/s/m. This scenario reduces overtopping to the north of the quay in 2033 for a 1 in 200-year wave height/water level event with the quay in place to less than the 2l/s/m specification.

In the longer term water levels are predicted to rise, reducing depth-limitation effects, leading to the potential for increased wave overtopping risk at the southern defences. However, in these potentially vulnerable areas to the south and north of the quay, increased sedimentation is predicted to occur[13]. Sedimentation due to the reduced flow regime at the foreshore adjacent to the quay is likely to lead to an elevation increase of about 0.6 to 0.9m. Rates of accumulation could be of the order 0.1m per year, reducing for higher inter-tidal areas. This suggests that reduction in flood risk due to increased depth-limitation effects will be significant within 20 years of the quay construction. It is therefore likely that, in the long term, any potential increase in flood risk due to wave reflection from the quay is more than offset by this increase in bed elevation around the affected areas. It will be important to monitor increased sedimentation to ensure this is the case. It is recommended that a review point several years following the quay development should be agreed with the Environment Agency.

7 CALCULATION LOCATIONS (SKIPTON NETWORK)

Location of wave overtopping calculation spreadsheet:

N:\2010\Projects\2010s4456 - Able UK Ltd - Humber Estuary Quay Design Modelling\Calculations\Wave overtopping\NN_overtopping_results.xls

Location of wave overtopping calculation Neural Network Tool input file:

N:\2010\Projects\2010s4456 - Able UK Ltd - Humber Estuary Quay Design Modelling\Calculations\Wave overtopping \NN_OVERTOPPING.inp

[13] JBA Consulting (2011) Review of the geomorphological dynamics of the Humber Estuary. Able UK. JBA Consulting

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Location of wave overtopping technical review (JH) file note:

N:\2010\Projects\2010s4456 - Able UK Ltd - Humber Estuary Quay Design Modelling\Project Management\Quality records\2010s4456 - Technical Review - Wave overtopping calculations.doc

Location of wave reflection model files:

N:\2010\Projects\2010s4456 - Able UK Ltd - Humber Estuary Quay Design Modelling\Calculations\Wave overtopping\wave_reflection_modelling

I. Breach Modelling

JBA Technical Note dated 4 August 2011: Subject: Tidal Breach Modelling and Hazard Assessment to Support FRA (v3).

Flood Depth Maps D1 - D10.

Flood Velocity Maps V1 - V10.

Flood Hazard Maps H1 - H10.

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TECHNICAL NOTE

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Contract	Able Marine Energy Park
Client	Able UK Ltd
Day, Date and Time	04/08/11
Author	K Smith
Review / Approval	Advice from K Frodsham and approval by K Keating
Subject	Tidal Breach Modelling and Hazard Assessment to Support FRA (v3)

1 INTRODUCTION

The purpose of this file note is to describe the methodology and results of tidal breach assessment completed as part of the Able Marine Energy Park (AMEP) Flood Risk Assessment (FRA) study being completed by JBA. It is expected that this note will form an appendix to the FRA.

The tidal breach modelling was completed to: **1)** provide data for an assessment as to whether the proposed site levels, which are raised above existing topography, have an adverse **impact on flood risk to the surrounding area** and **2)** check the speed and depth of inundation of the site during extreme events (to inform **residual risk management / emergency planning**). These two issues are important for FRA as a development should be safe for the occupants and not make flood risk worse to others.

Breaches during the following events are considered:

- 0.5% AEP event for present day conditions (5.18mAOD for year 2014) – for point 1) above
- 0.5% AEP event including 100 years of climate change (6.29mAOD) for point 1) and 2) - the latter being a worst case scenario and assuming 100 years of climate change

This criteria has been agreed with the Environment Agency (email from Clare Fravigar dated 12th April 2011). It is worth noting that there is an opportunity to shorten the end date of the run for the residual risk management assessment depending on the expected life of the buildings within the development. C Fravigar suggested that 60 to 75 years may be an alternative.

The TuFLOW model used was obtained from the Environment Agency (Northern Area Tidal Hazard Mapping Model, refer to letter from the Agency dated 31 March 2011). Some terminology used herein is taken from the Agency model (e.g. breach names). The figure below shows a schematic of the model. The development site is defined by the red line. The model does not assess the impact of overtopping of the tidal defences but assesses the impact of a breach only (no combined wave / still water overtopping and defence failure / breach model available). A brief synopsis of the model is given below.

Version v3 of this Technical Note was prepared in response to Environment Agency comments on breach modelling contained in their letters to Richard Cram of ABLE UK dated 22 June, 4 July and 14 July 2011. The associated revisions were carried out in close liaison with Clare Fravigar of the Environment Agency.

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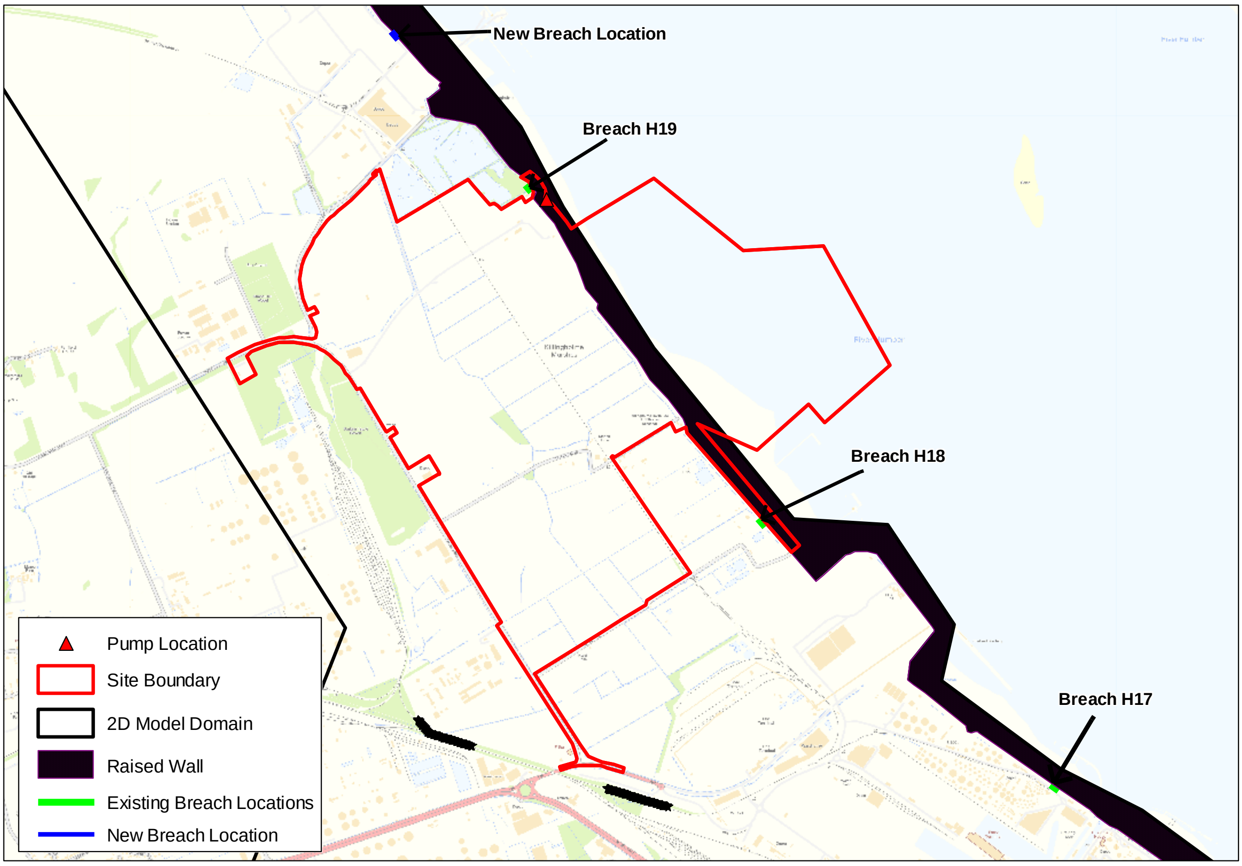
Figure 1: Basic Model Schematic



A preliminary run (future 0.5% AEP event, year 2115) was undertaken on the existing model to assess the suitability and stability. The mass balance error of the model is consistently above the normal acceptable threshold (= ±1%). This is likely to be caused due to a combination of cell size (20m) and breach width (50m), as the model struggles to compute the volume of water coming in and out of the model over a relatively small area (two/ three cells). Despite this, the model should provide a reasonable indication of flood risk from a breach to the site and surrounding area and therefore is fit for purpose for a FRA.

Other notes worthy of recording:

Model Cell Size – 20m – this was retained for all subsequent model runs. Agreed with C Fravigar from the EA as fit for purpose.

Model Start Time – as supplied was 110 hours. Following the hazard guidance[1] supplied by the EA, this has been changed to 138 hours for the initial run, as the guidance states that the breach should occur one hour prior to the peak of the surge (peak surge ~139 hours).

Model End Time – as supplied was 182 hours. This has been changed to 210 hours for the initial run, to ensure the model runs for 72 hours, stated as the time taken to close an estuary breach as per EA hazard guidance.

Breach and Embankment Geometry - The model has three breach locations (H17-19) which have been modelled with a Head-Time (HT) boundary. The HT boundary applies the tidal series

[1] Environment Agency, Anglian Region North Area, September 2009. Requirements for Hazard Mapping, Version 5.

and assumes the breach occurs at the start of the model run. Each breach is run separately and for the purpose of the initial run H18 has been used. Breach H18 has a breach width of 50m and an invert level of ~3m AOD (floodplain level approx ~2.8m AOD). The model represents the coastal embankment with a raised wall, set above the tidal level. As a result, no spilling / overtopping occur along the un-breached embankments - the model as provided represents inflow and outflow through the breach only.

Tidal Boundaries – The existing model has three separate tidal curves for the three breach locations. There is very little difference between the three curves.

Model Run Time – 2.4 hours.

Model domain – Extensive and retained as provided in the original EA model for all work completed.

2 BREACH ASSESSMENT METHOD

Two breaches have been assessed for the breach assessment. These are located to the north and south of the site. The existing breach H18 is used along with a new breach location 1km north of breach H19 as shown in Figure 1. This new location was chosen as H19 was considered too close to the development (to model). The two breaches are modelled in separate model simulations as this should provide the worst case adverse impact.

In order to assess the impact of the site, the present day (year 2014) 0.5% AEP event and the future (with climate change allowance) 0.5% AEP event has been investigated with and without the development in place.

The following points are provided below to document detail of the methodology:

Ground Levels at the Site – In order to represent the raised ground levels at the site, a new elevation layer has been for the “developed” model simulations. These elevations have been taken from the drawing AME - 04001 D Finished Ground Levels.dwg - revision D (14/09/10) as contour lines and imported into MapInfo. A detailed methodology of how the raised ground levels have been incorporated into the model is included at the back of this note (purely to act as a record of the method used). A check has been made to ensure the final revised model elevations represent the raised ground level appropriately.

Main Tidal Events – The 0.5% AEP present day (year 2014) event and the 0.5% AEP plus Climate Change event (as stated above) have been used. The existing tidal curves (supplied with the model) are used based on the 2006 water levels derived as part of the Humber Strategy study. This has been discussed with the Agency, who do not want us to use the recently published Coastal Extremes guidance, as, in their view, the guidance is only applicable up to Immingham (south of the development site). Water levels are only applicable up to Immingham. JBA do not agree with the EA conclusion on the use of this data but will use the previous analysis first in order to avoid disagreement and will, hopefully, not need to repeat the analysis with the newer data. It should be noted that the existing 2006 tidal curve has been updated with an additional 8 years of climate change, in order to run the present day (taken to be year 2014) model simulations. In reality the exact choice of “present day” makes little difference.

New Buildings in the Floodplain - It should be noted that the proposed buildings are not represented directly in the model and in reality floodwater will flow around the buildings. Therefore there may be localised variations in the depth and velocity (most probably the main feature) at buildings that is not represented by the modelling. Again, if this were important then additional modelling would be required. The need for this is dependant on the proposed emergency planning procedures for the development.

Internal Drainage Board (IDB) channels/ Pump at Tidal Outfall - The model is presently unable to investigate the impact of detailed changes to the local drainage system (meaning below surface

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systems and within small open channels / ditches). There are existing IDB channels that pass through the site and it is proposed to change the drainage path of the channels and add a pump at the tidal outfall with site development. Given the channel sizes and existing model cell size, it is not appropriate to include these features within the model. In any case, such small hydraulic features are unlikely to be important within the context of tidal breach modelling. The alternative approach of modelling the drainage network in 1D (ESTRY) is an option but has not been completed here. If it was thought necessary, which seems unlikely, more detailed modelling could be completed at a later date. For this, more detail regarding the channels capacity and typical flows would be needed.

Breach Geometry – The coastal floodplain is defended by extensive embankments. The existing defences, which are maintained by the Environment Agency, have a typical crest height of 6.2mAOD. This compares with the peak extreme sea levels examined (5.18mAOD for the 0.5% AEP present day and 6.29mAOD with climate change). The embankments near the development site typically have a reinforced / armoured front face and wave return wall on the crest. As the defences are aging, with the “harder” elements apparently retro-fitted, and the landward slope remains unreinforced it is considered appropriate to regard the structure as relatively “soft” in engineering terms. This influences the definition of breach characteristics (width and depth). The hazard guidance supplied suggests a breach width of 50m (earth embankment) and 20m (hard estuary embankment). JBA and the EA (C Fravigar) have agreed that a 50m breach width is appropriate given the definition of the model (cell size 20m), despite the hard nature of the front face of the defence. This will provide a conservative view.

H18 has been used as the breach south of the site and is described above. The second breach located to the north of the site has an invert level of 3.9m AOD. Both breach widths have been set at 50m, retained from the existing modelling. Following EA hazard guidance, the model will be run for 72 hours (time to breach closure).

General Overtopping of Defences (at un-breached locations) – 1) The model runs assessing the potential impact on flood risk to others has been set up to only include flood water inundating the site via the breaches, ignoring potential overtopping of the defences in the climate change run (perhaps based on the assumption that the Agency will take action to increase defence height). This is represented in TuFLOW using the original model set up as described in section 2. This provides relatively conservative results in terms of the impact of the development. 2) The residual risk simulation has been modelled using the 0.5% AEP plus climate change event, with the breaches as above (each breach simulation run separately), but also with general overtopping of the un-breached lengths of defence. This has been represented in the TuFLOW model, using a 2d_zln line, which has been set to a consistent defence height along the coastal frontage (6.2m AOD as per the drawing number AME-02045B), with the exception of the new quay which has been set at the proposed as built level (6.3m AOD). The elevation of the breaches (modelled in separate runs) has been lowered to the floodplain level, based on the elevation of the DTM. Again, this will provide a conservative assessment for residual risk assessment as the site would be inundated more quickly

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3 RESULTS

3.1 General Comments

The general results are presented in a suite of maps accompanying this file note, which includes depth, velocity and hazard maps for all runs completed. The colour scheme for each map has been developed using the colour schemes in the 'Requirements for Hazard Mapping v7' document[2] as supplied by the EA. Further information and discussion is presented in the following section. As would be expected given its size, the floodplain is not completely filled during the breach events examined (see Table 1).

Table 1 – Water Levels Adjacent to the Development for the 0.5% AEP Event

Event / Location of Interest	Estuary Peak Water Level (mAOD)	Floodplain Peak Level (mAOD)
Present day (2014) run, north of the development** (results in map D2 & D6 - Q200 Present Day Without Development Site Breach 2 Flood Depth.pdf & Q200 Present Day With Development Site Breach 2 Flood Depth.pdf)	5.18	3.8 vs 4.1m AOD (existing vs developed case) immediately north of the development, increasing to 4.9~5.0mAOD (same for existing and developed case) inland from the breach and to the north.
Present day run, south of the development^ (results in map D1 & D5 - Q200 Present Day Without Development Site Breach 1 Flood Depth.pdf & Q200 Present Day With Development Site Breach 1 Flood Depth.pdf)	5.18	4.2 vs 4.6mAOD (existing vs developed case) south of the development throughout the floodplain away from the breach.
Climate change run (CC – yr 2114), north of development** (results in map D4 & D8 - Q200 Present Day with 100yrs Climate Change Without Development Breach 2 Flood Depth.pdf & Q200 Present Day with 100yrs Climate Change With Development Breach 2 Flood Depth.pdf)	6.29	4.9 vs 5.1m AOD (existing vs developed case) immediately north of the development, increasing to 5.6mAOD (same for existing and developed case) inland from the breach and to the north.
Climate change run (CC – yr 2114), south of development^ (results in map D3 & D7 - Q200 Present Day with 100yrs Climate Change Without Development Breach 1 Flood Depth.pdf & Q200 Present Day with 100yrs Climate Change With Development Breach 1 Flood Depth.pdf)	6.29	5.5 vs 5.8mAOD (existing vs developed case) south of the development throughout the floodplain away from the breach.

** Results from the northern breach run (Breach 2). ^ Results from the southern breach run (Breach 1).

It should be noted that the floodplain levels in Table 1 above are based on the model runs completed without overtopping of any un-breached defence.

The general pattern of the results for the model runs (present day and future conditions) are a function of the floodplain geometry to the north and south of the site. The floodplain to the north is much more extensive and this acts to keep water levels lower following a breach in the defences. The invert of the northern breach is also higher, representing the more typical higher ground level elevation in the area, which will also contribute in terms of limited flood ingress.

[2] Requirements for Hazard Mapping V7. Environment Agency, Anglian Region, Northern Area.

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Client	Able UK Ltd
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Author	K Smith
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Subject	Tidal Breach Modelling and Hazard Assessment to Support FRA (v3)

Flood velocities outside the development footprint are very similar to the existing case. The only exception to this is immediately north of the development where, due to the obstruction introduced by land raising, peak velocities are reduced by of the order 1.5m/s for the present day 0.5% AEP simulation. It should be noted that velocity results appear to be subject to some instability issues and the results provided need to be read in this context (small and inconsistent variations in the results being ignored).

Table 2 below provides summary information regarding the depth and velocity in the development site boundary during present day and future scenario, both with and without the development in place. These values have been taken from the middle of the site at the building which has the lowest floor level (3.7m AOD), as shown with a red triangle on Figure 2.

Table 2 – Peak Depth and Velocity within the Development Site for the 0.5%AEP Event

Model Simulations	**Breach 1 (South of Development)**			**Breach 2 (North of Development)**		
	Maximum Water Level at Building (m AOD)	**Maximum Depth at Building (m)**	**Maximum Velocity at Building (m/s)**	**Maximum Water Level at Building (m AOD)**	**Maximum Depth at Building (m)**	**Maximum Velocity at Building (m/s)**
Present day (yr 2014) run without development	4.2	1.8	0.8	3.2	0.8	0.4
Present day run with development	4.4	0.9	0.3	3.7	0.2	0.1
CC scenario (yr 2114) without development	5.4	3.0	1.3	4.2	1.8	1.0
Future (yr 2114) CC with development	5.6	2.1	0.7	4.7	1.2	0.6

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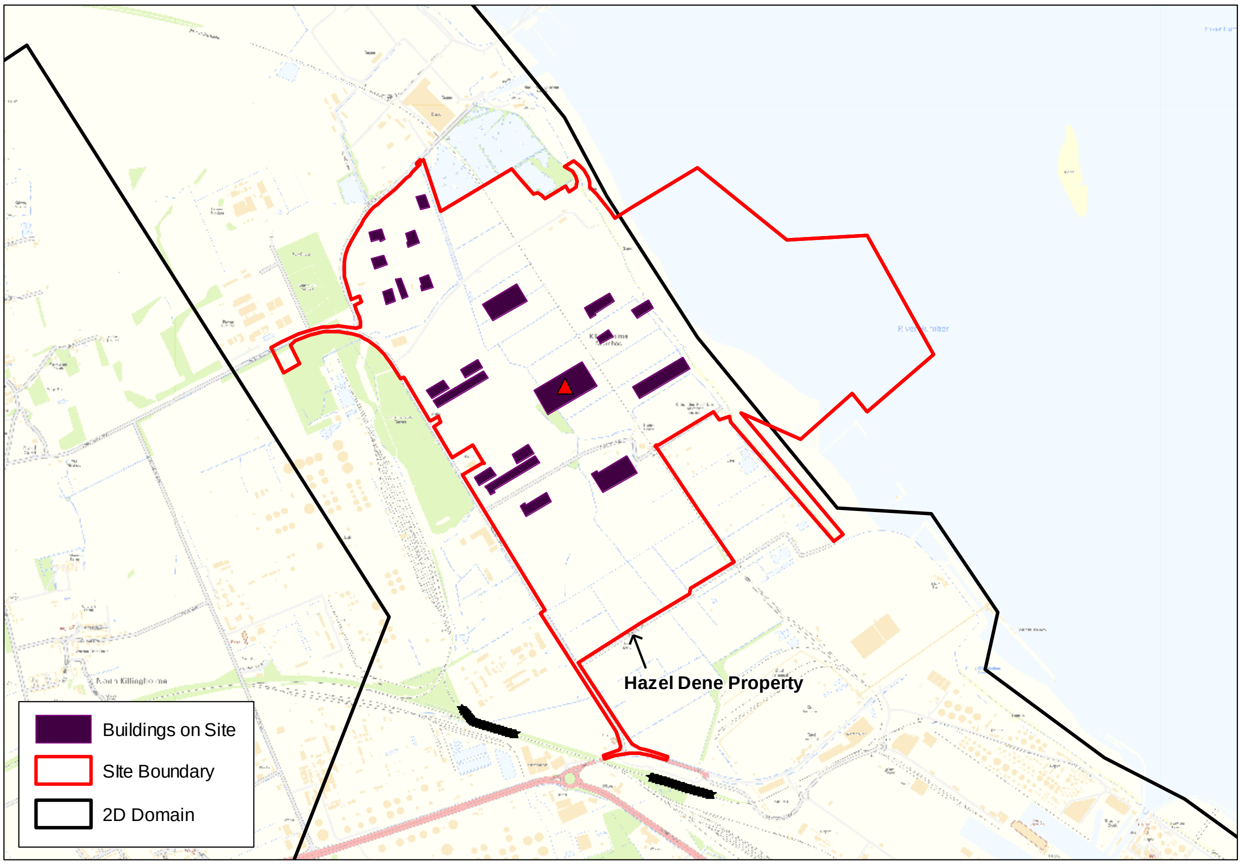
Figure 2 – Location of Buildings in the Development Site



3.2 Detailed Commentary: Breach 1 (South of the Development)

The present day (with and without the development site) flood extents produced with a breach south of the site (Breach 1) are shown in maps D1 and D5 (accompanying this note). The extents and depths within the development site are greater than that produced from a breach north of the site (Breach 2) – see Table 2 and maps. With the development in place, the flood extent and flood depth is increased (compared to depths without the development site in place) at the coal and ore terminal to the south of the site and the residential property (Hazel Dene) located on Marsh Lane (at the south extent on the property (see Figure 2 above and attached maps). This is caused as less water is able to pass through the development site and therefore the depth of water south of the development has increased by approx. 350mm during the extreme events (both 0.5% and 0.5%+CC simulations) examined. The speed of inundation to the property (Hazel Dene) at Marsh Lane is fast (within 15mins of the breach occurring). However this is the case with and without the development in place. The development site does not increase the onset of flooding to the property. The maximum depth (estimated from residual run) predicted at Hazel Dene is approximately 2.7m. This property is a 3-storey accommodation and therefore safe refuge would be available on the second floor above flood levels. In addition to this, there are a number of industrial buildings located on the western side of Rosper Road, at the junction with Marsh Lane that flood with the development site in place. With the development site in place, these flood to a depth of 0 – 0.25m in the 0.5% AEP event and 0.25 – 0.5m in the 0.5% AEP with climate change allowance.

Floodwater to the north of the development site inundates a number of buildings around the depot near North Killingholme Haven. These properties flood with and without the development site in place but flood depths are shown to be slightly lower with the development in place (by approximately 40mm)

The pattern of peak flood velocity remains largely unchanged outside the developed area. Flood velocity north of the site is very low. Velocities south of the site are dominated by the placement of the breach, with the development itself having no apparent impact, within the context of limitations of the modelling techniques used.

3.3 Detailed Commentary: Breach 2 (North of the Site)

Flooding from Breach 2 inundates less of the development site than Breach 1 and extends further south of the site, as shown in map D2 and D6 (accompanying this note) highlighting the present day flood extent with and without the development site in place. With the development in place, the pattern of flooding through the site is changed, as flood water initially backs up against the now higher land, and then follows the lower lying contours through the heart of the site. It should be noted that the ditch itself has not been represented in the model.

Flooding to the north of the site remains largely unchanged in extent, but flood levels increase locally to the development by up to 300mm. This diminishes to no change nearer the breach location. Refer to Table 1.

As noted above, peak flood velocities reduce by 1.5m/s north of the site, in the low lying wetland area and diminishing to no change toward the breach location and beyond.

3.4 Detailed Commentary: Residual Risk to the Development Site incl. Flood Evacuation Times

Residual risk has been assessed based on the 0.5% AEP event plus 100 years of sea level rise due to climate change. This run included allowing for spilling over all the flood defences (refer to section 2).

The results from the residual runs are presented as depth and velocity animations (attached avi files) and in the accompanying maps (D9 and D10). The residual maps produced (which includes overtopping) remain focused on the development site and are therefore at the same map scale as the 0.5% AEP with climate change allowance runs. Breach 1 (southern breach) dominates and produces the greater flood risk to the site. The clock (located in the top right hand corner of the animation) start is set at 5 days and 18hrs, a feature of the model inherited from the Agency. The animation is presented in 15 minute intervals.

Breach 1 (south of the development site) Animation

The animation highlights that floodwater quickly inundates the site: within half an hour of the breach occurring floodwater reaches the first building. Flood depth also increases quickly and increases from 0 to 1m at the first building within the 15 minute timestep. The animation also shows that floodwater crosses the whole of the site in 1.5 hours.

Flood velocity peaks at around 0.75m/s in the lower lying parts of the site, but it should be noted that local variations in this pattern should be expected due to the influence of the buildings.

Breach 2 (north of the development site) Animation

The extent of flooding is less with a breach north of the site. Floodwater inundates the first building within the site within 45 minutes of the breach and is slower to cross the site than breach 1 taking approximately 2 hours to cross the site. Flood depth across the site is also lower with a breach north of the site, at a maximum of ~1.6m. Flood velocity for breach 2 remains similar to breach 1 at around 0.75m/s in the lower lying parts of the site.

These results will be important when considering the flood evacuation measures of the site.

4 ADDITIONAL NOTES

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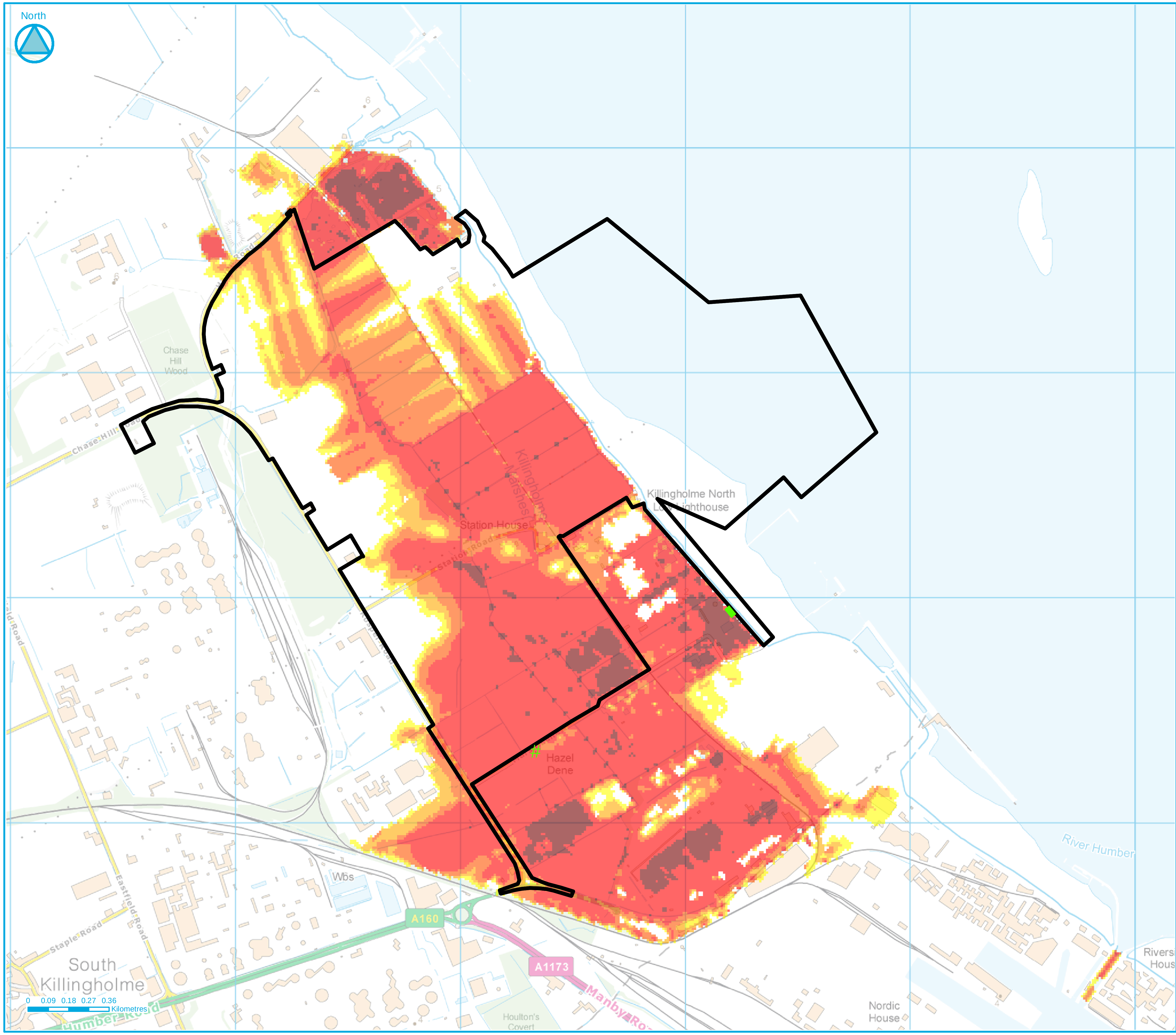
Methodology - Raised Elevation at Development Site.

The raised developed site has been added to the model using the following methodology:

- The proposed elevations for the site have been extracted from the developed ground levels drawing (AME - 04001 D Finished Ground Levels.dwg - revision D (14/09/10)) as contour lines and imported into MapInfo.
- The contour lines (polylines) were changed to points with 2m spacing, in order to interpolate an elevation grid using triangulation with smoothing.
- The grid created from the MapInfo triangulation with smoothing method was defined at a 1m cell size.
- The resultant grid was checked to ensure the elevation at points were correct and the interpolation between points was realistic. The grid was trimmed around the site boundary, as the triangulation method caused some triangulation outside the site. This ensures that the model elevation is raised within the site boundary only. The trimmed grid is saved in the following location: N:\2010\Projects\2010s4400 - AMEP Tidal Breach Modelling (Warr office)\Graphical\MapInfo\Tab\Raised Site Grids.
- A new version of the existing Zpts (used to define the elevation on the DTM) was saved (2d_zpt_developed_site.MID) and the points inspected (Grid Manager/Analysis/Point Inspection) using the new grid (developed above). This created a large number of null values (all zpts outside the grid), which were deleted leaving the Zpts covering the developed site only. The updated zpts layer was added to model as an additional layer.



Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Breach Assessment.

Q200 Present Day Flood Depth & Extent without Development Site (Breach 1)

Drawn By:	Kathryn Smith	**Scale:** 1:16,500	Original @ A3
Checked By:	David Stark		
Date:	August 2011		
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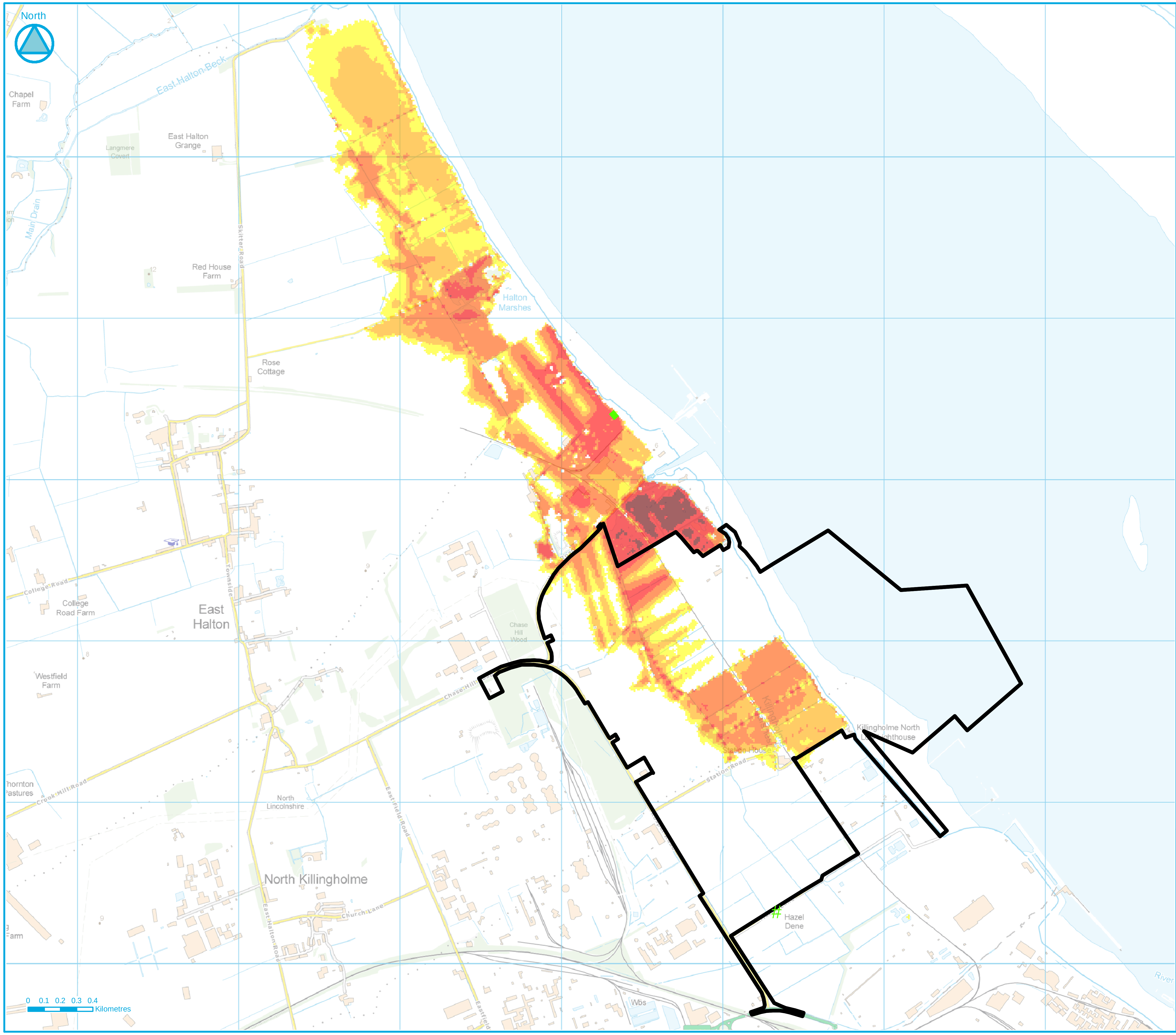

Legend

\# Hazel Dene Property

Breach 2 Location

Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Drawn By:	Kathryn Smith	Scale:	1:23,000
Checked By:	David Stark		
Date:	August 2011		Original @ A3
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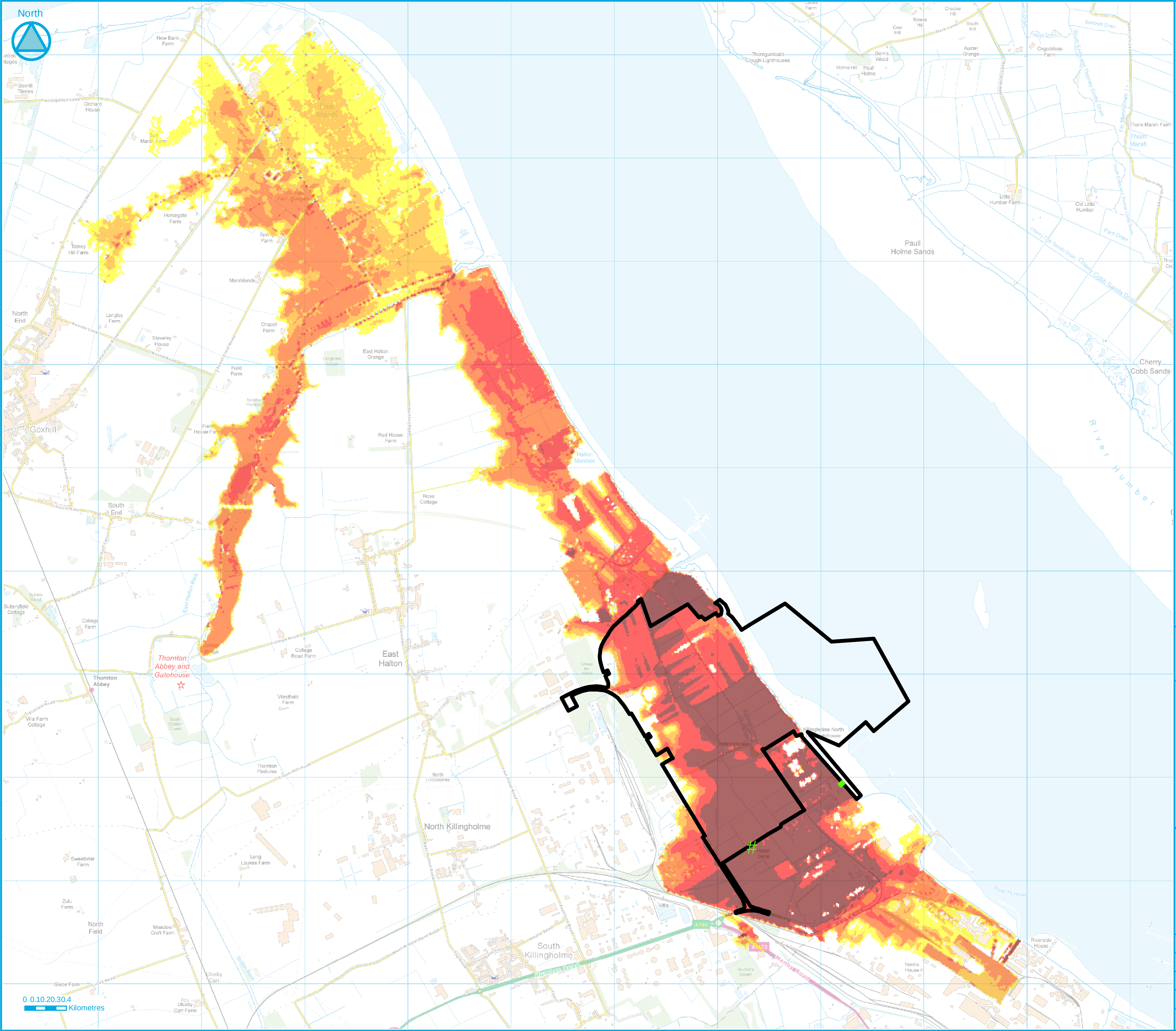

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 Present Day with 100 Years of Climate Change Flood Depth & Extent without Development Site (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:36,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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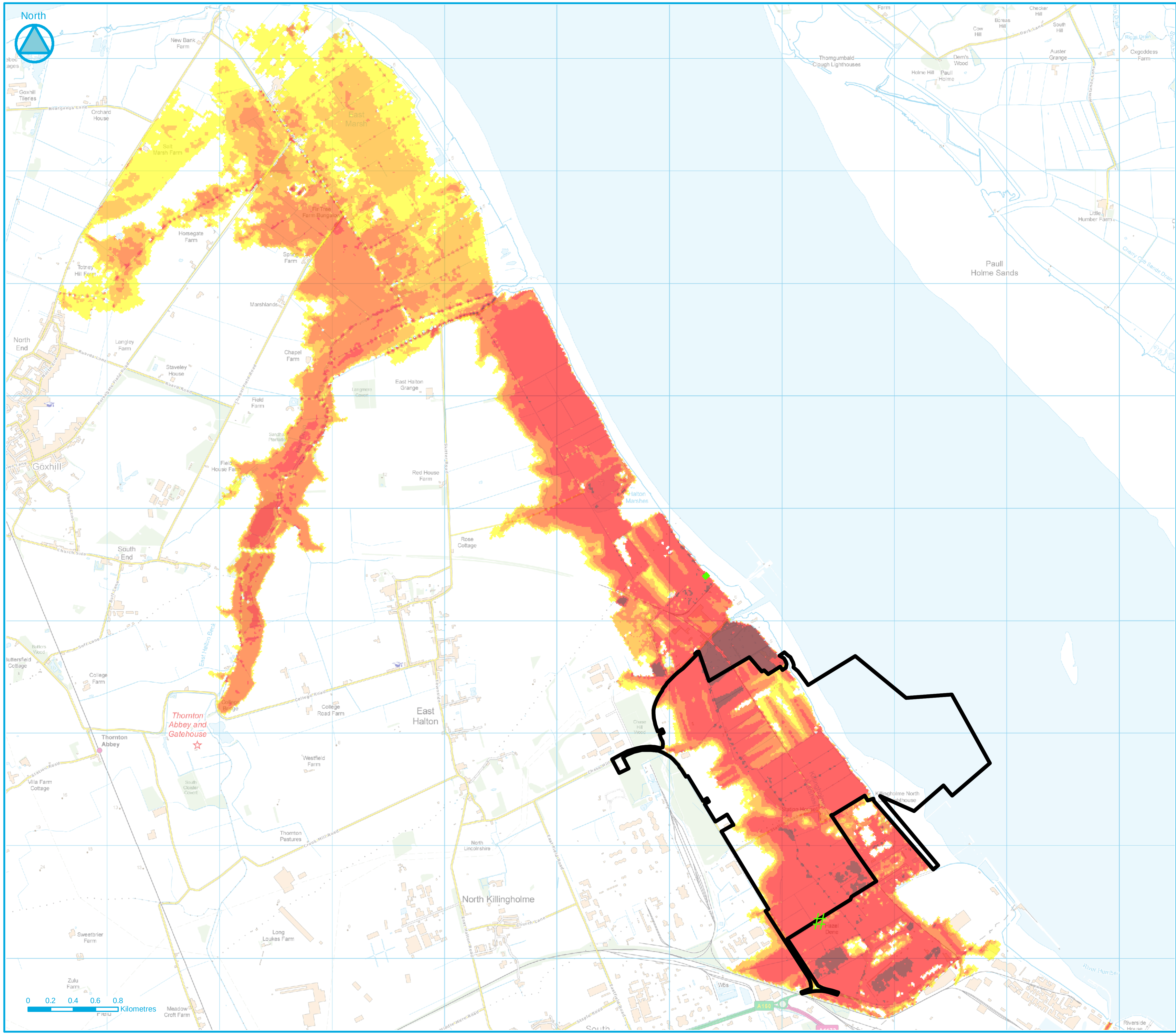

Legend

Hazel Dene Property

Breach 2 Location

Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 Present Day with 100yrs Climate Change Flood Depth & Extent without Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:33,000
Checked By:	David Stark	
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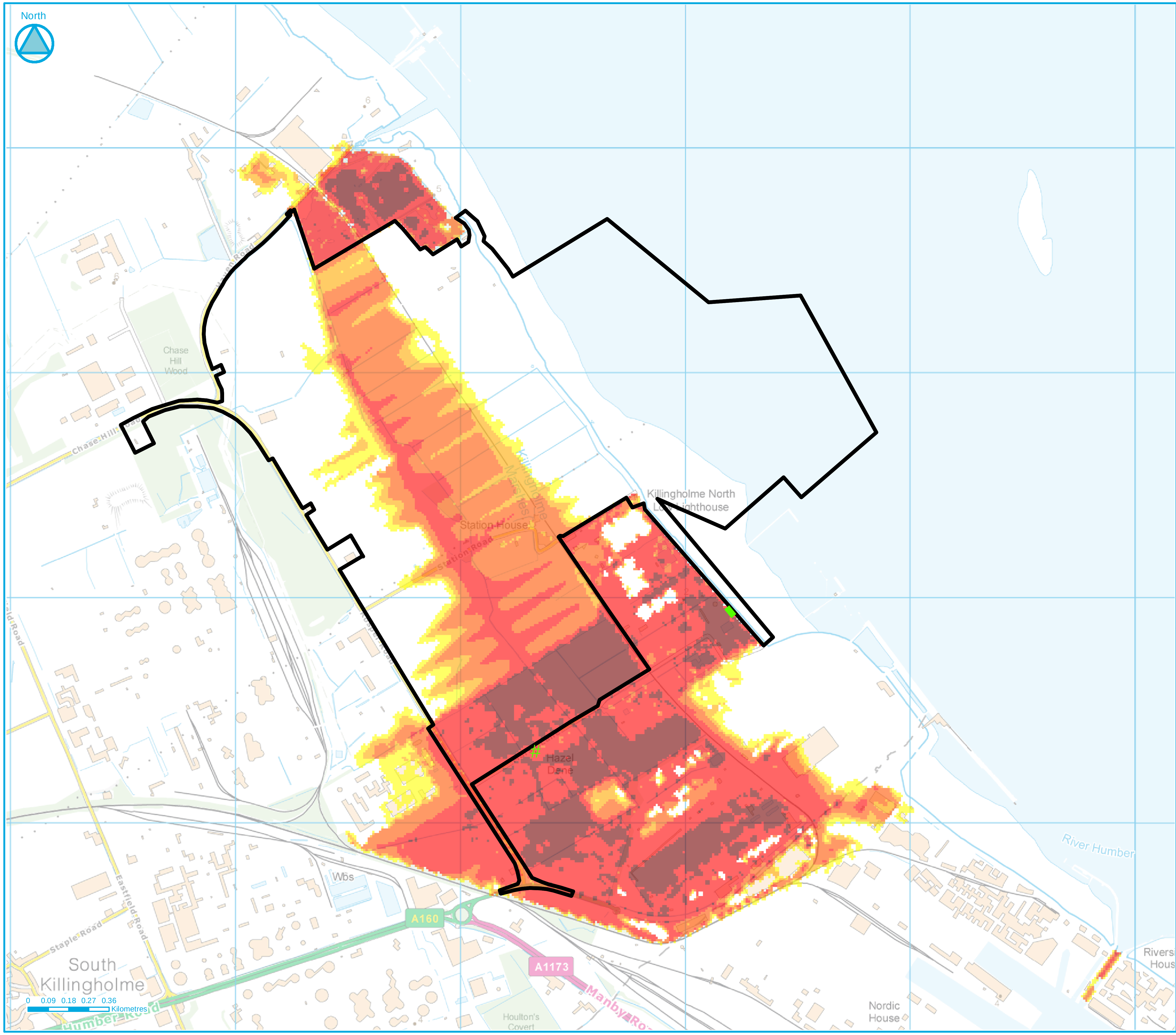

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 Present Day Flood Depth & Extent with Development Site (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:16,500
Checked By:	David Stark	
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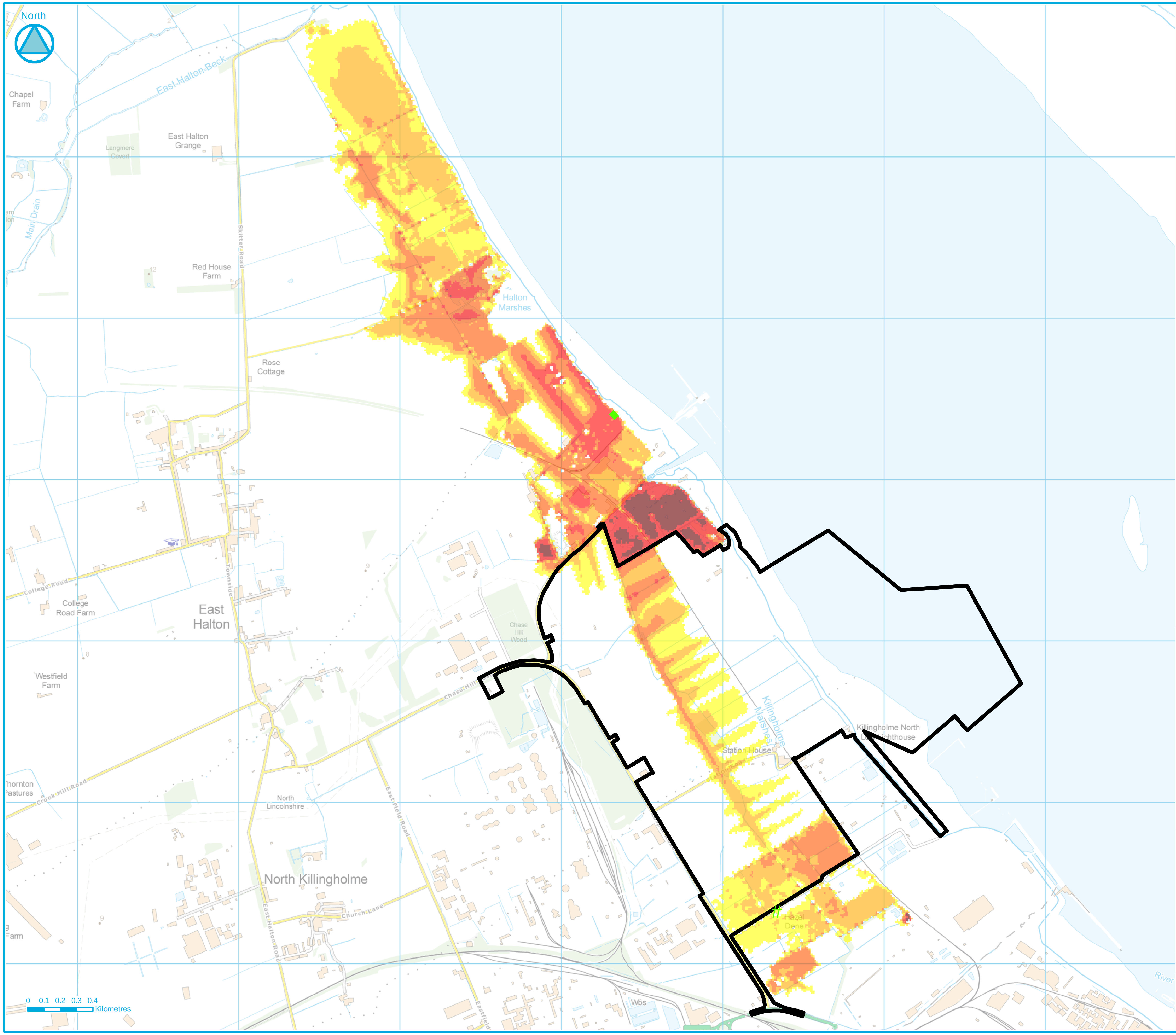

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 Present Day Flood Depth & Extent with Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:23,000
Checked By:	David Stark	
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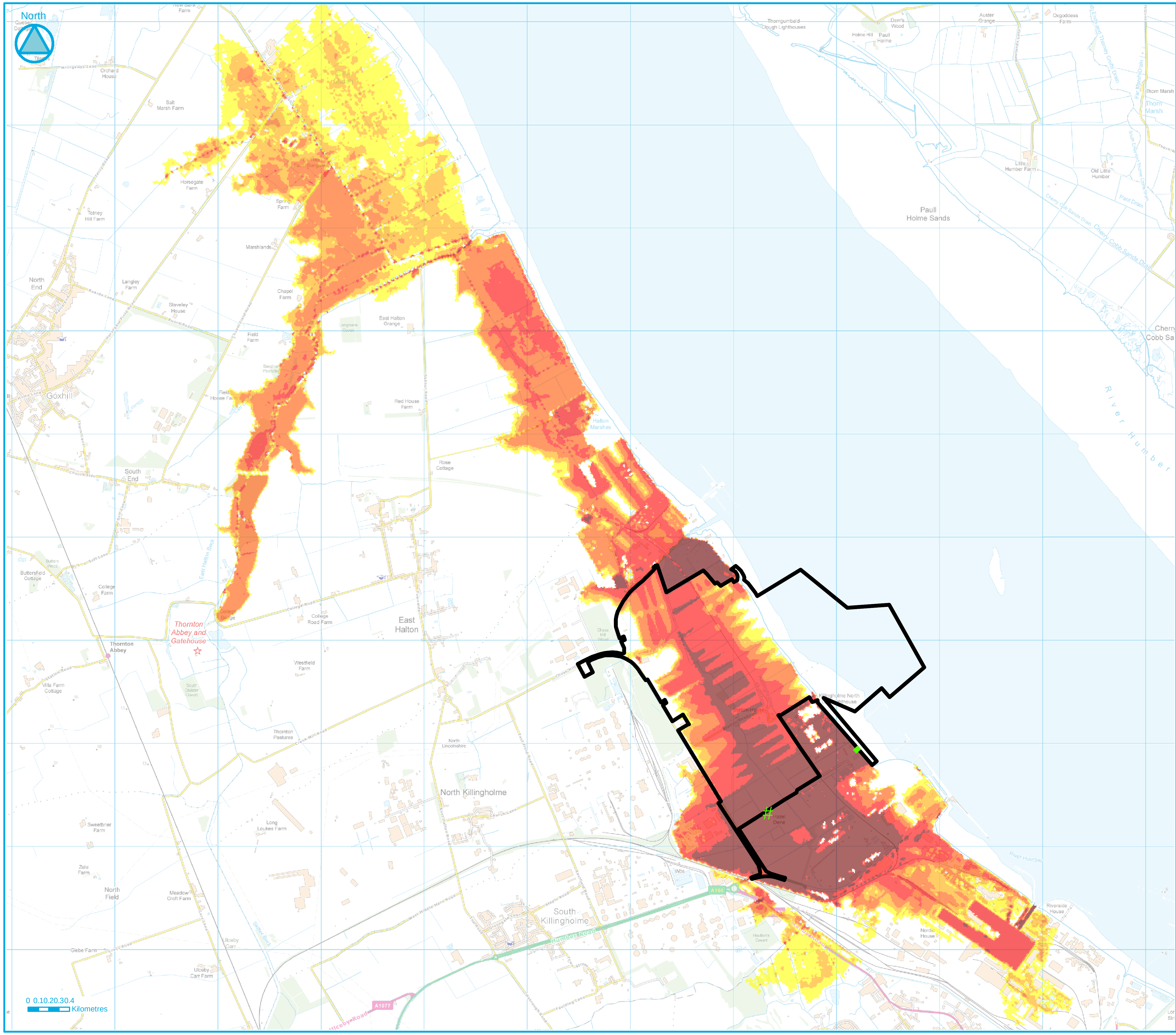

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 Present Day with 100 Years of Climate Change Flood Depth & Extent with Development Site (Breach 1)

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Checked By:	David Stark	
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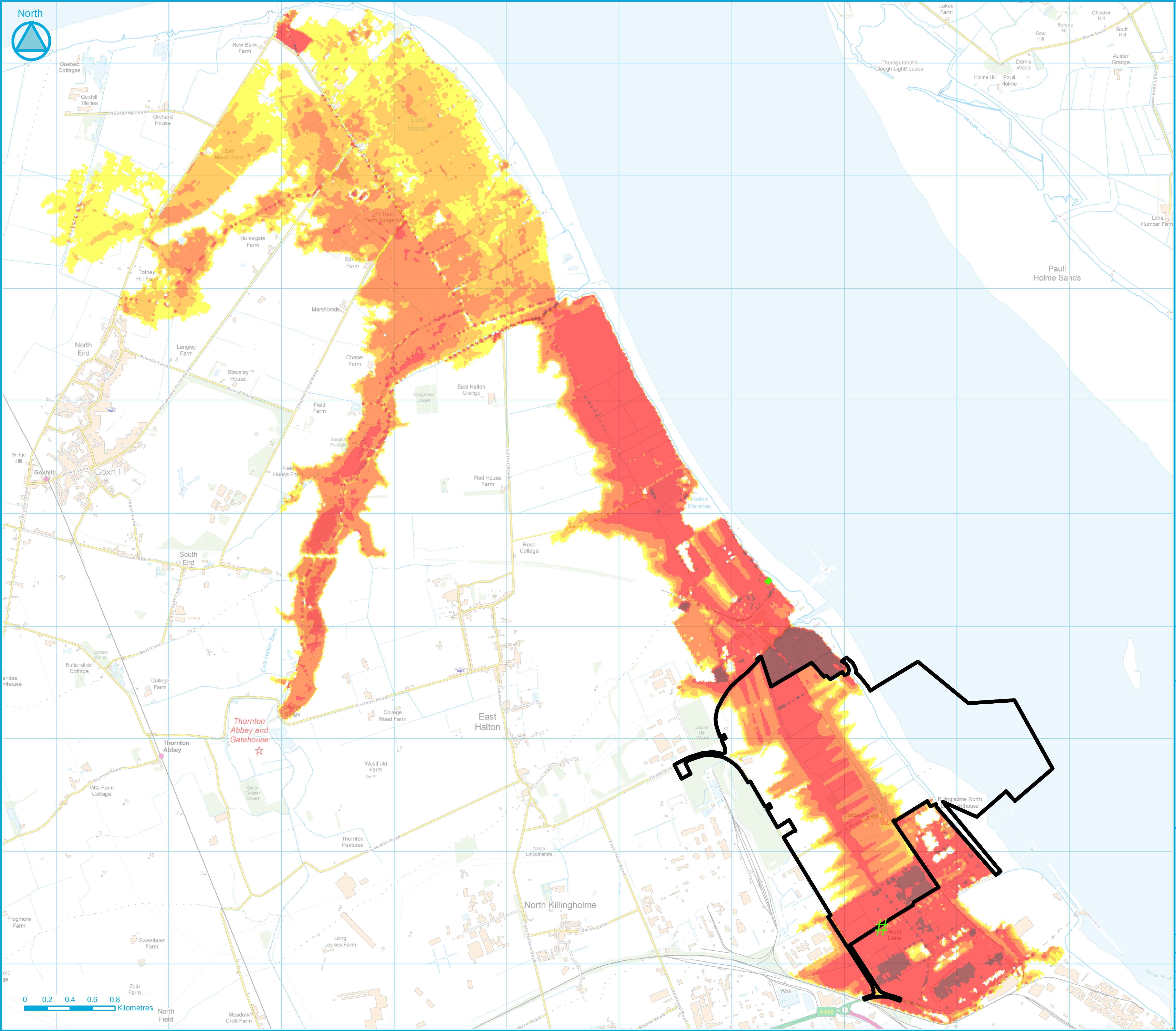

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 Present Day with 100yrs Climate Change Flood Depth & Extent with Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale:	1:33,000
Checked By:	David Stark		
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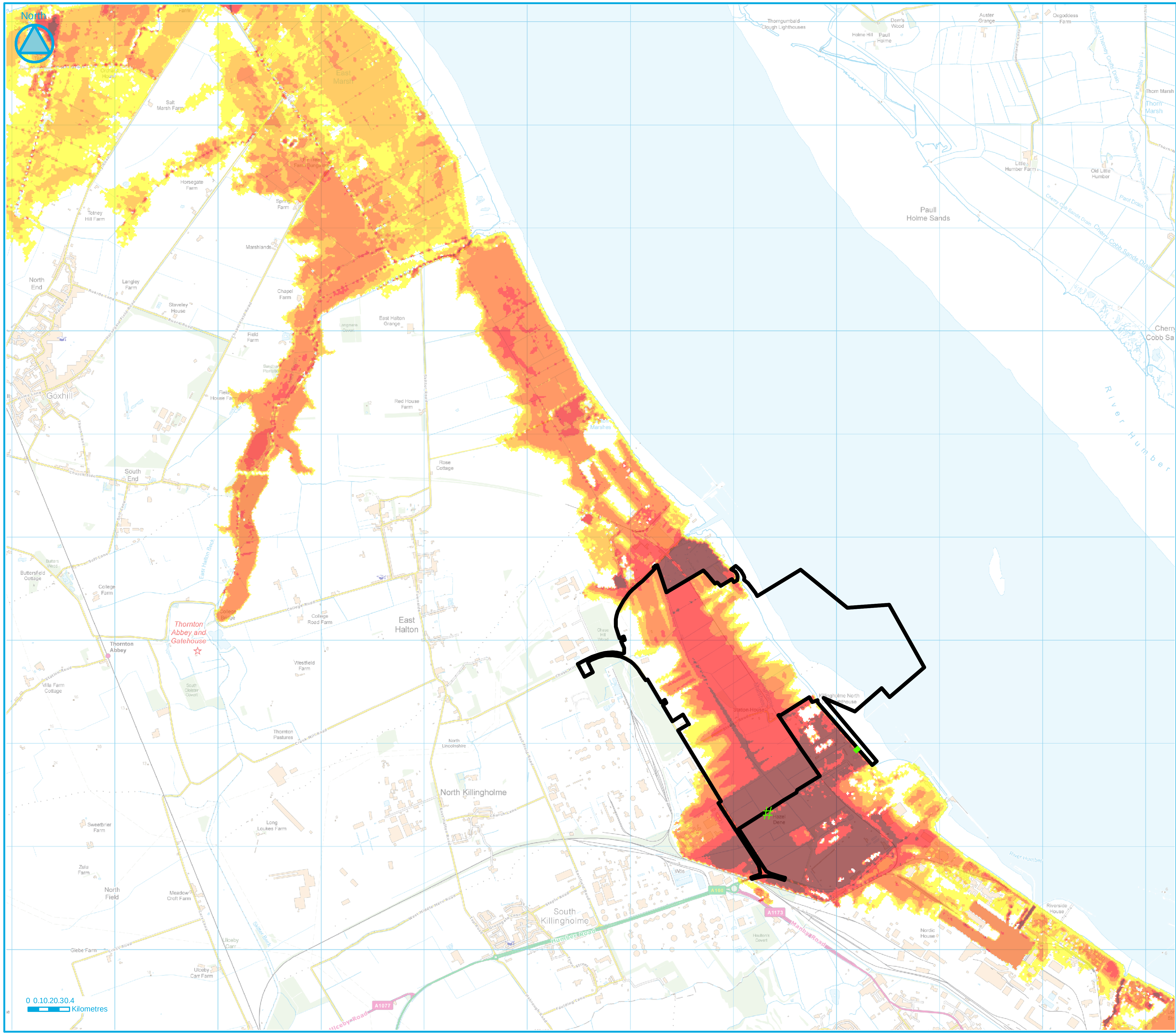

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 with 100 Years of Climate Change Flood Depth & Extent (Residual Run) with Development Site & Overtopping (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:36,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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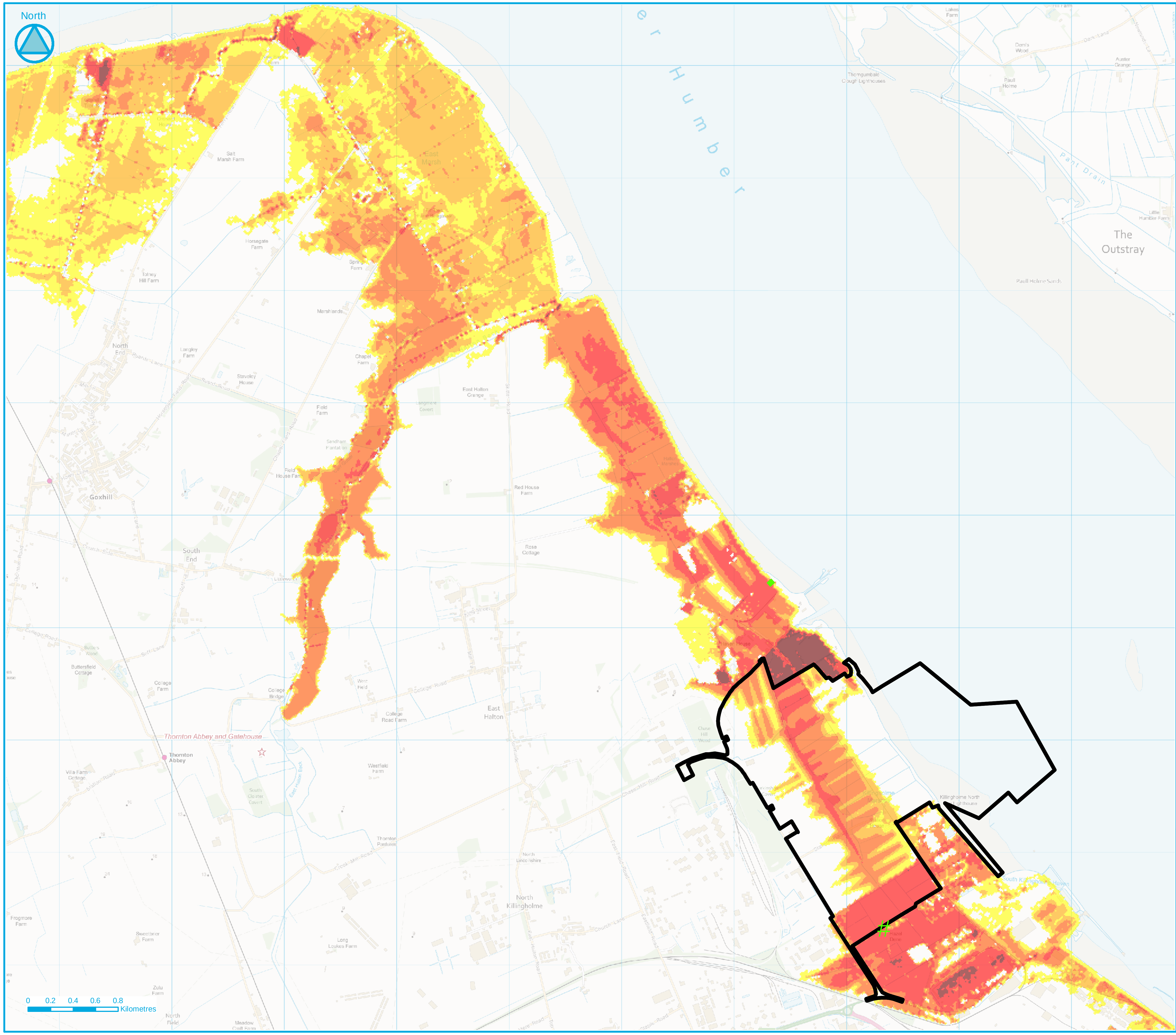

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 +

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Q200 with 100yrs Climate Change Flood Depth & Extent (Residual Run) with Development Site & Overtopping (Breach 2)

Drawn By:	Kathryn Smith	Scale:	1:33,000
Checked By:	David Stark		
Date:	August 2011		Original @ A3
File Name:	N:\ArcView\Projects\Map Layouts\A3_Q200+CC Residual Run (With Development & Overtopping) B2 Flood Depth.mxd		
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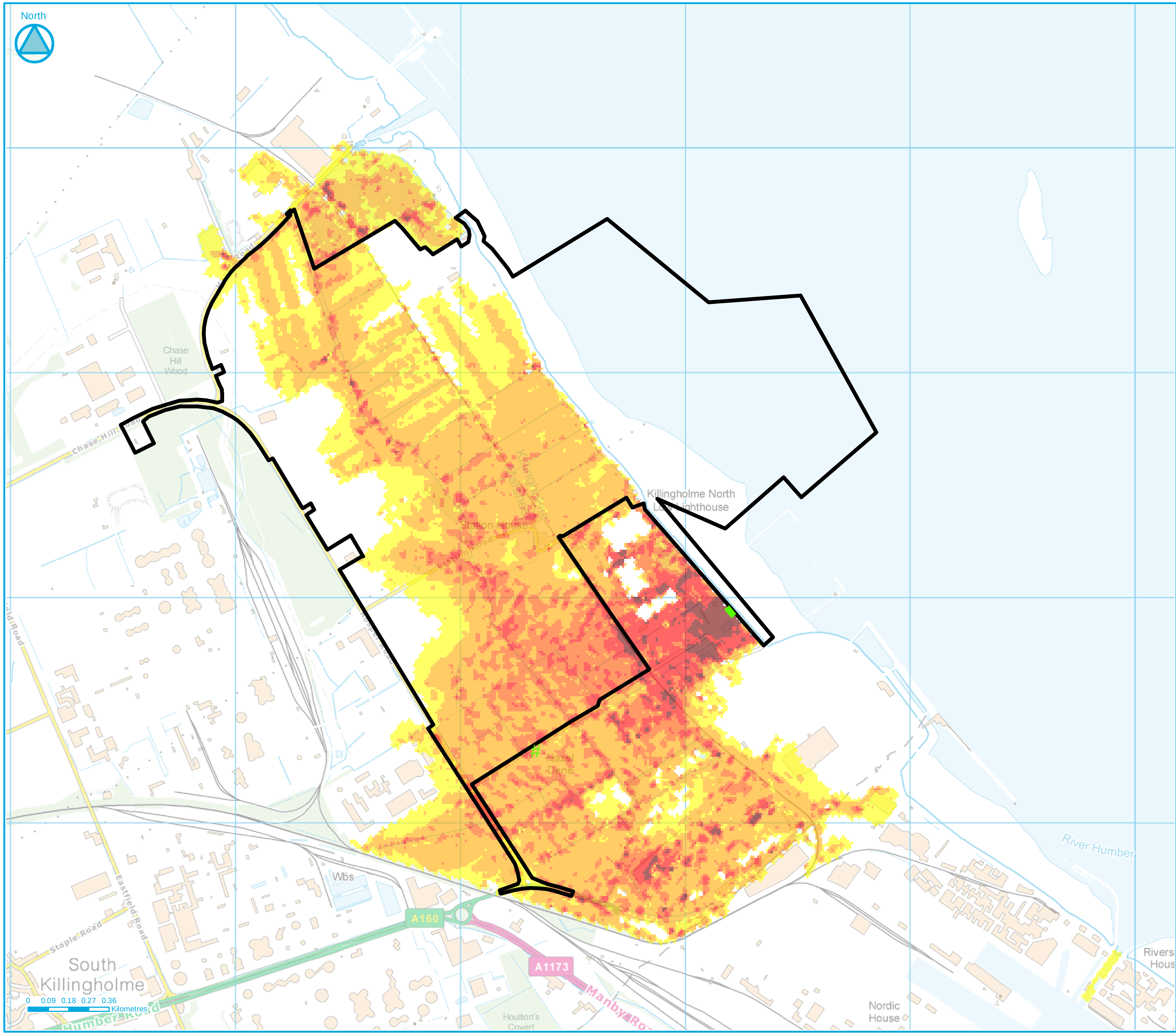

Legend

Hazel Dene Property

Breach 1 Location

Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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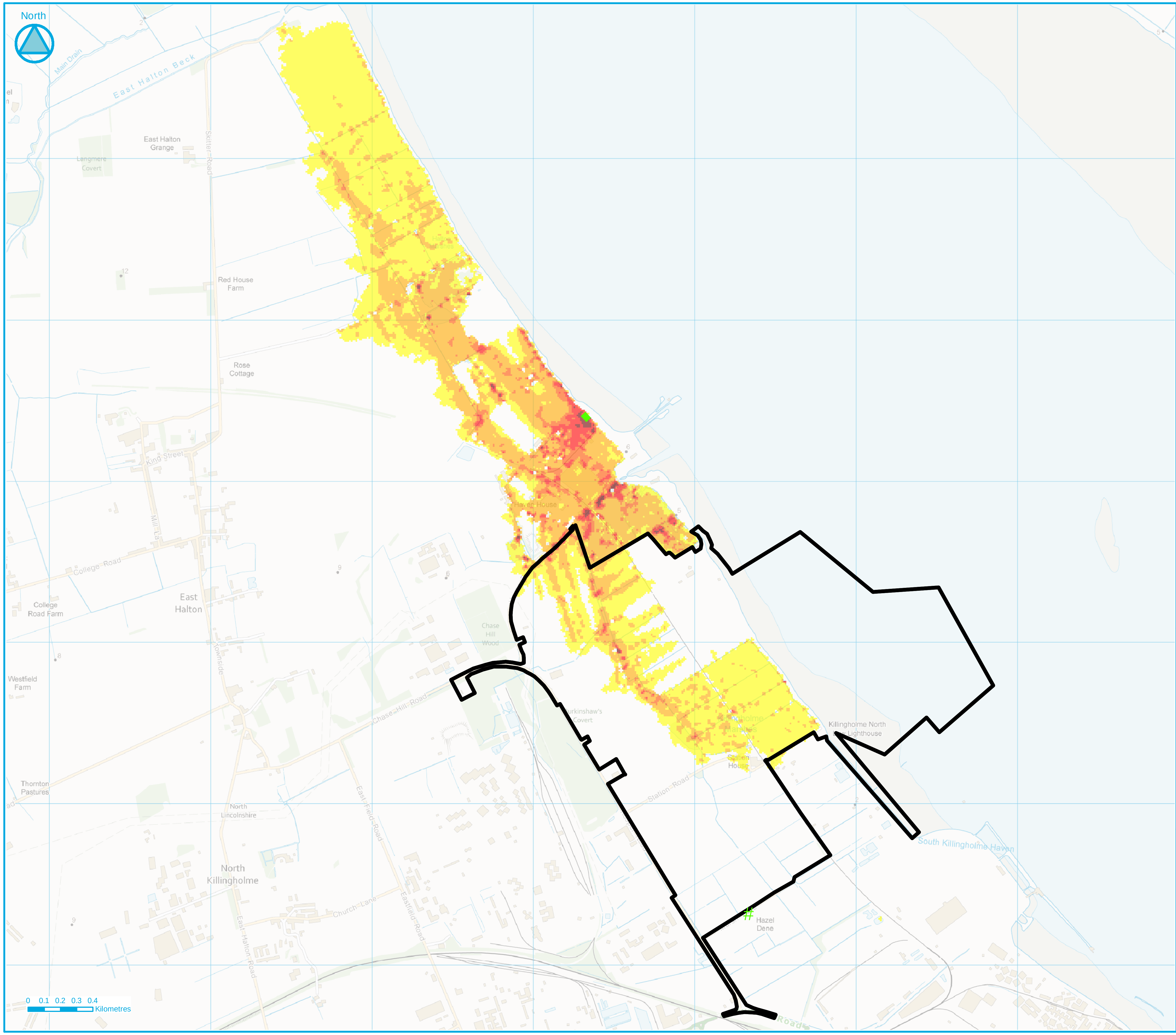
Q200 Present Day Peak Velocity without Development Site (Breach 1)

Drawn By: Kathryn Smith	**Scale:** 1:16,500
Checked By: David Stark	
Date: August 2011	Original @ A3
File Name: N:\ArcView\\Projects\Map Layouts\A3_Q200 Present Day Without Development B1 Peak Velocity.mxd	
Drawing Number: V1	



Legend

Hazel Dene Property

Breach 2 Location

Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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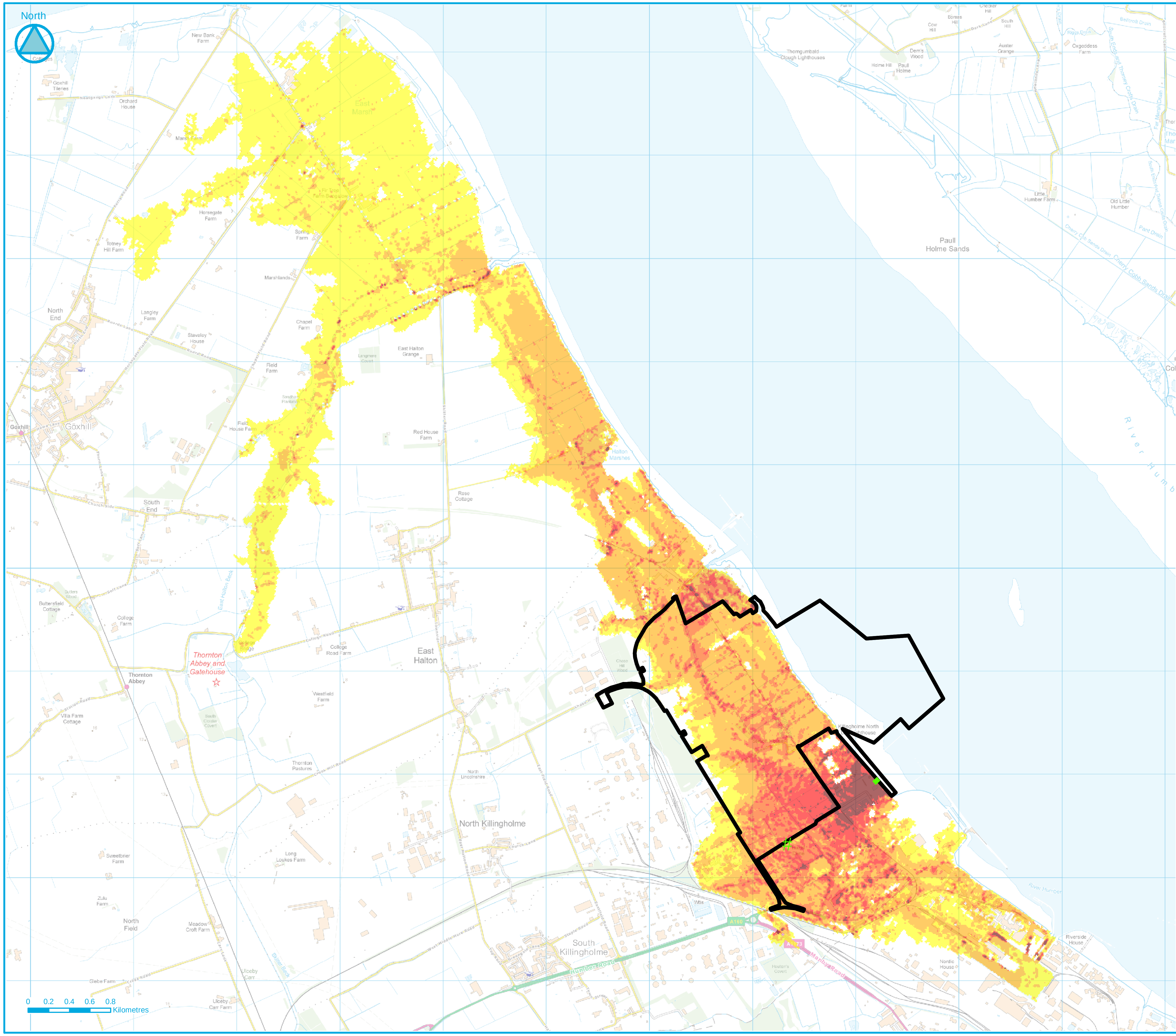
for

Able Marine Energy Park Flood Risk Assessment
Breach Assessment.

Q200 Present Day Peak Velocity without Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:23,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
File Name:	N:\ArcView\Projects\Map Layouts\A3_Q200 Present Day Without Development B2 Peak Velocity.mxd	
Drawing Number:	V2	



Legend

\# Hazel Dene Property

Breach 1 Location

Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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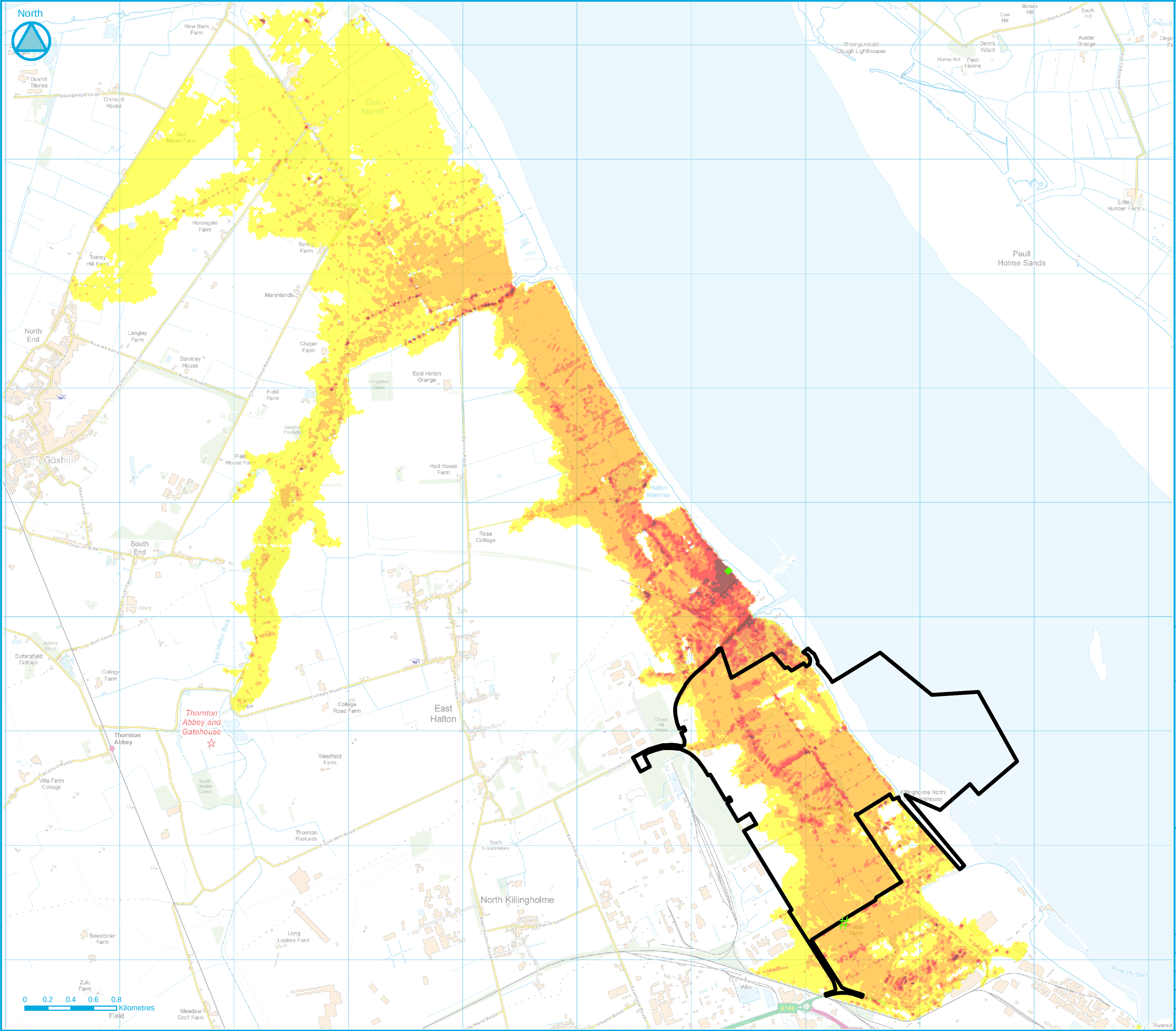
Q200 Present Day with 100 Years Climate Change Peak Velocity without Development Site (Breach 1)

Drawn By:	Kathryn Smith	Scale:	1:36,000
Checked By:	David Stark		
Date:	August 2011		Original @ A3
File Name:	N:\ArcView\Projects\Map Layouts\A3_Q200 Present Day+CC Without Development B1 Peak Velocity.mxd		
Drawing Number:	V3		



Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 Present Day with 100 Years Climate Change Peak Velocity without Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:32,500
Checked By:	David Stark	
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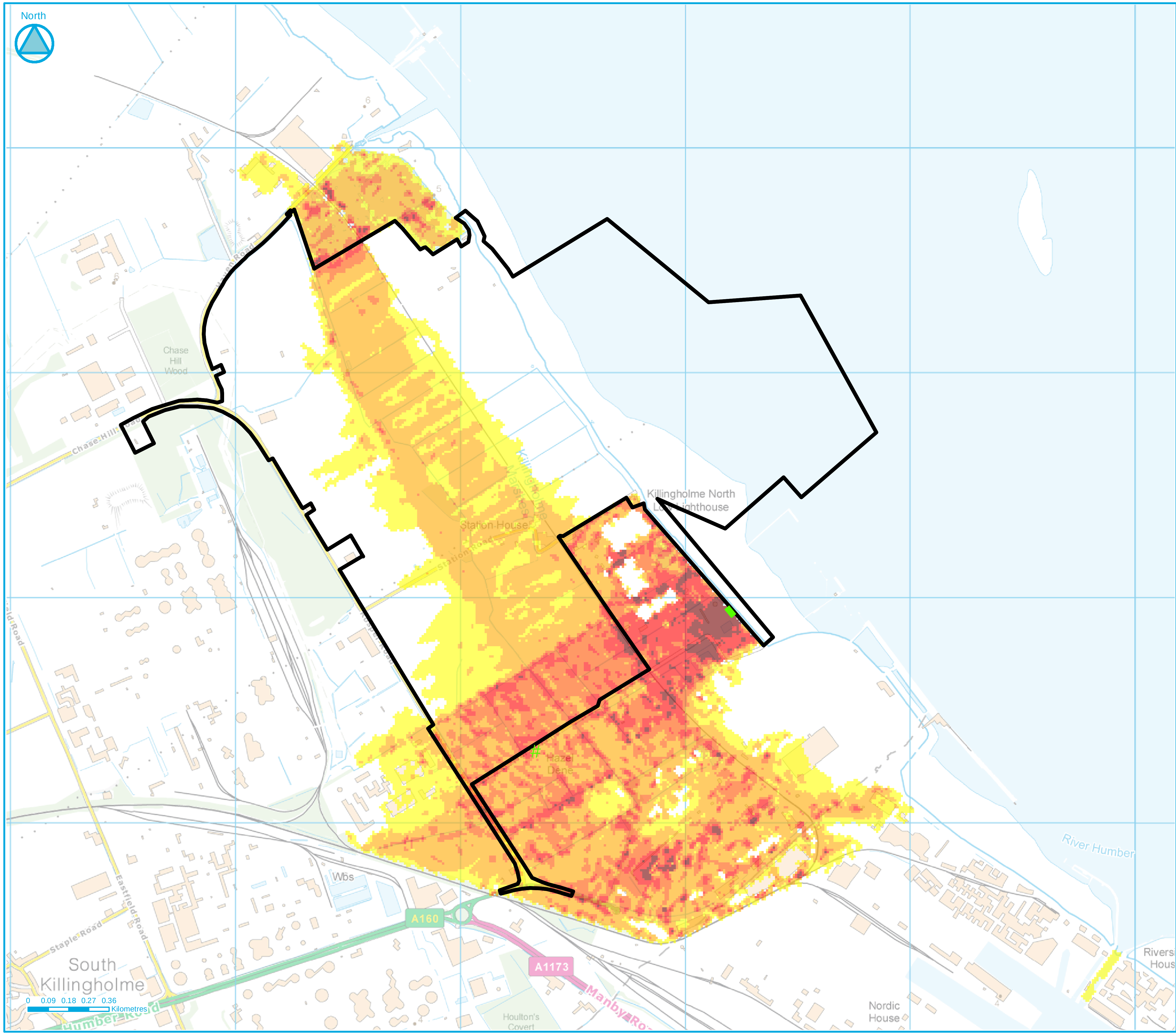

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 Present Day Peak Velocity with Development Site (Breach 1)

Drawn By: Kathryn Smith		Scale: 1:16,500
Checked By: David Stark		
Date: August 2011		Original @ A3
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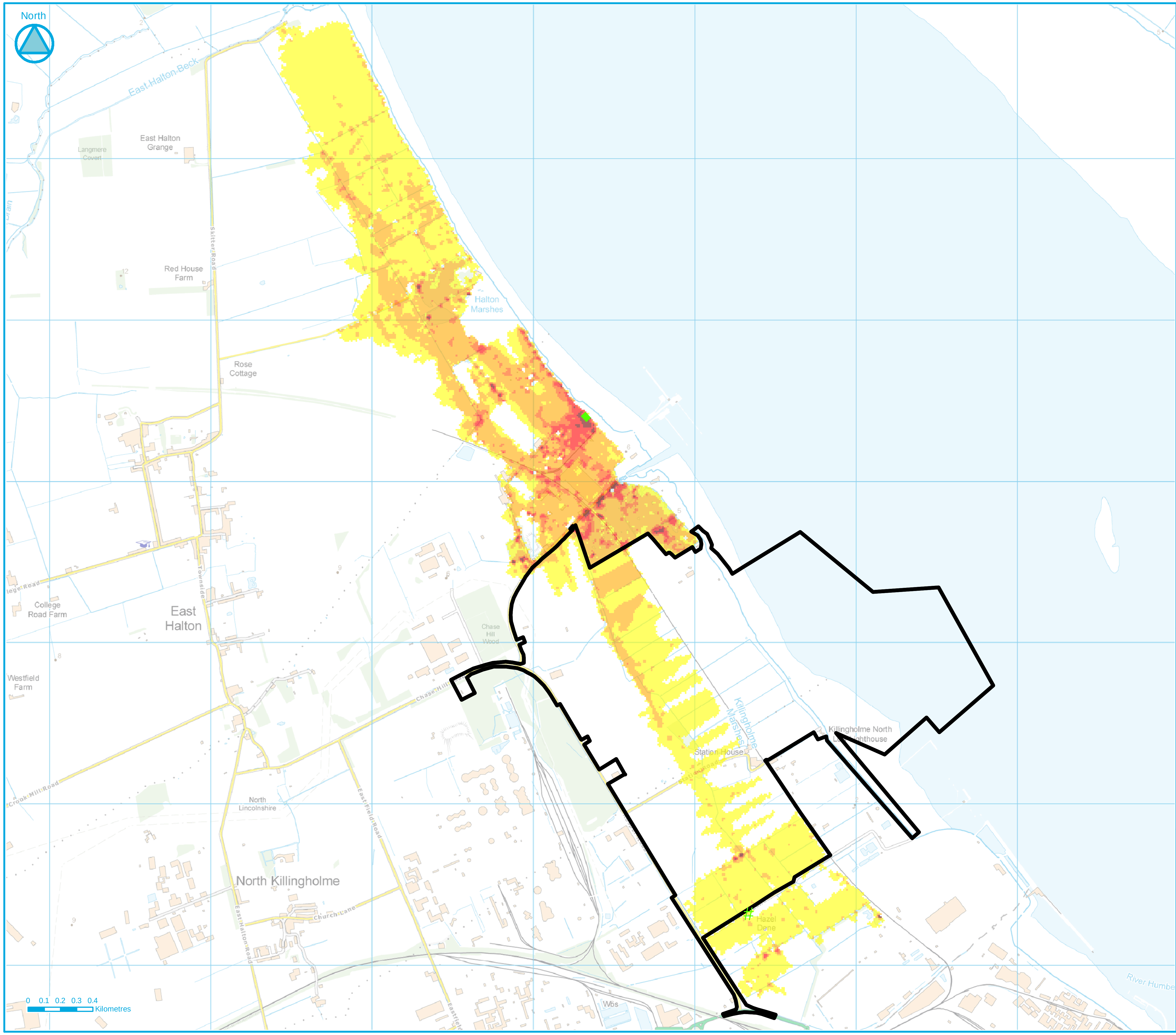

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 Present Day Peak Velocity with Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale:	1:23,000
Checked By:	David Stark		
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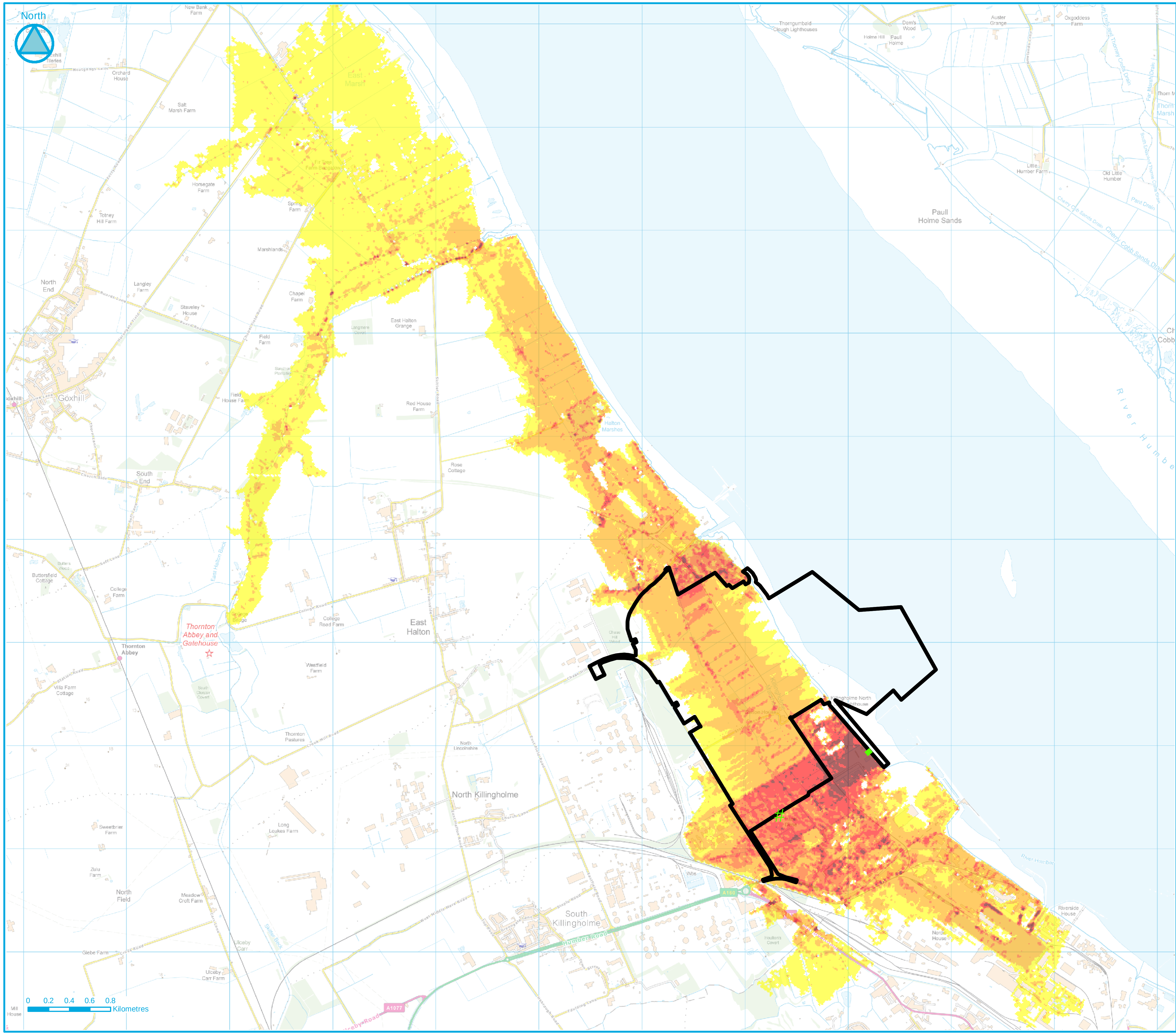

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 Present Day with 100 Years Climate Change Peak Velocity with Development Site (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:36,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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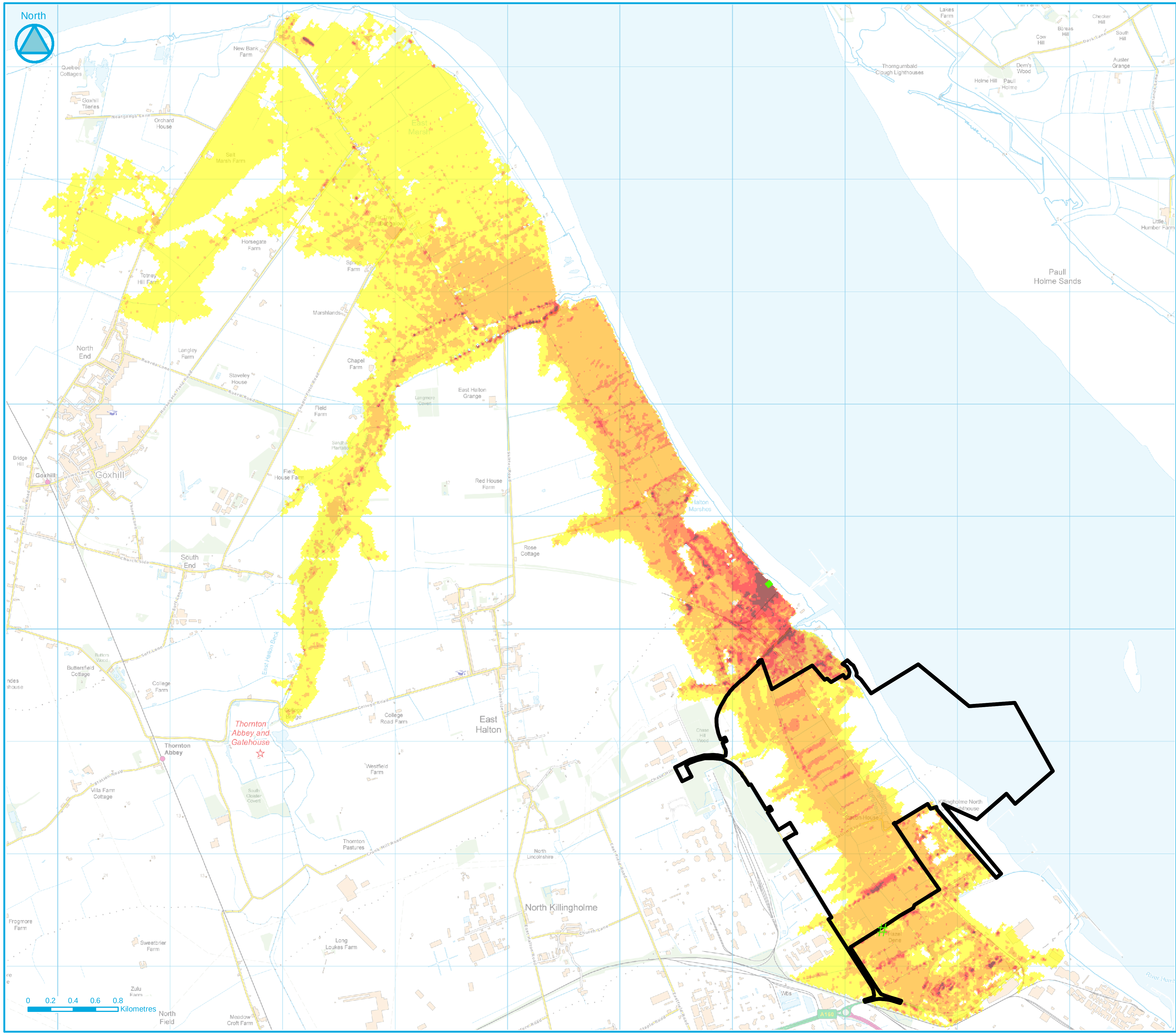

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 Present Day with 100 Years Climate Change Peak Velocity with Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:33,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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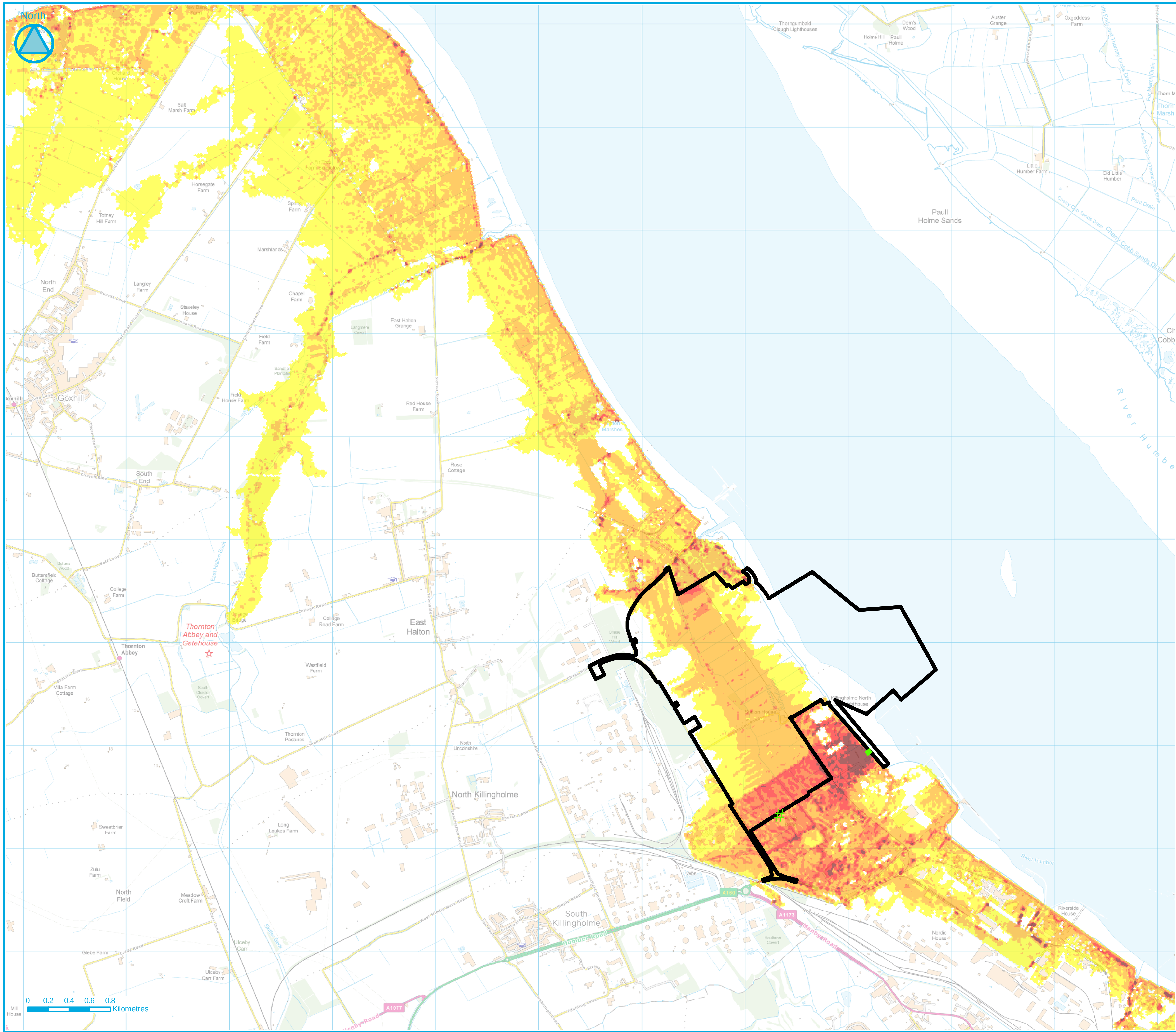

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 with 100 Years Climate Change Peak Velocity (Residual Run) with Development Site & Overtopping (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:36,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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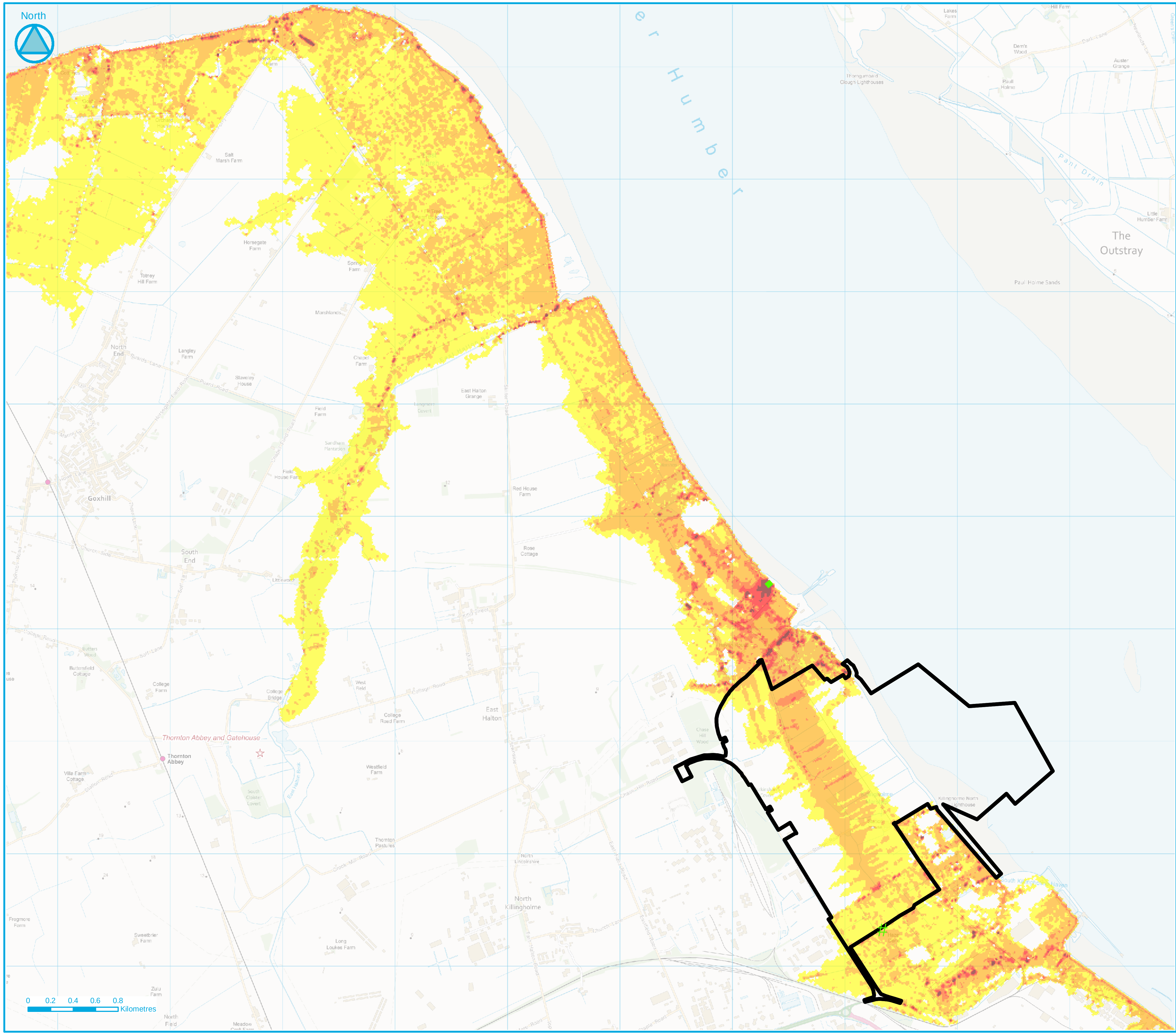

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Peak Velocity (m/s)

- 0 - 0.3
- 0.3 - 1
- 1.0 - 1.5
- 1.5 - 2.5
- 2.5+

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Q200 with 100 Years Climate Change Peak Velocity (Residual Run) with Development Site & Overtopping (Breach 2)

Drawn By:	Kathryn Smith	**Scale:** 1:33,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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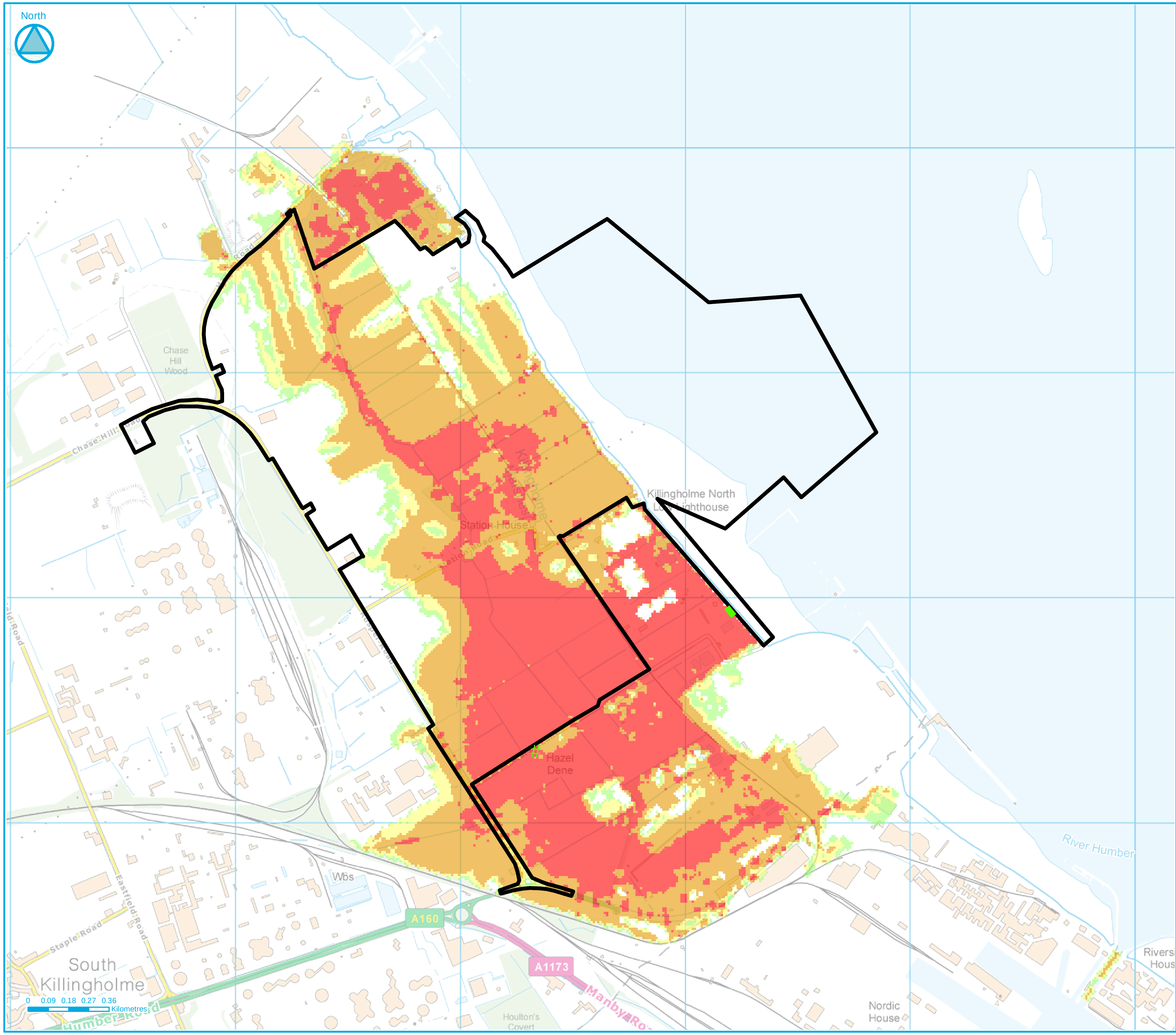

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
- 2.0+ (Danger for All)

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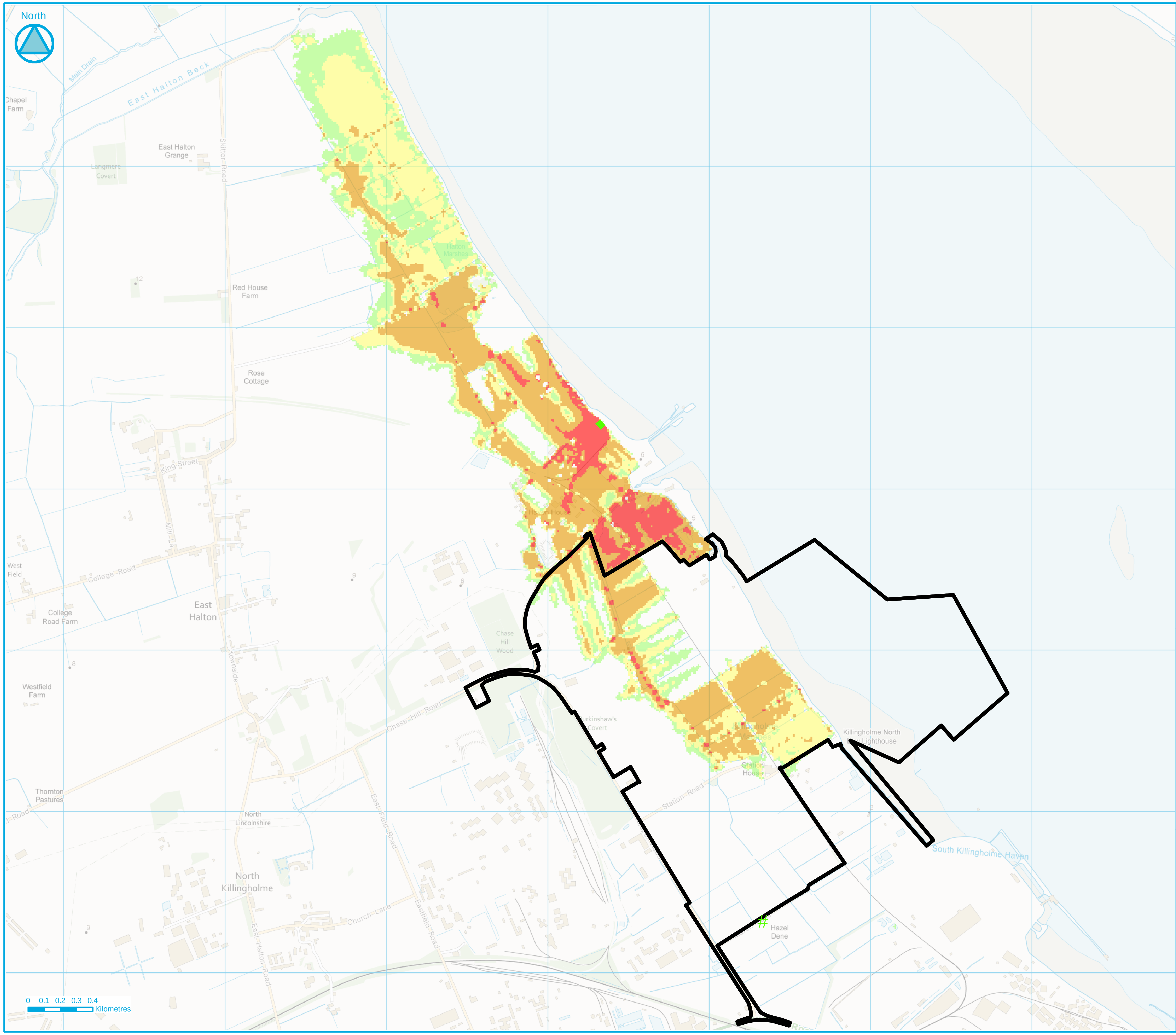
Q200 Present Day Flood Hazard without Development Site (Breach 1)

Drawn By:	Kathryn Smith	Scale:	1:16,500
Checked By:	David Stark		
Date:	August 2011		Original @ A3
File Name:	N:\ArcView\\Projects\Map Layouts\A3_Q200 Present Day Without Development B1 Flood Hazard.mxd		
Drawing Number:	H1		



Legend

Hazel Dene Property

Breach 2 Location

Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
- 2.0+ (Danger for All)

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Q200 Present Day Flood Hazard without Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale:	1:23,000
Checked By:	David Stark		
Date:	August 2011		Original @ A3
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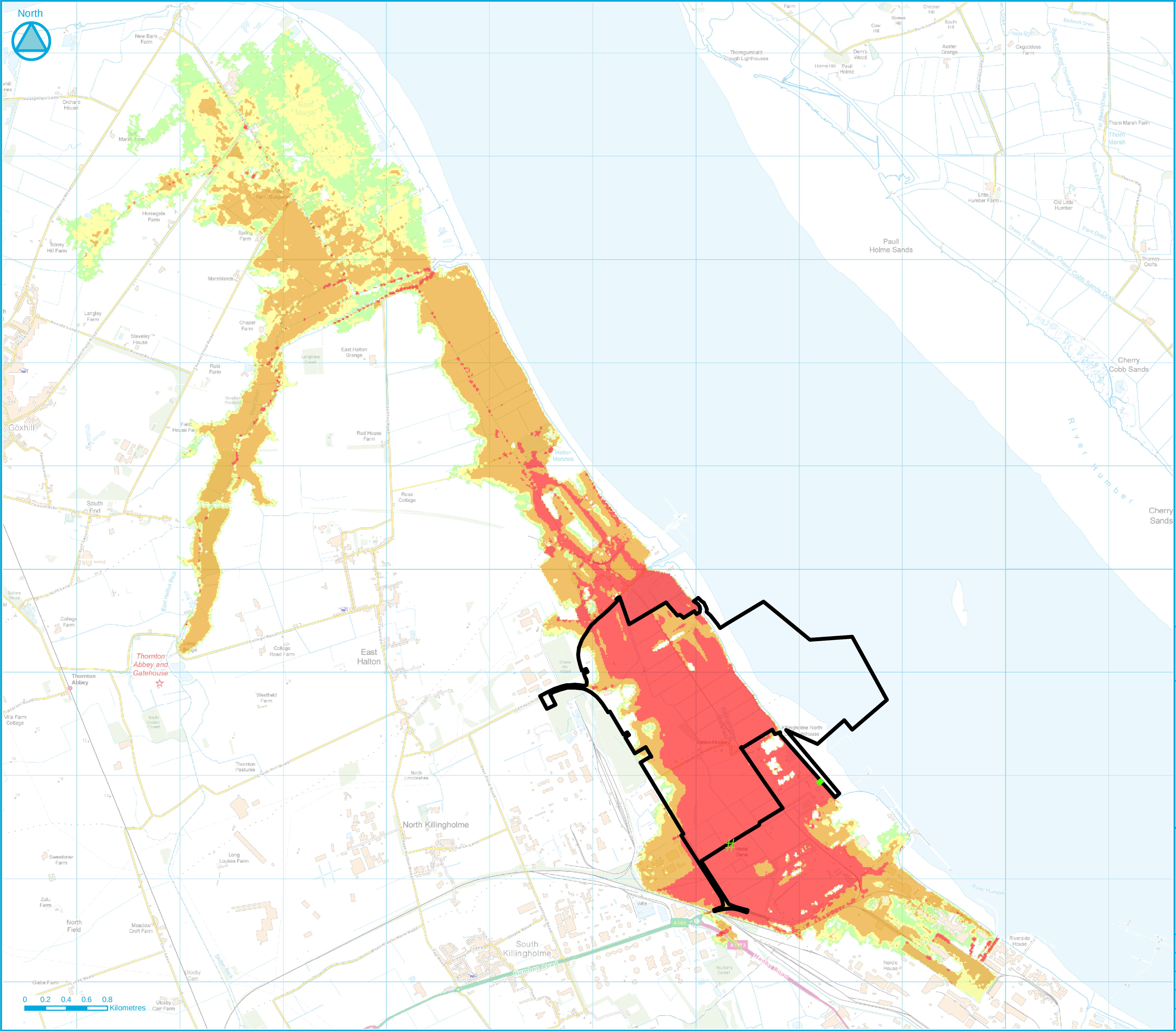

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
- 2.0+ (Danger for All)

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Q200 Present Day with 100 Years Climate Change Flood Hazard without Development Site (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:36,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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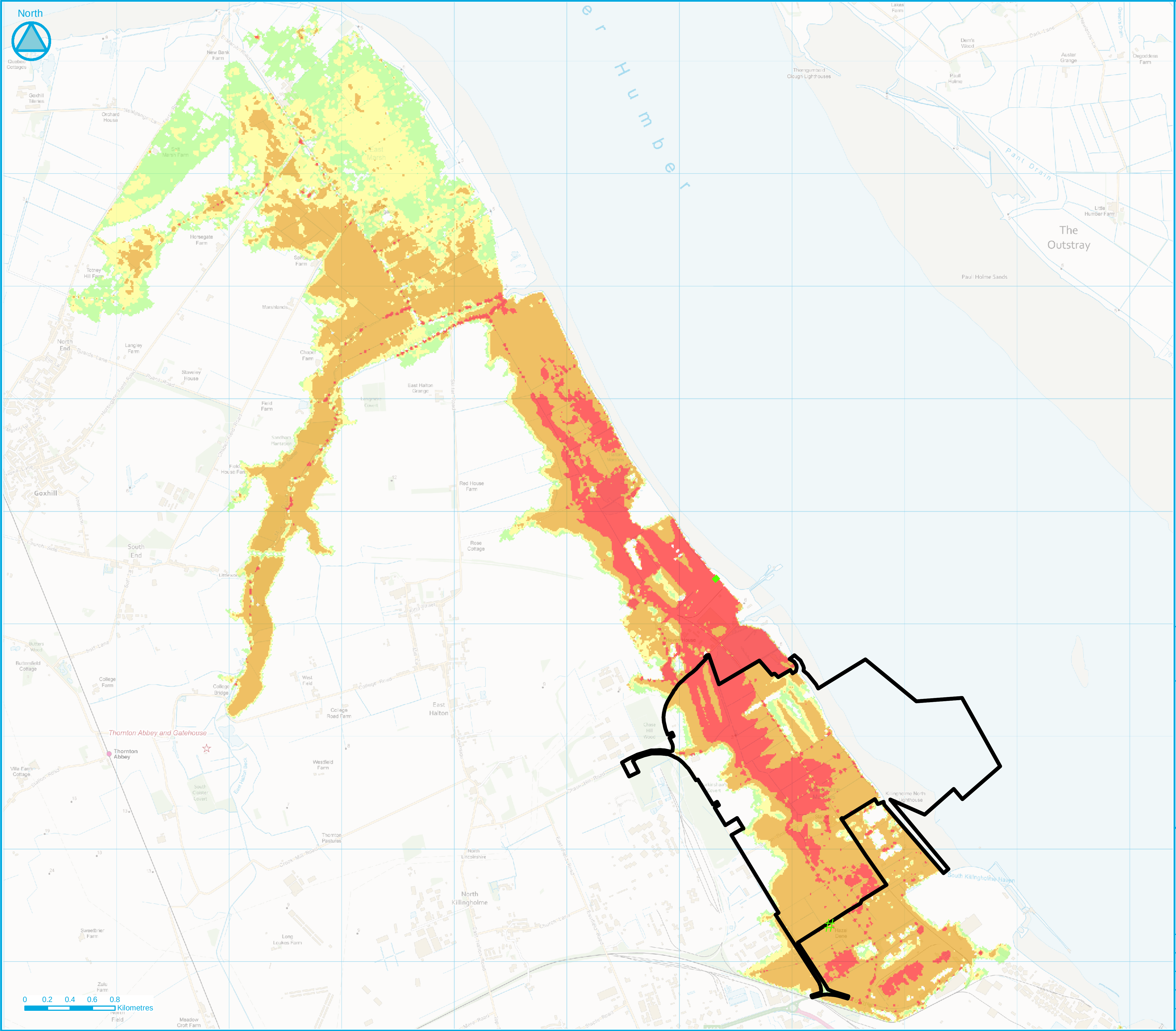

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
- 2.0+ (Danger for All)

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Q200 Present Day with 100 Years Climate Change Flood Hazard without Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale:	1:33,000
Checked By:	David Stark		
Date:	August 2011		Original @ A3
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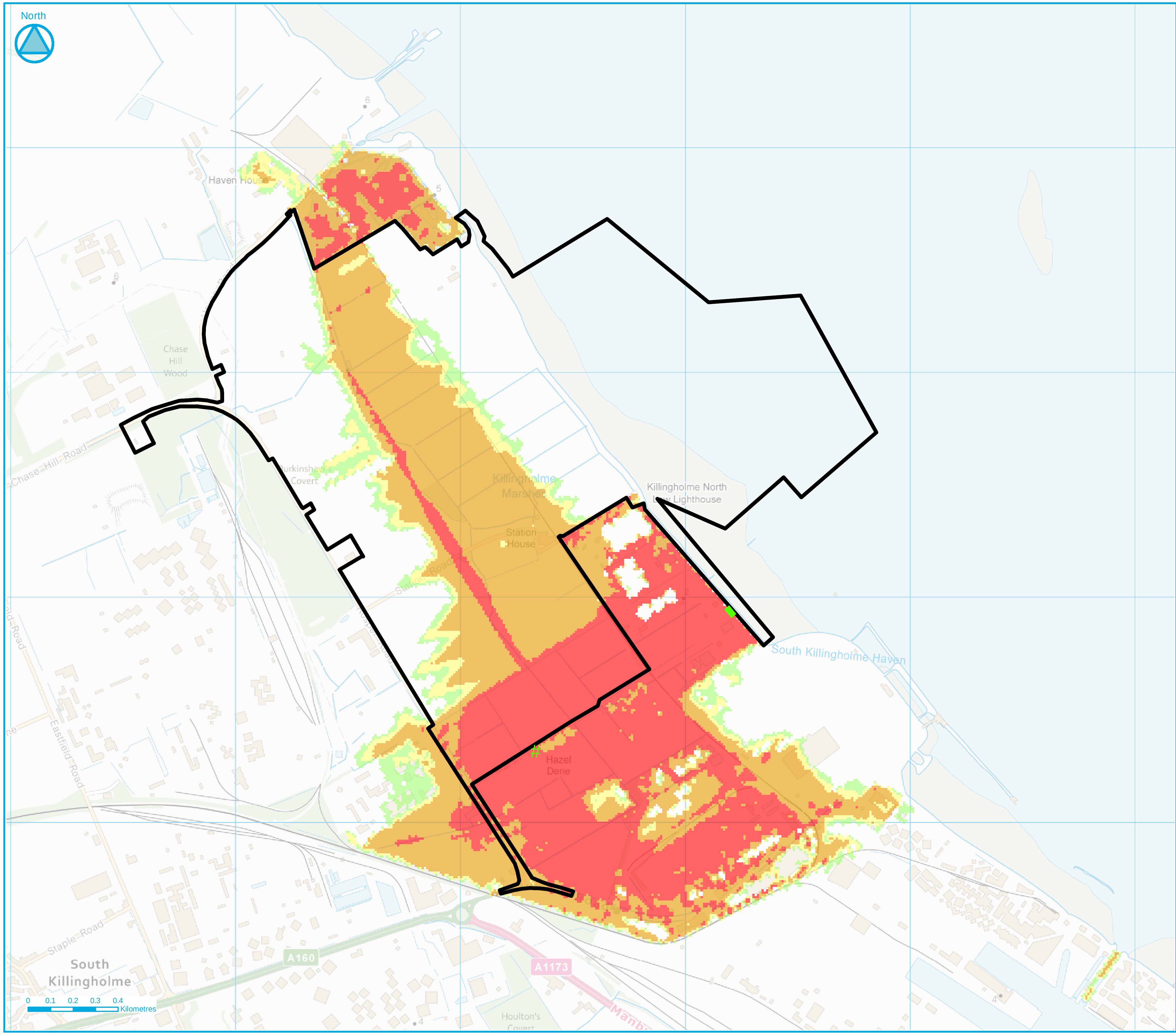

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
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Breach Assessment.

Q200 Present Day Flood Hazard with Development Site (Breach 1)

Drawn By: Kathryn Smith		**Scale:** 1:16,500
Checked By: David Stark		
Date: August 2011		Original @ A3
File Name: N:\ArcView\\Projects\Map Layouts\A3_Q200 Present Day With Development B1 Flood Hazard.mxd		
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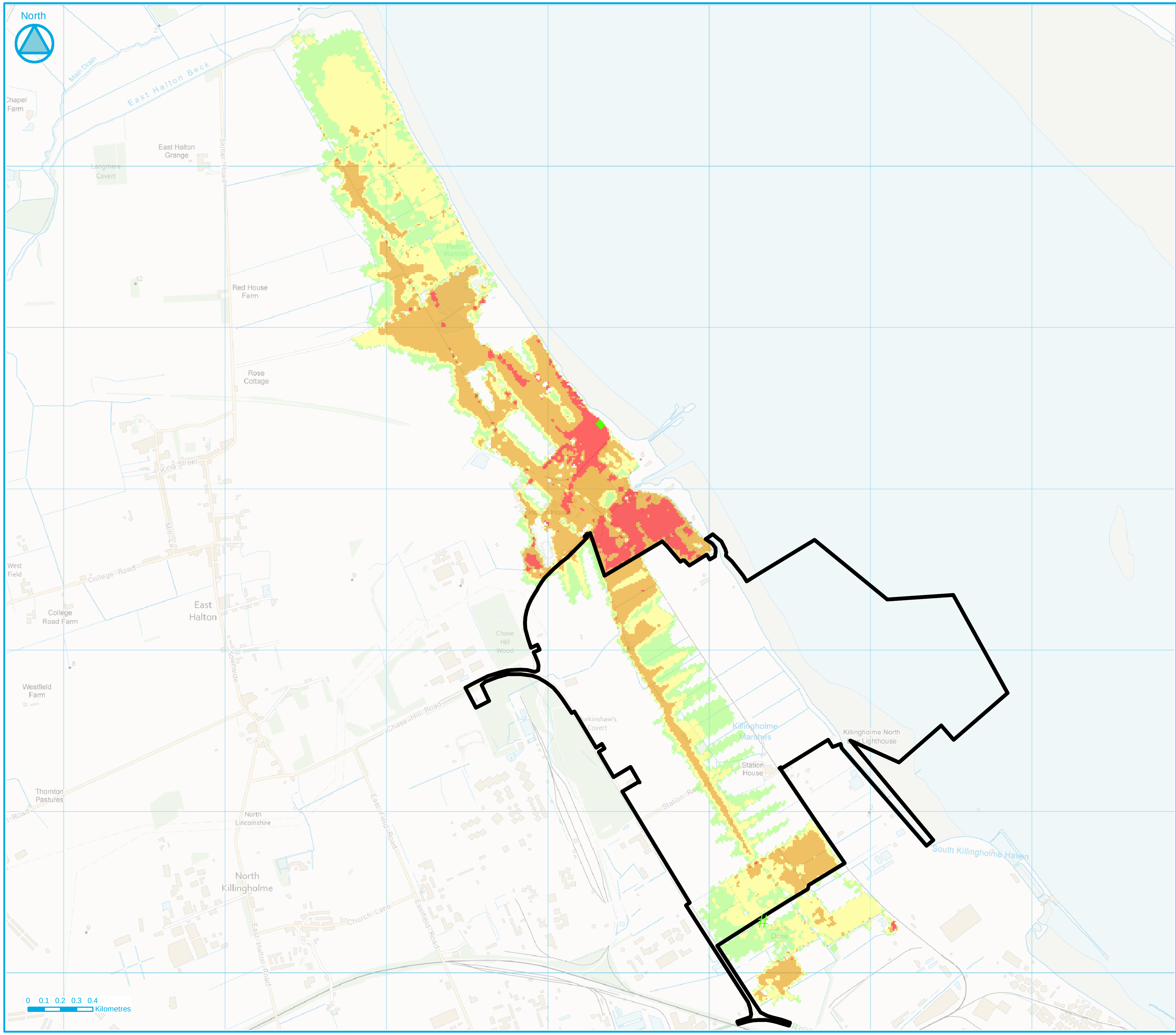

Legend

\# Hazel Dene Property

Breach 2 Location

Site Boundary

Predicted Flood Hazard

0.0 - 0.75 (Low Hazard)

0.75 - 1.25 (Danger for Some)

1.25 - 2 (Danger for Most)

2.0+ (Danger for All)

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Q200 Present Day Flood Hazard with Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:23,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
File Name:	N:\ArcView\Projects\Map Layouts\A3_Q200 Present Day With Development B2 Flood Hazard.mxd	
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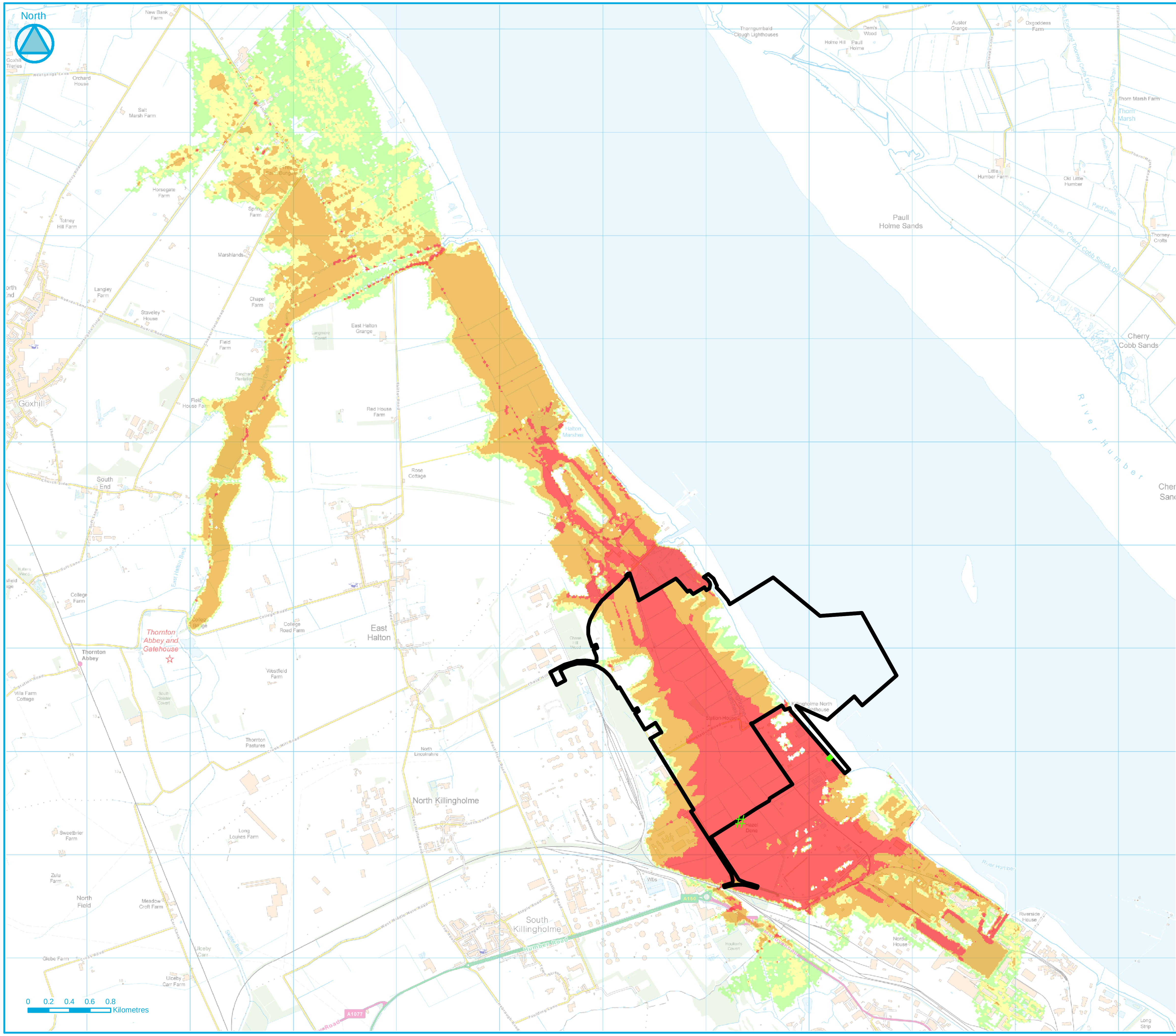

Legend

\# Hazel Dene Property

Breach 1 Location

Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
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Q200 Present Day with 100 Years Climate Change Flood Hazard with Development Site (Breach 1)

Drawn By: Kathryn Smith	Scale: 1:36,000
Checked By: David Stark	
Date: August 2011	Original @ A3
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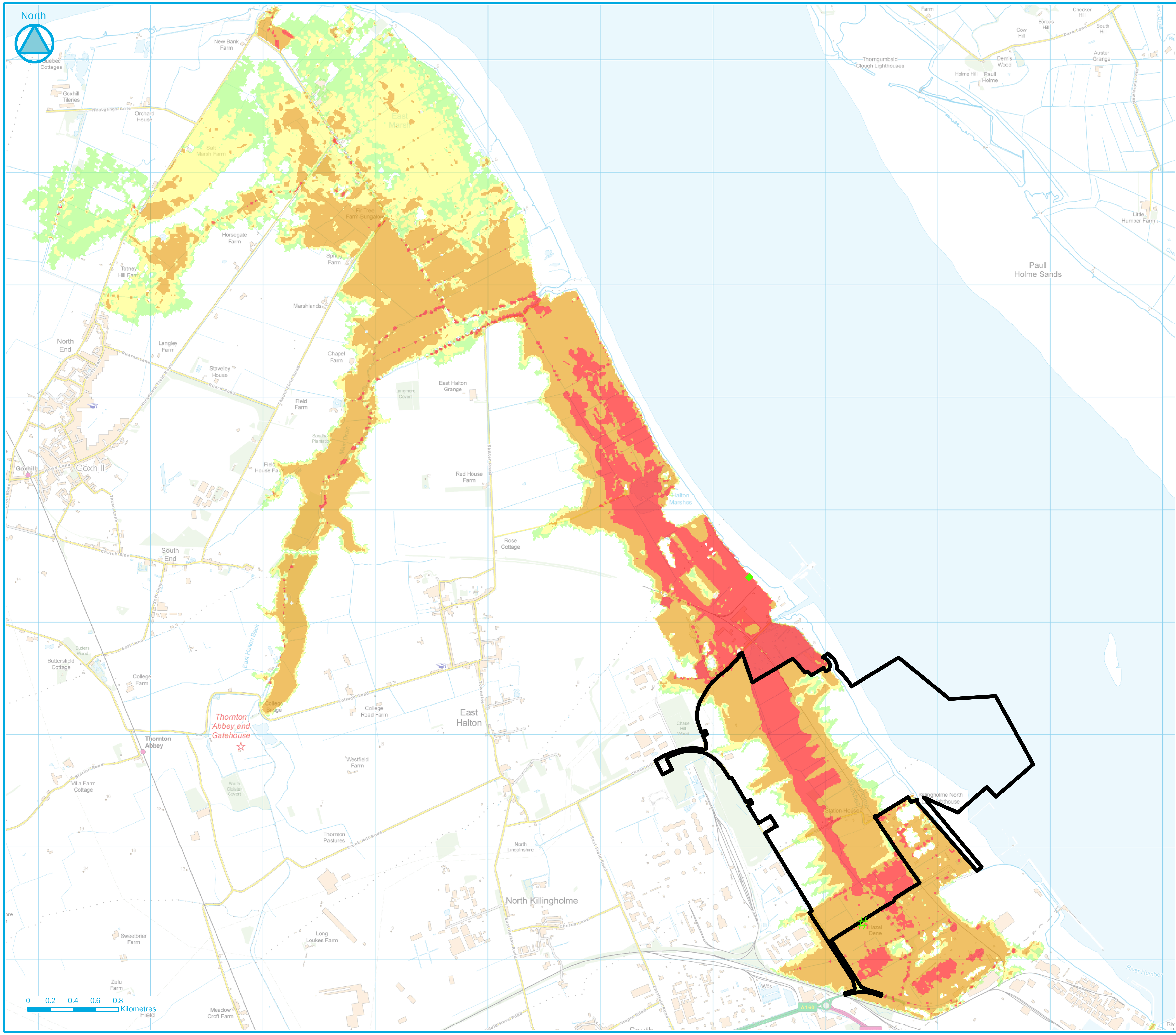

Legend

\# Hazel Dene Property

Breach 2 Location

Site Boundary

Predicted Flood Hazard

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0.75 - 1.25 (Danger for Some)

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Q200 Present Day with 100 Years Climate Change Flood Hazard with Development Site (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:33,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
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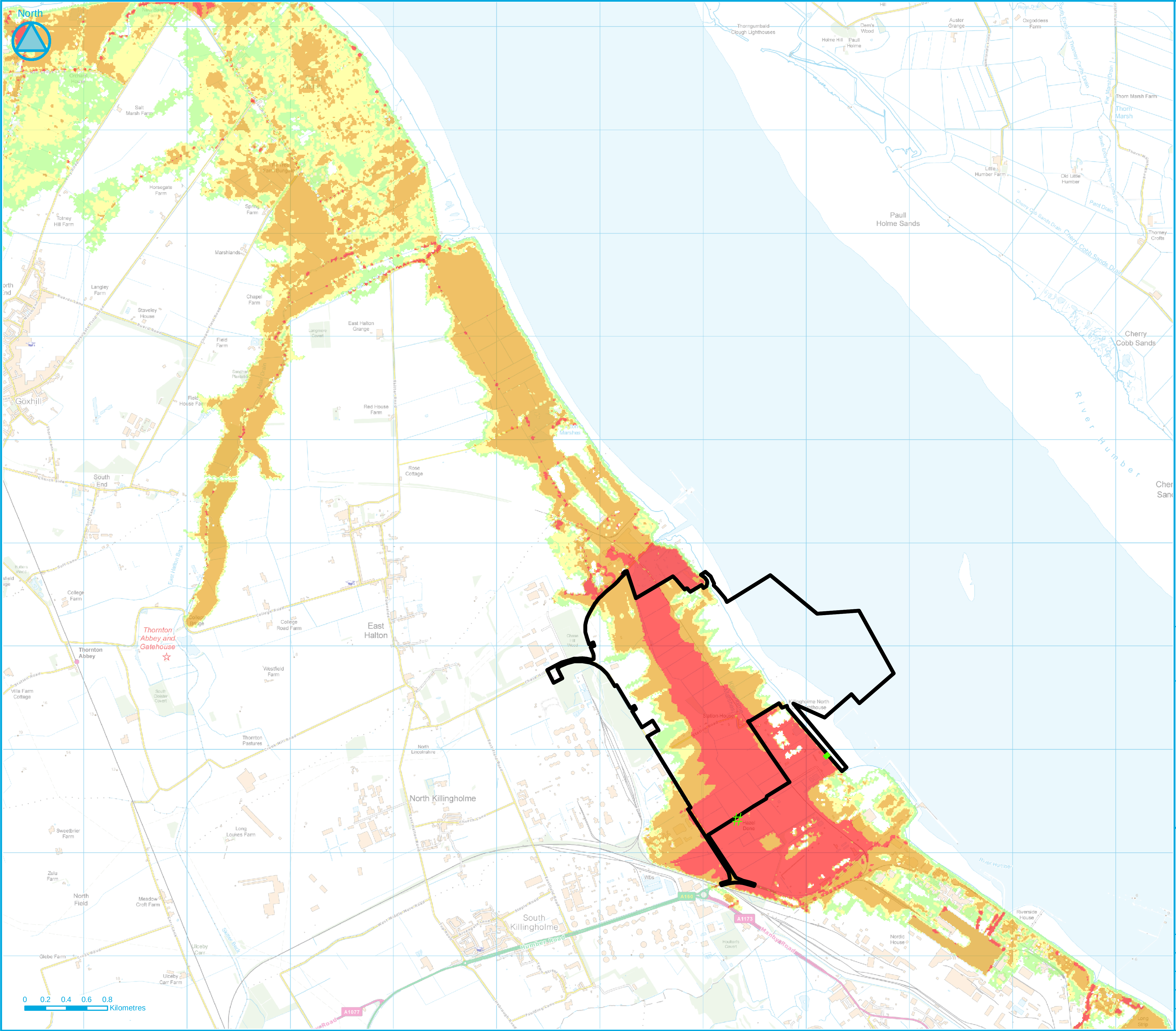

Legend

- # Hazel Dene Property
- Breach 1 Location
- Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
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Q200 with 100 Years Climate Change Flood Hazard (Residual Run) with Development Site & Overtopping (Breach 1)

Drawn By:	Kathryn Smith	Scale: 1:36,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
File Name:	N:\ArcView\Projects\Map Layouts\A3_Q200+CC Residual Run (With Development & Overtopping) B1 Flood Hazard.mxd	
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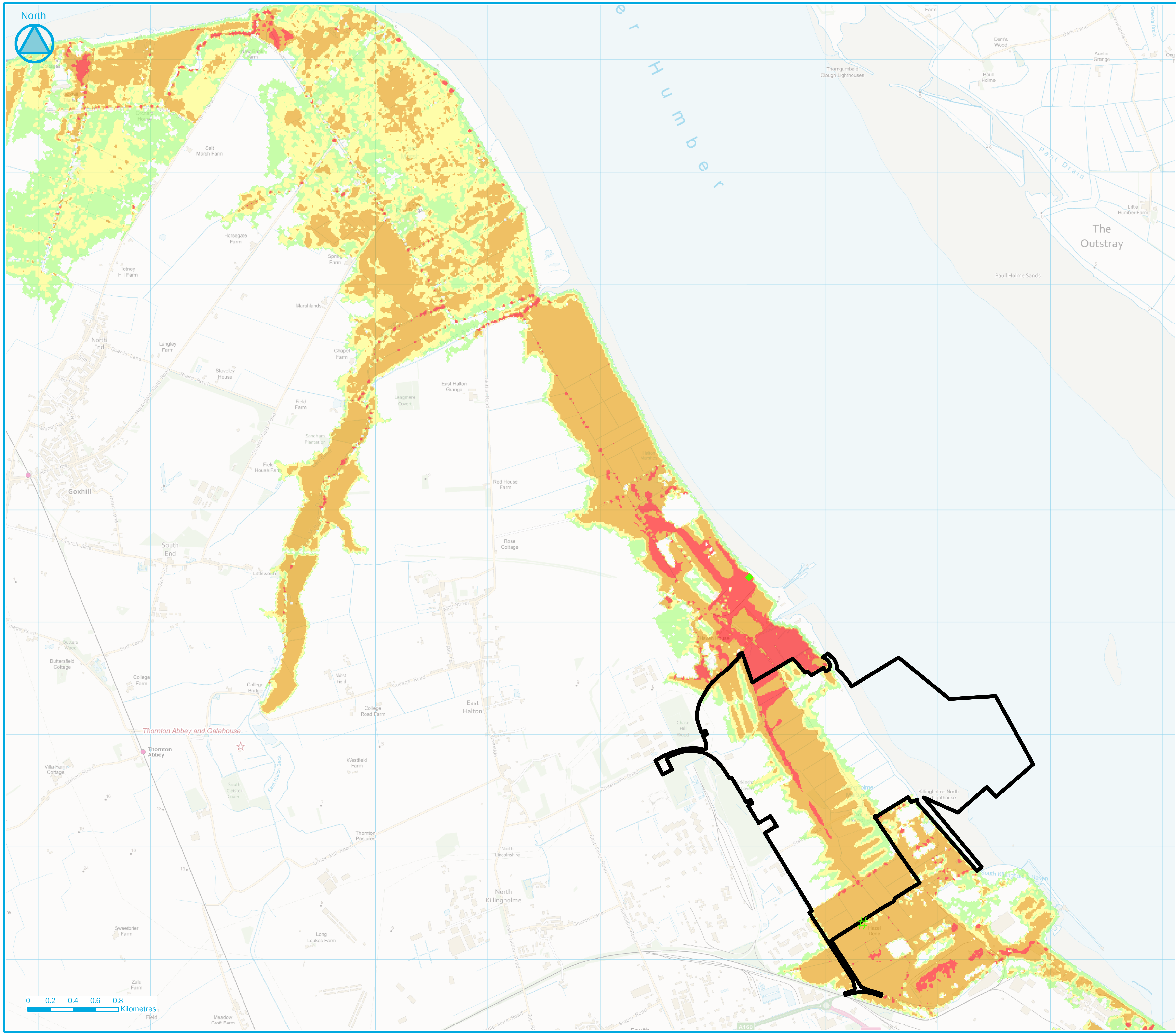

Legend

- # Hazel Dene Property
- Breach 2 Location
- Site Boundary

Predicted Flood Hazard

- 0.0 - 0.75 (Low Hazard)
- 0.75 - 1.25 (Danger for Some)
- 1.25 - 2 (Danger for Most)
- 2.0+ (Danger for All)

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Q200 with 100 Years Climate Change Flood Hazard (Residual Run) with Development Site & Overtopping) (Breach 2)

Drawn By:	Kathryn Smith	Scale: 1:33,000
Checked By:	David Stark	
Date:	August 2011	Original @ A3
File Name:	N:\ArcView\Projects\Map Layouts\A3_Q200+CC Residual Run (With Development & Overtopping) B2 Flood Hazard.mxd	
Drawing Number:	H10	

J. Response from North Lincolnshire Council

Email from Barrie Onions dated 25 May 2011 responding to the Flood Warning and Evacuation Plan.

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David Stark

From: Barrie Onions [Barrie.Onions@northlincs.gov.uk]
Sent: 25 May 2011 17:12
To: rcram@ableuk.com
Subject: Fw: Re: Re: Fw: AMEP Flood Warning & Evacuation Plan

Hello Richard.

As instructed by Marcus - see e-mails below. Not sure who consultants are (re Marcus's instruction)?

Regards Barrie.

-----Forwarded by Barrie Onions/PL/NorthLincs on 25/05/2011 05:09PM -----

> To: Barrie Onions/PL/NorthLincs@NorthLincs
> From: Marcus Walker/PL/NorthLincs
> Date: 24/05/2011 07:24AM
> Subject: Re: Re: Fw: AMEP Flood Warning & Evacuation Plan
>
> Barrie can you send on to able and consulatants
> Thanks
>
>
> Email Sent By Blackberry
>
> ---
>
> **From:** Barrie Onions
> **Sent:** 12/05/2011 13:03 GDT
> **To:** Marcus Walker
> **Cc:** Iain Cunningham
> **Subject:** Fw: Re: Fw: AMEP Flood Warning & Evacuation Plan
>
> Marcus - as you see no further comments from Humber Emergency Planning.
>
> I have no further comments.
>
> So ok.
>
> Regards Barrie.
>
> -----Forwarded by Barrie Onions/PL/NorthLincs on 12/05/2011 12:57PM -----
>
> > To: Barrie Onions/PL/NorthLincs@NorthLincs
> > From: David Harrison/HT/NorthLincs
> > Date: 12/05/2011 11:13AM
> > Subject: Fw: Re: Fw: AMEP Flood Warning & Evacuation Plan
> >
> > Barrie
> >
> > Comments from HEPs. I've nothing further to add
> > Regards
> >
> > David Harrison
> > 01724 297530

-----Forwarded by David Harrison/HT/NorthLincs on 12/05/2011 11:10AM -----

To: David Harrison/HT/NorthLincs@NorthLincs
From: Graham Wilkinson/HT/NorthLincs
Date: 12/05/2011 09:38AM
Cc: alan.bravey@eastriding.gov.uk
Subject: Fw: Re: Fw: AMEP Flood Warning & Evacuation Plan

Dave

Please see Alan's response laying out the Heps position. Do we need to meet to discuss?

Regards

Graham Wilkinson
Senior Emergency Planning Officer
North Lincolnshire Council
Church Square House
Scunthorpe
DN15 6NL

Tel: 01724 297618

-----Forwarded by Graham Wilkinson/HT/NorthLincs on 12/05/2011 9:36 -----

To: Graham.Wilkinson@northlincs.gov.uk
From: Alan.Bravey@eastriding.gov.uk
Date: 11/05/2011 17:39
Subject: Re: Fw: AMEP Flood Warning & Evacuation Plan

Graham

The outline plan itself looks comprehensive and sensible to me, but the problem is that we have no real basis to say whether it is sufficient or not. I think that the HEPS position is that:

The role of Heps is primarily to ensure that North Lincolnshire Council meets the obligations placed on it by their Civil Contingencies Act. We have no expertise to provide an assessment on whether specific evacuation plans or other emergency plans of external organisations are fit for purpose and we have no basis for making such statements. This is particularly so when the evacuation of an area is likely to involve the sites own resources, or the emergency services rather than the local authority.

The main source of our guidance is taken from the CCA, and we can signpost developers to that guidance, (e.g. plan templates / self assessment checklists etc) , but I think we would be stepping outside of our remit if we did any more than that.

Happy to meet with anyone from NLC to discuss further.

Thanks

Alan

Alan Bravey
Emergency Planning Manager

Humber Emergency Planning Service
01482 393050

From:
"Graham Wilkinson" <Graham.Wilkinson@northlincs.gov.uk>
To:
alan.bravey@eastriding.gov.uk
Date:
11/05/2011 17:05
Subject:
Fw: AMEP Flood Warning & Evacuation Plan

Al - please see attached.

Haven't we done some work on PPS25? Do I need to be careful about my response?

Regards

Graham Wilkinson
Senior Emergency Planning Officer
North Lincolnshire Council
Church Square House
Scunthorpe
DN15 6NL

Tel: 01724 297618

-----Forwarded by Graham Wilkinson/HT/NorthLincs on 11/05/2011 16:17 -----

To: Rod Chapman/HT/NorthLincs@NorthLincs
From: David Harrison/HT/NorthLincs
Date: 10/05/2011 16:57
cc: Graham Wilkinson/HT/NorthLincs@NorthLincs
Subject: Fw: AMEP Flood Warning & Evacuation Plan

Rod

See the attached forwarded by Barrie. Do you have any comments?
Graham

I assume you've seen this?

Regards

David Harrison
01724 297530

-----Forwarded by David Harrison/HT/NorthLincs on 10/05/2011 04:54PM -----

To: David Harrison/HT/NorthLincs@NorthLincs
From: Barrie Onions/PL/NorthLincs
Date: 10/05/2011 02:45PM
Subject: Fw: AMEP Flood Warning & Evacuation Plan

Dave - have you seen this. I think this is more your side of things - Evacuation Plan for the Able MEP IPC proposal.

Do you have any comments to make?

Kind Regards Barrie.

-----Forwarded by Barrie Onions/PL/NorthLincs on 10/05/2011 02:42PM -----
To: Iain Cunningham/PL/NorthLincs@NorthLincs, Barrie Onions/PL/NorthLincs@NorthLincs
From: Marcus Walker/PL/NorthLincs
Date: 05/05/2011 01:36PM
Subject: Fw: AMEP Flood Warning & Evacuation Plan
(See attached file: 2010s4400 Final FRA Ch.4 Flood Warning and Evacuation Plan 21-04-2011.doc)

Can you advise please
-----Forwarded by Marcus Walker/PL/NorthLincs on 05/05/2011 01:36PM -----

To: "'Marcus Walker'" <Marcus.Walker@northlincs.gov.uk>
From: "Richard Cram" <rcram@ableuk.com>
Date: 21/04/2011 03:21PM
cc: "'WALKER Angus'" <AngusWALKER@bdb-law.co.uk>, "'David Stark'" <david.stark@jbaconsulting.co.uk>, "'MONK JONATHAN'" <jmonk@ableuk.com>
Subject: AMEP Flood Warning & Evacuation Plan

Marcus,

In accordance with the PPS 25 Guidance Note, the LA should be consulted on evacuation plans.

I attach the outline plan that will be included in the FRA. Can you please advise if NLC is content with the proposals and whether you need a specific requirement in the DCO for the final evacuation plan to be approved prior to occupation of any buildings.

Thanks.

Kind regards

RICHARD CRAM
Design Manager

Able UK Ltd
Able House
Billingham Reach Industrial Estate
Billingham
Teesside TS23 1PX

Tel: 01642-806080
Fax: 01642-655655
Email: rcram@ableuk.com
Web: www.ableuk.com & www.ableshiprecycling.com

From: David Stark [mailto:david.stark@jbaconsulting.co.uk]
Sent: 21 April 2011 13:27
To: rcram@ableuk.com
Cc: Richard Annable
Subject: 2010s4400 AMEP - Flood Warning & Evacuation Plan

Richard,

In response to your phone call today I attach a copy of the Chapter entitled ?Flood Warning & Evacuation Plan? from my working draft of the Final FRA. The text is essentially the same as the Draft FRA with minor changes. The imminent results of Breach Modelling by our Warrington Office will influence this text. I have been in contact with Warrington staff today and I understand that floodwaters from a breach reach the site within 15 minutes and significant flood depths occur on the site within 30-45 minutes. My view is that the site should be evacuated upon receipt of a flood warning from the Environment Agency and not ?when significant waves are frequently overtopping the defences? as currently proposed. I propose to amend this text when I have received and reviewed the Breach Modelling report. It may be better to refrain from sending the attached version to NLC and to wait for my revised chapter next week.

Kind regards

David Stark

JBA Consulting
South Barn
Broughton Hall
Skipton
North Yorkshire
BD23 3AE
United Kingdom

t: +44 (0)1756 799919 | f: +44 (0)1756 799449

[attachment "2010s4400 Final FRA Ch.4 Flood Warning and Evacuation Plan 21-04-2011.doc" deleted by Alan Bravey/CR/ERC]

> > > Whilst every effort has been made to check for viruses in this e-mail
> > > and any attachments, the Council does not warrant that it or they are
> > > free of viruses. If in any doubt then please ask for the hard copy.
> > > **E

K. Advice from Anglian Water

Letter dated 4 August 2011.

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Anglian Water
Services Limited
Business Customer Services
3 Lancaster Road
Hartlepool
TS24 8LW

Tel 08457 626 784
Fax 01223 201108

Our ref:
Date: 04 August 2011

Richard Cram
Able UK Limited
Able House
Billingham Reach Industrial Estate
Billingham
TS23 1PX

Dear Mr Cram

Humber Bank Developments

Further to our recent discussions I am writing to confirm Anglian Water's commitment to your projects on the South Humber Gateway.

Able UK and Anglian Water have been routinely meeting for the last three years to progress the East Halton development, for the last 15 months these meetings have included the Marine Energy Park opportunity.

Water resources are currently available to supply both these developments, based upon your water demand forecasts. As you know these water resources are not reserved for Able UK; they are available to customers on a 'first come first supply' basis.

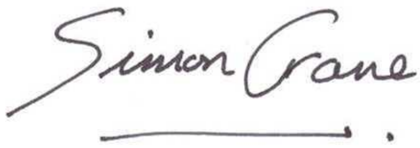
Water to the East Halton development will require a new water main adjacent to Eastfield Road. To support the Marine Energy Park additional water mains need to be constructed along Chase Hill Road and Rosper Road.

Receiving domestic sewage from both the East Halton development and Marine Energy Park has also been considered. Public sewers will need to be constructed for both these developments.

Additional waste water treatment capacity will also be required at the receiving sewerage treatment works located on Chase Hill Road.

Application forms and related information packs to progress these significant investment opportunities can be accessed on the Anglian Water our web site http://www.anglianwater.co.uk/developers/application-forms/ .

Yours sincerely



Simon Crane
Senior National Business Account Manager
Anglian Water Services, Business Customer Services
Tel 07968 539 489

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